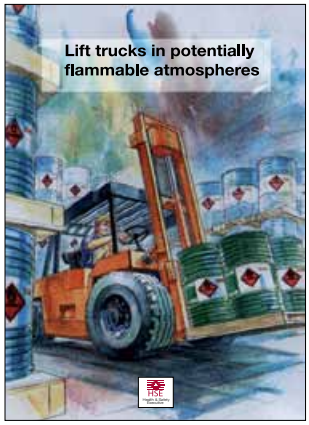
Lift trucks in potentially flammable atmospheres



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This publication describes methods of reducing the risk of trucks igniting gases and vapours and causing a fire or explosion. The guidance is intended to promote a greater understanding of the risks associated with the use of lift trucks in potentially flammable atmospheres and includes advice on diesel-engined and battery-powered trucks. It also gives details of relevant national and international legislation. It is directed at managers and supervisors who control the use of lift trucks at sites storing or using flammable gases and liquids. It may also be of interest to trade organisations and associations.

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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

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Introduction

1 Lift trucks are widely used at premises where flammable liquids and gases are processed or stored. These processes include the production of solvents, chemicals and pharmaceuticals, gas cylinder and aerosol filling and the manufacture of many solvent-based products such as paints, plastics, perfumes and cosmetics.

2 Typically, lift trucks are used for carrying raw materials into process areas and finished product into storage areas, and for loading delivery vehicles. Occasionally, accidents occur, such as dropping or puncturing the load, knocking over stacks, and driving into pipework and equipment. If flammable materials are being processed or stored then such accidents may result in a leak or spillage. If the leak or spillage is ignited then a serious fire or explosion may result. A lift truck, unless suitably protected may act as the source of ignition.

3 Releases of flammable materials are not always the results of accidents. They may arise during normal processes such as venting or if a vessel is opened. Again, an unprotected lift truck may act as a source of ignition. Examples of incidents involving unprotected lift trucks are given in Table 1.

4 This booklet provides information about the hazards associated with the use of lift trucks in areas where flammable atmospheres may occur. It describes methods to reduce the risk of the truck igniting gases and vapours and causing a fire or explosion. It replaces HSE guidance PM58 *Diesel-engined lift trucks in hazardous areas* and includes advice on the use of both diesel-engined and battery powered trucks. It does not apply to spark-ignition engines (eg petrol and LPG) which are unsuitable for use in potentially flammable atmospheres. Nor does it apply to the use of lift trucks in dusty atmospheres or in mines.

5 It is aimed at managers and supervisors who control the use of lift trucks at sites storing or using flammable gases and liquids. It may also be of interest to trade organisations or associations who may wish to use the guidance as a basis for more specific guidance for their own members.

6 General guidance on the safe operation and use of lift trucks is given in the HSE publication *Safety in working with lift trucks.*[1] Advice on the handling and storage of flammable liquids is available in various HSE publications.[2] In general, the handling of containers of flammable liquids and gases should be kept to a minimum. When containers are moved, suitable precautions should be taken to ensure that they are securely closed and cannot fall.

7 Where a British Standard is quoted, any other national or international standard that provides an equivalent level of safety is acceptable. Harmonised European Standards that bear the prefix BS EN may supersede some British Standards, and these are equally acceptable, when published.

Legal requirements

8 There is currently no legislation which relates specifically to the use of lift trucks in potentially flammable atmospheres. However, there are general duties under health and safety law which are relevant. The main pieces of legislation are outlined below. Further information is given in Appendix 1. A glossary of terms is provided in Appendix 2.

9 The Health and Safety at Work etc Act 1974[3] requires employers to provide and maintain safe systems of work. They are also required to take all reasonably practicable precautions to ensure the health and safety of employees and anybody else who could be affected by the work activity. Employees and the self-employed also have a legal duty to take care of their own and others' health and safety.

10 Under the Management of Health and Safety at Work Regulations 1992[4], it is the duty of employers and the self-employed to carry out an assessment of the risks to the health and safety of employees and of anyone who may be affected by the work activity. This is so that the necessary preventive and protective measures can be applied.

11 The Highly Flammable Liquids and Liquefied Petroleum Regulations 1972[5] require that precautions should be taken to reduce the risk of fires and explosions, where flammable liquids or gases are stored or processed. These precautions include measures to prevent the formation of a flammable atmosphere and to control sources of ignition.

12 The Provision and Use of Work Equipment Regulations 1992[6] aim to ensure the provision of safe work equipment and its safe use. They include general duties covering the selection of suitable equipment, maintenance, information, instructions and training.

