

RC56: Recommendations for fire safety in the storage, handling and use of highly flammable and flammable liquids: storage in containers other than external fixed tanks



Symbols used in this guide



Good practice



Bad practice



Discussion topic



Frequently asked question

Acknowledgements

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Summary of Key Points

Comply with fire safety legislation	<ul style="list-style-type: none">• In addition to a fire risk assessment undertaken in compliance with national fire safety legislation an assessment should also be undertaken by a competent person in accordance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).
Protect business continuity	<ul style="list-style-type: none">• All businesses should take steps to maintain the continuity of their operations by making and rehearsing a suitable emergency plan.
Minimise the use of flammable liquids in the workplace	<ul style="list-style-type: none">• Priority should be given to eliminating flammable and highly flammable liquids from the workplace wherever possible.
Provide suitable training for staff	<ul style="list-style-type: none">• All staff should be familiar with the hazards associated with the flammable liquids in use in the workplace and the precautions to be taken when handling and dispensing them.• All staff should be aware of the actions to be followed in the event of fire or spillage.
Identify hazard zones	<ul style="list-style-type: none">• The DSEAR assessment should include identifying hazard zones in the workplace.
Plan the fire risk assessment	<ul style="list-style-type: none">• The 'VICES' acronym is a key element of fire safety with flammable liquids and should be followed when carrying out the assessment.
Ventilation	<ul style="list-style-type: none">• Ensure there is sufficient ventilation at high and low level to maintain the concentration of the liquid's vapour well below its lower explosive limit.• Dampers should not be installed in ducts used for the extraction of flammable vapours.
Ignition	<ul style="list-style-type: none">• Take care to identify all potential ignition sources in the workplace, including:<ul style="list-style-type: none">- Heating and hot surfaces- Contractors' operations- Sources of static electricity- Vehicles being used for the transportation of drums and containers- Deliberate fire setting
Containment	<ul style="list-style-type: none">• Provide catchment areas in case of leaks and spillages in order to retain leakage, guard against the risk of pollution and contain a possible flowing liquid fire.
Exchange	<ul style="list-style-type: none">• Consider possible non-flammable or less flammable alternatives for each flammable solvent in use.
Separation	<ul style="list-style-type: none">• Wherever possible, drums and other containers for flammable liquids should be stored in a designated safe position in the open air.
Ensure that hazard zones are observed	<ul style="list-style-type: none">• All vehicles used for transporting drums and containers should be suitable for the hazard zone(s) in which they are to be used.
Fire protection	<ul style="list-style-type: none">• Consider installing a foam enhanced sprinkler installation to protect stocks of flammable and highly flammable liquids.

1 Synopsis

These recommendations give advice on the storage of flammable and highly flammable liquids in industry. Information includes the design of secondary containment areas for external storage, internal flammable liquid stores and flammable liquid cupboards for the workplace.

Detailed guidance includes advice on ventilation, containment, the heating of stores, the selection of electrical equipment and provisions in case of spillage.

2 Scope

These recommendations present measures relevant to fire safety in the storage of highly flammable and flammable liquids in drums, cans and containers other than in external fixed tanks. Such liquids (which may include solvents, adhesives, resins etc) may have flashpoints of up to 55°C. Some of these liquids may present hazards additional to those relating to fire, for example, to health, but such hazards are not discussed in this document.

This document does not apply to the use or storage of liquefied petroleum gas (LPG), aerosol products or automobile or other spraying processes, for which more specific guidance is available in RISC Authority recommendations RC8, RC19, RC31 and RC32 (see refs 1-4).

Legislation not specifically concerned with fire safety may impose additional requirements to those in this document and due regard should also be given to environmental considerations. (See refs 5 to 9.)

These recommendations are part of a suite of documents and should be read in conjunction with RC55 and RC57 (refs 10 and 11).

The guidance set out here should be taken into consideration when risk assessments are carried out in compliance with the Regulatory Reform (Fire Safety) Order 2005 and equivalent legislation in Scotland and Northern Ireland (refs 12-16) and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 (ref 17).

3 Definitions

Auto-ignition temperature

The minimum temperature at which a material will ignite spontaneously without the presence of a source of ignition.

Bund

A secondary enclosure to retain spills and leakage from tanks or containers to prevent contamination and spread of fire.

Classification of hazardous areas (BS EN 60079-10-1) (ref 18)

(This classification refers to areas in which open processes are carried out; areas in which closed processes are undertaken should be subject to a risk assessment.)

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 does occur, is likely to do so only infrequently and will exist for a short period only.

Competent

Someone with sufficient training and experience or knowledge and other qualities to enable them properly to implement the relevant measures.

Explosive limits (BS EN 60079-10-1) (ref 18)

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 of flammable gas or vapour in air, above which the gas atmosphere is not explosive.

Flammable liquid

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

Flashpoint (BS EN 60079-10) (ref 18)

The lowest liquid temperature 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.

Highly flammable liquid (DSEAR 2002) (ref 17)

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

- (a) when tested in accordance with Part A.9 of the Annex to the Directive (ref 19) has a flashpoint of less than 32°C; and
- (b) when tested at 50°C using the procedure referred to in Appendix B to the 'Approved requirements and test methods for the classification and packaging of dangerous goods for carriage' with a heating time of 60 seconds supports combustion.

4 Introduction

Flammable and highly flammable liquids fall within the definition of 'dangerous substance' as referred to in the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref 17).

Where a dangerous substance is either present or liable to be present at the workplace, a suitable assessment of the risks likely to arise should be conducted and action taken to eliminate or reduce the hazard. Where an explosive atmosphere may occur the workplace must be classified into zones based on the frequency and duration of the explosive atmosphere and the zones checked by a competent person.

