NEBOSH FIRE SAFETY AND RISK MANAGEMENT

Element 3: Causes and prevention of fires and explosions

Learning outcomes

On completion of this element, candidates should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular they should be able to:

3.1 Explain the causes of fires and explosions in typical work activities

3.2 Outline appropriate control measures to minimise fire and explosion risks.

3.1 THE CAUSES OF FIRES AND EXPLOSIONS IN TYPICAL WORK ACTIVITIES

Accidental Fires - Common sources of ignition

There are a variety of different situations or processes which could generate a heat or spark which could lead to a fire.

A. Electrical hazards

Electricity can cause electric shock but it can also cause fires in the workplace. Conductors may be overloaded so the wire overheats and the insulating material breaks down which in turn creates a build-up of heat and cause a fire. Sparks from electrical equipment and circuits may ignite flammable vapours and ignite other combustible materials in the near vicinity.

Electrical hazards are the cause of numerous workplace fires each year. Faulty electrical equipment or misuse of equipment produces heat and sparks that serve as ignition sources in the presence of flammable and combustible materials.

Examples of common ignition hazards:

- overloading circuits
- use of unapproved electrical devices
- damaged or worn wiring
- loose wiring connections
- Electrical "octopuses" such as that seen here can overload circuits and result in fire.
- Electrical arcing / insulation damage– this is usually caused when wiring insulation has been damaged, this may be from vehicles moving over it and damaging the insulation. It may be cut on rough surfaces. The copper

cable inside may come into contact with another cable or metal objects nearby. The current flows and might not trigger a circuit breaker to activate. Heating and sparks may result which could lead to a fire.

- Vermin may bite through cables and damage insulation
- Lack of maintenance or impromptu repairs to the electrical system can lead to heat spots
- Hotplates, coffee makers, irons, space heaters left unattended near combustibles
- An arc-blast is a luminous electrical discharge that occurs when high voltages exist across a gap between conductors and current travels through the air.
- Temperatures as high as 10,000°C have been reached in arc-blasts.

Figure Electrical arc blast

B. Lightning

Lightning is an electrical discharge caused by imbalances between storm clouds and the ground, or within the clouds themselves. Most lightning occurs within the clouds. "Sheet lightning" describes a distant bolt that lights up an entire cloud base. Other visible bolts may appear as bead, ribbon, or rocket lightning.

During a storm, colliding particles of rain, ice, or snow inside storm clouds increase the imbalance between storm clouds and the ground, and often negatively charge the lower reaches of storm clouds. Objects on the ground, like steeples, trees, and the Earth itself, become positively charged—creating an imbalance that nature seeks to remedy by passing current between the two charges.

Lightning is not only spectacular, it's dangerous. About 2,000 people are killed worldwide by lightning each year. Hundreds more survive strikes but suffer from a variety of lasting symptoms, including memory loss, dizziness, weakness, numbness, and other life-altering ailments. Strikes can cause cardiac arrest and severe burns, but 9 of every 10 people survive.

Cars are havens from lightning—but not for the reason that most believe. Tyres conduct current, as do metal frames that carry a charge harmlessly to the ground. Lightning can lead to a building fire when there is adequate fuel available.

C. Cooking

Cooking fires are usually caused by one of the following reasons:

1 Grease or food that caught fire.
2. Faulty cooking equipment.

3. Combustible items placed too close to the hob.

Most of these incidents involve cooking grease. When cooking grease catches fires, it burns hot and fast. If not brought under control quickly, it will spread and cause extensive damage.

The easiest way to put out a cooking fire is to shut off the burner and then place a pan lid or some other non-combustible object (such as a cookie sheet, large pan or skillet) over the pan to cut off the oxygen supply. Leave it covered until the pan cools. Taking the lid off too quickly may cause the fire to reignite. Throwing materials onto the pan such as salt, sugar, flour, baking soda or wet towels is too risky. This can spread the fire, which can also lead to injury.

D. Heating and lighting

Electric space heaters are involved in the most incidents and the most deaths and injuries. Gas, solid fuel and LPG (liquid petroleum gas) space heaters are also significant contributors. Oil and paraffin heaters carry a high risk but their use has fallen considerably over the last 20 years.

E. Smoking

Discarded cigarettes or smoking materials is the UK's leading cause of domestic fires, equally it is responsible for a significant number of workplace fires. Smoking is another common cause of fire in the workplace with over a third of deaths in non-domestic buildings being attributed to smokers' materials. It's easy for fires to start if workers smoke near flammable materials or in hazardous environments. When cigarettes are not put out properly, they can ignite surrounding materials and a fire can spread. Designate smoking areas in your premises and educate staff fully on the risks of smoking in hazardous environments to reduce the risk of a fire caused by smoking

One of the by-products of a no smoking policy on site may lead to employees going to certain areas such as storage rooms or boiler rooms. Security and checks of this area are needed to ensure they do not become unofficial smoking areas.

F. Overheating of machinery

2,000 fires in the 2013-2014 period resulted from a misuse of equipment. To help prevent this from happening, ensure your staff are trained properly with all equipment. In addition to this, ensure that pre use checks are carried out on a regular basis and that safety equipment is available at all times. Poorly maintained equipment which is not lubricated correctly may over heat and generate sparks.

G. Spontaneous ignition of oil and solvent soaked materials

A fire occurred in a Church undergoing refurbishment, after a contractor left a pile of linseed oil soaked rags in a bin overnight. The rags had just been used to apply the linseed oil as a sealer to some flooring. The fire was caused by an exothermic chemical reaction within the rags, which eventually led to flaming combustion, which spread to a container of white spirit stored close by.

Rags soaked with linseed oil (especially when stored in a restricted space where any heat produced cannot dissipate) are a known fire hazard. This is because they provide a large surface area for the evaporation and oxidation of the oil. Linseed oil evaporates very rapidly causing an exothermic reaction, which accelerates as the temperature of the rags increases.

