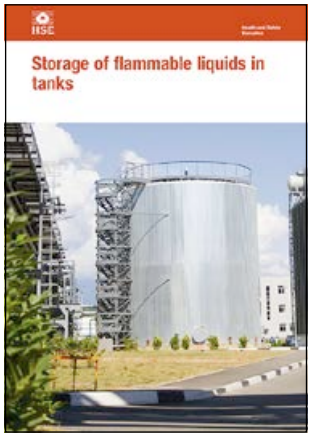
Storage of flammable liquids in tanks



HSG176 (Second edition) Published 2015

This guidance applies to above and below ground fixed bulk storage tanks. It applies to premises where flammable liquids are stored in individual tanks or groups of tanks. It may also be applied to portable or skid-mounted vessels with capacities in excess of 1000 litres.

It also gives guidance on the design, construction, operation and maintenance of installation used for the storage of flammable liquids in fixed and transportable tanks operating at or near atmospheric pressure.

It will help you assess the risks arising from the use of flammable liquids and decide how to control those risks.

The guidance is one of three documents dealing with fire and explosion hazards associated with flammable liquids. The other two are:

- *Storage of flammable liquids in containers* HSG51;
- *Safe use and handling of flammable liquids* HSG140.

It supplements the advice contained in *Dangerous substances and explosive atmospheres: Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance* L138.

The guidance has been updated to align with the recommendations of the Buncefield report.

HSE Books

Contents

Introduction

1 This guidance applies to above and below ground fixed bulk storage tanks. It applies to premises where flammable liquids are stored in individual tanks or groups of tanks. It may also be applied to portable or skid-mounted vessels with capacities in excess of 1000 litres.

2 It also gives guidance on the design, construction, operation and maintenance of installations used for the storage of flammable liquids in fixed and transportable tanks operating at or near atmospheric pressure. It will help you assess the risks arising from the use of flammable liquids, and decide how to control the risks.

3 The guidance is for those responsible for the safe storage of flammable liquids. It provides information on the fire and explosion hazards associated with flammable liquids and sets out practical measures to protect people at work and others who may be affected by work activities involving flammable liquids. It is relevant to many industries such as:

- chemical;
- petrochemical;
- paints;
- solvents;
- pharmaceutical.

4 Advice is provided on transfer facilities for road and rail loading and unloading.

5 The guidance is one of three documents published by HSE dealing with the fire and explosion hazards associated with flammable liquids. The other two documents are:

- *Storage of flammable liquids in containers* HSG51;[1]
- *Safe use and handling of flammable liquids* HSG140.[2]

6 This document complements *Dangerous substances and explosive atmospheres. Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance* L138.[3] You will be referred to L138 for additional information.

7 The guidance will also provide a useful source of reference for:

- employees;
- employee-elected representatives;
- trade union appointed health and safety representatives; and
- all other people who have a role in ensuring and assessing the adequacy of health and safety in the workplace.

8 The guidance may also be useful to professional bodies, trade organisations and associations, and other safety specialists to inform the development of more specific guidance for their own members.

9 The objectives of this guidance are to:

- increase awareness of the potential fire and explosion hazards associated with the storage of flammable liquids;
- give guidance on appropriate standards for plant and equipment;

- advise on the need for appropriate fire precautions, maintenance, training and good housekeeping where flammable liquids are stored.

10 In this guidance, 'flammable liquid' means a liquid with a flashpoint of 60 °C or below. This reflects the EU Classification, Labelling and Packaging of Substances and Mixtures Regulation (no 1272/2008) (the CLP Regulation), which sets the criterion for substances and mixtures to be classified as flammable to be those with a flashpoint of up to 60 °C. The guidance is also relevant to liquids with a flashpoint above 60 °C which are handled at temperatures above their flashpoint, as they may also present a fire and explosion hazard.

11 This publication provides a suitable standard for the design of new installations and for major modifications to existing installations. It may be difficult to adopt all the recommendations at existing premises, but any improvements that are reasonably practicable should be made, taking into account the hazards at the site and the cost and feasibility of additional precautions. This document describes ways of achieving an adequate standard of safety. Individual circumstances, for both new and existing installations, may require variations from the recommendations, so alternative designs, materials and methods can be used as long as they provide an equivalent level of safety. Advice on applying the guidance to specific sites may be obtained from the relevant trade association or health and safety professional.

12 The storage of flammable liquids and the management of any released vapours can have environmental consequences. Although this guidance does not cover environmental issues, the advice it contains for the safe storage of flammable liquids will generally also provide protection for the environment. However, some activities, such as reducing vapour levels by ventilation techniques, may require additional environmental controls; those involved in these activities are advised to refer to specific guidance on these controls and on other environmental issues. Further guidance on environmental considerations is available from:

- the Environment Agency in England www.environment-agency.gov.uk/business/sectors/wastemanagement.aspx
- the Scottish Environment Protection Agency (SEPA) in Scotland www.sepa.org.uk/waste.aspx
- Natural Resources Wales (NRW) Cyfoeth Naturiol Cymru http://naturalresourceswales.gov.uk

13 Following the fire and explosion at Buncefield in 2005, additional recommendations were made by the Process Safety Leadership Group (PSLG) for the storage of gasoline and a small range of other liquids in large tanks. The final report of PSLG, *Safety and environmental standards for fuel storage sites*[4] can be found on the HSE website. Details of the other liquids which may be in scope can be found in the Chemicals and Downstream Oil Industries Forum (CDOIF) *Guideline: Process Safety Leadership Group – Other Products in Scope*.[5]

14 The precautions described in this document may not be necessary for those flammable liquids whose temperature is always likely to be significantly below the flashpoint and where there is no potential for a flammable mist or spray to form. Advice on less restrictive measures for these liquids is given in the chapter 'Higher flashpoint liquids'. Where no variation is given, the advice in the main text applies.

What the guidance does not apply to

15 This guidance does not apply to:

- flammable liquids stored in portable containers and drums with capacities of 1000 litres or less. These are covered by *Storage of flammable liquids in containers* HSG51.[1] Generally, the storage of flammable liquids in fixed bulk tanks is preferable to storage of the same quantity in drums or similar containers, as spillage during handling is reduced;
- flammable liquids which present special hazards requiring specific precautions and storage conditions (such as ethylene oxide, peroxides and other liquids which entail a risk of rapid decomposition, polymerisation or spontaneous combustion);
- petroleum kept in fixed tanks at retail filling stations. Guidance on filling stations and similar private premises is available in *Petrol Filling Stations Guidance on Managing The Risks Of Fire & Explosion (The Red Guide)*.[6]
- carriage of flammable liquids (on or off site), including temporary storage at lorry parks and transit areas;
- liquefied petroleum gas and other substances which are gases at ambient temperature and pressure but are stored as liquids under pressure or refrigeration;
- flammable liquids stored under pressure. In these cases the guidance on LPG storage (UKLPG Code of Practice)[7] may be appropriate;
- vessels, which are an integral part of process plant;
- loading and unloading of ships. This is covered by *The bulk transfer of dangerous liquids and gases between ship and shore* HSG186[8] and *International Safety Guide for Oil Tankers and Terminals*.[9]
- filling from pipelines. Additional advice is also contained in the *International Oil Tanker and Terminal Safety Guide*.

16 Health and safety legislation relevant to sites manufacturing, using or storing flammable liquids is outlined below. Legal requirements, guidance and the standards referred to in this publication are subject to amendment from time to time. Where a British Standard is quoted, any other national or international standard which provides an equivalent level of safety is acceptable. The glossary at the back of this book explains the particular terms used in association with flammable liquids.

Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)

17 Avoiding fire or explosion at workplaces manufacturing, storing or using flammable liquids can be ensured by compliance with DSEAR. The primary purpose of DSEAR is to protect the safety of workers and others who may be at risk from dangerous substances that can cause a fire, explosion or similar energy-releasing event, such as a runaway exothermic reaction.

18 DSEAR is enforced by HSE or local authority inspectors, except at commercial premises holding a petroleum storage certificate (previously a petroleum licence) where the Regulations are enforced by Petroleum Enforcing Authorities (PEAs) in respect of any activities related to refuelling motor vehicles. At most workplaces, the local fire and rescue authority or the joint fire and rescue board for the area will enforce those parts of DSEAR that relate to general fire precautions (see paragraphs 247 to 261).

General fire safety legislation

19 General fire safety requirements in the workplace in England and Wales are applied through the Regulatory Reform (Fire Safety) Order 2005 (SI 2005/1541). The Scottish equivalents are the Fire (Scotland) Act 2005 (2005 (asp 5)) and the Fire Safety (Scotland) Regulations 2006 (SSI 2006/456). The legislation consolidated and revoked legislation that previously covered general fire safety, including the requirement for fire certification. Current legislation requires the employer to carry out a risk assessment to determine the general fire safety requirements for their workplace and implement those requirements, including maintaining a general fire safety management plan.

20 General fire safety legislation is normally enforced by the local fire and rescue authority or in Scotland, the Scottish Fire and Rescue Service. However, there are other enforcing authorities for certain specific workplaces/worksites. HSE is the enforcing authority for general fire safety in shipbuilding and on most construction sites. The Office for Nuclear Regulation (ONR) is the enforcing authority for fire safety in licensed nuclear premises.

21 Any general fire safety provision which could be imposed by regulations 1–6, 8, 9 and 11 of DSEAR is covered instead under this general fire safety legislation, with enforcement responsibility falling to the relevant authority, depending on the activity at the premises.

Hazards

22 The main hazards from the use of flammable liquids are fire and explosion, involving either the liquid or the vapour given off from it. For a fire or explosion to occur it requires three things to come together:

- flammable liquid;
- source of ignition; and
- air.

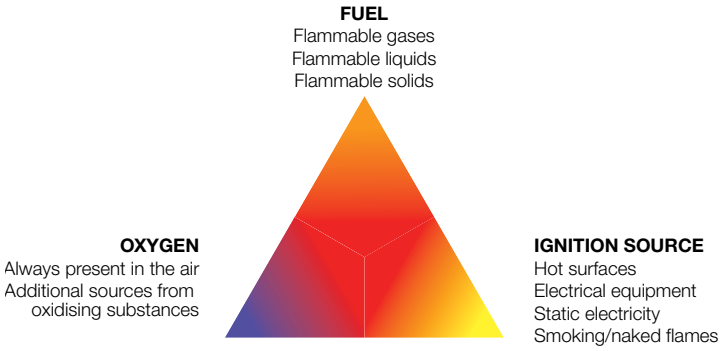


Figure 1 The fire triangle

Common causes of incidents

23 Fires or explosions are likely to 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 awareness of the properties of flammable liquids;
- operator error, due to lack of training;
- hot work on or close to flammable liquid containers;
- inadequate design of equipment;
- inadequate installation or maintenance;
- failure or malfunction of equipment;
- exposure to heat from a nearby fire;
- misuse of flammable liquids, for example, to burn waste materials or brighten fires;
- inadequate control of ignition sources;
- electrostatic discharges;
- heating materials above their auto-ignition temperature;
- dismantling or disposing of equipment containing flammable liquids.

24 Incidents involving flammable liquids commonly arise during transfer operations, including:

- movement from storage;
- decanting or dispensing;
- movement within premises;
- use in processes;
- disposal;
- dealing with spillages.

Flammable vapours

25 Combustion of liquids occurs when flammable vapours released from the surface of the liquid ignite. The amount of flammable vapour given off from a liquid, and therefore the extent of the fire or explosion hazard, depends largely on the temperature of the liquid, its volatility, how much of the surface area is exposed, how long it is exposed for, and air movement over the surface. Other physical properties of the liquid, such as flashpoint, auto-ignition temperature (AIT), viscosity, lower explosion limit (LEL) and upper explosion limit (UEL), give further information as to how vapour/air mixtures may develop and also on the potential hazards.

Flashpoint

26 Flashpoint is the lowest temperature at which a liquid gives off vapour in sufficient concentration to form a combustible mixture with air near the surface of the liquid. Generally, a liquid with a flashpoint below ambient temperature will give off a vapour that can mix with air and be ignited. Liquids with a flashpoint greater than ambient temperature are less likely to give off flammable concentrations of vapours unless they are heated, mixed with low flashpoint materials or released under pressure as a mist or spray. However, a material below its flashpoint can also be ignited when spread out as a thin film over a large area of ground or when spilled onto clothing.

Explosion limits

27 The explosion limits define the concentrations (normally by volume) of vapour–air mixtures at specified temperatures that will propagate a flame. Explosion limits vary greatly for different substances, but for many they are in the range of 1% to 10%.

Vapours

28 Some materials, such as water/solvent mixtures or emulsions, only release vapours slowly. These materials can flash during a flashpoint determination and be assigned a flashpoint, but may not have the ability to sustain combustion at the temperatures encountered in normal use, though these may well be in excess of the measured flashpoint. However, flammable vapours may build up in enclosed spaces above the liquid, and could explode if ignited.

Viscosity

29 The viscosity of the liquid is significant as it determines how far any spilt material will spread and therefore the size of any exposed surface. Solvents generally have a low viscosity and when spilt spread quickly, allowing a rapid build-up of vapours from the surface of the liquid. Some liquid formulations, such as paints and resins, may have a high viscosity; if they are spilt, they spread and produce vapours more slowly than would the individual solvent constituents.

Ignition

30 A flammable vapour–air mix is easily ignited by the external ignition sources discussed in paragraph 52. Even if there are no external sources present the mixture may self-ignite if it is heated above its auto-ignition temperature. The properties of a flammable liquid should therefore be established (for example, from the relevant data sheet) before the material is used, so that adequate precautions can be taken.

Physical environment

31 The physical environment in which flammable liquids are handled also determines how the hazards may develop. Whether the released vapour is able to build up to a concentration within its flammable range will depend on the ventilation at the surface of the liquid and on the presence of enclosures to trap or contain the vapours. In many cases the vapour will be heavier than air, and it will therefore tend to accumulate in lower areas or in depressions such as pits, gulleys and drains. Bear in mind that vapours can spread away from the liquid; if they are ignited the flame will travel or 'flash' back to the liquid.

32 Typical fire and explosion events include:

- pool fire where the released flammable liquid forms a pool (often within the bund);
- jet fire where the flammable liquid is released under pressure;
- tank fire where the liquid or its vapour burn within the tank (or on the surface of a floating roof tank);
- rim seal fire on a floating roof tank where a fire burns at the rim seal area only;
- vapour cloud explosion where flammable vapours accumulate in an enclosed or partially enclosed area and on ignition produce significant over-pressures.

Health hazards

33 Flammable liquids can also pose a health hazard if they are inhaled, ingested or come into contact with skin or eyes. Information on the health hazards of a particular liquid and on any specific precautions required should be obtained from the safety data sheet or from the supplier. COSHH (see Appendix) requires employers to assess the risks from exposure to hazardous substances and the precautions needed.

34 An obvious precaution to take against skin and eye contact is to provide items such as gloves, protective clothing and goggles. Suitable respiratory protection may be needed during any operations to deal with leaks and spillages.

Risk assessment

35 In addition to the requirements under the Management of Health and Safety at Work Regulations (the Management Regulations) (see Appendix), where flammable liquids are intentionally present in the workplace, there is a specific requirement under regulation 5 of DSEAR for you to identify the potential risks such activity may pose to your employees and others whose health and safety may be affected, and to determine the measures to be taken to eliminate or reduce these risks so far as reasonably practicable.

36 The risk assessment required under DSEAR may be carried out as part of the risk assessment requirements of the Management Regulations and general fire safety legislation, which follows the same approach as that used in health and safety legislation. In particular, given the need to take account of the presence of flammable liquids in the general fire safety risk assessment, you may find it of benefit to carry out the required risk assessments as a consolidated exercise.

37 A risk assessment should be carried out regardless of the quantity of flammable liquid present at the workplace, as it will enable you to decide whether existing measures are sufficient or whether any additional controls or precautions are necessary. As well as assessing the normal activities within the workplace, you will also need to assess non-routine activities, such as maintenance work, where there is often a higher potential for fire and explosion incidents to occur. 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 you must consider what you need to do to comply fully with the requirements of DSEAR.

38 Further guidance on the risk assessment requirement under DSEAR is given in L138.

39 This guidance assumes that you have concluded from your risk assessment that the storage of flammable liquids in tanks is appropriate at your workplace.

40 The performance objectives and control measures described in this guidance reflect current and readily achievable good industrial practice and are intended to help you minimise the risks associated with the storage of flammable liquids in tanks. You are free to take alternative measures, or vary those described, if you have determined through your risk assessment that they provide at least an equivalent level of health and safety.