The flashpoint is the property that is conventionally used to classify and indicate the flammability of liquids. Those with flashpoints close to ambient temperatures are more hazardous than those with flashpoints at temperatures unlikely to be reached in the workplace.

Two main dangers need to be recognised:

- the danger of explosion, when flammable vapour/air mixtures fall within their explosive limits;
- the danger of fire, which may involve the flow of burning liquid over a wide area, or the rupture or explosion of unvented or inadequately vented containers.

All flammable liquids, regardless of flashpoint, will contribute greatly to the severity and spread of fire. Physical properties, the auto-ignition temperature, explosive limits, specific gravity, vapour density and oxygen enrichment or depletion of the atmosphere, will need to be considered when specifying risk control measures. Changes of state of a material when heated and the effect of gravity inducing a flow of liquids and vapours also require serious consideration.

The intensity of a fire or its rate of growth may be increased if incompatible materials, such as organic peroxides, are stored adjacent to flammable liquids. In addition, a fire may grow and involve dangerous substances which are themselves not combustible (see Health and Safety booklet HSG 71 (ref 20)).

These recommendations apply to all flammable and highly flammable liquids although under certain conditions some of these requirements, where liquids with higher flashpoints are

concerned, may be relaxed. The extent of hazard reduction and management will be one of the outcomes of the specific risk assessment conducted in terms of DSEAR and the general fire risk assessment carried out in compliance with fire safety legislation.

To comply with the requirements of DSEAR, the management of flammable and highly flammable liquids should be subject to a risk assessment undertaken by a competent person. When considering such an assessment it should be remembered that the control measures that may be appropriate in the case of an open process, where flammable vapours are exposed to the atmosphere, may be very different from those which should be observed in an area where a process in which such substances are handled in pipelines and closed containers is undertaken.

The risk assessment is not a once in a lifetime approach. It should be reviewed periodically, and also following an incident or near-miss and when there are changes in the:

- equipment being used;
- materials being used in the process;
- operating procedures;
- operating parameters and control measures that are observed;
- management of the process;
- size of the operation; or
- process times involved.

The risk assessment should also be reviewed following an incident or near miss.

Specialist advice should be sought where materials, such as organic peroxides and monomers, are in use that present not only flammability, but also other special hazards.

The main causes of fire involving flammable liquids, which should be borne in mind when carrying out the risk assessment, include:

- lack of awareness: incorrect/improper installation or use of equipment; hazardous situations not being recognised; or people being ignorant of the hazards associated with flammable liquids;
- lack of training in the handling of flammable liquids;
- lack of maintenance: where no problem areas are apparent (such as in the case of a closed process) and it is felt that the cost of regular maintenance is not justified;
- misuse: poor management procedures where a person engages in an unsuitable or prohibited practice (for example, smoking) with disregard for safety regulations;
- carelessness: where an existing problem is recognised but ignored;
- improper design: possibly by a person not qualified to do so and ignoring relevant legislation and/or standards;
- static electricity: where movement of flammable liquid in the handling process may lead to a build up of charge;
- absence of good housekeeping: where areas are not kept free from other combustible materials;
- lack of appropriate waste management, for example of 'empty' containers: where containers used in large scale operations have been decommissioned but subsequently inadvertent steam injection has raised the temperature inside a container high enough to reach the auto-ignition temperature of the residual deposits.

In addition to DSEAR, the requirements of the Control of Pollution (Oil Storage) (England) Regulations 2001 should be observed, particularly those relating to the provision of bunds (ref 9).

Changes in legislation

In 2015 a number of amendments to current legislation affecting the control and management of flammable liquids will come into operation. Most importantly:

- The Seveso II Directive, implemented in the UK as the COMAH Regulations, will be replaced in 2015 by the new Seveso III Directive. A major change will be the use of the Globally Harmonised System (GHS) for classification of chemicals to determine whether they are within the scope of the Directive. There is also the potential for sites to change their COMAH status (top tier, lower tier or non-COMAH) when the new Directive is implemented, depending on the substances and quantities held.
- From 1 June 2015 European Regulation (EC) No 1272/2008: Classification, labelling and packaging of substances and mixtures (already known as the 'CLP Regulations') will replace the Chemicals (Hazard Information and Packaging for Supply) Regulations 2009.

5 Recommendations

5.1 Compliance with fire safety legislation

- 5.1.1 A suitable and sufficient fire risk assessment should be undertaken for all premises to which the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) applies (refs 12-16).
- 5.1.2 As well as the staff handling and using flammable liquids, the assessment should consider staff remote from the process area who may be affected by smoke, heat and flying debris in the event of a fire. Where large volumes of flammable liquids are stored, handled or in use the implications for other people in the neighbourhood should also be addressed. In business critical areas the implications for property protection and business continuity, as well as life safety, should also feature prominently in the assessment.
- 5.1.3 An assessment should be undertaken in accordance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref 17). In common with the fire risk assessment, this should be undertaken by a competent person; it should identify any hazard zones in the workplace.
- 5.1.4 Risk assessments should be the subject of periodic review, including at the time when any changes to the process, the substances involved, the method of storing or handling the substances or the treatment of waste solvents are being considered.
- 5.1.5 The response by fire and rescue services to 999/112 calls and signals routed via fire alarm monitoring organisations varies widely throughout the UK, and differs from day to night-time. Fire safety managers should refer to the relevant fire and rescue service to make themselves aware of the levels of response in the areas in which their premises are located and consider this information when undertaking and reviewing their fire risk assessments.



All businesses should take steps to maintain the continuity of their operations by making a suitable emergency plan. The plan should address the implications of a fire, flood or other perceived disaster on all facets of the business.

5.2 Business continuity

Even a small fire can have a disproportionate effect on a business if it occurs in a critical area. The use of solvents is hazardous and must be carefully managed to avoid unnecessary disruption to the efficient functioning of the business.