When the accumulated heat exceeds the rate of heat dissipation, the temperature increases and may eventually become hot enough to cause the rags to spontaneously combust. Whilst this fire was caused by linseed oil, there are other oils that can also create a similar hazard - especially when heated on radiators and other similar hot surfaces. A number of fires have occurred in vehicle workshops when oily cloths and towels have been discarded into enclosed bins.

Some other similar incidents that East Sussex Fire & Rescue Service has attended have included: a fire in a stack of tea towels that had just been laundered and tumble dried and another incident where a householder had used a linseed oil soaked rag to seal a hardwood door sill - where the rag caught fire later that night when it was stored in a plastic box under the kitchen sink.

H. Hot work

Welding fires are caused by sparks, hot slag (droplets of melted metal), and torch flames. They also can result from combustible materials touching a hot workpiece or heat igniting flammable vapours.

Sparks can travel some distances horizontally and even farther when falling. They can pass through or become lodged in cracks, clothing, pipe holes, and other small openings. Torch flames can ignite substances within several feet of the flame. Material in contact with the hot workpiece,

even away from the flame source and actual weld, can ignite.

1. Holes, openings, and cracks in which a slag can hide and smoulder, sometimes going unnoticed for hours before breaking out.
2. Flammable materials, such as sawdust, rags, and even dust in the air, that will burn if enough heat and oxygen are available. Fires can ignite suddenly and violently, or smoulder undetected for hours before flaring up.
3. Flammable vapours and gases that can cause powerful explosions if they mix in the right proportion with air. Sources of flammable vapours are fuel tanks and volatile liquids left by other workers. Flammable gases can come from faulty gas lines or tanks, or even from leaks in the welding equipment itself.

I. Oxidisers

When reactive chemicals are mixed they may react and generate heat. Mis-handling LPG cylinders can lead to them exploding without a heat source. Oxidisers generate heat when in contact with the air.

J. Electro Static Sparks

Electrostatic discharges may be generated by machinery, the transfer of solids and liquids. Poorly maintained equipment can generate sparks.

K. Temporary Electrical Installations

When construction work is being undertaken often they will install or use a temporary supply for their power tools or to light the area. The working environment around them will be more hostile than a typical workplace, it could include dust, smoke, acidic fumes, damp surfaces and abrasive surfaces which could damage insulation. Construction electrical hazards which could generate a spark include damage to cables crushed by vehicles driving over them, unsuitable extension leads, over loading electrical sockets and cables laid near combustibles.

L. Arson

There were 4,950 deliberate fires in non-dwelling premises during the 2013-2014 period. To reduce the risk of arson, keep flammable materials locked away so they cannot be accessed easily. In addition to this, security measures such as CCTV cameras and security guards can act as a major deterrent to arsonists.

Arson can lead to loss of life, building, vehicles and properties. It is the largest cause of fires in the UK typically each year. Arson may be linked to break-ins or someone who has a grievance. Sometimes the building owner themselves causes arson to try and make a fraudulent insurance claim.

Factors influencing the severity and frequency of an arson attack:

Location – arson is more likely in urban and built up areas where there are larger numbers of people in the area. The layout of the site or building could increase the risk if there are areas where an arsonist can hide or move around without being detected. Temporary sites such as construction sites can be a high risk situation. Areas such as warehouses and store rooms are at risk. Depending on the type of company and its activities this may lead to the site being targeted e.g. animal rights protestors.

Security – A high percentage of arson attempts occur at night on unoccupied sites. Sites with lights on or PIR sensors on lights could reduce the risk. On site security can stop unauthorised visitors. Letters boxes, louvered windows and air vents can be weak links in the control of access to the building. There needs to be a system to allow authorised visitors to enter but restrict access to others. When staff see someone they should check that the person on site is an authorised visitor and challenge those they think may not be authorised. Sites unoccupied at night are at risk. CCTV and security guards can be used to reduce the fire risk on site.

Access control – open sites and buildings create a higher risk as the arsonist can easily gain access. Mesh fencing allows visibly from the outside so others in the area can see if there is an unauthorised person is on site and are more likely to raise the alarm. Thorny hedges around the outside of a site can be a natural barrier against those opportunists.

3.1.1 Sources of fuel

You can't remove all sources of fuel, but by identifying what they are you have an opportunity to see if the risk can be reduced. For example, if the foam filling is exposed in upholstered furniture, the fire risk is much higher because there's no covering of treated fabric. Flammable liquids not stored in the designated place or waste being allowed to accumulate too much before collection can increase the risk. There are a range of different fuels including:-

- Flammable liquid based products such as paints varnish thinners and adhesives. Flammable liquids and solvents such as petrol, white spirit, methylated spirit and paraffin.
- Flammable chemicals
- Wood Paper and card
- Plastics, rubber and foam such as polystyrene and polyurethane, e.g. the foam used in upholstered furniture.
- Flammable gases such as liquefied petroleum gas (LPG) and acetylene
- Furniture, including fixtures and fittings textiles
- Dusts in large quantities, e.g. wood dust collectors, powdered products
- Plastics, rubber or foam
- Polystyrene beads, boxes, packaging
- Upholstered furniture and textiles
- Loose packaging material
- Waste materials, in particular finely divided materials such as wood shavings, off-cuts, dust, paper and textiles.
- Hardboard, chipboard, block board walls or ceilings
- Synthetic ceiling or wall coverings, such as polystyrene tiles.