Table 1 Incidents involving unprotected lift trucks

- ***One man was killed and five injured in a series of explosions at a chemical plant. The incident began when a container fell over, spilling flammable material on the floor. The material was ignited by a passing lift truck.***

- A lift truck was being used to move containers of chemicals in an outdoor storage compound. The fork of the truck pierced a 200 litre drum of flammable liquid. The liquid was ignited by the truck and the fire spread rapidly through the compound. The incident escalated when bulk tanks, affected by the radiant heat, collapsed.

- ***A lift truck was being used in a paint spraying area during a shut-down. The truck wheels spun on overspray deposits and ignited them.***

- Flammable gas was released when a fork lift truck hit and pierced a propane cylinder. The gas exploded and three people were badly burned. The driver had not been trained.

- ***A lift truck was driven close to a ball mill dropping solvent-based paint into open containers. The truck ignited the flammable vapours and a flash fire resulted.***

- A lift truck was being used to stack cardboard boxes holding small tins of lacquer. There was a small spillage of flammable material when a box was dropped. Sparks from the lift truck ignited the spilled material. The warehouse was completely destroyed by the ensuing fire.

- ***A leak of highly flammable liquid from a chemical plant was ignited by a passing lift truck. Two people were killed in the fire.***

- An overhead valve was damaged when it was hit by a lift truck. The escaping flammable material was ignited by the truck. The driver was burnt and the chemical plant was destroyed.

- ***A driver suffered severe burns when his truck ignited a spillage from an open container of acetone.***

Hazardous area classification

13 The main objective when handling flammable gases or liquids is always to prevent the creation of flammable atmospheres, by containment, process control and ventilation. However, in certain areas, flammable atmospheres are likely to occur either during normal operation or due to accidental leaks or spills. These areas are called hazardous areas, and measures to control the introduction of ignition sources are required in these areas.

14 Hazardous area classification is the method used to identify (i) areas where flammable concentrations of gases or vapours are likely to be present, and (ii) the standard of protection necessary to prevent ignition. It is normally used as the basis for the selection of fixed electrical 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 on hazardous area classification is available in British Standard BS EN 60079-10: 1996 *Electrical apparatus for explosive atmospheres, Part 10: Classification of hazardous areas.*[7]

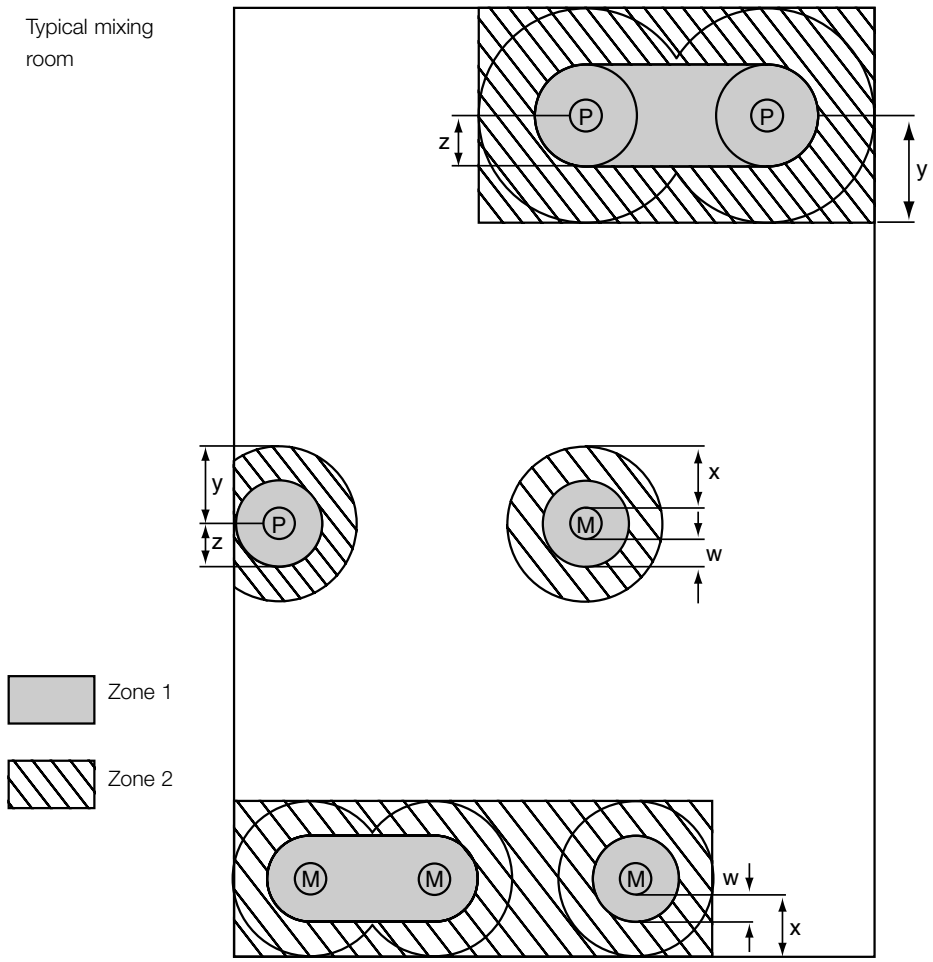
15 There are three main types of hazardous area or zone: zone 0, zone 1 and zone 2. A zone is a three dimensional space in which flammable concentrations of vapours may be present. The higher the zone number, the lower the likelihood that a flammable vapour will exist within the zone. The definitions of the three hazardous zones, according to British Standard BS EN 60079-10 are given in Table 2. Also included in the table are examples of each zone and comments relating to the use of lift trucks.