41 The assessment should include risks arising from the tank contents, from the associated operational activities, and risks to the tank from external sources. The aims of the assessment are to determine:

- how the flammable liquid could be released;
- the consequences of such a release;
- how such a release could be ignited;
- what external risks are present;
- how to mitigate the consequences of a release.

42 Factors which should be considered when assessing a storage installation include:

- storage capacity;
- location of the tank, in relation to site boundaries, buildings, process areas and fixed sources of ignition;

- design standards for the installation;
- quantities and locations of other flammable liquids;
- quantities and locations of other dangerous substances;
- tank contents and any likely residues;
- activities on adjacent premises;
- training and competence of site operatives;
- supervision of staff;
- frequency of deliveries;
- loading and unloading operations;
- inspection and maintenance;
- the surrounding environment.

43 Guidance and further details of the requirements of DSEAR can be found in the Approved Code of Practice L138.

44 Risk assessments should be carried out before the installation of new facilities, modification of existing facilities and the demolition of obsolete facilities.

Substitution

45 In some instances, such as at production sites, it may be possible to eliminate or reduce the quantity of flammable liquid on site. For some processes, higher flashpoint or water-based products are now available. It may be practicable to reduce the storage inventory by better planning and stock control, by maintaining smaller buffer stocks and by removing from site any materials which are no longer used in the process.

Control measures

46 This section will briefly describe control measures for the storage of flammable liquids. More detailed information is supplied in later sections of the book.

Containment

47 Flammable liquids should be stored in tanks or containers and systems constructed to a national or international standard to ensure their strength and integrity. Further information is given in chapter 'Design and construction'.

48 There should also be means to contain spillage and fire water to prevent it spreading to other parts of the premises. Information on bunding is given in paragraphs 154–169 and on fire water control in paragraphs 62–65.

49 PSLG requirements[4] apply to tanks storing gasoline (petrol) and a small range of similar liquids in vertical cylindrical tanks greater than 5 m in height and filled at rates exceeding 100 m^3/hour. For in-scope tanks there are additional safety and environmental measures – the CDOIF *Guideline: Process Safety Leadership Group – Other Products in Scope*.[5]

Separation

50 Separation is an important means of providing protection for tanks containing flammable liquids. Separation has particular advantages because it protects people and property from the effects of a fire at the tank, and protects the tank from fires which may occur elsewhere on site. Further advice on the recommended separation distances is given in chapter 'Location and layout of tanks'.

Ventilation

51 Good ventilation ensures that any flammable vapours given off from a spill, leak or release will be rapidly dispersed. This may be achieved by locating storage tanks, transfer facilities, vent pipes etc in the open air, in an unobstructed position. Locating plant and storage facilities in the open air normally ensures the best possible dispersion of dangerous substances to limit the formation and extent of hazardous explosive atmospheres. Certain features may affect the ready dispersal of any releases of dangerous substances, eg buildings, pits, and structures providing weather protection. Employers should ensure, as appropriate:

- these are sufficient distance away; or
- they are of suitable design to prevent the accumulation of dangerous substances; and
- where necessary, the ground is graded to direct vapours away from occupied buildings and vulnerable populations (eg to provide safe dispersal of vapourising liquid leaks from fixed liquefied gas vessels).

Control of ignition sources

52 In certain areas, flammable atmospheres may occur either during normal operation or due to accidental spills or leakage. These areas are called hazardous areas, and measures to control the introduction of sources of ignition are required in these areas. Common ignition sources include:

- unprotected electrical and mechanical equipment;
- naked flames including welding and cutting equipment;
- smoking materials;
- vehicles with internal combustion engines;
- hot surfaces;
- frictional heating or sparking;
- static electricity;
- lightning.

Further advice can be found in BS EN 1127-1.[10]

Hazardous area classification

53 Regulation 7 of DSEAR requires employers to classify places at the workplace where an explosive atmosphere may occur into hazardous and non-hazardous areas.

54 Hazardous area classification (HAC) (see L138, regulation 7 and Schedules 2–4) is the method used to identify areas where flammable concentrations of gases or vapours are likely to be present. The aim is to reduce to a minimum acceptable level the probability of a flammable atmosphere coinciding with an electrical or other ignition source. It is normally used to select fixed electrical and mechanical equipment, but it can also be used in the control of other potential ignition sources such as portable electrical equipment, hot surfaces and vehicles. Advice is available in BS EN 60079-10[11] and also in Energy Institute *Model Code of Safe Practice Part 15: Area classification code for petroleum installations handling flammable fluids*.[12]

55 For flammable vapours there are three classes of hazardous area or zone: zone 0, zone 1 and zone 2. A zone is an area around a process or activity where a flammable atmosphere may be present. The definitions of hazardous zones and further details on hazardous area classification definitions may be found in L138 (regulation 7 and Schedules 2–4).

56 Any area which does not meet these criteria is unclassified and no special precautions are required in relation to storage tanks.

57 The extent of the zones will depend on:

- rate of release;
- ventilation;
- design of the tank;
- the source of the release;
- the flashpoint; and
- vapour density.

58 Examples of hazardous area classification for a fixed-roof tank and tanker-filling installations are shown in Figure 2, Figure 3 and Figure 4. These examples are for general guidance only, as local conditions should always be taken into account

when carrying out a classification.

59 Lightning protection may need to be considered where it could be an initiator of a major incident.

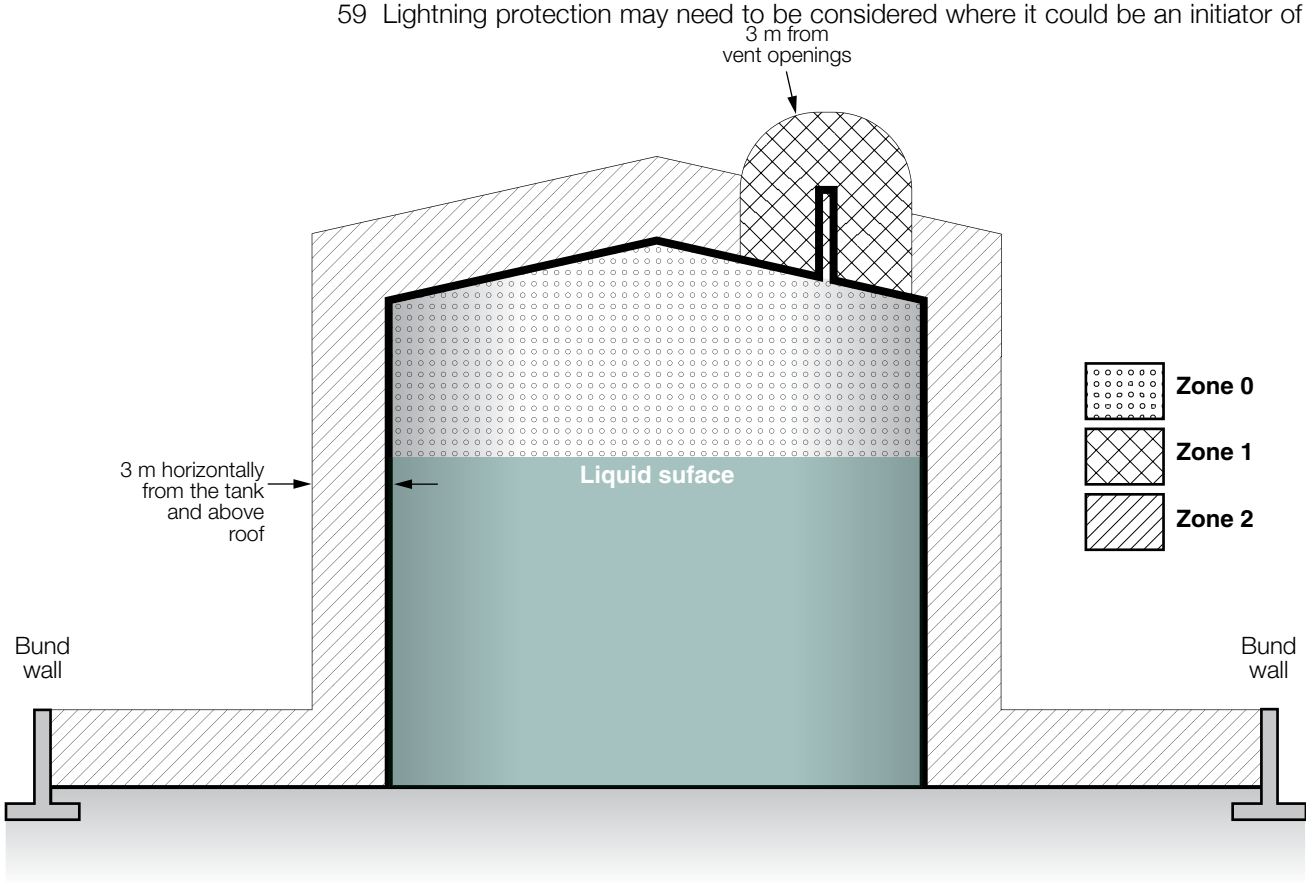
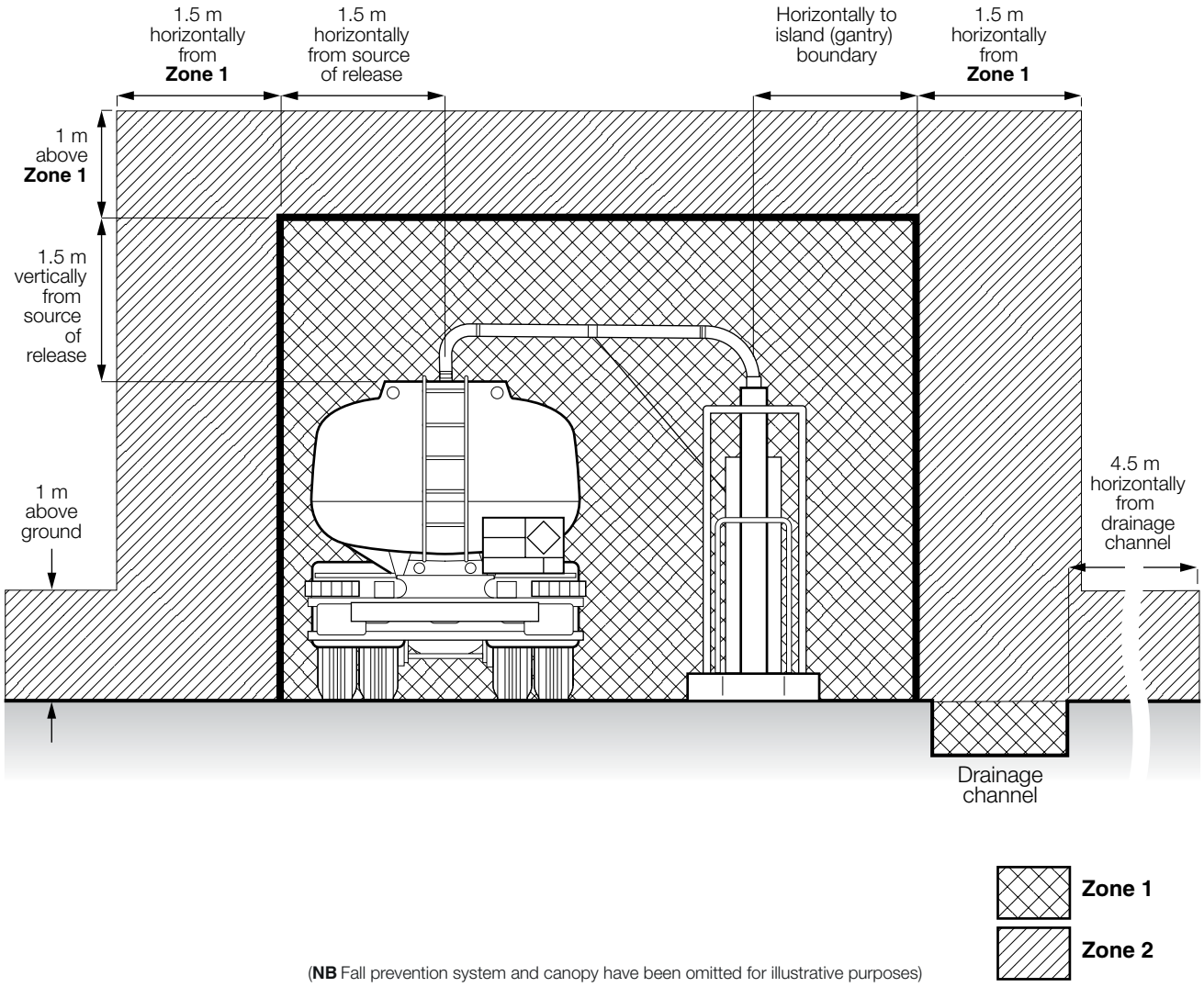
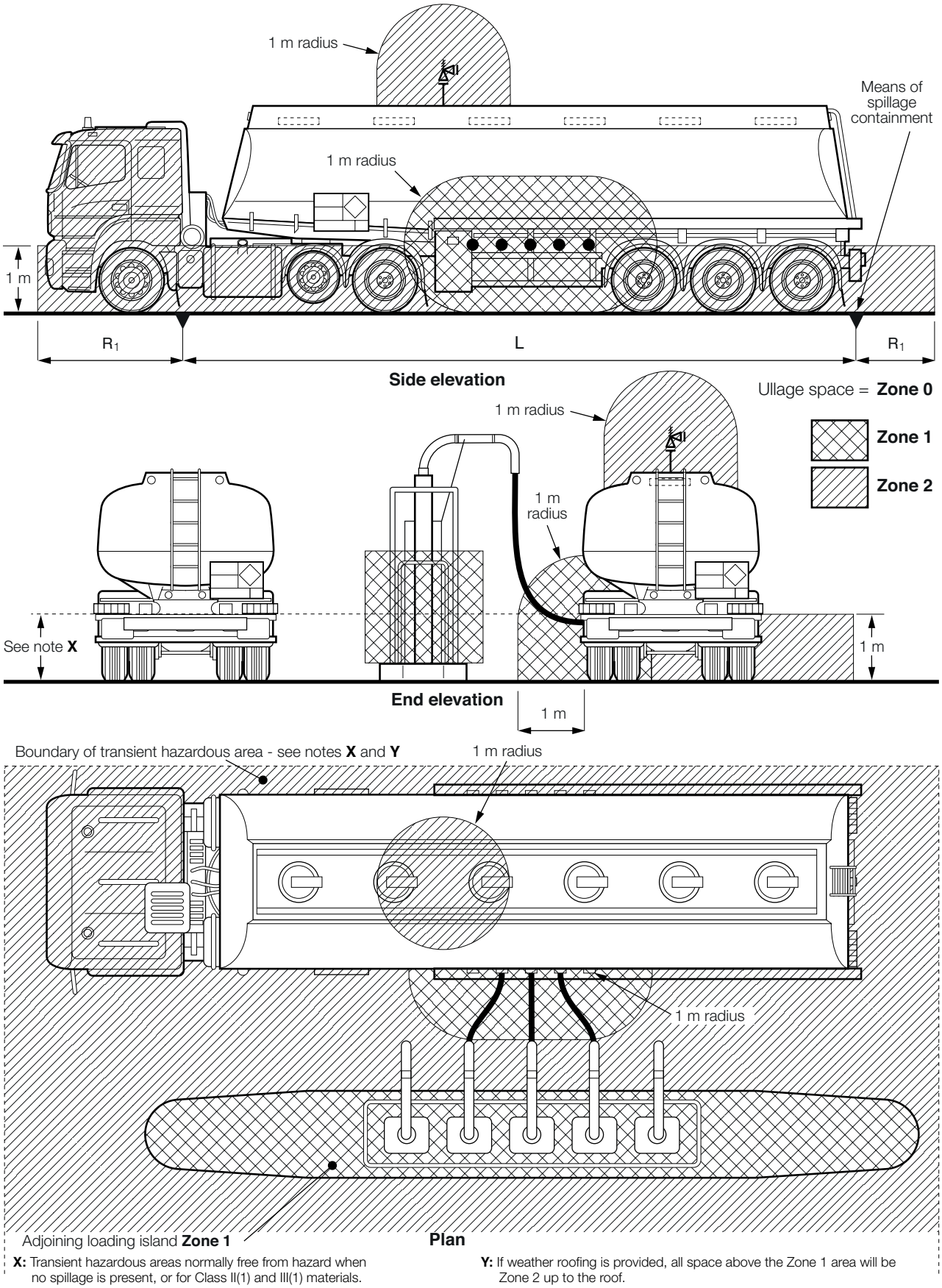


Figure 2 Vertical storage tank – typical hazardous area classification



(**NB** Fall prevention system and canopy have been omitted for illustrative purposes)

Figure 3 Tanker filling installation for highly flammable liquids – typical hazardous area classification



(**NB** Fall prevention system and canopy have been omitted for illustrative purposes)

Figure 4 Road tanker equipped for bottom loading with vapour collection during loading

60 Where reasonably practicable, electrical equipment should be installed in non-hazardous areas. Where this cannot be done, equipment should be selected, installed and maintained in accordance with the Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations 1996 (see Appendix).