- 5.2.1 In commercial premises where processes routinely involve the use of flammable or highly flammable liquids, the fire hazards and thus the threat to the business are increased if the processes are allowed to continue unattended. If it is intended that equipment is to be left operating without staff in attendance then a specific risk

assessment for the process should be undertaken. (Further information regarding unattended processes is set out in RISC Authority recommendations RC42 (ref 21)).

- 5.2.2 All businesses should take steps to maintain the continuity of their operations by making a suitable emergency plan. Guidance for this is set out in *Business resilience: A guide to protecting your business and its people* (ref 22). The emergency plan should address the implications of a fire, flood or other perceived disaster on all facets of the business model. It should indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of replacement equipment.
- 5.2.3 Tabletop exercises should be held periodically to test the effectiveness and suitability of the emergency plans.
- 5.2.4 Consideration may be given to applying commercially available computer programs, such as the ROBUST software (Resilient Business Software Toolkit) that is available free of charge (ref 23), or similar product, to develop and check the adequacy of the plan.

5.3 Fire safety management

- 5.3.1 At the outset, attention should be given to eliminating flammable and highly flammable liquids from the workplace wherever possible. Serious consideration should be given to the need for the use of such liquids in the process and the possibility of replacing them with non-flammable liquids as alternatives, or at least with those having a flashpoint above 55°C.
- 5.3.2 The storage location should be clearly identified by an appropriate pictogram and prominent signs stating 'Highly flammable liquid' or 'Flammable liquid' depending upon the flashpoints of the products being stored.
- 5.3.3 For quantities greater than 25 tonnes the storage location should be marked in accordance with the Health and Safety (Safety Signs and Signals) Regulations 1996 (ref 24). On certain sites where highly dangerous substances are stored, signs in accordance with the Dangerous Substances (Notification and Marking of Sites) Regulations 1990 (ref 25) should be displayed.
- 5.3.4 Individual containers shall be marked as required to identify their contents in accordance with the Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 as amended (ref 26) and the Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996 (ref 27).
- 5.3.5 Where appropriate, competent authorities should be notified and emergency action plans prepared in compliance with the Control of Emergency Accident Hazards (COMAH) Regulations 1999 (as amended) (ref 28).
- 5.3.6 Flammable liquids and 'empty' containers should not be accessible to intruders; suitable security measures should be in place.
- 5.3.7 Installed and portable electrical equipment, including electric lighting should be appropriate for the zone (assessed according to BS EN 60079-10-1) (ref 18) in which it is to be used. In areas where unenclosed liquids are being used and zones have not been defined, measures should be taken as would be appropriate when considering the whole area as an area of highest hazard (ie zone 0).

Training and supervision

- 5.3.8 A training scheme should be established and monitored for the training and refresher training of people who are using or could be called upon to use flammable liquids.
- 5.3.9 All staff members should be trained in:
- the hazards associated with the processes being carried out on the premises;
 - the correct opening, handling, use and disposal of containers of flammable and highly flammable liquids;



Prominent signs should be displayed at the entrance to the site and on flammable liquid storage areas to warn fire fighters of the hazards present.

- action in the event of spillage or fire;
- raising the alarm and implementing the emergency procedures;
- how to attack the fire if it is safe to do so; and
- ventilation of the area concerned.

5.3.10 Staff should be made aware of the hazards of deliberate fire raising, which may be carried out by colleagues as well as by intruders.

5.4 VICES

5.4.1 The HSE guidance in booklet HS(G)51 (ref 29) suggests the use of the acronym VICES to help apply five basic principles which ensure that any flammable or highly flammable liquid that is absolutely necessary in the workplace is used and stored with appropriate care.

5.4.2 Suitable staff training should be in place to ensure all personnel are aware of the hazards in the workplace and apply VICES to ensure a safer working environment for all.

5.4.3 The acronym may be explained as follows:

V Ventilation (see section 5)

- Is there sufficient ventilation to keep the concentration of the liquid's vapour below its lower explosive limit?

I Ignition (see section 6)

- Have all possible ignition sources been removed?
- Is the electrical equipment used in this area suited to the risk category?

C Containment (see section 7)

- Are the liquids stored in suitable containers?
- In the event of a spill will they be contained?
- Is it possible to prevent spillages from spreading?
- Are bunds or catchment trays present where required?
- Are 'empty' containers properly managed?

E Exchange (see section 8)

- Can flammable substances be eliminated?
- Can the substance be replaced by a less flammable one?

S Separation (see section 9)

- Is the storage of liquids separated from other stored materials?
- Are incompatible materials suitably separated?
- Are physical barriers (examples might be walls, doors, cabinets and bins) present as required?

5.5 Ventilation

5.5.1 Adequate ventilation should be provided by natural or mechanical means to prevent the concentration of vapour accumulating to within the relevant explosive limits of the most hazardous solvent likely to be present. The degree of ventilation required will

depend on the flashpoint of the liquid, the quantities in use, the location of the work and the type of process.