16 The aim of hazardous area classification is to reduce to a minimum acceptable level the probability of a flammable atmosphere coinciding with an electrical or other source of ignition. Electrical and other types of equipment can be constructed or protected specifically for use in hazardous areas. As might be expected, a higher standard of protection is needed for zone 0 than for zone 1 and zone 2. Likewise, a higher standard of protection is needed for zone 1 than for zone 2. Examples of typical hazardous area classifications for containers of highly flammable liquids are illustrated in Figures 1 and 2.

17 When a hazardous area classification has been carried out, a plan showing the location of the zones should be drawn up. The extent of each zone will vary with the layout of the building, the design of the plant, ventilation and the type of materials handled. This may then be used to prevent trucks being used in areas for which they were not designed. The driver should be given clear instructions which may be reinforced with signs at the entry points to zoned areas. Other systems to help prevent access to unauthorised areas include the provision of physical barriers or painted lines or the colour coding of trucks. In addition, vulnerable plant, such as pipework and vessels, may need to be protected from impact.

Table 2 Hazardous areas

Zone	*Definition*	*Examples*	*Comments*
Zone 0	An area in which an explosive gas mixture is continuously present, or present for long periods.	a) Enclosed spaces such as the inside of process vessels and storage containers; b) The immediate vicinity of continuously operating vents.	Lift trucks should not be used in or near zone 0 areas.
Zone 1	An area in which an explosive gas mixture is likely to occur in normal operation.	a) Around filling connections, vents and liquid surfaces; the zone extending down to ground level; b) Where the ventilation or drainage is inadequate to quickly disperse a flammable atmosphere such as in pits, trenches and enclosed roof spaces.	a) Attention should be paid to process precautions and layout to ensure that the zone 1 area is as small as practicable; b) Vehicles which may enter zone 1 areas should be protected to zone 1 standard. c) Where vehicles are frequently operating close to designated zone 1 areas, such as in process areas, protection to zone 1 standard should also be considered.
Zone 2	An area in which an explosive gas mixture is not likely to occur in normal operation, and, if it does occur, is likely to do so only infrequently and will exist for a short period only.	Storage and process areas where flammable materials are held in closed vessels, pipes or containers but where a leak or spill is foreseeable.	Vehicles which may enter zone 2 areas should be protected to zone 2 standard.
Safe areas		Generally, areas which are not used for the handling, processing or storage of flammable liquids at temperatures above their flashpoint.	Protected vehicles are not required but some caution should be exercised to ensure: a) that the maximum temperature of the area (eg in summer) does not exceed the flashpoint of the liquid; b) that there is no local heating (eg steam pipes) which might produce a flammable vapour; c) that there is little likelihood of a flammable mist or spray occurring; d) that reasonable precautions are taken to ensure that the vehicle does not come into contact with flammable liquids (eg from leaks and splashes).



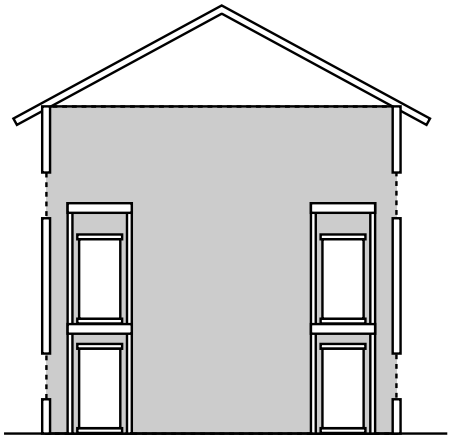
M = mixing vessel P = pump

The following are typical values: w = 2 m; x = 4 m; y = 3 m; z = 1.5 m

They are dependent primarily on the level of ventilation, the source of the release, flashpoint and vapour density.