61 When a hazardous area classification has been carried out, the location of the zones should be recorded on a plan. This may then be used to prevent sources of ignition being brought into hazardous areas. The hazardous area classification drawing could be in the form of two separate drawings showing a simplified approach to the configuration of the plant. Such drawings should be supplemented by text giving information about the flammable liquids that will be present, the work activities that have been considered, and other assumptions made by the study. The drawings and documents should be retained as part of the documentation in support of the risk assessment carried out under regulation 5 of DSEAR. The information in these documents should be considered whenever new equipment is to be introduced into a zoned area.

Controls for off-site risks

62 The potential consequences of spillages of flammable liquid, with or without fire, to cause environmental harm should also be considered. Advice on assessing environmental risks can be obtained from the environment agencies.

63 In the event of fire, and fire water run-off can place a major strain on normal drainage facilities – interceptors or special drainage schemes may be necessary, particularly at large installations, to minimise the risk of contaminating local water courses. In developing appropriate emergency procedures for the workplace, you may need to consult with the appropriate agencies and the local fire authority. Relevant guidance can be found in:

- Environment Agency/SEPA Pollution Prevention Guidelines: *Managing fire and water and major spillages* PPG18;[13]
- *Control of fire-water run-off from CIMAH sites to prevent environmental damage* EH70;[14]
- *Containment systems for the prevention of pollution* CIRIA.[15]

64 Formal on-site and off-site emergency plans are required at sites subject to COMAH. See *Emergency planning for major accidents: Control of Major Accident Hazards Regulations 1999 (COMAH)* HSG191.[16]

Recovery

65 You should have arrangements for making the situation safe after an incident, for example:

- safe recovery and clean-up of spilt flammable liquids;
- repairing or decommissioning leaking or unsafe plant;
- making safe damaged or unstable buildings.

Location and layout of tanks

66 The location and layout of a storage installation should be selected with care. The aims are to protect people and property from the effects of a fire at the tank, and to protect the tank from fires which may occur elsewhere on site.

67 Storage tanks may be located above ground, underground or in mounds. Each location has different advantages and disadvantages. Storage at ground level in the open air has advantages because leaks are more readily detected and contained, and any vapour produced will normally be dispersed by natural ventilation. Examinations, modifications and repairs are also easier, and corrosion can be more readily identified and controlled.

68 Underground or mounded tanks give better fire protection and save space, but leakage resulting from damage or corrosion may be difficult to detect. This could lead to ground contamination, environmental impact to land, surface water and groundwater, and possible fire and explosion risks to nearby buildings and basements.

69 When selecting the location of a single or multi-tank installation, you should consider the distance of the proposed storage from:

- the site boundary and any off-site receptors such as vulnerable populations or sensitive environments;
- on-site buildings, particularly those that are occupied;
- fixed ignition sources;
- storage or processing of other dangerous substances;
- road or rail tanker transfer facilities.

70 Other factors to consider are:

- the position of the tanks (above ground or below ground);
- their size and capacity;
- their design (fixed roof or floating roof).

71 Tanks should not be located:

- under buildings;
- on the roofs of buildings;
- in positions raised unnecessarily high above ground level;
- on top of one another;
- above tunnels, culverts or sewers.

72 Tank locations inside buildings should be avoided (but see paragraphs 84–87).

Tanks above ground

73 Tanks above ground should be sited in a well-ventilated position separated from the site boundary, occupied buildings, sources of ignition and process areas. Figure 5 shows a plan of a typical layout for storage tanks. The layout of tanks should always take into account the accessibility needed for the emergency services. Vertical tanks are normally mounted on a suitable base directly on the ground, horizontal tanks are usually mounted on saddles above ground. In some circumstances it may be necessary to raise the tank to provide suction head for a

pump or to allow gravity discharge. When this is necessary, the tank should only be raised to the minimum amount.

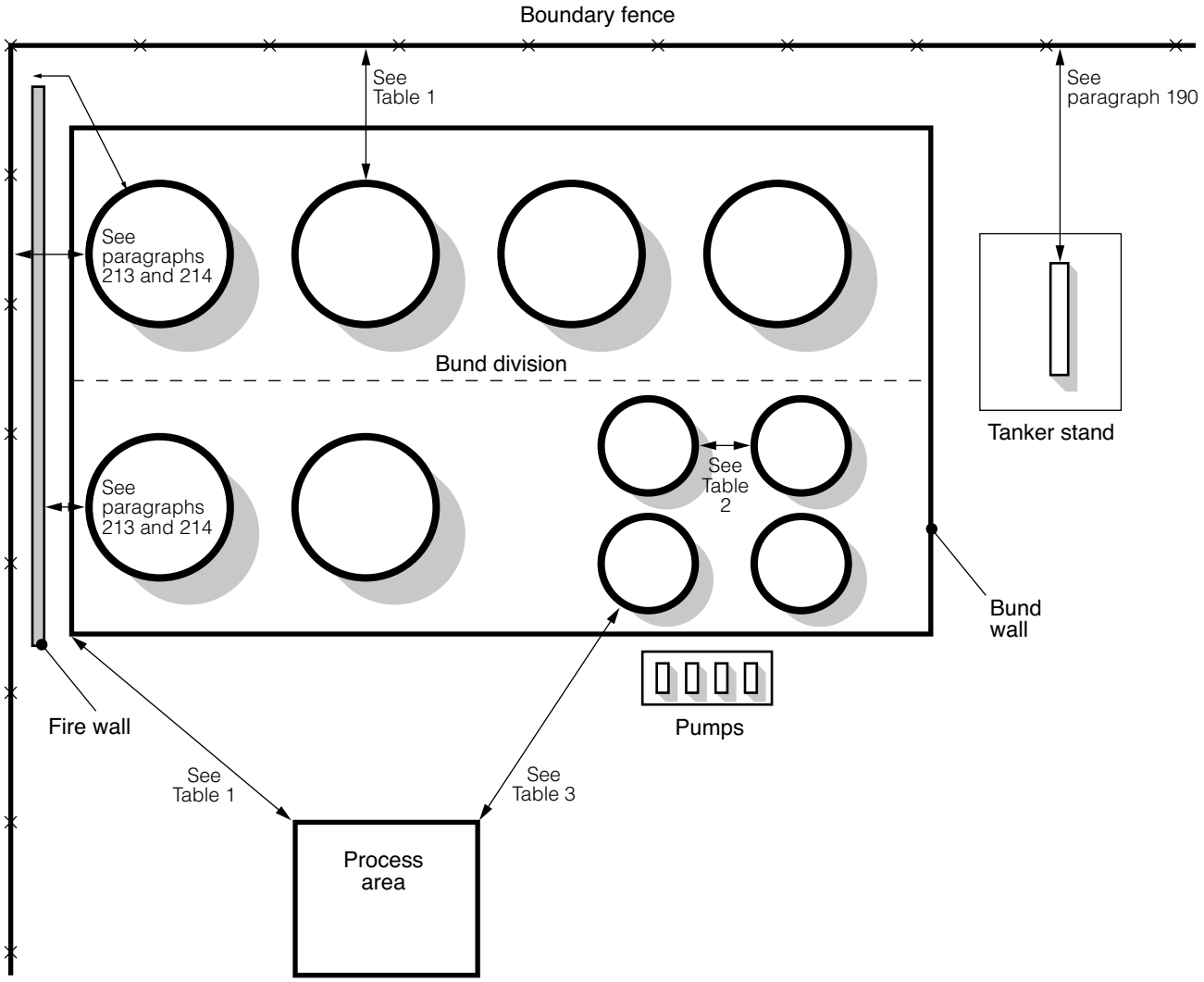


Figure 5 Typical layout of storage tanks showing separation distances

74 The separation distances will depend on various factors but primarily on the capacity of the tank. Advice on separation distances is given for 'small' tanks, generally associated with small to medium chemical processes, and for 'large' tanks associated with refinery and other large-scale storage facilities.

75 The separation distances given are unlikely to give complete protection in the event of a fire or explosion involving the tank, but should allow sufficient time for people to be evacuated, provided there are adequate means of escape. They should also allow sufficient time for additional firefighting equipment and emergency procedures to be mobilised.

76 Under certain circumstances, it may be necessary to increase the separation distances or provide additional fire protection. Such circumstances may include:

- where there are problems with the local water supply;
- where the site is remote from external help (such as the fire and rescue service);
- where the tank is close to a heavily populated area.

77 The separation distances recommended in Table 1 below are based on common industry practice for standard conditions. Where non-standard conditions occur, fire consequence modelling could be carried out to determine the required separation distance for specific circumstances.

Separation distances for 'small' tanks

78 In this guidance, 'small' tanks are considered to be tanks with a diameter of less than 10 m. Table 1 shows the minimum recommended separation distances for single 'small' tanks. The distances are based on widely accepted industry practice. The minimum separation distance is the minimum distance between any point on the tank and any building, boundary, process unit, or fixed source of ignition.

Table 1 Minimum recommended separation distances for single 'small' tanks from site boundaries, buildings, process areas and fixed sources of ignition

Tank capacity (m^3)	Separation distance (m)
Less than or equal to 1	1*
Greater than 1 and less than or equal to 5	4
Greater than 5 and less than or equal to 33	6
Greater than 33 and less than or equal to 100	8
Greater than 100 and less than or equal to 250	10
Greater than 250	15

** But at least 2 m from doors, plain-glazed windows, or other openings or means of escape. Also not below any opening (including building eaves and means of escape) from an upper floor, regardless of vertical distance.*

Separation distances for groups of 'small' tanks

79 Small tanks may be placed together in groups. A tank is considered as part of a group if adjacent tanks are within the separation distances given in Table 1. The aggregate capacity of the group should be no more than 8000 m^3 and the tanks should be arranged so that they are all accessible for firefighting purposes.

80 The recommended minimum separation distances between individual tanks in a group are given in Table 2. If a serious fire develops involving one tank in a group then it is unlikely that these between-tank separation distances will prevent damage or even destruction of the adjacent tanks. However, they should allow sufficient time for emergency procedures to be implemented and for people to be evacuated from areas threatened by the incident.

Table 2 Minimum between-tank separation distances for groups of 'small' tanks

Tank size	Recommended separation distance between tanks
Less than or equal to 100 m^3	The minimum required for safe construction and operation
Greater than 100 m^3 but less than 10 m in diameter	Equal to or greater than 2 m

81 For the purpose of determining separation distances from site boundaries, buildings, process areas and fixed sources of ignition, a group of small tanks may be regarded as one tank. The minimum recommended separation distances for groups of small tanks are given in Table 3. The minimum recommended separation distance between adjacent groups of small tanks is 15 m.

Table 3 Minimum recommended separation distances for groups of 'small' tanks from site boundaries, buildings, process areas and fixed sources of ignition

Total capacity of the group (m^3)	Separation distance (m)
Less than or equal to 3	1*
Greater than 3 and less than or equal to 15	4
Greater than 15 and less than or equal to 100	6
Greater than 100 and less than or equal to 300	8
Greater than 300 and less than or equal to 750	10
Greater than 750 and less than or equal to 8000	15

** But at least 2 m from doors, plain-glazed windows, or other openings or means of escape. Also not below any opening (including building eaves and means of escape) from an upper floor, regardless of vertical distance.*

Separation distances for 'large' tanks

82 The minimum recommended separation distances for 'large' tanks are given in Table 4. The table is based on the Energy Institute's *Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations*.[17]

Table 4 Minimum separation distances for 'large' tanks

Factor	Minimum separation from any part of the tank
Between adjacent fixed-roof tanks	Equal to the smaller of the following: □ the diameter of the smaller tank □ half the diameter of the larger tank □ 15 m, but not less than 10 m
Between adjacent floating-roof tanks	□ 10 m for tanks up to and including 45 m diameter □ 15 m for tanks over 45 m diameter The spacing is determined by the size of the larger tank
Between a floating-roof tank and a fixed-roof tank	Equal to the smaller of the following: □ the diameter of the smaller tank; □ half the diameter of the larger tank; □ not less than 10 m
Between a group of small tanks and any tank outside the group	15 m
Between a tank and the site boundary, any designated non-hazardous area, process area or any fixed source of ignition	15 m

Separation from other dangerous substances

83 Separation may also be used to prevent or delay the spread of fire to and from storage or process areas where other dangerous substances may be present in quantity. Table 5 shows the minimum recommended separation distances from LPG storage. Table 1 may be used to estimate separation distances from other hazardous substances. If published guidance exists for the particular hazardous substance concerned, the recommended minimum separation distance is the greater of the distances given in Table 1 and the relevant guidance.

Table 5 Minimum recommended separation distance

	LPG cylinders (>50 kg total capacity)	**LPG vessels (up to 135 m^3)**	**LPG vessel (over 135 m^3)**
Flammable liquid (flashpoint <32 °C)	3 m to bund wall	6 m to bund wall	15 m to bund wall
Flammable liquid (flashpoint 32–65 °C) Tank size up to 3000 litres	3 m to bund wall	3 m to bund wall	6 m to bund wall
Flammable liquid (flashpoint 32–65 °C) Tank size over 3000 litres	3 m to bund wall	3 m to bund wall	15 m to bund wall

Storage of flammable liquids in buildings

84 Storage of flammable liquids in bulk tanks within buildings should be avoided if possible. If storage is required in buildings then only the minimum amount should be stored and for the minimum time, preferably no more than that needed for one day or one shift.

85 Additional safety measures may be needed for the building. These include:

- a single-storey and generally non-combustible construction;
- a lightweight roof or other means of explosion relief. Where this is not reasonably practicable an acceptable alternative is to provide sufficient mechanical ventilation to remove flammable vapour released in the event of an incident;
- a high standard of natural ventilation, using high and low-level openings in the walls (typically 2.5% of the total wall and roof leading directly to the open air). Alternatively, if natural ventilation is not possible, permanent mechanical ventilation can be used, equivalent to at least five air changes per hour;
- fire separation (by means of a partition of at least 30 minutes' fire resistance) between the part of the building housing the tank and other parts of the building, or other buildings within 4 m; and
- adequate means of escape.

86 The tank should have the following features:

- effective means of preventing the spread of leakage. Where appropriate the building walls may form part of the bund, providing they are impervious, have sufficient strength and doorways are fitted with kerbs, ramps or sills;
- vents which discharge to a safe place in the open air.

87 Adequate means of cooling the tank surface in the event of fire in the building may be needed. In some cases this may be done using portable equipment, but in others a fixed water installation may be necessary. Controlled drainage is essential to avoid tank flotation and local flooding. Further advice on bund drainage can be found in paragraphs 163–167.

Underground tanks

88 The minimum recommended separation distance from any underground tank to any building line is at least 2 m, to avoid undermining the building foundations. It is advisable to increase this distance to 6 m for a basement or pit, to minimise the risk of vapour accumulation.

Design and construction

The design of the tank

89 To ensure mechanical integrity, storage tanks should be designed and constructed in accordance with a British, European or international standard (see list in references section).[18]

90 The materials used in the construction of the tank or, where appropriate, the tank lining, should be compatible with the chemical and physical properties of the liquid, to ensure that no interaction occurs which might cause failure of the tank.

91 Above-ground tanks are generally constructed of steel or other material which can withstand for a short period the effects of direct flame impingement or radiant heat from a fire in the vicinity. If glass reinforced plastic (GRP) tanks are installed above ground, then they may need additional precautions to ensure that their integrity is not lost rapidly in the event of fire. For guidance on GRP see HSE guidance notes *Glass reinforced plastic vessels and tanks* PM75[19] and *Thermoplastic tank integrity management* PM86.[20]

92 Where a manhole is fitted to a tank, it should be at least 460 mm inside diameter. For tanks over 2 m in diameter and for tanks where personnel may have to wear protective clothing and breathing apparatus for entry, the manhole should be at least 600 mm inside diameter.