A. Fuel - Electrical insulation

- Heating can melt insulation
- Allows copper cables to touch each other
- Allows copper to touch other metal surfaces
- Small current flows
- Hot spots
- Melt insulation
- Can transfer fire to other combustibles in the area

B. Fuel - Structural materials – Construction Materials

A variety of different materials will be used in the building of a structure, these can effect fire spread and smoke movement. This may include bricks, concrete blocks, concrete, metals, plastic and timber. (See Element 2)

C. Fuel Ceilings and walls linings

There are rating systems for different types of linings, some will increase the severity of the fire if they catch alight. Unsuitable linings and coatings on walls, especially on a means of escape could prove fatal. If the covering is flammable it may encourage the spread of fire along walls and ceilings which may heat other areas. The material may burn generating toxic fumes and gases which may travel under doors or through gaps into adjacent areas. Materials may melt and drop on to those in the area or onto other materials setting them on fire. Some coverings may generate lots more smoke than others.

Class 0

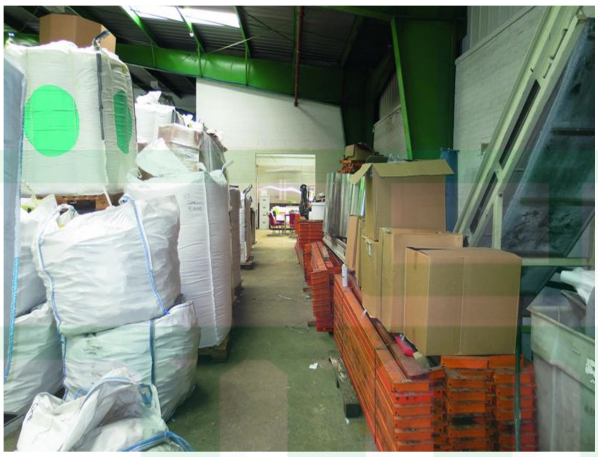
May be used anywhere in the workplace. Brickwork, block work, concrete, plasterboard, ceramic tiles, plaster finishes and paper coverings on inorganic surface (other than heavy flock wallpapers)

Class 1

Should not be used on escape routes including stairways, corridors, entrance halls and lobbies but can be used elsewhere. Timber, hardboard, block board, particleboard (chipboard), heavy flock wallpapers, and thermosetting plastics.

Class 3

Should only be used in small rooms (floor area not exceeding 30m²) and parts of large rooms (does not exceed half of the total floor area up to a maximum of 60m²).
Timber, hardboard, block board, particleboard (chipboard), heavy flock wallpapers, thermosetting plastics and thermoplastics (expanded polystyrene wall and ceiling linings).



Combustibles on fire exit route

Piped gas supply

Cylinders of flammable gas

Flammable chemicals, liquids and solvents

3.1.2 Sources of oxygen

In a majority of workplaces there will be a suitable supply of oxygen in the air. This may be from - natural ventilation, forced ventilation or air-conditioning systems. Additionally oxidisers materials may generate oxygen which will add to the fire as they contain lots of oxygen molecules which can be released. More oxygen can make the area more hazardous, just 2% more oxygen is enough to make the likelihood of a fire or explosion more likely. Oxygen enrichment is a hazard in its own right.

Some chemicals, although not normally spontaneously flammable, contain a source of oxygen which can support combustion; common examples are chlorates, nitrates, permanganates and nitric acid. Precautions to take with these substances include:

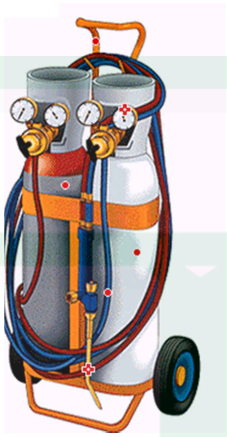
- Handle and store the minimum quantities practicable for the process or experiments in progress.
- Segregate the materials from other chemicals, particularly reducing agents, paper, straw, cloth or materials of low flashpoint.
- Handle in the most dilute form possible in clearly designated areas, away from potential ignition sources.
- Provide and use appropriate eye/face protection, overalls and gloves.

3.1.3 Fire and explosion risks from flammable materials in use, storage and transport within the workplace

Flammable liquids are in common use in many industries, yet they have the power to destroy very easily if appropriate precautions are not taken. Substances with low flash points present the highest risks. It is normally the flammable vapour which the liquid produces which is the fire hazard, mixed with air these can ignite very rapidly to give an explosion. The exact mixture will determine whether an explosion will occur or not, too much air and the explosion may not occur and equally too little may prevent the explosion.

Almost all highly flammable (HF) vapours are denser than air, this means they will accumulate at the lowest point available, and this may be away from the flammable liquid itself. The use of correct and suitable equipment for the storage, use and transfer of these liquids is essential if the risks are to be minimised.

3.1.4. Use of Oxy Fuel Equipment



Welding, covers a number of processes in which two or more pieces of metal are joined together by the application of heat, pressure, or a combination of both. Most welding fumes is of a size range which can penetrate the inner parts of the lungs. Inhalation is normally the main route of entry. Safety and fire related issues are:

Contact with Live Electricity – from electric arc welding

Fire - from arcs, flames & splatter

Explosion - vessels under pressure can explode

Heat - from the weld can cause bums

Radiation - ultra violet, infra-red and visible light can be formed during welding.