- 5.5.2 Flammable liquid stores should be at or above ground level unless sufficient mechanical ventilation is provided. Where storage is in the open air sites selected for this purpose should not be in hollows or close to drains and other areas below surrounding ground level where released flammable vapours that are heavier than air may accumulate.
- 5.5.3 In a storage building or compartment low-level and high-level ventilation direct to the open air should be provided to prevent the accumulation of flammable vapour. This may be achieved by the use of air-bricks. The vent area should comprise at least 2.5% of the combined area of the roof (ceiling) and walls. Care should be taken to prevent drums and containers from obstructing the openings.
- 5.5.4 Mechanical ventilation may be used to provide at least six air changes per hour. Extract must be at low level, inlet at high level, positioned so as to provide cross-flow. Duct openings should not allow fire spread. Fan motors should not be positioned within ductwork and should be suitable for the hazard zone. All mechanical ventilation installations shall comply with BS 5925 (ref 30).
- 5.5.5 Where mechanical ventilation is installed the location of the exhaust outlet should be subject to a risk assessment in compliance with DSEAR. In most cases it should be adequate if the ventilation ductwork is terminated at least 3m above ground level and the same distance from building openings (including the eaves of buildings), boundaries, natural hazards such as drains and sources of ignition.
- 5.5.6 Ducting should:
- be of non-combustible construction;
 - take as short a route as possible;
 - have as few directional changes as possible;
 - be arranged so that vapours cannot condense and collect at low points in the ductwork;
 - be routed to a safe place in the open air.
- 5.5.7 No fire dampers should be fitted in extract ducts for flammable vapours.
- 5.5.8 Open air storage areas should be away from buildings and structures that may prevent an adequate flow of air for ventilation.
- 5.5.9 In buildings or compartments where highly flammable liquids are stored, at least 10% of the combined area of the roof (ceiling) and walls should have openings and/or construction capable of providing explosion relief direct to a safe place in the open.



Fire dampers should not be installed in extract ducts used for transporting flammable vapours.

5.6 Ignition

- 5.6.1 One of the major objectives of any fire risk assessment is to identify potential sources of ignition in the workplace. These will include flames, hot surfaces and areas of movement that may lead to the generation of heat by friction or the build up of static charges. All sources of ignition should be eliminated and temperatures maintained well below the autoignition temperature of the most hazardous product in the area.
- 5.6.2 Smoking must be prohibited in the vicinity of all external areas where flammable liquids are used or stored and suitable notices should be prominently displayed. Care should be taken when identifying the locations of designated smoking areas where large volumes of flammable liquids are stored outside in drums and containers. Further information regarding designated smoking areas is set out in RISA Authority recommendations RC51 (ref 31).
- 5.6.3 Hot work should be prohibited unless totally unavoidable. In these cases a permit to work shall be issued under a hot work permit scheme and the use of acetylene on site should be avoided where practicable. The use of alternative methods of working

should be adopted wherever possible. Further information is set out in RISCAuthority recommendations RC7 and RC49 (refs 32 and 33). The measurement of vapour concentrations might be required in areas where the liquids cannot be safely removed or where it is suspected that high concentrations still exist, to ensure that the concentration is below the product's lower explosive limit.

- 5.6.4 Risk assessments undertaken for open air storage areas for highly flammable and flammable liquids should seek to mitigate the hazards associated with motor vehicles being introduced into the proximity.

Heating

- 5.6.5 Heating must be suitable for the hazard zone in which the work is being carried out.
- 5.6.6 The use of an indirect system such as hot water radiators is preferred for heating; further details are set out in RISCAuthority recommendations RC27 (ref 34).

Electrical equipment

- 5.6.7 Ideally, electrical wiring and equipment should be located outside the building in which the flammable liquids are being stored or handled.
- 5.6.8 Installed or portable electrical equipment, including electric lighting should be appropriate for the zone (assessed according to BS EN 60079-10-1) (ref 18) in which it is to be used. In areas where unenclosed liquids are being used and zones have not been defined, measures should be taken as would be appropriate when considering the whole area as an area of highest hazard (ie zone 0).

Static electricity

- 5.6.9 The potential hazard of ignition due to a build-up of static electricity should be assessed and precautions taken to eliminate it (see ref 35).
- 5.6.10 All plant and equipment used for handling highly flammable liquids must be electrically bonded and earthed (see ref 35); non-static tools should also be used. Consideration should be given to any additional measures necessary to prevent the build up and uncontrolled discharge of static electricity. Bonding and earthing should be subject to an annual continuity test.
- 5.6.11 Where high concentrations of vapours are present the use of synthetic clothing and non-conducting shoes should be prohibited to prevent a build-up of static electricity and possible discharge.
- 5.6.12 Where decanting takes place into a container with a small opening, a long-necked funnel should be used. Where a hose is used it should be ensured that the hose is of a conducting type.
- 5.6.13 Filling lines should terminate as close as possible to the bottom of tanks/containers to reduce the likelihood of a static build-up and discharge.
- 5.6.14 Safety drum transfer pumps incorporating controlled flow dispensing valves, flame arresters, self-closing lids and suitable earth bonding arrangements should be used for transferring large volumes of liquids. Drip trays should be provided.
- 5.6.15 Small volumes of highly flammable and flammable liquids should be handled using safety dispensing cans.
- 5.6.16 Copper earthing strips may be needed around the perimeter of the store room to facilitate the discharge of static electricity.

Lift trucks

- 5.6.17 Only lift trucks certified to the appropriate electrical zoning standard should be used (see HSE Guidance HSG 113 (ref 36)).
- 5.6.18 Gangways should be sufficiently wide to permit safe manoeuvring of trucks.
- 5.6.19 Suitably positioned barrier rails or bollards should be considered where appropriate to minimise the risk of impact damage.



Where storage is in the open air, sites selected for this purpose should not be in hollows or close to drains and other areas below surrounding ground level where released flammable vapours that are heavier than air may accumulate.

FAQ

- How can secondary containment be provided for drums of flammable liquid that may have to be moved from time to time?
- How can flammable liquids be stored safely inside a building where there is no outside storage facility available?



Polluted water removed from bunds must not be allowed to enter drains.

- 5.6.20 Battery-powered trucks should not be charged within a zone in which a hazardous atmosphere may be present.
- 5.6.21 The gas cylinders of LPG fuelled trucks should be changed in the open air where possible, they should not be changed in areas where highly flammable or flammable liquids are stored or used.
- 5.6.22 Further guidance on the safe use of lift trucks can be found in RISC Authority recommendations RC11 (ref 37).