93 If the tank is to be heated, additional precautions may be needed. These are outlined in paragraphs 176–178.

94 Tanks may be compartmented. Different materials should not be stored in the same tank, if leakage from one compartment to another is likely to cause a hazard. Mixing of chemically incompatible materials may cause an unwanted and possibly dangerous reaction within the tank. Even accidental mixing of apparently compatible solvents may create a hazard if the contaminated solvent is then fed into a process.

95 Figure 6 and Figure 7 show examples of horizontal and vertical tank installations. Figure 8 shows a typical underground tank installation.

Double-skin storage tanks

96 A double-skin storage tank could be considered as a tank within a tank. The space between the tanks is kept to a minimum and should be used to monitor the soundness of both the inner and outer skin. The monitoring system should be an intrinsically safe system using either liquid level, vacuum or pressure to provide an alarm if one of the skins fails. This is of particular benefit for tanks below ground. Initial and ongoing integrity management should be applied to double-skin storage tanks. See paragraph 221 and APEA publication *Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations*.[21]

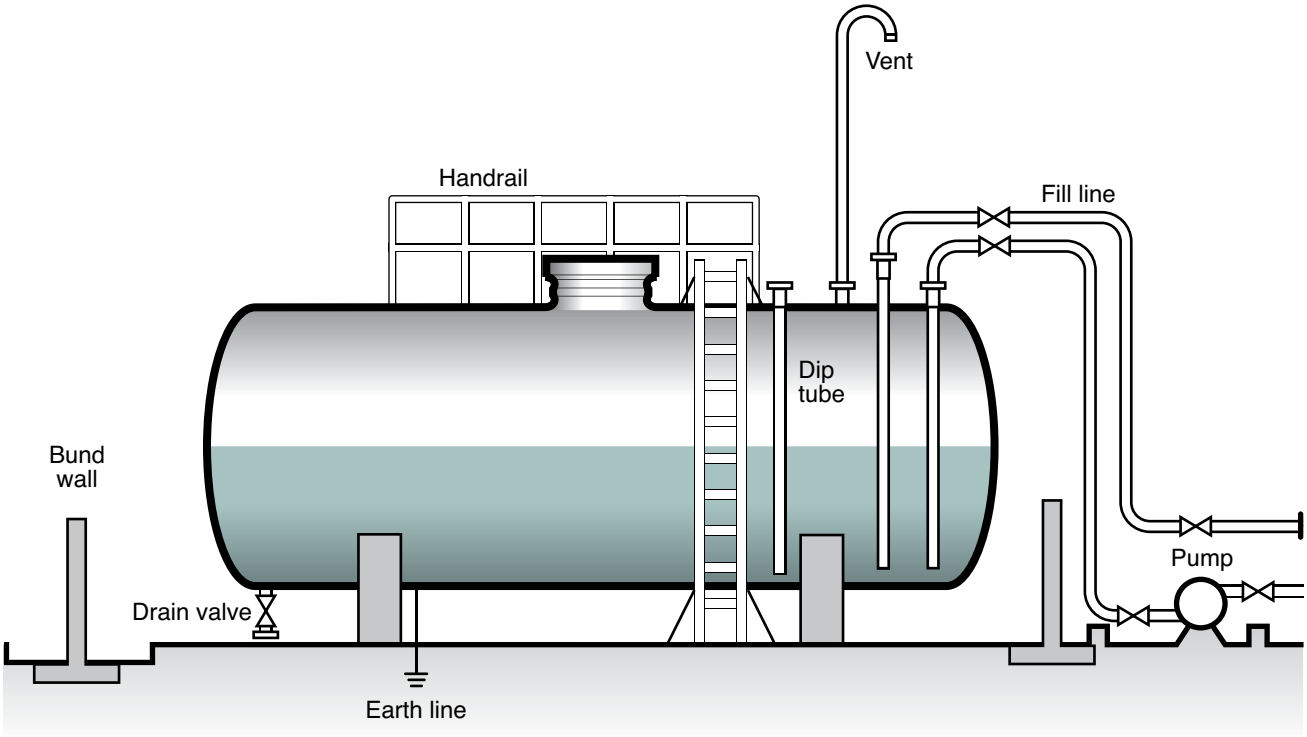


Figure 6 Typical horizontal storage tank (top discharge)

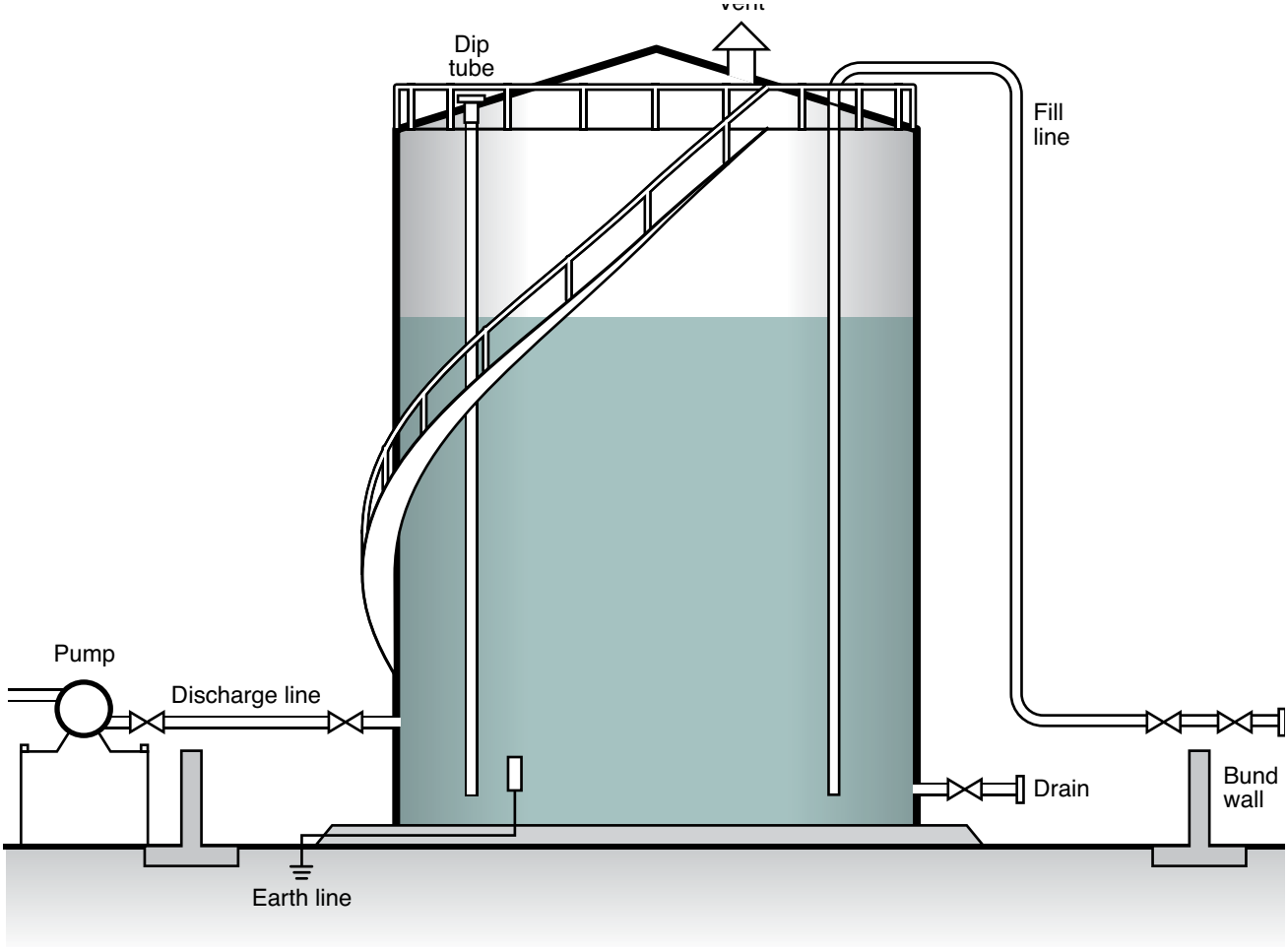


Figure 7 Typical vertical storage tank (top filled)

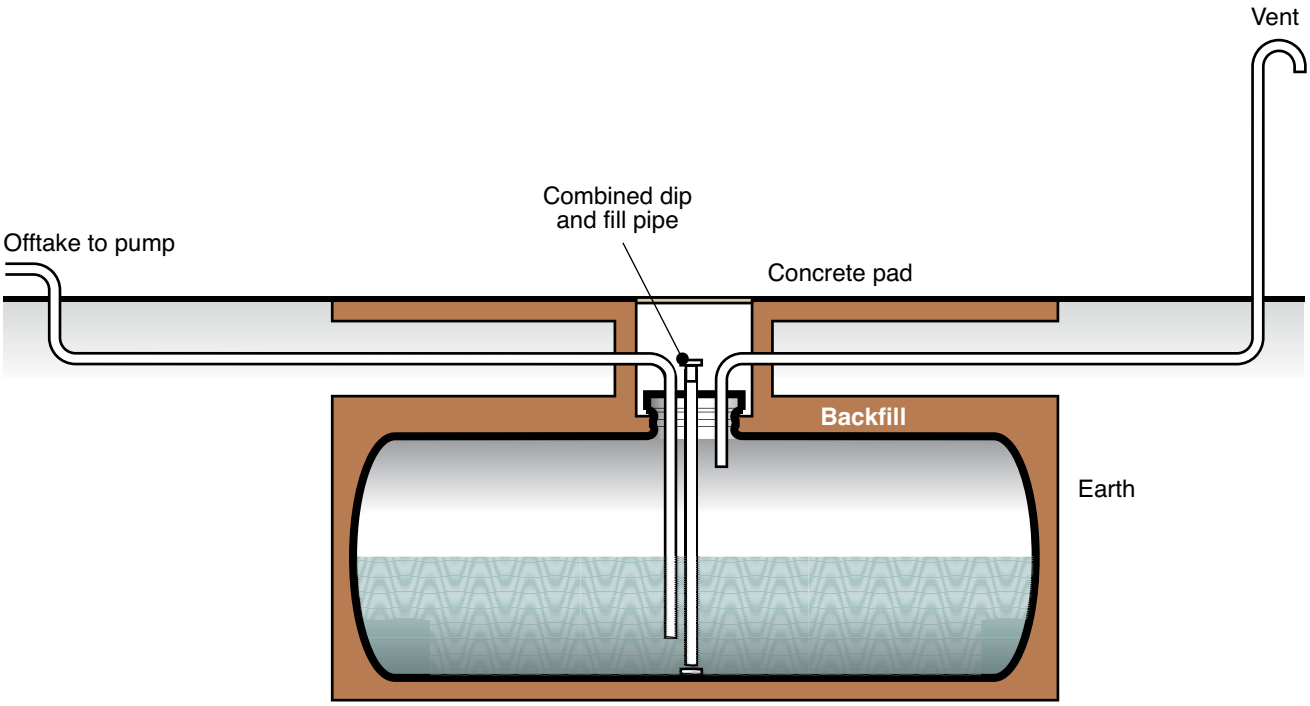


Figure 8 Typical underground tank

Corrosion protection

97 Corrosion is one of the main causes of equipment failure. It can occur both internally and externally at any exposed metal surface. Protection may be provided by paints or other coatings – see BS EN ISO 12944-1.[22] Cathodic protection may be used as an additional precaution (see international standard AP 620).[18]

98 Chemical-resistant coatings or paints are available. These are generally sprayed on in several layers to the required thickness. Coatings should be inspected for thickness, continuity and hardness prior to installing the tank. For underground tanks, a bituminous coating can be applied using the appropriate standards (BS 3416[23] and BS 6949.[24]

99 Internal corrosion may result from the accumulation of water in the tank. A means to remove such water may be necessary. Caution is essential when draining water from beneath the product. Reliance on a single valve to retain the tank contents is not sufficient. Two permanent in-line valves to the drainage point are recommended, or temporary replacement of the blanking plate by a second valve during the draining operation.

100 Certain flammable liquids can be aggressively corrosive and may merit consideration of alternative tank floor design. BS EN 14015 offers an alternative double-bottom configuration. If adopted, robust integrity management arrangements should be provided in line with EEMUA publication 159.[25]

Corrosion under insulation

101 Corrosion may occur unnoticed under thermal insulation or lagging. Corrosion under insulation should be addressed as part of the planned preventive

maintenance schedule for the site. Further guidance can be found from European Federation of Corrosion Working Party 13: *Corrosion in Oil and Gas Production*.[26]

Installing the tank

102 When installing an above-ground tank, you should consider:

- that the foundations are designed and constructed to support the full tank loading. Advice on foundations for vertical tanks is given in BS EN 14015;
- that the tank is securely anchored or weighted to avoid flotation from flood water or from spillage of liquid into the bund;
- that the supports of raised tanks are fire resistant to a two-hour standard;
- that the supports permit any movement of the tank due to temperature changes. Horizontal tanks may be supported on concrete, masonry or steel saddles. One end is secured and the other left free to move. Pipework is connected to the secure end.

103 Similarly, underground tanks require:

- foundations and adequate support (concrete or masonry);
- to be securely anchored or weighted to avoid flotation from flood water or a high water table;
- backfilling with inert material such as rounded pea gravel or with concrete. Large stones or rocks may damage the protective coating on the tank. (Note: concrete is not suitable for double-skin tanks);
- protection from loadings from above ground, particularly from traffic. A reinforced concrete slab may be suitable. Alternatively the area around the tank should be fenced off, with the perimeter of the tank clearly marked;
- an excavation of sufficient size to prevent damage to the tank's protective coating and to allow safe work during installation and backfilling.

Pipework to and from the tank

104 Pipework may be installed above or underground, but preferably should be above-ground. The key aims when installing pipework are:

- to ensure mechanical integrity;
- to keep the diameter and length to the minimum practicable;
- to ensure it is adequately protected from damage.

105 The reason to keep the length and diameter of pipework to a minimum is to reduce the inventory of flammable liquid in the lines. This reduces the potential for damage and spillage.

106 To ensure mechanical integrity of pipework, all parts of piping systems, including valve seals and flange gaskets, should be made from material compatible with the liquids being handled. They should be constructed to a suitable standard such as that of American Society of Mechanical Engineers B31.3 *Process Piping*.[27]

107 Metal pipework should generally be used. Where metal pipework is not suitable (such as where product purity is an issue), other materials may be used if an equivalent standard of construction can be achieved. Avoid mixing materials to avoid electrostatic generation.

108 The potential for leakage may be reduced by keeping the number of joints to a minimum and by using welded joints rather than flanged or screwed, particularly for joints underground.

109 Pressure can build up in pipework due to the thermal expansion of liquids trapped in the pipes. For example liquid may be trapped between shut-off valves. This risk should be assessed and appropriate operating procedures should be introduced to minimise the risk. Alternatively, hydrostatic relief valves may be fitted which discharge back to the tank or to a safe place such as a sump or vessel designed for the recovery or disposal of flammable liquids.

Above-ground pipework

110 Above-ground pipework has advantages because leaks are more readily detected and any vapour produced will normally be dissipated by natural ventilation. Examinations, modifications and repairs are also easier and corrosion can be more readily identified and controlled. Piping should be designed to a suitable standard (such as B31.3 *Process Piping*).

111 Piping supports should be designed to suit the piping layout. The design should allow for differential movement between tanks and pipework to allow for temperature changes in heated tanks or settlement. If supports are located near tanks a two-hour standard of fire resistance is advisable.

112 Above-ground pipework and its supports may be at risk from damage particularly from vehicles. It is advisable to design the layout of the plant to minimise the risk of physical damage. Alternatively, the use of impact protection such as barriers or bollards may be appropriate.

Underground pipework

113 Underground pipework may have advantages: providing better fire protection; saving space; and providing greater security. But leakage resulting from damage or corrosion may be difficult to detect – leading to ground contamination and potential environmental problems.

114 Underground pipework should be laid in a shallow concrete or masonry-lined trench provided with load bearing covers if vehicles will be passing over the trench. The design of the trench should prevent water or moisture from accumulating around the pipework and allow for inspection of the pipework, particularly joints. The design should also allow for any extra loading imposed, such as by vehicles. The route of the trench should be recorded and marked at ground level.

115 The same trench should not be used for piping carrying corrosive or reactive materials such as oxygen or chlorine. In addition, the same trench should not normally be used for electrical cables. Where this is not practicable, the cables should be selected and installed in accordance with BS EN 60079-14.[28]

Flexible hoses

116 Flexible hoses should only be used where rigid piping is unsuitable, such as at filling connections or where vibration is a problem. Hoses should be made to a

standard suitable for the application and should be compatible with the materials handled. They should be adequately supported (for example by slings or saddles) so that the bend radius is not less than the minimum recommended by the manufacturer.