Metal projectiles – injuring the individual or setting fire to adjacent combustibles

General Precautions for welding fire related hazards

Move the work piece to a safe location; Remove combustible material from the welding area and cover remaining flammable material with fire-resistant material;

- Use covers to prevent spatter passing through openings in floors and walls; Keep appropriate fire-fighting equipment nearby;
- After welding, observe surrounding work area for at least an hour afterwards to ensure no fire is developing.
- There is a danger of explosion when welding tanks or drums that previously contained flammable substances. Even 'empty' containers may still have residues in the bottom enough to cause an explosion.
- Effective general ventilation must be provided, supplying 6 - 10 air changes an hour.
- Local Exhaust Ventilation will be required in designated welding areas to remove the gases and fumes.
- Ensure oxygen enrichment does not occur – good general ventilation is needed
- Welding in confined spaces will need to be controlled by a permit to work
- Keeping combustible materials away from the welding activities
- Barriers/shielding
- Limit access to area
- Signage
- Trained operators only

- Pre use checks – hoses in good condition, regulator fitted and working, cylinders upright and secured, flash back arrestors to stop flame going back into the cylinder. Ensure connectors on hoses are correct for the specific type of gas.
- Fire watch – after welding a person needs to check the area and everything has cooled before leaving. This will be needed in areas where sparks or flames cannot be avoided e.g. welding areas. It is important to maintain separation of ignition sources and fuel sources.

3.1.5 The concept of fire load

In simple terms fire loading is a measurement used by fire-fighters and other fire safety professionals to determine the potential severity of a fire in a given space. It describes the amount of combustible material in a building or confined space and the amount of heat this can generate. The more flammable materials there are present in a space, the higher the fire load and therefore the faster a fire will spread, increasing the potential impact of the fire.

A bare room with no furnishings or items present and concrete walls will have a fire loading of nearly zero. The problem occurs when people bring combustible materials into a space, as this increases the fire loading. However these materials are often essential for the useful functioning of the building, so you can't completely eliminate fire loading in a building, although you can take steps to reduce it.

Some specific uses of a building may carry a high fire load than others however. For example, art galleries tend to have paints, solvents and wooden picture frames present, so therefore the fire load is higher. Storing combustibles separately, with space left in between is advisable and even though it may not be the most efficient use of space, it can dramatically help limit the spread of fire. Also thinking about the types of materials that are being stored in a building and considering the possibility of moving them elsewhere is a good idea.

To calculate the fire loading of a building multiply the number of flammable materials in a room which have different ratings, this number is then divided this by the number of square feet in the room to get the fire loading.

$$\text{Fire Load} = \frac{\text{Combustibles in kg X calorific value in kcal/kg}}{\text{Floor area in square metres}}$$

Different materials have different calorific figures based on how well they burn items with more carbon in will burn more readily. Highly flammables such as LPG burn readily and would have a higher calorific value than a material such as paper.

One of the reasons why calculating the amount of heat generated by a particular substance when burning is so important, is that the build-up of heat in a fire can trigger deadly flashovers – that can engulf a room in seconds. Flashover occurs when organic materials are heated and undergo thermal decomposition. They then give off flammable gases which lead to simultaneous ignition of the combustible materials in a room.

Control of Fire Load

- **Quantity:** fire risk can be reduced by controlling the amount of combustible material in the work area until it is needed;
- **Flammability:** it may be possible to specify materials that are less combustible. Remember that when worked on, materials may become more easily ignited e.g. solids turned to dust or crumb;
- **Storage:** combustible materials should ideally be stored outside buildings under construction, especially volatile materials e.g. LPG. Internal storage must be planned and located where it will not put workers at risk;
- **Rubbish:** good housekeeping and site tidiness are important to prevent fire and to ensure that emergency routes do not become obstructed;
- **Volatile flammable materials:** extra precautions are needed for flammable liquids, gases and oxygen cylinders especially when internally stored;
- **Coverings and sheeting:** protective coverings and scaffold sheeting may add to fire risk. This can be reduced by use of flame retardant materials;

- **LPG:** liquefied petroleum gas (LPG) is widely used in construction e.g. in connection with bitumen boilers and site accommodation. LPG has been involved in many serious fires and explosions, particularly where there have been leaks in confined areas. Strict precautions are required where LPG is stored and used; and
- **Tanks and services:** demolition projects can involve an increased risk of fire and explosion. Dismantling of tank structures may cause ignition of flammable residues or disruption and ignition of buried gas services.

3.1.6 Fire risks in construction and maintenance work

Every year many construction workers are injured by fires, children and others may also be put at risk if construction activities are not managed correctly, in particular hot work such as welding may ignite other combustible materials which if not identified quickly may soon spread the fire to uncontrollable limits. (HSG168 Fire Safety in Construction Work)
There are around 4000 construction related fire annually. It is estimated that over 100 of these result in damages exceeding £50K and lead to major dislocation of project schedules.

Fire safety on site for new building and construction work is cover primarily by the **Construction Design and Management Regulations part 4** and t**he Regulatory Reform (Fire Safety) Order 2005.** The CDM requirements cover new build sites during their construction. Where work is undertaken in an existing building the requirements of the Regulatory Reform order will also apply.

Even small quantities of waste contaminated with highly flammables (HF) can cause problems if not stored correctly. Such waste should be placed in a waste bin with a self-closing lid. It should be emptied regularly via arrangements with an approved contractor. It is best to avoid mixing wastes from different processes unless the substances are known to be compatible.

Issues relating to fire with contractors, construction work and building refurbishment

- Carrying out hot work
- Blocking fire exits
- Isolating and interfering with fire detection devices
- Leaving exits open
- Not signing in or out
- Leaving holes in walls / floors, not filling up around pipes or cables
- Failing to restore fire systems e.g. alarm not reactivated after work completed
- Using high risk / non-suitable materials in the renovation
- Overloading fixed or temporary electrical installations

Demolition hazards which could contribute to fires include the use of explosives and possible contact with gas and electrical services.

3.2 APPROPRIATE CONTROL MEASURES TO MINIMISE FIRE AND EXPLOSION RISKS

3.2.1 Control of sources of ignition

A. Intrinsically safe electrical equipment for use in flammable and explosive atmospheres

Where flammable materials which are likely to produce a flammable atmosphere are

produced, handled, stored etc., each of the locations will be classed as a "flammable zone" and graded according to the potential danger i.e. the degree of risk of ignition. The zones are not related to the type of flammable atmosphere but to the probability of a flammable atmosphere existing. There are 3 flammable zones:

Zone 0 (20)

Locations where a flammable atmosphere is always present or present for long periods e.g. in storage tanks

Zone 1 (21)

Locations where, during normal operations, a flammable atmosphere is likely to be present e.g. where the material is processed, handled or stored

Zone 2 (22)

Locations where a flammable atmosphere is not likely to occur during normal operations, but if it does occur, it will be for a short period of time.