Protection from direct sunlight

- 5.6.23 For unstable liquids or solvents with low auto-ignition temperature or very low flashpoint (or in the exceptional circumstances of less than 5% vapour space being provided in drums), serious consideration should be given to shielding the containers from direct sunlight, for example by providing an open-sided canopy of non-combustible material.

Arson prevention

- 5.6.24 Storage of flammable liquids should be permitted in the open only where there are adequate security precautions against arson and vandalism. Precautionary measures should be considered depending on the character of the neighbourhood and the quantity and nature of the flammable liquids stored. (See RISC Authority recommendations RC48 (ref 38) and the FPA book *The prevention and control of arson* (ref 39).)
- 5.6.25 The storage area and its immediate surroundings should be kept free from combustible materials, including waste, weeds and dried vegetation. The use of chlorate based weed killers should be avoided.

5.7 Containment

- 5.7.1. Safe catchment areas, or bunds, need to be provided to retain leakage, guard against the risk of pollution and contain a possible flowing liquid fire.
 - The catchment area should incorporate an impervious sill or low bund, at least 150mm high, and must have a capacity of not less than 110% of the contents of the largest container in the bund or 25% of their aggregate storage capacity, whichever is greater;
 - the base and walls of the bund must be impermeable to oil and water and be treated with a proprietary sealing product where necessary to maintain this property;
 - the base and walls must not be penetrated by any drain pipe, valve or opening;
 - if any fill or draw-off pipe passes through the base or wall of the bund the junction between the pipe and the base or wall must be adequately sealed to prevent the escape of oil or water;
 - provision needs to be made for the drainage of rain water from the bund area. To avoid pollution, however, rain water should not be allowed to enter surface water drains;
 - where the bund is deeper than 300mm it is recommended that mechanical ventilation be provided;
 - tanks and bunds must be positioned so as to minimise the risk of damage by impact as far as practicable.
- 5.7.2. Only liquid products should be stored in the bund area; the bund should be kept free from any other combustible materials.
- 5.7.3. The bund may incorporate a ramped sill at the entrance to allow wheeled access for the safe handling of products.



Figure 1: Containers should be stored on pallets which incorporate a sump

- 5.7.4. All drums should be accessible to enable leakages to be easily identified and to minimise the amount of handling needed to remove any specific container.
- 5.7.5. Drums in bunds should be stored off the ground on non-combustible stillage to limit corrosion.
- 5.7.6. All flammable liquid storage boxes and cabinets should incorporate sumps to retain any possible leakage.

Dispensing

- 5.7.7. Storage containers shall be suitable for the product stored. They should be robust, with tight fitting lids to resist spillage. Where small containers of about 2.5 litres are used, they should be fitted with a carrying handle or be conveyed in suitable carriers. Glass should not be used for containers with a volume greater than 2.5 litres.
- 5.7.8. Flammable liquids for routine use should be conveyed in suitable proprietary safety containers.
- 5.7.9. Dispensing from drums should be by means of a safety transfer pump or valve incorporating quick-action release and built-in flame arrester.
- 5.7.10. Unloading of drums should be minimised and when necessary be carried out using proprietary drum handling equipment.

Spillage

- 5.7.11. Where possible, drums and large containers not stored in bunds or banded stores should be stored on pallets which incorporate sumps to retain any leakage. The sumps should be inspected periodically, emptied when necessary and cleaned following any leaks.
- 5.7.12. Appropriate quantities of suitable materials should be available to retain and absorb spillages. Staff should be trained in the safe use and disposal of these materials.

5.8 Exchange

- 5.8.1 The fourth letter of the acronym 'VICES', exchange, refers to the primary need to ensure that flammable and highly flammable liquids are eliminated from the workplace if at all possible. Each such liquid should be considered in turn and possible non-combustible or aqueous alternatives be considered. (A successful example of the practical application of this principle is to be found in several industries where flammable white spirit-based paints have been replaced with water-based alternatives.)

5.9 Separation

External storage in drums

- 5.9.1 Wherever possible, drums and other containers for flammable liquids should be stored in a designated safe position in the open air. When selecting a location for outdoor storage cognisance should be taken of:
 - the fall of ground in relation to residential areas and exposed risks in the event of a large spillage;
 - access to and around the site;
 - drainage systems;
 - available water supplies;
 - population densities around the site;
 - the location of boreholes, aquifers or artesian wells within 500m of the site; and



Figure 2: Small containers in the workplace should be stored in a purpose-built flammable liquid cabinet

- the exposure to impact damage from vehicular movements.
- 5.9.2 External storage areas should be clearly marked 'Highly flammable liquids' or 'Flammable liquids' as appropriate.
- 5.9.3 The distance between any point on the perimeter of the drum storage area and any boundary fence, adjacent building or toxic or corrosive chemicals should not be less than the distances specified in paragraph 5.9.13 below (see also 5.9.14 and 5.9.18).