117 When they are not in use, flexible hoses should be protected from accidental damage, extremes of temperature and direct sunlight. They should be inspected daily for signs of leaks, wear and mechanical damage, and examined and pressure tested annually or according to the manufacturer's recommendations. Hoses should be electrically continuous or bridged with an earthing cable to avoid electrostatic charging. There are a number of national and harmonised standards for hose assemblies some of which are listed in the reference section.[29]

Tank connections and fittings

118 Storage tank filling and emptying connections, and openings for dipping and venting, should be located at least 4 m from any source of ignition, building opening, trench or depression. Any drain in the vicinity should be either fitted with an interceptor or routed to an appropriate waste collection/treatment facility.

119 The connecting point for filling or discharge of above-ground tanks should be outside the bund wall, close to the tanker stand. This will ensure that the flexible connecting hose is kept short and will also ease access. It may be necessary to protect the tank connections to prevent mechanical damage by tanker vehicles.

120 Above-ground tanks can be filled from road tankers either using vehicle equipment or a fixed pump on site. Use of a fixed pump has advantages as all the equipment on the vehicle can be switched off during off-loading, and the vehicle flexible hose and coupling are not subject to pump discharge pressures. Filling points should be equipped with non-return valves (close to the shut-off valve to minimise any spillage if the shut-off valve fails to seal) or dry break couplings.

121 Filling lines should be fitted with a suitable flange or coupling to connect with the hose of the delivery vehicle, rail car etc, and should be capped when not in use. A locking cap may be advisable. Spillage from making and breaking connections should be contained by a drip tray or a low sill, or be drained to a safe place. An interceptor for liquids not miscible with water, or other suitable collection method, may be required.

122 The end of the tank filling line should extend below the lowest normal operating level of the liquid to minimise the generation of static electricity from splash filling. To prevent siphoning, the line should be self draining. Where separate lines are used for filling and emptying, a liquid seal can be maintained by ending the discharge line at least 150 mm above the bottom of the filling line. To minimise the risk of tank leakage, it is preferable for lines to enter the tank at the top. This may not always be reasonably practicable, particularly for large vertical tanks, which are normally filled through a low-level nozzle.

123 All dip rods and tubes should be earthed and, where appropriate, an earthing lead for connection to a road tanker should be fitted. See PD IEC/TS 60079-32-1.[30]

124 Where several different liquids are loaded/unloaded from a common location, labelling pipes and fittings is advisable to prevent loading to or from the wrong tank. Additional precautions, such as unique fittings or dedicated lock off arrangements, may be required if there is a possibility of mixing incompatible liquids. Methods of operating isolation and control valves should be indicated by labels or signs where

necessary.

125 Tank connections to underground tanks may be located in the open air above the tank or in a chamber below ground (See Figure 8). The chamber may be closed by a watertight manhole cover or it may be raised slightly above ground level.

Valves

126 Pipes connected to tanks are a potential source of a leakage and should therefore be provided with suitable shut-off valves which are fire safe when tested to BS EN ISO 10497.[31] The shut-off valves should be located inside the bund wall and close to the tank. The tank filling line should also be fitted with a shut-off valve outside the bund wall and close to the filling connection. Any line used only for filling and which enters the tank at the bottom should also be provided with a non-return valve.

127 Other valves may be necessary depending on process conditions, such as automatic double block and bleed systems to prevent back-flow of process materials into the storage tank or additional isolation valves to allow safe shutdown in an emergency. Important valves should be labelled to indicate their function and their method of operation, where necessary.

128 It is essential that isolating valves can be closed quickly in an emergency. Remotely operated shut-off valves (ROSOVs) may be necessary. They may be operated remotely by an electrical or pneumatic signal, or by a lever at ground level. In the event of a power failure, the controls to the ROSOVs should remain operational or the valve should fail-safe. Advice on selecting ROSOVs can be found in *Remotely operated shutoff valves (ROSOVs) for emergency isolation of hazardous substances: Guidance on good practice* HSG244.[32]

129 Tank drainage valves should be blanked off when not in use. Draining operations to remove accumulations of water from beneath the product should be carried out with caution; establish procedures to avoid relying on only one valve to retain the tank contents. This may involve the permanent fitting of two valves in line to the drainage point or temporary replacement of the blanking plate by an additional valve during the draining operation. When draining horizontal tanks the blank should be removed and a suitable length of piping attached to ensure that the liquid is drained away from the tank rather than underneath it.

130 All isolation valves should be tested periodically to ensure they are working correctly.

Pumps

131 Pumps are potential ignition sources and should be located outside the bund, on an impervious base, preferably in the open air. This will also avoid damage from fires or spillages in the bund and facilitate access for maintenance. IP15 *Area classification code for petroleum installations handling flammable fluids*[12] contains a methodology to determine the required separation for pumps from the tank and other features.

132 Any leakage from pump seals may be contained by a low sill or by drainage to a safe place.

133 Pumps may be located in a pump room, provided the room has adequate

high- and low-level natural or mechanical ventilation. Interlocks should be fitted to mechanical systems, so that the pumps cannot be operated unless the ventilation is working satisfactorily. If the non-operation of a pump could cause a greater hazard than a lack of ventilation in the pump room, then a clearly audible alarm should be linked to the ventilation system.

134 Where a pump is controlled remotely, there should be a stop control at the pump itself, as well as at the control point.

Contents measurement

135 Every tank and tank compartment should have a suitable means of measuring the quantity of material stored. It should be tested and calibrated at the time of installation to ensure accuracy, and at regular intervals in line with an inspection and maintenance schedule or if a tank is modified. A maximum working level and an absolute maximum level for each tank should be established, one way of doing this is shown in Figure 9.

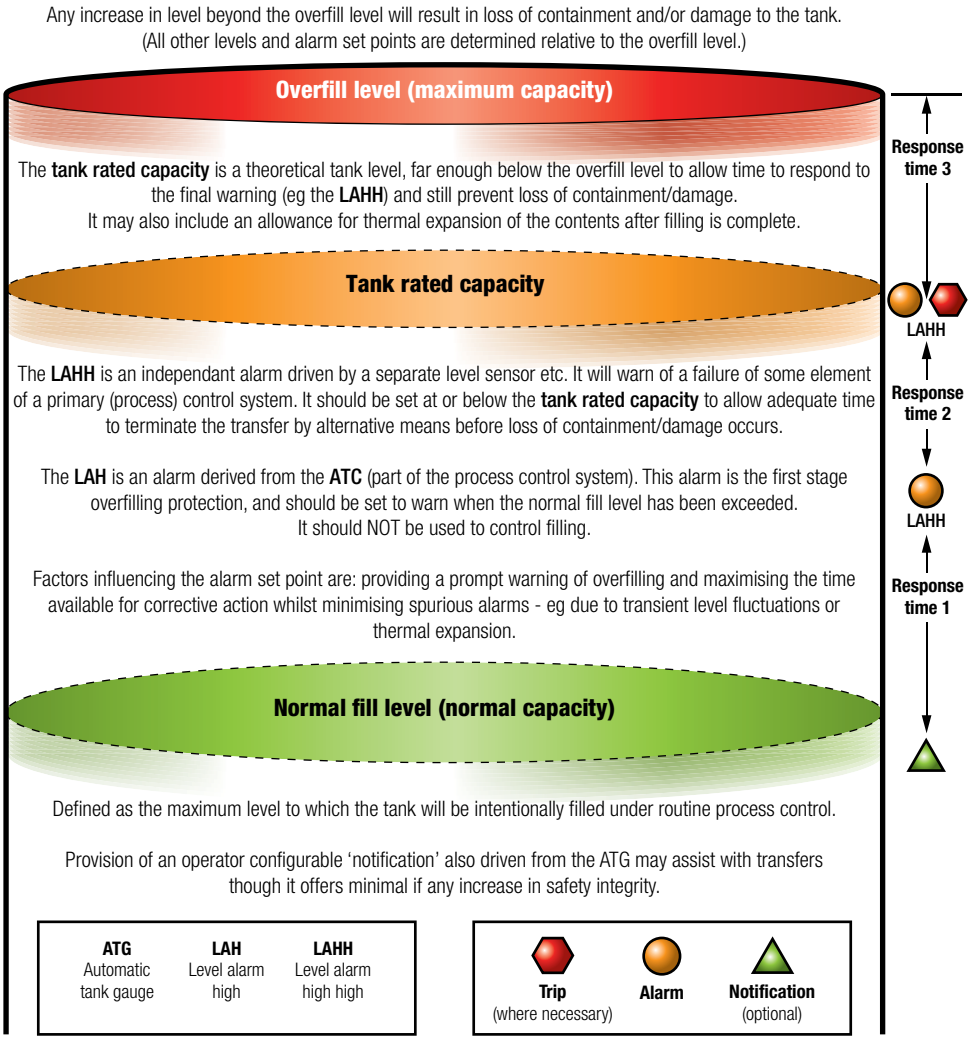


Figure 9 Overfilling protection: Tank levels (based on API2350)

Tank gauging systems

136 Automatic gauging is preferred to manual dipping as it allows determination of the quantity of liquid without opening the tank. The gauge measures parameters such as:

- height;
- mass;
- temperature;
- density; or
- pressure.

The readings are then used to determine the tank content.

137 The use of a high-level alarm is recommended, particularly if the person controlling the operation is remote from the tank or if toxic liquids or highly flammable liquids are being handled. The alarm may also be arranged to stop the filling pump, unless such action could cause an additional hazard, for example, shock loading. A high, high-level trip may also be fitted, which will trigger shutdown of the pump or divert the flow, if no action has been taken following the high-level alarm. This high, high-level trip should be independent of the gauging system to provide overfill protection if the gauging system fails. The Process Safety Leadership Group Final report *Safety and environmental standards for fuel storage sites*[4] made detailed recommendations for in-scope tanks on level gauging and overfill protection.

Dipping

138 Where gauging is done by dip rods, a suitable dip tube should be provided, with the dipping rod substantially smaller in diameter than the dip tube to minimise measurement errors. Dipping should not be done through open manholes.

139 Dipsticks are potential sources of ignition in that they may produce frictional heating or sparking, or static electricity. They should be made of non-sparking alloys and are earthed. Further guidance may be found in Energy Institute *Model Code of Safe Practice Part 21: Guidelines for the control of hazards arising from static electricity*.[33]

140 Manual dipping is not as accurate as an automatic gauge but provides an adequate estimate of the contents. Each tank should have its own calibrated dipstick, not to be used for other tanks. It may be necessary to protect the bottom of the tank to avoid damage from repeated dipping.

141 Dipsticks for large tanks are difficult to handle. Dip tapes may be an alternative. They measure depth and are used with calibration tables for individual tanks.

Vents

142 During normal tank operation, the pressure in the tank may vary. Pressures may increase during filling or if the ambient temperature rises. Conversely pressures may drop during emptying or with temperature falls. The tank venting system should provide:

- normal pressure relief;
- normal vacuum relief;
- emergency pressure relief.

143 Traditionally vents discharged into the atmosphere but there is increasing environmental pressure for vapour emission controls. Vapour recovery systems are now a legal requirement for petrol storage installations and it is likely that the requirements will be extended to other flammable liquids. Further information on the design and operation of vapour recovery systems is contained Energy Institute publication *Guidelines for the design and operation of gasoline vapour emission controls at distribution terminals*.[34]

144 If flammable vapours are discharged into the open air, they may ignite if there are ignition sources nearby. The minimum recommended separation distance of vent outlets from sources of ignition, air intakes, buildings, walkways and the site boundary is 3 m. Vents should be located on top of the tank. The discharge height above the tank and above the ground should be sufficient to ensure safe dispersion of the vapours. A discharge height of 0.3 m above the tank or at least 3 m (preferably 5 m) above ground level, whichever is the higher, is usually adequate. The height of the vent outlet should be above the liquid level in the tanker. It may be necessary to increase the recommended separation distances and discharge height of the vent if there is a possibility of poor vapour dispersion and to meet the requirements of the Environmental Protection Act.

145 Lightning or other ignition sources may ignite vented vapours from atmospheric vents. A flame arrester installed at the vent outlet will prevent flames spreading into the tank. A flame arrester should normally be installed at the vent outlet of a fixed-roof tank containing a liquid with a flashpoint below 23 °C. Flame arresters need regular maintenance to prevent blocking by paint, scale or other material. They should be incorporated into a planned preventive inspection scheme. A flame arrester is not advisable where the liquid stored is liable to polymerise or foul the arrester.

146 Pressure relief valves or vents prevent excessive pressure build-up and vacuum valves prevent the tank collapsing due to internal negative pressure. These functions may be combined in a pressure-vacuum (PV) valve. PV valves are recommended (see BS EN ISO 28300)[35] for use on atmospheric storage tanks in which a flammable liquid is stored, and for use on tanks containing product that is heated above its flashpoint. See paragraph 287 for further advice for venting of higher flashpoint liquids.

147 Pressure control devices should/must be correctly sized in accordance with an appropriate code or standard, such as BS EN 14015;[36] ANSI/API Standard 2000;[37] or BS EN ISO 28300:2008.

Emergency relief venting

148 The vents described above are designed to cope with the pressure fluctuations during normal operation. Additional pressure relief is necessary for above-ground tanks to cope with possible fire engulfment.

149 Emergency relief venting may be provided by:

- larger or additional vents;
- manhole or hatch covers which lift under abnormal internal pressure;
- a weak wall-to-roof joint;
- purpose-built relief devices.

150 Again, emergency relief devices should be correctly sized in accordance with

an appropriate code or standard. BS EN 14025;[38] EEMUA 180 *Frangible Roof Joints for Fixed Roof Storage Tanks: Guide for Designers and Users*[39] and API 2000 *Venting Atmospheric and Low Pressure Storage Tanks*[37] are commonly used.

Bonding and earthing: Static electricity

151 Static electricity is generated when movement separates charge which can then accumulate on plant and equipment, and on liquid surfaces. If the plant is not earthed or the liquid has a low electrical conductivity, then the charge may be generated faster than it can dissipate. Eventually, there may be an electrical discharge or spark. If this has sufficient energy it could ignite a flammable gas or vapour.

152 To minimise the accumulation of electrostatic charge and prevent incendive sparks, all metal parts of the storage installation should be bonded together and earthed. A maximum resistance to earth of 10 ohms is recommended. It should be possible to disconnect the earthing facilities for periodic test measurement. Further advice on earthing and bonding is in BS 7430.[40]

153 If the liquid has a particularly low electrical conductivity and is being stored above its flashpoint, it may be advisable to store it under a blanket of nitrogen or inject it with a static dissipating additive; if used, these degrade with time and the concentration and effectiveness should be monitored.

Bunding

154 The probability of a major leak from a well-designed and maintained storage system is low, particularly if overfill protection has been fitted. However, the consequences of a spillage of flammable liquid are potentially catastrophic. Therefore measures to contain spillages or leaks from storage tanks are essential.

155 Bunding is the method used to contain a liquid which has spilled or leaked from a vessel. It is recommended that bunding is provided for all flammable liquids with a flashpoint of 60 °C or below, and for materials which are stored at temperatures above their flashpoints. Bunding of bulk tanks has been the standard for many years and is required by environmental law. In addition, provision of a suitable bund will in part satisfy the requirements of DSEAR regulation 6(4)(e).

156 The purpose of bunding is to:

- prevent the flammable liquid or vapour from reaching ignition sources;
- prevent the liquid entering the drainage or water systems where it may spread to uncontrolled ignition sources;
- allow the controlled recovery or treatment of the spilled material;
- minimise the surface area of the liquid and so reduce the size of any fire that may occur;
- prevent the spread of burning liquids which could present a hazard to other plant or personnel both on and off site;
- contain water used in firefighting or tank cooling;
- prevent contamination of land and water courses.

Capacity

157 The bund should have sufficient capacity to contain the largest predictable spillage. A bund capacity of 110% of the capacity of the largest storage vessel located within the bund or 25% of the total capacity of tanks in the bund.

Whichever is the greater will normally be regarded as the minimum. When estimating the bund capacity, the space occupied by other tanks should be taken into account.

158 Smaller capacity bunds may be acceptable, where liquid can be directed to a separate evaporation area or impounding basin, using (where necessary) diversion walls up to 0.5 m high.