All certified equipment for use in flammable areas must be marked by the manufacturer and meet the European ATEX standard. The information which is required in the UK is as follows:

- The type of protection (e.g. EEx ia)
- Gas group (indicates suitability for gas present. Equipment suitable for use where specified gases are present is indicated by symbols I, IIA, IIB, and TIC e.g. Methane is a representative gas of group I)
- Temperature classification (classification TI-T6)
- CE Mark and number of notified body

It should be noted that equipment designed for a higher risk zone may be used in a lower risk zone.

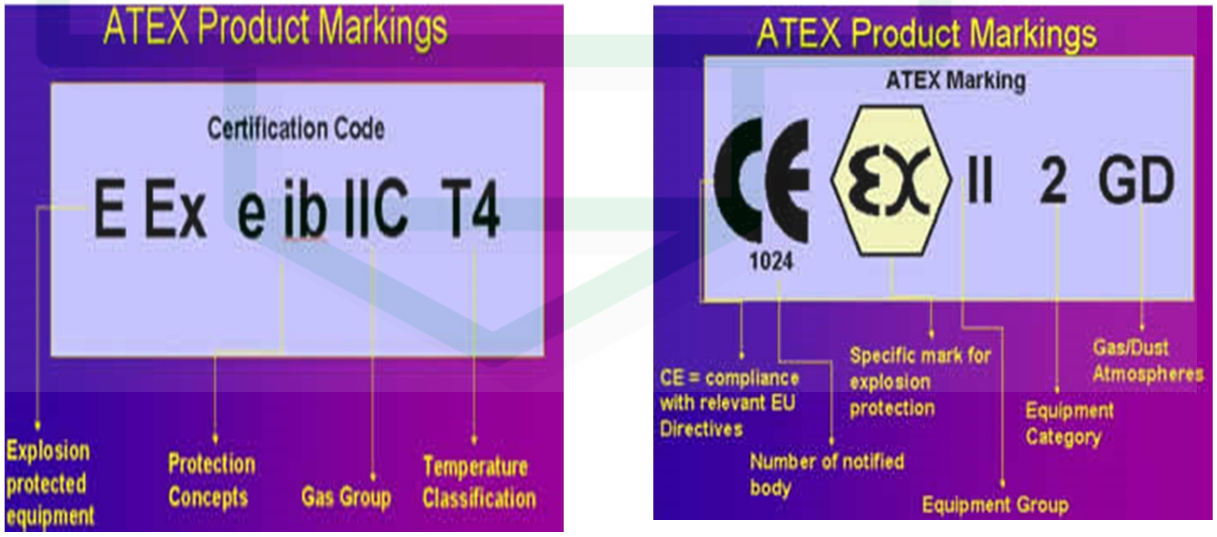


Figure Labelling and information on explosion protected equipment

Intrinsically Safe "i" Zone 0

This design ensures that the energy level is insufficient to produce an incendiary spark.

Two categories of intrinsically safe equipment exist, "ia" which is more stringent as it allows for two simultaneous faults and "ib" which allows for only one. Only "ia" equipment can be

used in Zone 0. Examples of type "i" are detecting and measuring instruments.

Flameproof "d" – Zone 1 or 2

This equipment is totally enclosed and the casing must be robust enough to withstand internal explosions without igniting the flammable atmosphere in which the equipment is located. Examples of type "d" equipment are motors, lighting, switchgear and portable hand lamps.

Increased Safety "e" Zones 1 & 2
This equipment does not arc, spark or generate temperatures high enough to ignite a flammable atmosphere. Examples of type "e" equipment are induction motors and certain types of luminaries.

Non-Sparking "N" or "n" Zone 2

Less stringent requirements have to be met by this category as compared with type "e" equipment above. It is intended for use in Zone 2 applications. Examples of type "n" or "N" equipment are some luminaries and solid state relays.

Oil Immersed" 0" Zone 1 & 2

Such equipment has all parts which are likely to arc under normal conditions immersed in oil to prevent ignition of a flammable atmosphere which may exist above the surface of the oil. All other parts are also protected by oil or by some other approved method. This category is not used much in the UK.

LOCATION	EXPLOSION PROTECTION	MEANING
Zones 0,1,2	**ATEX EEx ia**	Intrinsically safe
Zones 1 & 2	**ATEX EEx d**	Flameproof – this will withstand an explosion by stopping the ignition source entering the zone. Heavy substantial construction, still needs good cabling, mechanical protection and integrity of components.
	ATEX EEx ib	Intrinsically safe – this is designed not to produce a spark sufficient to ignite a flammable atmosphere
	ATEX EEX e	Increased safety – Like intrinsically safe but flammable gas may come into contact with internal components but sparks and hot surfaces are designed out, may also be protected against rain and dust.

B. Maintenance and portable appliance testing (PAT) of portable electrical appliances

Electrical equipment should be visually checked every time it is used as this will identify heat damage and scorching.

EQUIPMENT	USER	FORMAL	COMBINED
Hire	No	**Before issue After return**	**Before issue**
Construction	**110V weekly Mains daily**	**110V monthly**	**110v before 1st issue /3 monthly**
	No	**2-4 years**	**No if double insulated otherwise up to 5 years**
Hand held double insulated eqpt Class II	**Yes**	**6 month/year**	**No**
Cables and extension leads	**Yes**	**3 months**	**2 years**
Class I earthed eqpt e.g. kettles	**Yes**	**6 months to 4 years**	**1 – 5 years**

Table : PAT testing from HGS 107

C. User Checks (Visual)

Many faults with work equipment can be found during a simple visual inspection which should be switched off and unplugged before any checked are started.