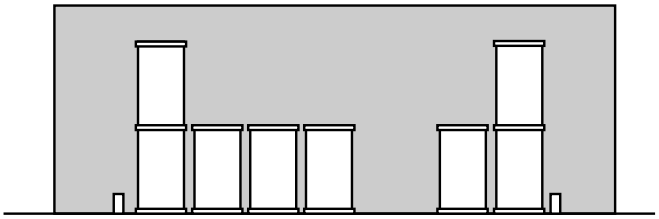
Figure 1 Hazardous area classification

a) Indoor storage



Zone 2

b) Outdoor storage



Typical hazardous area classification

	Extent of area	*Classification*
Store room and building	Every part*	Zone 2
Open-air storage areas	Vertically to 1 m above top of highest container, and horizontally to 1 m beyond bund or sill	

*For rooms and buildings which are well ventilated, areas more than 2 m above the top of the highest container can be considered safe areas

Figure 2 Typical storage areas

Precautions for diesel-engined lift trucks

Ignition hazards

18 The ignition hazards from an unprotected diesel engine are listed in Figure 3. The basic principles of protection[8] are:

(a) prevention of flashback from the air inlet system

(b) prevention of flame or spark emission from the exhaust system

(c) prevention of overspeeding from vapour ingestion

(d) control of surface temperatures

(e) elimination or protection of electrical equipment

(f) elimination or protection of spark-producing components

These are described in more detail below.

Prevention of flashback from the air inlet system

19 If flammable vapour is drawn into the air inlet system, it may be ignited in the combustion chamber. A flame arrester[9] is used to prevent flashback to atmosphere. A flame arrester is a device containing narrow passages or apertures through which gases or vapours can flow but which are too small for a flame to pass through.

20 To remain effective, flame arresters should be cleaned regularly. Sharp objects should not be inserted into the flame arrester element as this may cause damage and impair its performance.

Prevention of flame or spark emission from the exhaust system

21 Flame arresters are also used to prevent any flame from the exhaust system reaching the outside atmosphere.

22 A spark arrester fitted between the flame arrester and the atmosphere will prevent sparks being emitted from the exhaust system. Spark arresters are designed to trap (usually in a series of baffles) hot burning particles, normally of carbon, emitted from a sooty engine. They should be cleaned regularly.

(a) Flames or sparks from the exhaust system

(b) Flames from the air inlet system

(c) Overspeeding and overload

(d) Surface temperature of the exhaust system and other components

(e) Arcs and sparks from unprotected electrical equipment

(f) Sparks from a discharge of static electricity or from friction

Figure 3 Ignition hazards from a diesel engine

23 Suppliers will generally supply certification demonstrating that flame and spark arresters have been tested against recognised standards.[9, 10]

24 Both inlet and exhaust systems are designed to withstand internal explosions.

Vapour ingestion and overspeeding

25 Ingestion of flammable vapour may also result in overspeeding of the engine. Such overload conditions may lead to hot surfaces or flames, and damage or destruction of the engine. Turning off the fuel supply may not stop the engine, as it may continue to run on the ingested vapour.

26 An air inlet shut-off valve can be used to stop the engine if vapour ingestion leads to overspeeding. The valve may be operated manually by the driver or automatically with a manual reset. Automatic shutdown may be triggered either by a differential pressure sensor or by an overspeed detection device. In both methods it is important that the operating parameters are set according to the supplier's instructions.

Control of surface temperature

27 The surface temperature of the engine, exhaust, electrical equipment, brakes and any other 'hot-spots' on the truck should be kept below the lowest ignition temperature of any flammable materials likely to be encountered. The supplier will provide details of the maximum surface temperature which may be achieved by the truck in normal operation.

28 The exhaust manifold and associated piping may be cooled by using a water jacket or water-cooled heat exchanger, by passing the exhaust gases through a water bath or by air cooling. Water levels should be monitored regularly and maintained at the recommended level. (The waste residues from cleaning the water cooling system may pose a health and environmental hazard.)

29 Air cooling may be provided for hot-spots such as the friction surfaces of brakes and clutches and the outer casings of electrical equipment. In extreme cases (for example, a truck required for heavy work-cycles in an area where materials with a low ignition temperature are present) oil-filled or labyrinth-type brake enclosures may be required.

30 Thermal sensors may also be used to detect overheating. These may be used to trigger audible or visual alarms and to provide automatic shut-down of the engine.

31 The use of insulation cladding to provide protection from hot surfaces is not recommended because it is liable to be damaged and may be penetrated by flammable liquids and vapours.

Elimination or protection of electrical equipment

32 Arcs and sparks may arise from unprotected electrical equipment such as starters, batteries and instrumentation.

33 The vehicle should be supplied with electrical equipment suitable for use in zone 1 or zone 2[7], depending on the level of protection required. The temperature classification of the equipment should be checked to ensure it is appropriate for the range of gases and vapours likely to be encountered.

34 Care should be taken to ensure that vulnerable items, such as lights, are sufficiently robust for the purpose.

35 Electrical equipment may be eliminated by the use of mechanical alternatives, for example mechanical fuel, temperature and pressure gauges or starters operated by spring recoil, hydraulic fluid or compressed air.