Individual and common bunding

159 Individual bunding is preferred to common bunding, particularly for large tanks. Where several tanks are contained in one bunded area, intermediate lower bund walls are recommended to divide tanks into groups to contain small spillages and to minimise the surface area of any spillage. This may significantly limit the spread of fire. The total capacity of tanks in a bund should not exceed 60 000 m^3 (120 000 m^3 for floating-roof tanks).

Walls and floor

160 The bund wall should have sufficient strength to contain any spillage or firefighting water. For example, a bund wall constructed of 225 mm brick or block with a height in excess of 600 mm is likely to collapse if required to contain major spillages. If a height greater than 600 mm is required then additional strengthening will be needed, such as using greater thickness of brick or block, reinforced concrete or buttresses. A fixed means of escape from the bund may be necessary.

161 The bund wall should not be constructed too close to the tank. Minimum recommended separation distances between tank and bund wall are 1 m for tanks up to 100 m^3 and 2 m for tanks above 100 m^3.

162 The design of the bund wall is a compromise between minimising the surface area of the liquid that may be spilled and minimising the height of the bund wall. Increasing the bunded area and locating lower bund walls away from the tank provides better ventilation and facilitates access for firefighting. More space is taken but the hydrostatic loading on the wall will be less. The wall will be cheaper to design and construct.

163 The bund should be liquid tight. The integrity of the bund wall may be put at risk if pipework and other equipment are allowed to penetrate it. If it is necessary to pass pipes through the bund wall (for example, to the pump) then the effect on the structural strength should be assessed. Additional measures may be needed to ensure that the bund wall remains liquid tight.

164 The floor and walls of the bund should be of concrete or other fire-resistant material substantially impervious to the liquid being stored, and with drainage where necessary to prevent minor spillage collecting near tanks. Stone chippings and similar materials may be used for the floor providing the underlying ground is impervious. A suitable buried membrane can also be used as can specially designed systems using the water table to retain liquids not miscible with water.

Surface water

165 Surface water should not be allowed to collect in the bund. Sloping the bund floor from the tank will allow water to be siphoned or pumped over the bund wall. If an electrically driven pump is used, the electrical equipment should either be outside any hazardous area or be of a type suitable for the zone in which it is used. Guidance on bund design is contained in *Containment systems for the prevention*

of pollution C736 (see paragraph 63) and relevant information has been produced in the PSLG report.

166 Removal of surface water using pumps and siphons is not always practicable, particularly for large bunds. An alternative solution is to use a bund drain but if they are left open the integrity of the bund is destroyed. If a bund drain is used, there should be a system of work to ensure the valve remains closed – and preferably locked – except when water is being removed. Locating the valve outside the bund wall will ease access during normal operation and in an emergency situation. Gravity drains should ideally discharge to a sealed drain system.

167 Where flammable liquids not miscible with water are stored, surface water from bunds should be routed through an interceptor or separator to prevent flammable liquids entering the main drainage system. For liquids miscible with water, special drainage systems may be required. The Energy Institute has published information on water miscible liquids (eg ethanol); further information can be found in *Guidance for the storage and handling of fuel grade ethanol at petroleum distribution installations*[41] and Environment Agency *Pollution Prevention Guidelines 7*: *The safe operation of refuelling facilities*.[42]

Combustible materials

168 No combustible material, such as vegetation, litter or rubbish, should be allowed to accumulate in the bund, as this will increase the fire risk. Weedkiller containing oxidising substances should not be used at storage areas or tanker stands because of the increased fire hazard. Similarly, the bund should not be used for the storage of flammable liquid containers, gas cylinders (full or empty) or other hazardous substances.

Vehicles

169 Bunds can be easily damaged, particularly by vehicles. Where possible, traffic should be routed away from bunds. Damage may be prevented by using impact protection, such as crash barriers or bollards.

Marking tanks and fittings

170 Where the risks to employees cannot be avoided or adequately reduced by other means, it may be necessary under regulation 10 of DSEAR to label pipes, sampling points, joints, valves, etc. Typical examples include:

- locations where there are numerous pipes, in close proximity, conveying different dangerous substances, particularly if they have different hazardous properties;
- sampling or filling points and drain valves, particularly where they are located close to similar points for other pipes conveying dangerous substances;
- where there have been significant alterations or additions to fittings and pipe runs.

Lighting

171 Working areas associated with storage tanks, including loading and unloading points, should be adequately lit when in use. An average luminance of at least 50 lux is recommended at ground level and on stairs, access platforms etc. It may be necessary to increase this to 100 lux where perception of detail is required, for example to read level gauges. More detailed advice is in *Lighting at work* HSG38.[43] Lighting installed in zoned areas should be protected to an appropriate standard.

Testing tanks and pipework

172 The manufacturer will normally pressure test tanks before supply in accordance with the design code used and purchase agreement with the client. This is a standard pressure test to prove the quality of materials and construction to the relevant design code. For all tank types, hydraulic testing is preferred to pneumatic testing for safety reasons. For further information see *Safety requirements for pressure testing* GS4.[44]

173 Before filling with flammable liquids for the first time (or after modification or repair), a leak test may be undertaken of the installed tanks and pipework. Leak testing is normally carried out to prove the integrity of joints and seals. For tanks of both metallic and non-metallic construction a leak test pressure should be calculated by a competent person and agreed for use, but not exceed the design limits of the tank. Hydraulic testing is again preferred to pneumatic, although air may be used as a means of applying pressure to water-filled tanks and piping. Once the tank or system is ready for use, a final functional test may be carried out at the normal working pressure. The objective of this test is to ensure that the equipment within the system is functioning as per design.

174 Before testing using water or other test medium you should check that all parts of the system, including pipelines and supports, are strong enough to withstand the hydraulic loading, bearing in mind any difference in specific gravity between test medium and the liquid to be stored in the tank. All leaks or other faults should be corrected before the tank is first used.

175 Take care to ensure the compatibility of the test medium with the material of construction. For example, use of towns (or potable) water in stainless steel tanks may lead to chloride-induced stress corrosion cracking. After testing, the test medium should be drained and the tank dried where necessary, to prevent contamination of the stored liquid.

Heated tanks

176 Viscous liquids are often heated to ease pumping. Additional precautions should be taken to ensure that the storage tank is suitable for use as a heated tank. These precautions are outlined in the following paragraphs.

177 Heated tanks and their associated heating equipment should be constructed to an appropriate standard such as those listed in the references section.[45] Useful information on heated tanks and advice on the storage of bitumen can be found in the Energy Institute *Bitumen Safety Code*.[46]

178 Locating the outlet pipe above the heating coil or element will prevent exposure of any internal heated surface or any temperature control sensor. A second drainpipe may be fitted at a lower level so that the tank can be completely emptied when necessary. This pipe should be fitted with a closed valve and a blank flange so that it cannot be used during normal operations. If this arrangement is not feasible then an alternative is to fit a low liquid level alarm linked to a heater cutout.

Temperature control

179 The temperature of the tank should be controlled using a thermostat or similar device. It recommended that you select the minimum temperature sufficient for the

purpose, preferably below the flashpoint of the liquid. Control will be easier if the heating rate is slow.

180 As well as the thermostat control, it is advisable to have an independent cut-out device which will shut down the heater completely (no automatic reset) if the temperature exceeds a set high point. This is particularly important if the flammable liquids could be heated above their flashpoint in normal operation or under fault conditions.

181 The temperature sensor (independent of the thermostat) should be located where it is continuously immersed in the liquid. A second temperature sensor may be advantageous to indicate possible problems with the thermostat.

182 Temperature probes, thermostats and associated equipment should be maintained and recalibrated. They should be included in the preventive maintenance schedule.

183 Heaters should be used only when there is at least 150 mm of liquid covering the heating coil. The tank should not be emptied until the tubes have cooled to the temperature of the liquid. It may be advisable to install a low level alarm to ensure the heaters are not uncovered inadvertently.

184 Where vents, filters etc are liable to become blocked, or a build-up of coke or other material is liable to occur, a regular system of inspection and cleaning should be in place. This is particularly important for vents, as blockage by, for example, polymerisation, sublimation or condensation of product, may damage the tank. In some cases trace heating may be used to minimise the problem. Where electric surface heating is used, it should be selected and installed in accordance with the appropriate standard, such as BS EN 60079-30-1.[47]

Loading and unloading facilities

185 This section provides guidance on road and rail transfer facilities. It does not cover loading and unloading from ships. If required, advice is available in *The bulk transfer of dangerous liquids and gases between ship and shore* HSG186 and from the International Oil Tanker and Terminal Safety Guide.

186 All equipment including pumps, valves and hoses should be suitable for the liquids being handled and for the conditions of use. They should be made to an appropriate British Standard or equivalent.

187 Some tankers have their own offloading pump. If these are used, they should be checked to ensure that they are electrically protected and are of a capacity matched to the discharge pipework and the tank installation.

188 Where vehicles are bottom loaded, the recommendations in the Energy Institute code of practice for road tank vehicles equipped for bottom loading and vapour recovery contained in *Petroleum road tanker design and construction*[48] should be followed.

189 Further advice on terminal loading operations can be found in the CDOIF (Chemical and Downstream Oil Industries Forum) documents *Automatic Overfill Prevention Systems for Terminal Loading Racks*[49] and *Terminal Loading Operations Hazard Awareness*.[50]

Loading and unloading road tankers

190 Loading/unloading bays for road tankers should be located in a safe, well-ventilated position. The minimum recommended distance of a filling point from occupied buildings, the site boundary and fixed sources of ignition is 10 m.

191 The loading/unloading bay should have easy access and exit for tankers, preferably without reversing. The loading/unloading area and the access road should preferably be dedicated to tanker use only. If this is not practicable, barriers to control access by other vehicles and pedestrians may be necessary during transfer operations.

192 A separate parking bay for road tankers waiting to load or unload is advisable so that vehicles and documents can be checked with minimum interference to traffic flow. Tankers should not wait on public roads or busy internal roads.

193 Level ground is desirable, surfaced with a material resistant to the liquids being handled. A small gradient may be beneficial if this assists drainage. The drainage should be designed to minimise the surface area of any spillage and lead it away from vehicles to a slop tank or interceptor.

Design of a road tanker loading/unloading facility

194 To minimise the risk of overfilling, tankers should normally be loaded using a flow meter with a trip to stop the pump and close a shut-off valve automatically when a preset quantity has been delivered. Use of an independent high-level or overflow alarm is recommended to provide a warning if the meter fails. Meters may

be protected by installing flow control valves. CDOIF has published detailed guidance aimed at fuel distribution terminals.

195 Before liquids are unloaded from tankers into storage tanks, particular attention should be paid to ensuring enough ullage space is available in the storage tank to receive the load. The use of high-level alarms on storage tanks is described in paragraph 137. To reduce the likelihood of spillage, the use of self-sealing couplings on the hose connections should be considered.

196 Precautions should be in place to prevent spillage due to vehicles being moved with the hoses still connected or arms still in place. This can be done by providing barriers across the tanker stance, wheel chocks, brake interlocks on the vehicle or breakaway couplings on the hose connections.

197 In addition to any automatic shut-off devices on the tanker or the tank, an emergency stop button should be installed at the loading/unloading point which will activate a quick-action shut-off valve or pump stop control. This will enable the operator/driver to stop immediately loading/unloading if a problem is observed.

198 Precautions against static electricity should be provided. These include an earthing connection for the vehicle, electrically conducting hoses and elimination of splash filling. For additional protection an interlock may be fitted to prevent operation of the control valve or loading pump until the earth connection is made (see also BS 5958).[51] Splash filling may be avoided by ensuring that the fill pipe in a top-loading operation reaches to the bottom of the tank or tanker.

199 Safe access to equipment and safe means of escape for work above ground level should be in place. Access gantries with stairs or ladders and protective handrails will usually be required for top-loading of vehicles. Gantries should be made of fire-resisting materials and, where necessary, should include means of access to the top of the tanker vehicles.

200 Fire protection measures should be designed to minimise the risk of fire spread. This may be achieved by ensuring that a ready supply of water and/or foam is available from fixed or mobile equipment. Hand extinguishers should also be located at appropriate points within the transfer area. The loading/unloading facilities should also be fitted with easily accessible fire alarm activation points.

201 The information on tank connections and fittings, and contents measurement is also relevant. See paragraphs 118–153.

Rail loading/offloading

202 Most of the advice given above for road transfer can be applied to rail. In addition, the following advice is recommended for rail transfers:

- a separation distance of at least 15 m from any railway line in regular use;
- straight and level tracks with a maximum gradient of no more than 1 in 400, any dead end to slope down towards the buffers;
- isolation from other rail traffic by closing and locking barriers or points. If the siding is part of an electrified track system, it should be electrically isolated from the rest of the system and bonded to the site main earth;
- precautions to prevent the train from moving during loading or unloading;
- precautions to prevent the locomotive acting as a source of ignition. These may include keeping a separation distance of at least 9 m between the filling hose and the locomotive;

- remote pump controls at intervals along the siding;
- quick action manually-operated stop valves and non-return valves on the individual lines from a common header pipe used to fill/unload two or more rail cars simultaneously. This will prevent back-feeding;
- maintenance of track and line-side equipment to an appropriate standard.

Operation of road and rail facilities

203 All operations should be under the control of an authorised person, who should be present at all times during the transfer. In some circumstances, the authorised person may be the driver. This is common practice for the delivery of petrol in accordance with Schedule 12 of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (see Appendix). Before any transfer is made between a road or rail tanker and a storage installation, an authorised site representative should be notified.

204 To minimise the generation of static electricity, splash filling should be avoided, for example, by ensuring that the open end of the fill pipe is not above the normal minimum surface level of the tank contents. Further advice can be found in the Energy Institute's *Model Code of Safe Practice Part 21*.

205 The hazards from static charging can also be minimised during road and rail loading by avoiding switch loading, where a tanker that has contained low flashpoint liquid, such as petrol, is subsequently loaded with a higher-flashpoint liquid, such as kerosene.

206 Written instructions should be provided covering all aspects of the operation. These may include:

- tanker earthing;
- the careful checking of load details and tank ullages;
- inspection of hoses and other items of equipment;
- the measures to prevent the vehicle moving while hoses are connected;
- the transfer procedure; and
- emergency procedures.

207 Before unloading the tanker, placards and the accompanying delivery notes should be checked to ensure, so far as reasonably practicable, that the material being delivered is what it is supposed to be and is compatible with the destination storage tank. This is particularly important if incompatible materials are stored on site. Even substituting a flammable liquid with a highly flammable liquid can ultimately have serious consequences, such as loading petrol into a diesel tank. Similarly, before a loaded tanker leaves site, placards and paperwork should be checked to ensure they match the load.

208 An effective means of communication should be provided between personnel involved in the loading/unloading operations, and other parts of the site such as the control room. If radios are used they should be suitable for use in hazardous areas.

Fire protection

209 It may be necessary to provide fire protection where the storage conditions are less than ideal, such as where it is difficult to achieve adequate separation distances. Fire protection measures can be provided by:

- fire resistant claddings or coatings;
- fire walls;
- water cooling systems;
- foam blankets or extinguishing systems.

210 Combinations of the different measures may be used. Fire protection systems should be included in the inspection and maintenance schedule for the facility. Routine testing of water spray and deluge systems may be necessary. Further advice on fire protection is given in the Energy Institute's *Model Code of Safe Practice Part 19*.

Passive fire protection

211 Fire resistant claddings or coatings may be used to protect the tank from adjacent fires or from a liquid pool fire around its base. The fire resistance of structures which support vessels should be assessed – collapse in a fire could escalate the incident. Fire protection of structural steel should provide a minimum protection of two hours. See *Model Code of Safe Practice Part 19* and L138.

212 Thermal insulation materials are often used to reduce heat loss or heat gain. These materials may not provide passive fire protection unless specifically designed for the purpose.

Fire walls

213 A fire wall may be used to give additional protection to small tanks. They are not usually practicable or economic for larger tanks. Where a fire wall is installed, it should be at least the height of the tank, with a minimum height of 2 m, and should normally be sited between 1 and 3 m from the tank. It may form part of the bund wall or a building wall. A fire wall should normally be provided on only one side of a tank, to ensure adequate ventilation. The wall should be long enough to ensure that the distance between the tank and a building, boundary, process plant or source of ignition is at least the appropriate distance in Table 1 measured around the ends of the wall.

214 To be effective, reinforced concrete or masonry construction is recommended and in all cases the fire wall should:

- have no holes in it;
- have at least half-hour fire resistance;
- be weather-resistant;
- be sufficiently robust to withstand foreseeable accidental damage.