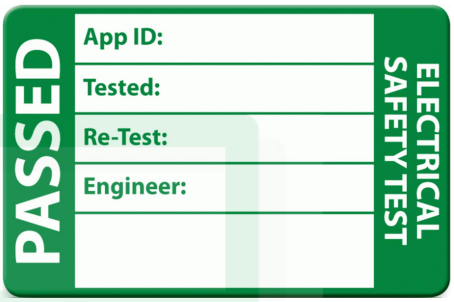
- Check that the plug is correctly wired
- Ensure the fuse is correctly rated by checking the equipment rating plate or instruction book
- Check that the plug is not damaged and that the cable is properly secured with no internal wires visible
- Check the electrical cable is not damaged and has not been repaired with insulating tape or an unsuitable connector. Damaged cable should be replaced with a new cable by a competent person
- Check that the outer cover of the equipment is not damaged in a way that will give rise to electrical or mechanical hazards
- Check for burn marks or staining that suggests the equipment is overheating
- Position any trailing wires so that they are not a trip hazard and are less likely to get damaged.

D. Formal Visual Inspections

This is the user Check Visual Inspection plus:

- Check correct rated fuse is in place
- Check termination of cables
- Check suitability of equipment
- Testing that the equipment works

- Cord grip is in place correctly
- Cable terminations in plug tight and fully inserted



E. Combined Inspection and Tests

The combined inspection and test is commonly known as a portable appliance test or PAT test.

PAT testing will test the effectiveness of the appliance and leads, the insulation standards, the effectiveness of any earthing and the polarity of the equipment. Records of this testing must be kept and equipment should be given a test date and unique ID number to ensure accurate and up to date records can be maintained.

Figure PAT Test label

F. Use of mobile phones

Mobile phones are not intrinsically safe, meaning that they have the potential to produce a spark of such intensity that it could ignite a vapour air mix. In work places where there is likely to be a flammable vapour air mixtures present, accidents do happen, so it makes sense to keep potential sources of ignition away from these areas.

G. Designated smoking areas

These should be way from fuel sources, there need to be arrangements to keep them clean and tidy, as there are a number of fires every year in bins in smoking areas where other materials such as paper cups are disposed of in the ash trays. It makes sense to ensure there are fire proof cigarette bins.

3.2.2 Control of sources of fuel

A. Safe storage, transport and use of flammable, highly flammable and combustible materials

Where possible the use of substances with low flash points should be avoided, if not areas where HF are used should normally be separated from the other parts of the workplace. Partitions should be in place but there should still be a clear means of escape.

Safety cabinets, ideally double walled for additional insulation, should be provided. These can be fitted with air vents to enable spillage and leakages to be taken away safely. Safety cans can be used for storing smaller quantities of up to 20 litres. These have spring loaded self-closing lids to minimise the vapour from them, some may have a flame arrestor in the neck to prevent a fire from occurring.

The minimum amount of HF possible should be kept in the work area.

Ideally HF should be transferred by enclosed systems using pipe work and enclosed valves. Self-closing drum taps should be used when flammable liquids are poured from large drums. These taps cannot be left open, they also have a flame arrestor to prevent the fire entering the drum. For faster extraction safety pumps can be used, but these must be earthed to prevent electrostatic charges.

- Use metal or heavy duty plastic containers
- Filling apertures fitted with flame arrestors
- Hoses fitted with small openings
- Carrying handles for containers to reduce risk of spills when dispensing.

- Open topped buckets are not suitable for use with HF.
- Operations such as mixing, filling and cleaning should be undertaken in a room or cabinet designed for that purpose.

A means of isolating the pipe work must be in place, shut off valves may be needed at each supply point externally at the beginning of each sub branch.

Bottles with self-closing lids should be used where possible, plunger cans can be used for moistening clothes and wipes. Bench cans and rinse trays enable parts to be cleaned safely in solvents etc.

Precautions to reduce the risk from static electricity will also be needed. Non-conducting foot wear should be worn and all fixed equipment must be earthed. Portable containers should also be earthed with bonding clips.

Smoking must not be allowed near HF.

Areas where HF are handled and stored must be well ventilated in order to ensure that any vapours released are diluted. A minimum of 6 air changes an hour is required. In booths or cabinets the air flow must be at least 1m/s to prevent vapours entering and building up in the workplace. Ventilation systems which exhaust to the open air must be at least 3m off the ground. Electric motors in the ventilation ducting must not be in the route of travel of the HF.

A spill can be defined as the uncontrolled release of a substance sufficient in size and nature to present a threat to the environment and / or people. Accidental spills of hazardous liquids, oil, fuel or chemicals can cause serious health and safety and environmental problems and current legislation is in place to protect people and the environment. If spillages are not controlled and damaging consequences occur then severe penalties can be issued to businesses.

Having the correct products and procedures in readiness will reduce the negative impact that a spill would cause, not only on people and the environment but also on your business. The two main methods of dealing with spills are: absorbents which are designed to contain and recover a spillage or loose absorbents such as clay granules and specialty powders which tend to be used on smaller spills.

Particular care should be taken to keep the floors of the warehouse or bunded areas free of contamination. Drip trays or containers used for repackaging must be clean before use.