36 Trucks may be fitted with electric starters, wired to a plug and socket connection for use with a starter battery which is stored and used in a safe area.

Elimination or protection of spark-producing components

37 Non-electrical items can cause electrostatic or frictional sparks by rubbing or impact. Therefore adequate clearance is needed between fixed and rotating parts, with allowance made for engine movement during normal operation. Engine-cooling fans are often made from non-metallic material such as plastic.

38 The use of aluminium, magnesium, titanium and light alloys is generally minimised because of the risk of sparks from a thermite reaction (this may occur on impact between light metals and rust). If such components are used they are shielded from impact by an enclosure. Surface coatings incorporating these materials are normally considered unsuitable.

39 The risks of sparks from static build-up is minimised by the use of electrically conducting materials for drive belts, tyres and other components. Further advice is given in British Standard 5958: *Control of undesirable static electricity*[11] and British Standard 2050: *Specification for electrical resistance of conducting or antistatic products made from flexible polymeric material.*[12]

40 The forks of lift trucks may cause frictional sparks when they contact a metal drum or other object. They are often fitted within brass or stainless steel sleeves.

Gas detection system

41 Another protection method is to use a gas detection system which triggers automatic shut-down of the truck in the event of a release of flammable vapour. This system is suitable for zone 2 areas only and will be described in more detail in paragraphs 45-50.

Precautions for battery powered lift trucks

Ignition hazards

42 The main ignition hazards from electric vehicles are arcing and sparking of unprotected electrical components, hot surfaces and sparks from static build-up or friction.

Protection methods

43 There are two approaches to the protection of battery powered trucks for use in potentially flammable atmospheres. The first approach is to ensure that the truck is fully protected to zone 1 or zone 2 standard. The second approach is to use an intrinsically safe gas detection system which will automatically shut down the truck in the event of a spillage or release of flammable vapour. This gas detection system is suitable for trucks operated in zone 2 only.

Electrical protection

44 Full electrical protection is provided primarily for trucks that are designed to operate in zone 1 areas. This entails housing the drive motor and other electrical components in explosion-proof enclosures. For switches and control circuits outside the enclosure, a method of protection is to use zener barriers which limit the main battery supply to provide an intrinsically safe source of power. The battery and battery connections are also explosion-protected. Suppliers will provide appropriate test reports and certification.

Gas detection system

45 This method of protection applies to trucks (both electric and diesel) which are operating in zone 2 areas only. If flammable vapour or gas is detected by the system then the truck shuts down automatically before electrical components can cause ignition.

46 The gas detection system itself is constructed to a zone 1 standard. It should normally be set to operate at a maximum of 25% of the lower explosive limit (LEL) of the gas or vapour likely to be encountered. If there are several potential gas or vapour hazards then it is important to check with the supplier that the setting is suitable for all the materials on the premises. A setting corresponding to 25% of the LEL for propane is generally satisfactory for the majority of gases and vapours.

47 It may be useful to have an early warning alarm (audible and/or visual) set at a lower level (for example 10%), to enable the truck to be driven away from the source of the vapour before automatic shutdown occurs.

48 If automatic shutdown does occur then it should not be possible to restart the vehicle until the detection system has resampled the atmosphere and confirmed that the gas hazard has dispersed. If there is a possibility that flammable gas may be trapped inside enclosures on the vehicle, then these should be purged before the engine is restarted. Some systems may be fitted with an automatic purge. As a rule, restart of the engine should not be attempted until the cause of the shutdown has been investigated and rectified (for example, spills should be cleaned up before the engine is restarted).

49 Regular testing and maintenance of the gas sensing devices is necessary as they are liable to catalyst poisoning from airborne contaminants. For example, sensor heads may be fouled by oil and grease and by exhaust fumes from diesel or petrol engines. Some systems incorporate a compulsory gas response test before the truck can be put into use.

50 The safety of this type of system depends on its response time. Clearly, it is essential that the truck has shut down before flammable vapours can reach potential sources of ignition. All components which may produce sparks or hot spots are therefore enclosed to limit the rate of access of flammable vapours. These enclosures are designed and tested to prevent the entry of flammable concentrations of vapour for at least 60 seconds after the gas detection system alarm has been activated. The covers may be fitted with locking devices to prevent casual access.

Other precautions

51 Thermal sensors may be used to detect overheating or fault conditions. These may be linked to the alarm and automatic shutdown system.

52 Measures to prevent sparking from static build-up or from friction may also be necessary. These measures are described in paragraphs 37-40.