Internal storage

- 5.9.4 Where it is not practicable to store flammable liquids in the open air owing to limitations of space or for reasons of security, small volumes suitable for the immediate work period may be kept in the workplace but larger quantities should be kept in suitable storage buildings.
- 5.9.5 Flammable liquids should be stored in suitable containers such as tanks and drums. These should be kept closed and stored on pallets with sumps or on suitable fixed shelving. Where they have to be kept on the floor appropriate physical protection should be provided.
- 5.9.6 Small containers of flammable liquids kept in the workplace should be stored in a purpose-built flammable liquid cabinet. Quantities of flammable liquids held in any working area should be kept to a minimum and be subject to a process risk assessment. In all cases the volumes should not exceed the requirements for the day or shift being worked.
- 5.9.7 Cupboards designed for the storage of flammable liquids should:
- be constructed of non-combustible materials;
 - have trays at each level to limit the spread of liquid should a spillage occur;
 - have a sill at the lowest level to prevent spilled liquid leaking from the cupboard;
 - be conspicuously signed to indicate the nature of their contents;
 - be free of incompatible materials that may react together if contamination, leakage or spillage occurs.
- 5.9.8 Drums should preferably not be stacked. Where this is impracticable, they should be stacked to a height not exceeding 2m (for example, not more than 2 × 205 litres drums high stored vertically). If greater storage is necessary the drums should be stacked on drum racks, to a height of 5m maximum, subject to a risk assessment.
- 5.9.9 Intermediate bulk containers (IBCs) should preferably be made of metal and not be stacked. Where stacking is unavoidable the manufacturer should be consulted and the storage be subject to a risk assessment. IBC containers should not be stacked more than two high (ie one on top of another).
- 5.9.10 During the fire risk assessment for the workplace particular attention should be paid to IBCs, if these are in use on the site. The assessment should consider:
- The material from which the IBC is formed; the containers may be manufactured of metal, plastic or a composite material. In the case of plastic and composite materials the fire related properties of the container, such as the melting and ignition temperatures should be determined.
 - The contents of the IBC; highly flammable liquids should not be stored in IBCs of plastic construction.
 - If IBCs are to be stored in protected premises it must be ensured that the contents, if involved in a fire, will not overpower the sprinkler or other fire suppression system.
- 5.9.11 Areas for the storage of drums, IBC and similar containers should be set out with aisles with a minimum width of 1.5m to allow inspection of the stored materials and with no dead ends to hamper the escape of personnel.
- 5.9.12 Mixing and other processes involving the use of flammable liquids should not be undertaken in storage areas.



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Figure 3: An intermediate bulk container (IBC)

Purpose-built or dedicated stores

- 5.9.13 Storage buildings should preferably be detached and may include proprietary stores. Unless of fire-resisting construction, storage buildings should be located more than 4m from any boundary fence or adjacent buildings for quantities <100,000 litres and 7.5m for quantities >100,000 litres. Storage should not be above ground level or on the roof unless the local authority approves a suitable non-combustible store with additional requirements for drainage and ventilation. Basement storage areas should also be avoided.
- 5.9.14 The storage buildings should be single storey and of non-combustible construction. Where the storage building is closer to other buildings or to the site boundary than the required distances cited above, then its walls, including the walls of any internal compartments, should have the fire resistance ratings specified in Table 1. Doors should be kept securely locked when not in use. Doors should be fitted with automatic self-closers. All doors/means of escape should be unlocked and unobstructed when the building is occupied.
- 5.9.15 Only limited amounts of combustible packaging should be permitted to be kept in the store.
- 5.9.16 There should be a minimum of two exits, the travel distance to either of which should be minimised and subject to the findings of the fire risk assessment for the area.

Storage in a compartment within a building

- 5.9.17 If it is not possible to store flammable liquids in a detached building, storage may be permitted in a designated compartment within a building. To facilitate ventilation, at least one wall of the compartment should be an external wall.
- 5.9.18 The storage compartment should preferably be within a single-storey part of the building. Where it is only possible to provide storage in a multi-storey building it should be at ground level. In each case there should be compartment walls and floors separating the storage area from the rest of the building and those walls and floors should have the levels of fire resistance shown in Table 1.
- 5.9.19 External walls of an internal storage area which are closer to other buildings than specified in 5.9.13 should have a fire resistance rating of 120 minutes.
- 5.9.20 There should preferably be no direct access to the internal store from the building in which it is located. All doorways from the designated storage compartment should lead to the open, unless fire-resisting separation is provided to the standard laid down in Table 1.

Table 1: Stores for drums, cans and small containers. This table is compiled in accordance with model construction requirements for petroleum spirit can and drum stores (ref 28), and assumes storage heights not exceeding 2m. Higher storage will require increased fire resistance.

Minimum quantity (litres)	Fire resistance (minutes)	Floor loading (litres/m ²)
(a) Separate structure, maximum floor loading 300 litres/m ²		
500	30	300 max
2500	60	300 max
100,000	120	300 max
500,000	240	300 max
(b) Part of another structure		
250	30	50
1250	60	100
5000	120	200
100,000	240	200



How can volumes of flammable liquids on site be minimised when there are no suitable non-flammable alternatives available?

How can I organise a tabletop exercise to test the effectiveness and suitability of my emergency plans?

Bulk storage tanks

- 5.9.21 Bulk storage tanks should not be sited within buildings but where there is no practicable alternative they should be within a compartment which meets the criteria set out in 5.9.18 to 5.9.20 above.
- 5.9.22 Any supplementary tanks should also be segregated from working areas by walls or partitions of not less than 120 minutes' fire resistance. Such tanks should be fitted with an overflow pipe capable of returning flammable liquid to the bulk storage tank or to a safe location in the event of overfilling.
- 5.9.23 Where tanks have to be located within a building, the principles set out in the RISC Authority recommendations RC57 (ref 11) relating to fire safety with external fixed tanks should generally apply.

Fire walls

- 5.9.24 Where fire walls are erected between container storage and buildings or boundaries, then the safety distances in 5.9.13 can be reduced, subject to a fire risk assessment, provided the wall is at least 2m high, offers 30 minutes' fire resistance and extends a suitable distance beyond the sides of the storage area. Where the fire wall forms part of the building there should be no storage against this wall, unless there are no openings or fire escapes above it.

Prohibited goods

- 5.9.25 Flammable liquid store rooms should not be used for any other purpose and particularly not for the storage of compressed gases or toxic, corrosive or oxidising substances.

Empty containers

- 5.9.26 Empty containers may still contain significant traces of liquid and/or flammable vapours. All empty containers should be:
- kept closed;
 - removed from the workplace on a regular basis;
 - stored as for full containers;
 - labelled as being empty or be segregated from full containers;
- 5.9.27 Prolonged storage of empty containers should be avoided.
- 5.9.28 Empty containers should be disposed of safely.