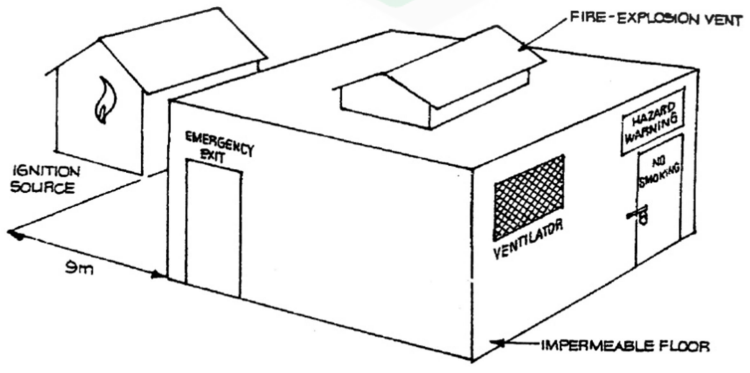


Figure Chemical storage facility

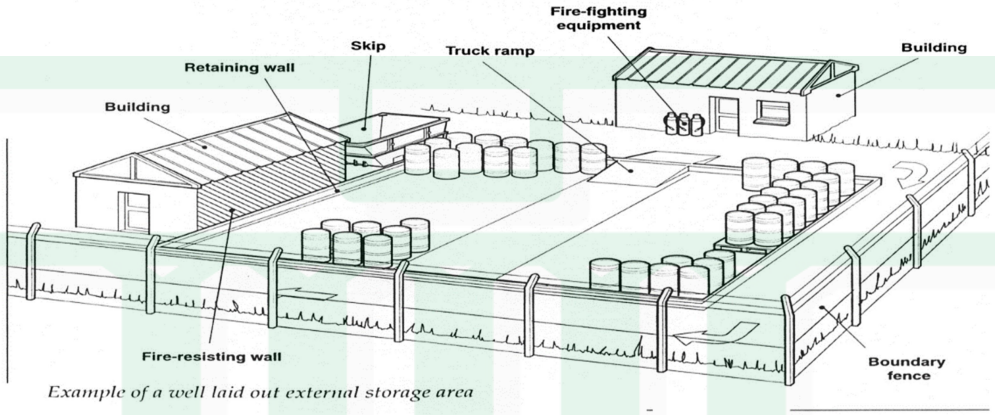


Figure Example outdoor storage compound

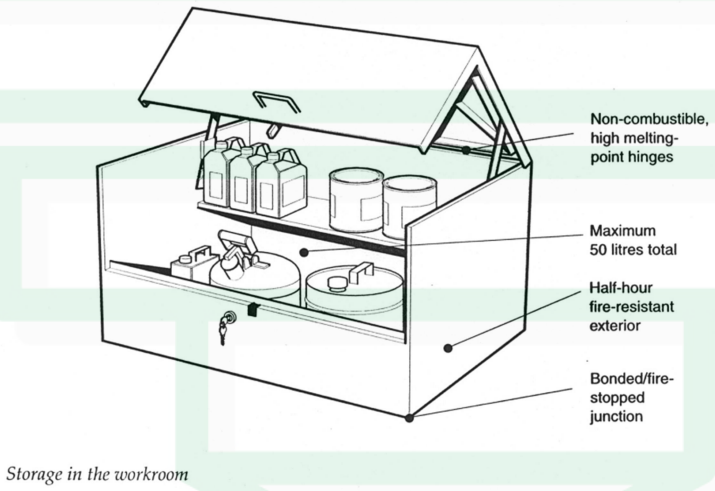


Figure Small scale storage

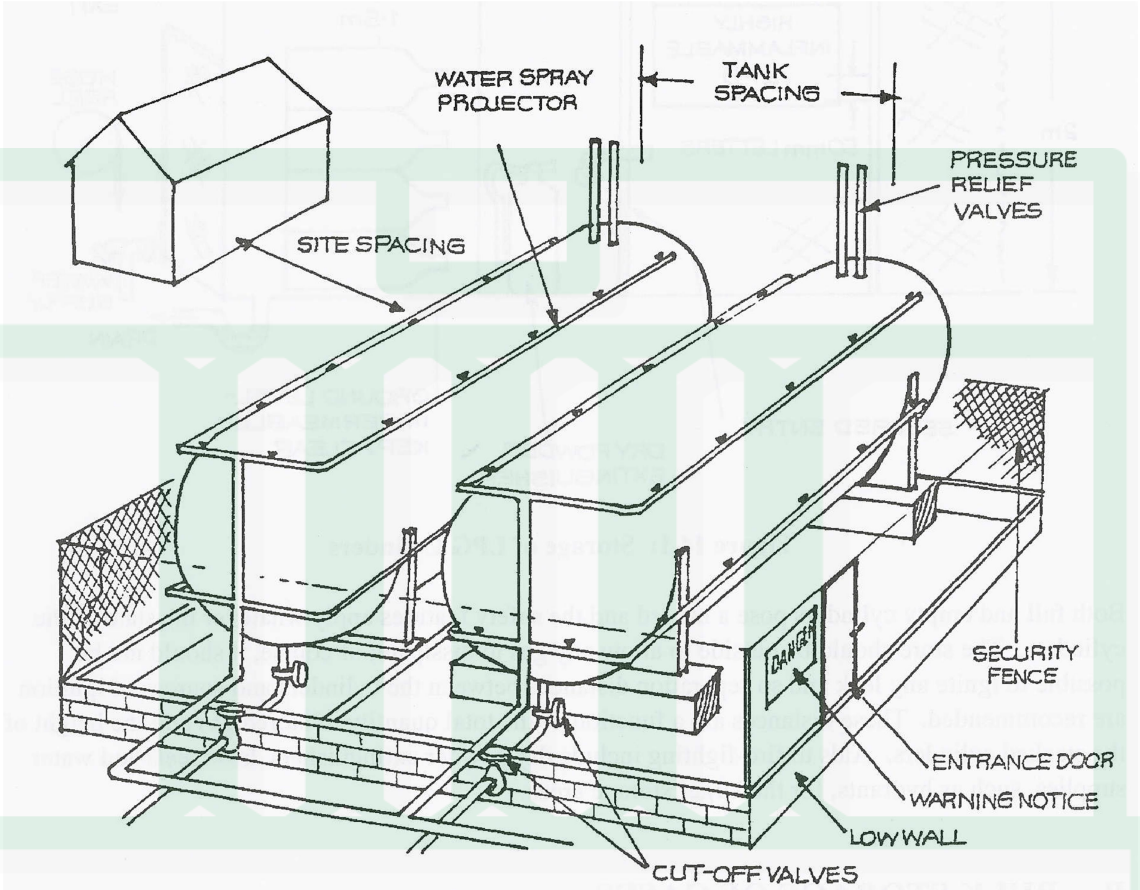
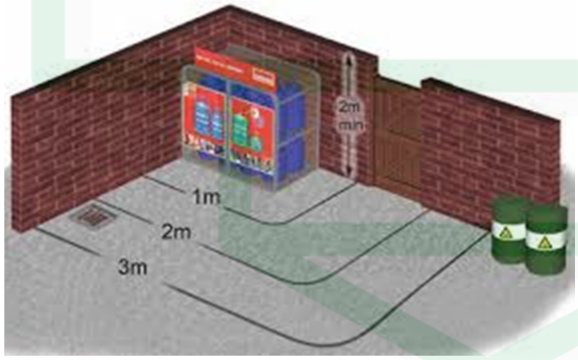
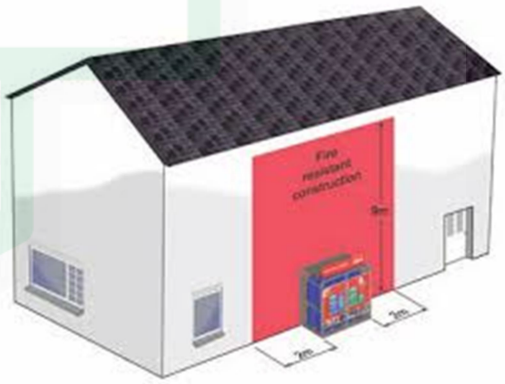