53 The changing and charging of batteries may result in sparks, and therefore these operations should not be carried out in areas where there may be flammable atmospheres. Further advice is given in *Electric storage batteries: Safe charging and use.*[13]

Inspection and maintenance

54 Health and safety law[3,6] requires that plant and equipment is maintained in a safe condition. The supplier will provide instructions on inspection, maintenance and servicing. Only personnel who are suitably qualified and authorised and who fully understand the safety features, should carry out repairs and adjustments to protected trucks. It may be advisable to put a label on the truck warning against unauthorised maintenance activities. For example, even changing a tyre may lead to problems - protected trucks are fitted with anti-static tyres to prevent the possibility of electrostatic sparking.

55 It is advisable to include lift trucks in a preventive maintenance schedule specifying:

(a) the daily or weekly checks to be carried out by the operator;

(b) the frequency of servicing and maintenance checks to be carried out by authorised personnel.

The frequency of checks will normally depend on the running hours of the vehicle.

56 The checks carried out by the operator may include:

(a) testing gas detectors;

(b) checking the levels in coolant systems;

(c) cleaning exhaust flame and spark arresters;

(d) visual checks of the general condition of the truck, eg signs of damage, and the presence of easily ignited items, such as oily rags.

57 It is advisable to keep a written record of maintenance activities showing the type of service and any repairs made. Any faults should be corrected immediately, or the truck should be withdrawn from service. Maintenance activities should not be carried out in hazardous areas.

58 If the vehicle is hired, then arrangements should be made to ensure adequate inspection, maintenance and servicing. Whether internal personnel or outside contractors are used to carry out all or part of the servicing, it is advisable to check their standards of work periodically.

Training

59 The provision of adequate training is a requirement of several pieces of legislation.[3,4,6] Guidance on the training of lift truck operators can be found in *Rider operated lift trucks - operator training*.[14] Additional training will be needed for drivers who may operate trucks in potentially flammable atmospheres. A typical training programme will include the following topics:

(a) hazards and properties of the materials being stored and handled in the plant and any vulnerable plant items (eg pipework and containers);

(b) ignition hazards of an unprotected truck;

(c) areas where the truck can and cannot be used, and the reasons why any restrictions are imposed, including the danger of working in poorly ventilated areas;

(d) how the protective methods work, including the importance of not removing or tampering with the safety devices. Where an active protection system is used (eg gas detection) training will be required on what action to take when the alarm sounds and after automatic shut-down. A practical demonstration may be useful;

(e) daily checks and preventive maintenance requirements of protective devices;

(f) action to be taken if a fault occurs on the truck, particularly with components that form part of protection systems;

(g) the action to be taken if an escape of flammable liquid or gas occurs near the truck while it is in use.

Emergency procedures

60 The impact of an incident involving flammable materials 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 material. Practical training and written procedures should be provided covering:

(a) raising the alarm;

(b) calling the fire brigade;

(c) controlling the spill or leak;

(d) tackling the fire (when it is safe to do so);

(e) evacuating the area safely.

Permits to work

61 Unprotected trucks may be allowed to enter a hazardous area if the plant has been cleared of flammable materials. For example, there may be a need to carry heavy plant items during a process shutdown. In these circumstances, a permit to work for entry of the vehicle into the area is recommended. A typical permit will include:

(a) the precautions to ensure that all flammable materials have been removed and cannot be accidentally reintroduced;

(b) the areas into which the truck is allowed access;

(c) the time limit on the permit.

Permit procedures are described in *Guidance on permit-to-work systems in the petroleum industry.*[15]

Appendix 1 Legal requirements

Health and Safety at Work etc Act 1974 (HSW Act)

The HSW Act[3] is concerned with securing the health, safety and welfare of people at work, and with protecting people who are not at work, from risks to their health and safety arising from work activities. The Act and its relevant statutory provisions are used to control the keeping and use of explosive or highly flammable substances and are concerned with precautions against the outbreak of fire in all work activities. The Act is enforced either by HSE or by local authorities, as determined by the Health and Safety (Enforcing Authority) Regulations 1989.[16] Further advice on these matters is obtainable from local offices of HSE or the Environmental Health Department of the local authority, as appropriate. Guidance on the Act is also available in *A Guide to the Health and Safety at Work etc Act 1974.*[3]

The Management of Health and Safety at Work Regulations 1992

These Regulations[4] require all employers and self-employed persons to assess the risks to workers and others who may be affected by their undertakings in order that they can decide upon the appropriate measures that need to be taken to fulfil their statutory obligations. These Regulations also require an assessment to determine the requirements for appropriate health and safety arrangements, health surveillance, emergency planning, provision of information and training. An Approved Code of Practice[4] gives guidance on the provisions of these Regulations. There is also an HSE leaflet[4] which gives basic advice on the steps involved in the risk assessment process.

Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972

These Regulations[5] apply when liquids with a flashpoint of less than 32°C and which support combustion (when tested in the prescribed manner) are present at premises subject to the Factories Act 1961.[17] Requirements include:

(a) precautions to be taken during storage;

(b) precautions to be taken against spills and leaks;

(c) controls for sources of ignition in areas where accumulations of vapours might occur;

(d) means to prevent the escape of vapours;

(e) dispersal of dangerous concentrations of vapours;

(f) controls on smoking.

An exception to the storage requirements of these Regulations applies where a petroleum licence is in force.[18]

The Provision and Use of Work Equipment Regulations 1992

Under these Regulations[6] employers must ensure that:

(a) suitable equipment is provided for the jobs involved;

(b) information and instruction are adequate;

(c) equipment is maintained in good working order and repair;

(d) training is provided for operators and supervisors;

(e) equipment is safeguarded to prevent risks from mechanical and other specific hazards;

(f) equipment is provided with appropriate and effective controls;

(g) maintenance is carried out safely.

Guidance on these Regulations is available in *Work equipment*.[6]

Workplace (Health, Safety and Welfare) Regulations 1992

These Regulations[19] require that the workplace and associated equipment, devices and systems should be maintained in working order and in good repair. Regulation 12 contains requirements that concern the condition of floors and traffic routes. It is important that floors and traffic routes are maintained so as to minimise the risk of damage to containers and avoid spills.

Electricity at Work Regulations 1989

These Regulations[20] impose requirements for electrical systems and equipment, including work activities on or near electrical equipment. They also require electrical equipment which is exposed to any flammable liquids or vapours to be constructed or protected so as to prevent danger. Advice is available in *Memorandum of guidance on the Electricity at Work Regulations 1989*.[20]

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

These Regulations[21] describe measures to prevent ignition by equipment and apply both to electrical and non-electrical (mechanical) equipment and protective systems. They apply to all equipment including vehicles intended for use in potentially explosive atmospheres.

At the time of this publication going to print a European standard[8] *Safety of industrial trucks - Operation in potentially flammable atmospheres* is in preparation.

Appendix 2 Glossary of terms

Auto-ignition temperature. The minimum temperature at which a material will ignite spontaneously under specified test conditions.

Combustible. Capable of burning in air when ignited.

Flame arrester. A device consisting of an element, a housing and associated fittings which is constructed and used to prevent the passage of flame. Most flame arrester assemblies contain narrow passages or apertures through which gases or vapours can flow but which are too small for a flame to pass through. See BS 7244 *Flame arresters for general use*[9] for requirements and test methods.

Flammable. Capable of burning with a flame.

Flammable atmosphere. A concentration of flammable gas or vapour in air that falls between the upper and lower explosion limits. It may also be referred to as an **explosive mixture** or a **flammable concentration.**

Flammable materials. In this publication flammable materials are gases and liquids which are capable of producing a flammable atmosphere.

Flashpoint. This is a property of a flammable liquid. It is the minimum temperature at which a liquid, under specific test conditions, gives off sufficient flammable vapour to ignite momentarily when an ignition source is applied. Details of the flashpoint should be provided by the supplier of the flammable liquid.

Hazard. Something that has the potential to cause harm to people, property or the environment.

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.

Hazardous area classification. This is the assessment of an area and its division into hazardous areas and non-hazardous areas. The hazardous areas are further divided into zones which represent the probability of a flammable vapour (or gas) and air mixture being present.

Ignition temperature. The minimum temperature at which a material will ignite spontaneously under specified test conditions. It is also referred to as the auto-ignition, self-ignition or spontaneous ignition temperature.

Incendive. Having sufficient energy to ignite a flammable mixture.

Lower explosion limit (LEL). The minimum concentration of gas or vapour in air below which the propagation of a flame will not occur in the presence of an ignition source. It may also be referred to as the **lower flammable** limit or the **lower explosive limit.**

Permit to work. A formal written system used to control certain types of work that is identified as particularly hazardous. Guidance on permit-to-work systems is available.

Potentially flammable atmosphere. An area where there is a possibility that a flammable atmosphere could be generated by releases of flammable gases or vapours.

Protected equipment. Protected equipment, sometimes called **flameproof** equipment, is designed or modified to minimise the risk that it will be a source of ignition for a flammable atmosphere. There are different degrees of protection and the type of protection required will depend on the intended use of the equipment. For example, equipment certified for use only in zone 2 areas should not be used in zone 1 areas. There is also a system of classification depending on the maximum surface temperature of the equipment.

Risk. The likelihood that a **hazard** will lead to harm within a specified period or in specified circumstances.

Risk assessment. The process of identifying the hazards present (whether arising from work or other factors) and the people likely to be affected by those hazards. It also involves an evaluation of the extent of the risks involved, taking into account whatever precautions have already been taken.