Water cooling systems

215 Water sprays or deluge systems are used primarily to provide cooling and so protect the tank from the damaging effects of an adjacent fire or a liquid pool fire at its base.

216 The water application rates will depend on the level of thermal radiation to which the tank and associated equipment may be exposed. The recommended rate quoted in *Model Code of Safe Practice Part 19* to protect a fixed-roof tank from a pool fire at its base is not less than 10 l/min/m^2 of exposed uninsulated surface.

217 Protection of a tank from an adjacent fire depends on various factors such as the distance from the fire. A water rate of 2 l/min/m^2 is considered to be the minimum application rate for tank surfaces exposed to radiation from a non-impinging fire in adjacent equipment. Water coverage should be uniform and there should be no significant dry areas on the tank walls.

218 The application of water to the roof of floating-roof tanks is not recommended. For rim fires, water may be applied to the vertical tank walls while a foam blanket is applied to the roof.

Foam systems

219 Foam systems may be used to extinguish a fire or blanket spillages of flammable liquid and so reduce the risk of ignition. To avoid the build-up of static charges and possible ignition, foam should be applied using a foam pourer and not by jet. Recent research work carried out by the oil industry has shown that applying large volumes of foam rapidly can extinguish even a fully developed tank fire. This requires specialist equipment and high capacity pumps, foam generators and pourers or monitors.

220 Further advice on the design and specification of fire protection systems can be found in *Model Code of Safe Practice Part 19*.

Inspection and maintenance

221 All plant should be inspected for damage and deterioration. In addition to planned formal examinations, this inspection should be a combination of routine visual inspection by operations staff looking for obvious deterioration or damage.

222 There should be regular inspection and cleaning of interceptors, bunds, vents, slop tanks, loading and unloading facilities, and any buildings where flammable vapour may be present. Where a defect is identified, there should be a system in place to record this and to initiate appropriate remedial action.

223 The Health and Safety at Work etc Act requires that plant and equipment is maintained in a safe condition. Storage tanks and all associated equipment, including walls and fences, should be properly maintained. Only personnel who are suitably qualified and authorised, and who fully understand the hazards, should carry out inspection and maintenance.

224 It is recommended that you list the component parts of the installation on a preventive maintenance schedule, containing details of the scope and frequency of planned inspection and maintenance work. You should also pay attention to periodic inspection of electrical equipment and operation of isolation valves. There should be regular inspection and cleaning of interceptors, bunds, vents, slop tanks, loading and unloading facilities, and any buildings where flammable vapour may be present. Firefighting equipment should be regularly maintained and, where appropriate, tested.

225 Examination of tanks, pipework and fittings should be carried out by a competent person. This could be a specialist inspection engineer employed by an insurance company or other third-party inspection body. Alternatively, an employee with the appropriate qualifications, experience and competence and supporting management systems could provide some form of an inspection service. A scheme of examination should be agreed between the user and the competent person, to include the scope and frequency of thorough examination. The intervals between internal examinations should be determined using a risk assessment approach based on tank service, maintenance history, and known and potential damage mechanisms and their rates of attack. Intermediate external examinations should also be carried out on above-ground tanks.

221 Records should be kept of all examinations, tests, modifications and major maintenance. Schemes of examination should be in writing and should be reviewed regularly by the competent person and the equipment owner. Hoses and hose assemblies, where used, should be subject to an inspection regime, which includes a pressure test at least annually, and visual inspection on every day they are used. More detailed guidance on the inspection and maintenance of tanks can be gathered from EEMUA 159, and EEMUA 231 *The mechanical integrity of plant containing hazardous substances: A guide to periodic examination and testing*.[52]

Floating-roof tanks

227 For tanks with a floating or internal floating cover:

- avoid fouling or obstructing tank connections;
- ensure adequate buoyancy of the roof or cover;
- provide adequate roof space ventilation; and
- provide adequate electrical bonding.

228 Regular inspection for cracks and damage to the rim seal is advisable. The drainage system may need regular attention to prevent accumulation of rainwater.

229 A safe system of work should be in place for access to the roof (particularly when it is more than 2 m below the tank top) due to the possible accumulation of vapour. The system of work should include emergency procedures and means of escape, in the event of fire.

Permit-to-work systems

230 Many accidents have occurred while storage installations were being maintained, modified or demolished. The main cause is the introduction of a source of ignition, such as a cutting torch or an unprotected light, to pieces of equipment where flammable vapours remain. Any work carried out on equipment which may contain a flammable liquid or vapour should be covered by a permit-to-work (PTW) or similar system of authorisation.

231 In most cases, a PTW system should be used to control maintenance operations in areas where flammable liquids are stored or used. PTWs are formal management documents. They should only be issued by those with clearly assigned authority to do so, and the requirements stated in them must be complied with before the permit is issued and the work covered by it is undertaken. Individual PTWs should relate to clearly defined individual pieces of work.

232 PTWs should normally include:

- the area in which the permit applies;
- the work to be done and the method to be used;
- identification of the hazards, including the residual hazards and those introduced by the work itself;
- the precautions to ensure that all flammable materials have been removed and cannot be accidentally reintroduced;
- the personal protective equipment required;
- the proposed time and duration of the work;
- the limits of time for which the permit is valid; and
- the person in direct control of the work.

233 A range of guidance on PTW systems may be found on HSE's website www.hse.gov.uk/safemaintenance/permits.htm and in *Guidance on permit-to-work systems: A guide for the petroleum, chemical and allied industries* HSG250.[53]

234 Contractors and subcontractors should also be covered by the permit or authorisation system.

Modifying the storage installation

235 Modifications may affect the mechanical or electrical integrity of the storage installation. A risk assessment should be carried out at the planning stage to identify any additional hazards that the modification may introduce. The use of a competent person to oversee the work will ensure the installation remains fit for purpose. Additional testing may be required.

Decommissioning tanks

236 Tanks that are to be taken out of use should be made safe. The method will vary with the location of the tank, the product it has contained and whether it is to be taken out of use permanently or temporarily. A risk assessment should be carried out at the planning stage to identify any additional hazards that decommissioning may introduce. The work should also be covered by a PTW or similar authorisation procedure.

237 The preliminary steps in the decommissioning process (which also apply to pipework) are:

- isolation of the tank from any process, plant or storage vessel by either removing pipe sections or fitting spade pieces. Shut-off valves by themselves are not adequate;
- emptying the tank as much as possible;
- opening manholes to assist venting.

238 Tanks which are being decommissioned permanently should be made safe by thorough cleaning and gas freeing. Guidance is available in *The cleaning and gas freeing of tanks containing flammable residues* CS15.[54]

239 Tanks that are being decommissioned temporarily should be made safe by thorough cleaning as above, or by filling with water or an inert gas such as nitrogen. The advice given in CS15 is applicable in this situation. If inert gas is used, the tank should be labelled to make it clear that it contains a gas which could cause suffocation if the tank is entered. See also *Safe work in confined spaces. Confined Spaces Regulations 1997. Approved Code of Practice, Regulations and guidance* L101.[55] Regular inspection will help you ensure that the tank remains in a safe condition.

240 Advice on the decommissioning of underground tanks is given in APEA code of practice *Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations*.

Demolishing tanks

241 Demolition of tanks which have contained flammable liquids is potentially very hazardous. Hot work can cause an explosion if undertaken before the tank and pipework has been drained and cleaned. Tanks that have contained flammable liquids need special preparation to remove flammable vapours, or associated liquids and sludges. Residues that can evolve flammable vapours when heated may be present on the walls and underside of the roof. It may be advisable to use a specialist tank demolition company with the relevant expertise and equipment.

242 Guidance is available in CS15, the Energy Institute *Model Code of Safe Practice Part 16: Tank cleaning safety code*[56] and BS 6187.[57]

Fire precautions

243 The likelihood of a major fire may be minimised by:

- good plant design and layout;
- sound engineering;
- good operating practice;
- tight control of non-routine operations such as repairs and modifications;
- instruction and training of personnel in routine operations and in emergency procedures.

244 Plant design and layout should include consideration of:

- water supplies;
- fire protection equipment;
- firefighting;
- means of escape;
- means of access for fire and rescue service appliances;
- arrangements to ensure an early call out of the fire and rescue service in the event of fire;
- ability of the drainage/interceptor facilities to cope with fire water.

245 For means of escape, at least two separate exits will normally be needed. Exits should open outwards and be easily opened from inside when the area is occupied. One exit may be sufficient if the distance from any part of the storage area to the exit is not more than 24 m, measured around the tanks and any other obstructions.

246 The fire and rescue authority should be consulted on these matters (at the planning stage in the case of new or altered facilities). Further guidance is available in *Model Code of Safe Practice Part 19*.

General fire precautions

247 'General fire precautions' (the equivalent term 'general fire safety measures' is used in Scotland) are primarily concerned with ensuring people can safely escape to a place of safety in the event of a fire in the workplace. This includes provision of:

- adequate and appropriate means of detection and giving warning in case of fire;
- adequate means of escape;
- suitable means of fighting fire;
- specifying the action to be taken in the event of fire; and
- appropriate and adequate training of staff in the company's fire safety procedures.

248 You are responsible for carrying out a risk assessment to determine the general fire safety requirements for your workplace. As part of this, you should also consider the potential impact of fire involving flammable liquids and adapt the general fire precautions as necessary so they remain sufficient to ensure people's safety in the event of fire.

249 General fire precautions are subject to separate legislation (see paragraphs 19–21). This includes the requirement for the employer to ensure they are sufficient

for people's safety in the event of a fire involving dangerous substances at the workplace. The provisions of regulations 1–6, 8, 9 and 11 of DSEAR, as they relate to general fire safety, are embodied in this general fire safety legislation.

250 Detailed consideration of general fire precautions is outside the scope of this guidance. Guidance on how to comply with the law relating to general fire safety requirements and how to carry out a fire risk assessment can be found:

- for England and Wales, in 'Fire safety in the workplace' www.gov.uk/workplace-fire-safety-your-responsibilities;
- for Scotland, in 'FireLaw – General guidance' www.scotland.gov.uk/Topics/Justice/public-safety/Fire-Rescue/FireLaw;
- for England and Wales, 'Fire safety risk assessment: factories and warehouses' https://www.gov.uk/government/publications/fire-safety-risk-assessment-factories-and-warehouses;
- for Scotland, 'Factories & Storage Premises' www.scotland.gov.uk/Topics/Justice/public-safety/Fire-Rescue/FireLaw/FireLaw/SectorSpecificGuidance/FactoriesStorage;
- for construction sites, *Fire safety in construction* HSG168.[58]

251 Further detailed advice on general fire precautions may be found in BS 9999.[59]

Outside work areas

252 General fire safety legislation applies to the entire workplace. This includes indoor and outdoor work areas.

Detection and giving warning in case of fire

253 There should be an effective means of giving warning in case of fire in the process area. It should be audible to all those likely to be affected by the fire. This may vary from small process areas, where a shout of 'fire' might suffice, to larger areas where a klaxon or siren might be required. An assembly point in a safe location should be identified for people evacuating from such areas, where they can be accounted for.

Adequate means of escape

254 The layout of process plant and equipment should be planned and controlled to avoid dead-end situations where possible; ie where escape is only possible in one direction. Any that cannot be avoided should be as short as possible. Escape routes should be obvious, with directional escape signs as required. These signs should comply with the Health and Safety (Safety Signs and Signals) Regulations (see Appendix). Operational needs should ensure that the gangway widths are adequate, but wherever possible, they need to have a minimum width of 1.5 metres.

Firefighting equipment and facilities

255 Under general fire legislation (see paragraphs 19–21), it is the responsibility of the local fire and rescue authority to make provision for firefighting, and to equip and maintain a fire and rescue service to meet normal requirements. The fire authority may make arrangements with works' fire teams to provide assistance but the local authority fire and rescue service will assume control of firefighting operations on arrival at a fire. It may be possible to negotiate additional assistance with nearby sites, perhaps by a mutual aid agreement.

256 The firefighting equipment for bulk storage of flammable liquids will depend on the quantity and type of liquid, and on the conditions of storage. Firefighting equipment should be provided at readily accessible locations at the storage area, including identifiable danger points such as pump rafts, hose pits and loading gantries. Protection against the weather, particularly freezing, may be required. Firefighting equipment should be regularly maintained, and where appropriate, tested.

257 Dry powder or foam fire extinguishers (hand-held or trolley-mounted) are suitable to deal with fires from small leaks of flammable liquid. CO_2 extinguishers should be used for electrical fires. To guard against equipment failure, it is preferable to have extinguishers grouped in pairs. Fire extinguishers should be regularly inspected and tested by a competent agency. Extinguishers should be to a recognised standard such as BS EN 3-7.[60]

258 For other fires that might affect the storage, eg those involving rubbish or vegetation, water hoses are appropriate. Hoses may be in reels permanently connected to a water supply, or in lengths for connection to a hydrant, and should cover all parts of the storage installation. BS 5306 Parts 1 and 3[61] contains advice on selecting, installing and maintaining portable firefighting equipment.

259 Facilities to deal with larger fires include an adequate water supply for fire and rescue service use. This may consist of hydrants, ponds, canals etc and should be readily accessible and normally no more than 100 m from the tanks. The need for foam and the means of application may be discussed with the fire authority, taking into account the number, size, type, location and contents of tanks. Fixed foam pourers or high-capacity monitors designed to cover the entire liquid surface rapidly with foam together with the associated high capacity water pumps and other equipment has been shown to be able to rapidly extinguish full surface fires and their provision should be considered. Rapid extinguishment of such fires can substantially reduce the potential for escalation and minimise property damage. The total quantity of fire water used is also significantly reduced thus reducing the risk of environmental pollution and reducing clean-up costs. Provision of such systems could be considered for larger sites.

260 An adequate supply of water will also be needed to provide cooling for tanks exposed to heat from a nearby fire. Advice on the required cooling rates for tanks can be found in Annex D of *Model Code of Safe Practice Part 19*. The required rate will vary with the fire to which the tank may be exposed, but a rate of 10 $l/m^2/min$ may be required if the tank could be enveloped in flame. The entire tank wall should be covered with water to prevent hotspots developing. Fixed water sprays or portable monitors are an advantage, but are normally required only where the storage conditions are less than ideal, such as where it is difficult to achieve adequate separation distances.

261 Fire water run-off may place a major strain on normal drainage facilities. Interceptors or special draining systems may be necessary, particularly at large installations, to minimise the risk of contamination of local watercourses. For sites subject to COMAH (see Appendix), and those within scope of PSLG there are more detailed recommendations on the HSE website (www.hse.gov.uk/comah/index.htm).

Emergency procedures

262 The impact of an incident involving flammable liquids may be drastically reduced if prompt emergency action is taken. Everyone should know what to do in the event of spills, leaks or fires involving flammable liquids. Practical training and written procedures should be provided covering:

- raising the alarm;
- calling the fire and rescue service;
- controlling the spill or leak;
- tackling the fire (when it is safe to do so); and
- evacuating the area safely.

263 Where an incident may affect people or property beyond the site boundary, the emergency services should be consulted. At top-tier COMAH installations, operators must prepare on-site and off-site emergency plans (regulation 9(1)). Guidance on emergency plans can be found in HSG191.

Security

264 The consequences of trespassing or tampering may be very serious. Good security is essential. If the storage facility is within the security area of the premises as a whole then this may give adequate protection. Otherwise, it is advisable to enclose storage areas and areas used for loading or unloading tankers by using a substantial fence at least 1.8 m high. Use of welded mesh or chain-link fencing (which will not obstruct ventilation) is preferred.

265 Exits should open outwards and be easily opened from inside when the area is occupied. They should be kept locked when the area is unoccupied, with access to the keys restricted to authorised personnel. A written procedure covering key control may be advisable.

Information and training

266 Adequate training and knowledge of the properties of flammable liquids present on site are essential for their safe handling and implementation of the emergency procedures in the event of an incident.

267 Training is a requirement of the Management Regulations and DSEAR (see Appendix and paragraph 17–18). Carrying out risk assessments required by these Regulations will identify how much information, training and retraining are needed. Further guidance is available in L138.

268 You need to inform all staff on the site about the hazards of flammable liquids, and about the need to exclude sources of ignition and heat from the designated areas. Those responsible for the operation of the process areas also need to receive specific training in how to deal with spillages and leaks, and emergency procedures.