5.10 Fire protection

- 5.10.1 Fire protection measures for areas where flammable and highly flammable liquids are stored, handled or used should be proportionate to the risk and be based on the findings of the fire risk assessments carried out in compliance with fire safety legislation and DSEAR (refs 12-17).
- 5.10.2 All storage facilities are to be fitted with at least a manually operated fire alarm system that will sound and be audible in all areas of the storage facility above the background noises (assuming a minimum noise of 65dB(A)), in accordance with BS 5839-1 (ref 40).
- 5.10.3 In zoned hazardous areas, it may be necessary for fire detection systems and communications systems to be intrinsically safe and appropriate for the zone, temperature and other relevant parameters.

Automatic sprinkler system

- 5.10.4 Consideration should be given to installing a foam enhanced sprinkler installation. Such a system should be provided where the requirement of safety distances cannot be met or when required by a risk assessment. An automatic sprinkler system could

permit a reduction in safety distances provided the requirements of the *LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845* are satisfied and adhered to (ref 41).

Portable firefighting equipment

- 5.10.5 The requirements for portable firefighting equipment will depend on the quantities of flammable liquids stored, any associated hazards and the position of the storage facility. Appropriate portable fire extinguishers, approved and certificated by an independent, third-party certification body, should be provided in accordance with BS 5306-8 (ref 42) and be serviced in compliance with BS 5306-3 (ref 43).
- 5.10.6 Consideration should be given to suitable access and turning points for fire service vehicles. Unobstructed access should also be available to hydrants, monitors and fixed installations relevant to the site.

6. Checklist

6.1 Compliance with fire safety legislation (section 1)		Yes	No	N/A	Action required	Due date	Sign on completion
6.1.1	Has a suitable and sufficient fire risk assessment been undertaken for all premises to which the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) applies? (5.1.1)						
6.1.2	Does the assessment consider staff remote from the process area who may be affected by smoke and heat in the event of a fire? (5.1.2)						
6.1.3	In business critical areas, do the implications for property protection and business continuity, as well as life safety, feature prominently in the assessment? (5.1.2)						
6.1.4	Has an assessment been undertaken in accordance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) that identifies hazard zones in the workplace? (5.1.3)						
6.1.5	Are the risk assessments the subject of periodic review, including at the time when any changes to the process, the substances involved, the method of storing or handling the substances or the treatment of waste solvents are being considered? (5.1.4)						
6.1.6	Has reference been made to the relevant fire and rescue service to become aware of the levels of response in the areas in which the premises are located? (5.1.5)						
6.2 Business continuity (section 2)							
6.2.1	If it is intended that equipment is to be left operating without staff in attendance then has a specific risk assessment for the process been undertaken and appropriate control measures introduced? (5.2.1)						
6.2.2	Have steps been taken to maintain the continuity of operations by making a suitable emergency plan? (5.2.2)						
6.2.4	Does the emergency plan indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of replacement equipment? (5.2.2)						
6.2.5	Are table top exercises held periodically to test the effectiveness and suitability of the emergency plans? (5.2.3)						
6.2.6	Is consideration given to applying commercially available computer programmes, such as the ROBUST software (Resilient Business Software Toolkit) or a similar product to develop and check the adequacy of the plan? (5.2.4)						
6.3 Fire safety management (section 3)							
6.3.1	Is attention given to eliminating flammable and highly flammable liquids from the workplace wherever possible? (5.3.1)						
6.3.2	Is the storage location clearly identified by an appropriate pictogram and prominent signs stating 'Highly flammable liquid' or 'Flammable liquid' as appropriate? (5.3.2)						