Temperature classification. Equipment for use in potentially flammable atmospheres is assigned a temperature class that enables equipment to be selected so that the maximum surface temperature of the apparatus is below the ignition temperature of the gas or vapour.

Upper explosion limit (UEL). The maximum concentration of vapour in air, above which the propagation of a flame will not occur. It may also be referred to as the **upper flammable limit** or the **upper explosive limit**.

Zone. The classified part of a hazardous area. It represents the probability of a flammable gas (or vapour) and air mixture being present.

References and further reading

1 *Safety in working with lift trucks* HS(G)6 HSE Books
ISBN 0 11 886395 9

2 *The safe use and handling of flammable liquids* HS(G)140
HSE Books ISBN 0 7176 0967 7

The storage of flammable liquids in containers HS(G)51 HSE Books
ISBN 07176 0481 0

The storage of highly flammable liquids in fixed tanks (up to 10 000m^3 total capacity) HS(G)50 HSE Books ISBN 0 11 885532 8

The storage of highly flammable liquids in fixed tanks (exceeding 10 000m^3 total capacity) HS(G)52 HSE Books ISBN 0 11 885538 7

The cleaning and gas freeing of tanks containing flammable residues CS15
HSE Books ISBN 0 11 883518 1

The spraying of highly flammable liquids EH9 HSE Books
ISBN 0 11 883034 1

3 Health and Safety at Work etc Act 1974 ISBN 0 10 543774 3

A Guide to Health and Safety at Work etc Act 1974 L1 (5th edition)
HSE Books ISBN 0 7176 0441 1

4 Management of Health and Safety at Work Regulations 1992 SI 1992/2051
HMSO ISBN 0 11 025051 6

Management of health and safety at work Approved Code of Practice L21
HSE Books ISBN 0 7176 0412 8

5 steps to risk assessment IND(G) 163L HSE Books (single copies free)

5 Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972
SI 1972/917 HMSO ISBN 0 11 020917 6

6 Provision and Use of Work Equipment Regulations 1992,
SI 1992/2932, HMSO ISBN 0 11 025849 5

Work equipment Guidance on Regulations L22 HSE Books
ISBN 0 7176 0414 4

7 BS EN 60079-10: 1996 *Electrical apparatus for explosive gas atmospheres* Part 10: *Classification of hazardous areas*

Institute of Petroleum model code of safe practice in the petroleum industry Part 15 *Area classification - Code for petroleum installations* Wiley
ISBN 0 47 192160 2

8 prEN 1834-1: 1995 (Draft DC95/704201) RIC engines - *Reciprocating internal combustion engines - Safety for the design and construction of group 2 engines for flammable gas and vapour use in potentially flammable atmospheres*

prEN 1755: 1994 (Draft DC94/715213) *Safety of industrial trucks - Operation in potentially explosive atmospheres*

BS 6680: 1985 *Specification for flameproof equipment for diesel engines for use in coal mines and other mines susceptible to firedamp*

Recommendations for the protection of diesel engines for use in zone 2 hazardous areas Publication No 107, Engineering Equipment and Materials Users Association, ISBN 0 85931 060 4

9 BS 7244: 1990 *Specification for flame arresters for general use*

10 US Society of Automotive Engineers (SAE) recommended practice:

Spark arrester test procedure for large size engines SAE J 342 November 1980

Spark arrester test procedure for medium size engines SAE J 350 January 1980

Spark arrester test carbon SAE J 997 January 1980

11 BS 5958: 1991 *Code of practice for control of undesirable static electricity* Parts 1 and 2

12 BS 2050: 1978 *Specification for electrical resistance of conducting and antistatic products made from flexible polymeric material*

13 *Electric storage batteries: Safe charging and use* IND(G)139L HSE Books (free)

14 *Rider operated lift trucks - Operator training* COP26 Approved Code of Practice and supplementary guidance HSE Books ISBN 0 7176 0474 8

15 *Guidance on permit-to-work systems in the petroleum industry* HSE Books ISBN 0 11 885688 X

16 Health and Safety (Enforcing Authority) Regulations 1989 SI 1989/1903 HMSO ISBN 0 11 097903 6

17 Factories Act 1961 HMSO ISBN 0 10 850027 6

18 Petroleum (Consolidation) Act 1928 HMSO ISBN 0 11 850212 0 Petroleum (Mixtures) Order 1929 HMSO ISBN 0 11 100031 9

19 *Workplace health, safety and welfare* Approved Code of Practice L24 HSE Books ISBN 0 7176 1413 6

20 Electricity at Work Regulations 1989 SI 1989/635 HMSO ISBN 0 11 096635 X

Memorandum of guidance on the Electricity at Work Regulations 1989 HS(R)25 HSE Books ISBN 0 11 883963 2

21 Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 SI 1996/192 HMSO ISBN 0 11 053999 0

Further information

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