269 Periodic retraining will usually be necessary. A typical training schedule will include the following:

- hazards and properties of the liquids being stored;
- safe operating procedures for the installation and its associated equipment;
- the purpose of the safety features, including the importance of not removing or tampering with them;
- the action to be taken if a fault in the equipment is detected;
- dealing with minor leaks and spills;
- the importance of good housekeeping and preventive maintenance;
- emergency procedures.

270 Information on safety in the use of solvents can be found on the Solvents Industry Association website: www.sia-uk.org.uk.

271 You will need written procedures for controlling the risks from flammable liquids, and these should be used as the basis for training.

Signage

272 The Health and Safety (Safety Signs and Signals) Regulations (see Appendix) and DSEAR regulations 7(3) and 10 (see paragraph 17–18) require employers to post appropriate safety signs where identified significant risk remains following implementation of the other safety measures. The intention of posting safety signs (including fire safety signs) is to provide warning and instruction to employees of risks to their health and safety. The signs are intended to remind employees of the actions they should take. Employees should therefore receive adequate information and training on these actions and fully understand the meaning of the safety signs and what they require.

273 Your risk assessment will help you determine the nature and extent of safety signs required. Guidance on this is given in *Safety signs and signals. The Health and Safety (Safety Signs and Signals) Regulations 1996. Guidance on Regulations* L64.[62]

274 Safety signs that conform to a recognised standard such BS EN ISO 7010[63] are acceptable. The signs may be also supplemented with text where you have concluded this to be appropriate.

275 Typically, unless otherwise made obvious, safety signs are commonly posted at the entrances to the locations where flammable liquids are processed or stored, to warn and remind employees of the precautionary measures to be observed.

Figure 9 Example of warning and prohibition signs with supplementary text used at entry points to flammable liquid facilities

276 Similarly, unless it is otherwise made obvious (for example, by control of potential ignition sources throughout the site), at the entry points of places that have been classified as hazardous areas (eg gates/doors to process areas) an appropriate sign should be posted to warn people entering those areas that special precautions are required.

Figure 5 Example of warning sign with supplementary text used at entry points to locations where a potentially explosive atmosphere may exist

Higher flashpoint liquids

277 Where the flashpoint of the liquid is significantly above the highest operational temperature, some of the precautions described may be relaxed. Under these circumstances such liquids will not normally produce a flammable atmosphere. The risk assessment required under regulation 5 of DSEAR (see paragraph 17–18) should be used to determine which, if any, of the precautions can be relaxed. In general, a difference of at least 10 °C between the highest temperature and the flashpoint is recommended before such relaxations are permitted.

278 The following paragraphs indicate where the advice in the preceding guidance may be relaxed for higher flashpoint liquids stored at temperatures below their flashpoint. If no variation is shown for any particular aspect, the standards in the main text apply.

Sources of ignition

279 Where the temperature of a liquid is not likely to be raised near to its flashpoint, and there is little likelihood of a flammable mist or spray occurring, the liquid may be considered not to give rise to a hazardous area. Protection of nearby electrical equipment is not then required. However, there should be no likelihood of local heating of the liquid, which might produce a flammable vapour.

280 For tanks containing higher flashpoint liquids at temperatures near to or above their flashpoint, electrical equipment within 1 m of tank vents and other openings should be protected to zone 2 standards. Equipment located in the vapour space inside such tanks should be to zone 0 standards (see L138, regulation 7 and Schedules 2–4).

281 Irrespective of storage temperature, installations where liquid can escape as a mist or spray may require explosion-protection of adjacent electrical equipment. An example is a pump used to fill or empty a tank.

282 In all cases, precautions against the introduction of other sources of ignition such as smoking and hot work will be needed.

283 Protection against vehicles acting as a source of ignition is not required for vehicles used or parked in storage areas containing only higher flashpoint liquids.

Location of tanks above ground

284 In Table 3 the separation distance from buildings etc, for tanks above 250 m^3 capacity may be reduced to 10 m.

285 The recommended minimum separation distances for a tank containing higher flashpoint liquid are:

- from another tank containing a higher flashpoint liquid: the minimum needed for safe construction and operation;
- from a tank containing a low flashpoint liquid: in accordance with Table 2.

Storage in buildings

286 It is advisable to store all classes of flammable liquids outside wherever reasonably practicable. Where higher flashpoint liquids are stored in buildings the precautions in paragraphs 84–87 are relevant, with the following changes:

- a lightweight roof is recommended but other protection against explosion is not required;
- a lower standard of ventilation, eg a limited number of air bricks in external walls, is adequate;
- the building need not be single-storey (but the tanks should be located on the ground floor); and
- a fixed water installation is not necessary.

Venting

287 The minimum recommended heights for vent outlets do not apply to higher flashpoint liquids. The separation distance from buildings etc may be reduced to 1 m. Flame arresters and PV (pressure/vacuum) valves are not required but fire engulfment relief should be provided.

Marking and labelling

288 Tanks should be marked ‘Flammable Liquid’.

Road and rail tankers

289 The recommended separation distance between road transfer facilities and buildings etc may be reduced to 5 m. The restriction on approach of locomotives need not be applied.

Appendix Other relevant health and safety legislation

Management of Health and Safety at Work Regulations 1999 (the Management Regulations)

1 The Management Regulations require employers and the self-employed to assess the general risks to health and safety arising from their work activity and identify the preventive and protective measures that need to be taken to control the identified risks.

2 The more specific provisions of DSEAR (see paragraph 17–18) will only apply where dangerous substances are present or used. For example, an assessment of the risks from dangerous substances and arrangements for emergencies carried out under DSEAR will not need to be repeated under the Management Regulations, and may be incorporated into the more general 'management' assessment as a subset.

3 There are legal requirements, in other regulations, to consult employees. It can be helpful to involve employees or their representatives when carrying out risk assessments.

Control of Substances Hazardous to Health Regulations 2002 (COSHH)

4 Flammable liquids are dangerous (to safety) in terms of DSEAR, but they are also likely to present a health risk for which COSHH will apply. The supplier's SDS should provide information on this, where the employer will have duties to control the health and safety risks under both COSHH and DSEAR. By considering the requirements together, development and implementation of a single set of safety measures to satisfy the requirements of both sets of regulations should be possible.

CLP and CHIP

5 From 1 June 2015, chemical suppliers must comply only with the CLP Regulation.

6 European Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures (known as the CLP Regulation or CLP) has repealed both the Dangerous Substances Directive (67/548/EEC) and the Dangerous Preparations Directive (99/45/EC) and became the primary legislation in this area.

7 The CLP Regulation adopts across the European Union the United Nations' Globally Harmonised System on chemical classification and labelling (GHS). The CLP Regulation is directly acting on all European Union member states. This means that, unlike with directives, no national transposition is necessary and the need for the Chemicals (Hazard Information and Packaging for Supply) Regulations 2009 (CHIP Regulations) falls away. However, regulation 12 of CHIP requires that the person who is responsible for first supplying a dangerous preparation has to keep a record of the information for at least three years after it is last supplied; this provision of CHIP will remain until June 2018, after which CHIP is fully revoked.

8 Preparations classified, labelled and packaged in accordance with CHIP and placed on the market before 1 June 2015, do not need to be relabelled and repackaged in accordance with the CLP Regulation until 1 June 2017. Product hazard labels must only show the details of one regime – 'mixed' labels are not permitted.

Provision and Use of Work Equipment Regulations 1998 (PUWER)

9 These Regulations ensure that safe work equipment is provided, maintained in good working order and is safely used. Regulation 12 of PUWER is particularly relevant to equipment associated with flammable liquids, as it requires employers to ensure that people using work equipment are not exposed to hazards arising from:

- equipment catching fire or overheating;
- the unintended or premature discharge of any liquid or vapour;
- the unintended or premature explosion of the work equipment or any substance used or stored in it.

Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (EPS)

10 EPS applies to the supply of both electrical and mechanical equipment and protective systems intended for use in potentially explosive atmospheres. New equipment etc supplied for use in places where an explosive atmosphere may occur must meet the requirements of EPS whatever its source.

Planning (Hazardous Substance) Regulations 1992

11 Sites, manufacturing or processing flammable liquids may be required to apply for permission under the Planning (Hazardous Substance) Regulations 1992 in England and Wales or the Town and Country Planning (Hazardous Substances) (Scotland) Regulations 1993. Application is usually to the local planning authority with HSE being a statutory consultee in the application process.

Dangerous Substances (Notification and Marking of Sites) Regulations 1990 (NAMOS)

12 NAMOS aims to ensure that firefighters arriving at an incident are warned of the presence of dangerous substances. Advice on NAMOS is available in *Notification and marking of sites* HSR29.[64]

Control of Major Accident Hazards Regulations 1999 (COMAH)

13 COMAH aims to prevent and mitigate the effects of those major accidents involving dangerous substances which can cause serious damage/harm to people and/or the environment. The COMAH Regulations treat risks to the environment as seriously as those to people. For further guidance on COMAH see the HSE website www.hse.gov.uk/comah/guidance.htm.

Consulting employees and safety representatives

14 Employers must consult safety representatives appointed by recognised trades unions under the Safety Representatives and Safety Committees Regulations 1977. Employees who are not covered by such representatives must be consulted either directly or indirectly, through elected representatives of employee safety under the Health and Safety (Consultation with Employees) Regulations 1996.

15 Proper consultation with those who know precisely how the work is done, including short cuts, is crucial and helps to build a culture of awareness of health and safety. It can benefit the business by making it more efficient and reducing losses and damage.

Electricity at Work Regulations 1989

16 These Regulations impose health and safety duties for the safe use of electricity at work. They require electrical installations and equipment to be properly constructed, maintained and fit for the purpose and environment in which they are to be used. In particular, they require electrical equipment which is exposed (or reasonably expected to be exposed) to a flammable or explosive substances, including flammable vapours or gases, to be constructed or protected so as to prevent danger. Advice is available in *The Electricity at Work Regulations 1989. Guidance on Regulations* HSR25.[65]

Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG)

17 Carrying goods by road or rail involves the risk of traffic accidents. If the goods are dangerous, there is also the risk of incidents, such as spillage, leading to hazards such as fire, explosion, chemical burn or environmental damage. The CDG Regulations implement ADR with a number of exceptions which can be found in the *Carriage of dangerous goods: Approved derogations and transitional provisions* document at https://www.gov.uk/government/publications/the-carriage-of-dangerous-goods-approved-derogations-and-transitional-provisions.

18 Flammable liquids as defined in this guidance are within scope of CDG, the aim of which is to reduce the risks involved in transporting such substances by requiring them to be correctly classified, packaged and labelled. The Regulations specify that dangerous goods should be carried in suitable receptacles which will not leak under normal handling. These should bear appropriate warning labels giving information on the nature of the hazards.

Health and Safety (Safety Signs and Signals) Regulations 1996

19 These Regulations implement a European Council Directive on minimum requirements for provision of workplace safety signs. The Directive standardises use throughout EU member states to ensure particular signs provide the same message wherever witnessed.

Health and Safety Enforcing Authority Regulations 1998

20 These Regulations allocate to local authorities the responsibility for enforcing the HSW Act and its relevant statutory provisions, subject to specific exceptions, in all premises where the main activity is listed in Schedule 1 to the Regulations.

Food and Environment Protection Act 1985 (FEPA)

21 All pesticides are subject to FEPA, this guidance covers safety aspects of the flammability hazards of those pesticides which are also flammable liquids.

22 Further guidance on the safe storage of pesticides may be found in *Guidance on storing pesticides for farmers and other professional users* AIS16.[66]

Control of pollution (oil storage regulations)

23 Oil storage regulations require anyone in Great Britain who stores more than 200 l of oil to provide secure containment facilities for tanks, drums, intermediate bulk containers (IBCs) and mobile bowsers:

- Control of Pollution (Oil Storage) (England) Regulations 2001;
- Control of Pollution (Oil Storage) Regulations (Scotland) Regulations 2003;
- Water Resources (Control of Pollution) (Silage, Slurry and Agriculture Fuel Oil) (Wales) Regulations 2010;
- Control of Pollution (Oil Storage) Regulations (Northern Ireland) 2001.

Petroleum (Consolidation) Regulations 2014

24 These Regulations apply to workplaces that store petrol and dispense it through manual or electrical pumping from a storage tank directly into the tank of a vehicle with an internal combustion engine. These Regulations also apply to storage at non-workplace premises, eg private homes, clubs, associations etc.

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Glossary

ambient ambient temperature is the temperature of an immediate locality.

auto-ignition temperature the minimum temperature at which a material will ignite spontaneously under specified test conditions. Also referred to as the minimum ignition temperature.

bund an area surrounded by a bund wall in which liquid spillage is contained. Also the raised perimeter of an area used to contain and prevent the spreading of liquids.

combustible capable of burning in air when ignited.

element of construction any wall, floor, ceiling, roof, door or window (including the frame) etc which forms part of a building, room or other enclosure.

enforcing authority the authority with responsibility for enforcing the the HSW Act and other relevant statutory provisions.

fire resistance the ability of a material, product, assembly or structure to fulfil, for a stated period of time, the required stability against the passage of flame and hot gases, and if additionally specified, thermal insulation and/or load-bearing capacity in a standard fire resistance test. See L138 (regulation 7 and Schedules 2–4).

fire wall an imperforate wall, screen or partition capable of affording at least 30 minutes fire resistance, if tested in accordance with BS 476[67] against the passage of flame or heat.

fire-resisting able to fulfil, for a stated period of time, the required stability, fire integrity and/or thermal insulation, where appropriate, in a standard fire resistance test. See Appendix.

flame arrester a device consisting of an element, a housing and associated fittings which is constructed and used to prevent the passage of flame. An arrester may be categorised as either an end-of-line deflagration arrester, an in-line deflagration arrester or a detonation arrester – see BS EN ISO 16852[68] for requirements and test methods. Most flame arresters consist of an assembly containing narrow passages or apertures through which gases or vapours can flow but which are too small for a flame to pass through.

flammable capable of burning with a flame.

flammable liquid for the purpose of this book, flammable liquid means a liquid with a flashpoint of 60 °C or below and stored at a near atmospheric pressure.

flammable range the concentration of a flammable vapour in air falling between the upper and lower explosion limits.

flashpoint the minimum temperature at which a liquid, under specific test conditions, gives off sufficient flammable vapour to ignite momentarily on the application of an ignition source.

hazard anything with the potential for causing harm. The harm may be to people, property or the environment, and may result from substances, machines, methods of work or work organisation.

hazardous area an area where flammable or explosive gas, or vapour–air mixtures (often referred to as explosive gas–air mixtures) are, or may be expected to be, present in quantities which require special precautions to be taken against the risk of ignition.

HFL highly flammable liquid.

hot work this includes welding or the use of any equipment likely to cause flame, sparks or heat.

impounding basin an enclosure for collecting liquid spillage from one or more sources.

incendive having sufficient energy to ignite a flammable mixture.

inert incapable of supporting combustion; to render incapable of supporting combustion.

interceptor (also known as separator) a device installed in a surface water drainage system to separate out any immiscible solvents and thus prevent them from reaching public drains, sewers or watercourses.

lower explosion limit (LEL) the minimum concentration of vapour in air below which propagation of a flame will not occur in the presence of an ignition source. Also referred to as the lower flammable limit or lower explosive limit.

non-combustible material a material that fulfils the criteria for non-combustibility given in BS 476-4.[69] If tested to BS 476-11,[70] it does not flame nor causes any rise in temperature on either the centre (specimen) or furnace thermocouples. Non-combustible material is totally inorganic, such as concrete, fired clay, ceramic, masonry, plaster or steel/steel alloy.

permit-to-work (PTW) a document issued by an authorised person to permit work to be carried out safely in a defined area under specified conditions.

reasonably practicable this means balancing the level of risk against the measures needed to control the real risk in terms of money, time or trouble. However, you do not need to take action if it would be grossly disproportionate to the level of risk.

risk the chance – however large or small – that a hazard could cause harm.

ullage space the free space between the fluid level and the top of its container, to allow for expansion.

underground tank a tank buried in the ground so that no part of the tank is above ground except for fittings attached to the tank.

upper explosion limit (UEL) the maximum concentration of vapour in air above which the propagation of a flame will not occur. Also referred to as the upper flammable limit or the upper explosion limit.

vapour the gaseous phase released by evaporation from a material that is a liquid at normal temperatures and pressure.

viscosity the degree to which a fluid tends to resist relative motion within itself. Examples of viscous fluids are treacle and heavy fuel oils.

zone the classified part of a hazardous area, representing the probability of a flammable vapour (or gas) and air mixture being present. These are defined in Schedule 2 to regulation 7(1) of DSEAR.

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk/. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

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