	Yes	No	N/A	Action required	Due date	Sign on completion
6.3.3						
6.3.4						
6.3.5						
6.3.6						
6.3.7						
6.3.8						
6.3.9						
6.3.10						
6.4						
6.4.1						
6.4.2						
6.4.3						
6.4.4						
6.4.5						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.4.6	Exchange: Can the flammable substances can be eliminated from the workplace or be replaced by less flammable ones? (5.4.5)						
6.4.7	Separation: Are flammable liquids stored separate from other stored materials and are physical barriers present as required? (5.4.6)						
6.5 Ventilation (section 5)							
6.5.1	Is adequate ventilation provided by natural or mechanical means to prevent concentrations of vapour accumulating to within the relevant explosive limits of the most hazardous solvent likely to be present? (5.5.1)						
6.5.2	Are flammable liquid stores at or above ground level unless sufficient mechanical ventilation is provided? Where storage is in the open air are sites selected for this purpose away from hollows and drains and other areas below surrounding ground level where released flammable vapours may accumulate? (5.5.2)						
6.5.3	In a storage building or compartment is adequate low-level and high-level ventilation direct to the open air provided to prevent accumulations of flammable vapour? (5.5.3)						
6.5.4	If mechanical ventilation is used, does it provide at least six air changes per hour with extract at low level and inlet at high level, positioned so as to provide cross-flow? (5.5.4)						
6.5.5	Where mechanical ventilation is installed, is the location of the exhaust outlet subject to a risk assessment in compliance with DSEAR? (5.5.5)						
6.5.6	Is ducting of non-combustible construction, taking as short a route as possible, with as few directional changes as possible and arranged so that vapours cannot condense and collect at low points in the ductwork? (5.5.6)						
6.5.7	Is the ductwork for extracting flammable vapours free of dampers? (5.5.7)						
6.5.8	Are open air storage areas away from buildings and structures that may prevent an adequate flow of air for ventilation? (5.5.8)						
6.5.9	In buildings or compartments where highly flammable liquids are stored, does at least 10% of the combined area of the roof (ceiling) and walls have openings and/or be of a construction capable of providing explosion relief direct to a safe place in the open? (5.5.9)						
6.6 Ignition (section 6)							
6.6.1	Does the fire risk assessment identify all potential sources of ignition in the workplace? (5.6.1)						
6.6.2	Is smoking prohibited in the vicinity of all external areas where flammable liquids are used or stored with suitable notices being prominently displayed? (5.6.2)						
6.6.3	Is hot work prohibited unless totally unavoidable? (5.6.3)						
6.6.4	Do the risk assessments undertaken for open air storage areas for highly flammable and flammable liquids seek to mitigate the hazards associated with motor vehicles being introduced into the proximity? (5.6.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.6.5	Is heating suitable for the hazard zone in which the work is being carried out? (5.6.5)						
6.6.6	Is the use of an indirect system such as hot water radiators preferred for heating? (5.6.6)						
6.6.7	Is electrical wiring and equipment located outside the building in which the flammable liquids are being stored or handled? (5.6.7)						
6.6.8	Is installed or portable electrical equipment, including electric lighting appropriate for the zone in which it is to be used? (5.6.8)						
6.6.9	Has the potential hazard of ignition due to a build-up of static electricity been assessed and precautions taken to eliminate this hazard? (5.6.9)						
6.6.10	Is all plant and equipment used for handling highly flammable liquids electrically bonded and earthed? (5.6.10)						
6.6.11	Where high concentrations of vapours are present, is the use of synthetic clothing and non-conducting shoes prohibited to prevent a build-up of static electricity and possible discharge? (5.6.11)						
6.6.12	Where decanting takes place into a container with a small opening, is a long-necked funnel used, and where a hose is used is it of a conducting type? (5.6.12)						
6.6.13	Do filling lines terminate as close as possible to the bottom of tanks/containers to reduce the likelihood of a static build-up and discharge? (5.6.13)						
6.6.14	Are safety drum transfer pumps incorporating controlled flow dispensing valves, flame arresters, self-closing lids and suitable earth bonding arrangements used for transferring large volumes of liquids? (5.6.14)						
6.6.15	Are small volumes of highly flammable and flammable liquids handled using safety dispensing cans? (5.6.15)						
6.6.16	Are copper earthing strips provided around the perimeter of the store room to facilitate the discharge of static electricity? (5.6.16)						
6.6.17	Are only lift trucks certified to the appropriate electrical zoning standard used? (5.6.17)						
6.6.18	Are gangways sufficiently wide to permit safe manoeuvring of trucks? (5.6.18)						
6.6.19	Are suitably positioned barrier rails or bollards installed where appropriate to minimise the risk of impact damage? (5.6.19)						
6.6.20	Are battery, powered trucks charged away from zones in which a hazardous atmosphere may be present? (5.6.20)						
6.6.21	Are the gas cylinders of LPG fuelled trucks changed in the open air where possible? (5.6.21)						
6.6.22	Are containers of flammable and highly flammable liquids with low flashpoints protected from direct sunlight? (5.6.23)						
6.6.23	Is the storage of flammable liquids only permitted in the open only where there are adequate security precautions against arson and vandalism? (5.6.24)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.6.24	Is the storage area and its immediate surroundings kept free from combustible materials, including waste, weeds and dried vegetation? (5.6.25)						
6.7 Containment (section 7)							
6.7.1	Are safe catchment areas, or bunds, provided to retain leakage, guard against the risk of pollution and contain a possible flowing liquid fire? (5.7.1)						
6.7.2	Are only liquid products stored in the bund area, which is kept free from other combustible materials? (5.7.2)						
6.7.3	Does the bund incorporate a ramped sill at the entrance to allow wheeled access for the safe handling of products? (5.7.3)						
6.7.4	Are all drums accessible to enable leakages to be easily identified and to minimise the amount of handling needed to remove any specific container? (5.7.4)						
6.7.5	Are drums in bunds stored off the ground on non-combustible stillage to limit corrosion? (5.7.5)						
6.7.6	Do all flammable liquid storage boxes and cabinets incorporate sumps to retain any possible leakage? (5.7.6)						
6.7.7	Are storage containers suitable for the products stored? (5.7.7)						
6.7.8	Are flammable liquids for routine use conveyed in suitable proprietary safety containers? (5.7.8)						
6.7.9	Is dispensing from drums by means of a safety transfer pump or valve incorporating quick-action release and built-in flame arrester? (5.7.9)						
6.7.10	Are staff aware that upending of drums should be minimised and when necessary be carried out using proprietary drum handling equipment? (5.7.10)						
6.7.11	Are drums and large containers not stored in bunds or banded stores stored on pallets which incorporate sumps to retain any leakage? (5.7.11)						
6.7.12	Are appropriate quantities of suitable materials available to retain and absorb spillages, with staff trained in the safe use and disposal of these materials? (5.7.12)						
6.8 Exchange (section 8)							
6.8.1	Is each flammable and highly flammable liquid considered in turn and possible non-combustible or aqueous-based alternatives considered? (5.8.1)						
6.9 Separation (section 9)							
6.9.1	Are drums and other containers for flammable liquids stored in a designated safe position in the open air? (5.9.1)						
6.9.2	Are external storage areas clearly marked 'Highly flammable liquids' or 'Flammable liquids' as appropriate? (5.9.2)						
6.9.3	Is the drum storage area adequately separated from boundary fences, buildings and toxic or corrosive chemicals? (5.9.3)						

	Yes	No	N/A	Action required	Due date	Sign on completion
6.9.4						
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6.9.6						
6.9.7						
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6.9.18						
6.9.19						
6.9.20						
6.9.21						

	Yes	No	N/A	Action required	Due date	Sign on completion
6.9.22						
6.9.23						
6.9.24						
6.9.25						
6.9.26						
6.9.27						
6.9.28						
6.10 Fire protection (section 10)						
6.10.1						
6.10.2						
6.10.3						
6.10.4						
6.10.5						
6.10.6						

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