Figure Large Scale Bulk Storage





B. LPG - Storage In The Open Air For Less Than 400kg

Storage in an outside is good practice. In brief, the following should be adhered to:

- If the whole yard is accessible to the public then the LPG must be stored in a cage.
- This should be constructed of weld mesh 12 gauge 50 x 50mm or similar standard. Any walk-in cage should be at least 1.8 metres high.
- It should have two outward opening exits which are lockable, but which permit immediate escape from inside without the use of a key. One exit is acceptable if the maximum travel distance is less than 12 metres within the cage.

- The stack must be at least 1 metre from the boundary, 2 metres from a cellar opening, drain, gully, door or window and 3 metres from any combustibles unless they are behind a 30-minute fire resisting structure.
- Storage of LPG may be directly against a wall greater than 2 metres high on a boundary if it is of 30 minutes fire resistance and imperforate for a width of 2 metres on either side of the LPG and for a height of 9 metres before any window etc. above.
- No smoking or naked lights allowed within 1 metre of the stack nor any vehicles except those which are specifically delivering or collecting the LPG.
- Only electrical apparatus suitable for use in a "Zone 2" area is allowed in the storage area or in the separation distance. The separation distance for this quantity is 1.5 metre above the tallest cylinder and within 1 metre horizontally. You are advised to consult on any other quantity or circumstance.
- The area must be kept weed and litter free, but do not use sodium chlorate weed killer.
- Floors must be concreted. Any slope should be away from the building or the stored materials.
- Notices such as, 'LPG Area', 'Flammable', 'No Smoking/ No Naked Lights' and 'Fire Procedure' should be prominently displayed. The signage provided must comply with the current regulations. .
- Flammable, combustible, corrosive, oxidising or toxic chemicals must not be kept in the separation distance.
- Procedures should be in place for checking, removing, storing (in open air) any damaged or leaking cylinders.
- Every container must be stored upright and kept closed and the protective caps in place on the valves.
- No stack should be higher than 2.5 metres.
- A non-combustible roof is acceptable provided at least 0.3 metres high clear ventilation space exists all round.

The following table gives general separation distances for specified stacks of LPG.

Total quantity of LPG storage in cylinders(tonnes)		**Largest stack** (tonnes)	**Separation distance to boundary if no firewall** (m)	**WITH FIREWALL**	
From	**To**			**Firewall to boundary** (m)	**Stack to firewall** (m)
0.015	0.4	0.4	1	0	1
0.4	1	1	3	1	1.5
1	4	1	4	1	1.5
4	6	3	5	1.5	1.5

C. Transportation of LPG

- Any vehicle used to transport LPG cylinders should:
  - Be suitable for the task, of adequate strength and in good condition.
  - Permit the cylinders to be transported in the upright position.
  - Be open (preferred) or have adequate ventilation.
- Drivers and members of the vehicle crew are not permitted to smoke in or near any vehicle that is being loaded or unloaded with or transporting LPG cylinders. Means of ignition i.e. cigarette lighters, lanterns, portable cooking stoves, etc. are not permitted to be carried or operated on or in the vehicle.

D. Inspection and maintenance programmes

Workplace inspections should be completed to ensure that combustible materials are not accumulating in the workplace where they could come in contact with any heat sources.

The workplace and machinery needs to be maintained to ensure it runs smoothly and does not generate heat or sparks which could cause a workplace fire.

E. Safe/correct waste disposal methods

All construction sites, especially in the latter stages such as fit-out, can generate large amounts of mostly combustible and easily ignitable rubbish. Implementing simple site rules can prevent the accumulation of rubbish. The following should be considered.
Set site rules and ensure that they are followed, e.g. contractors must clear rubbish daily or more often. Provide facilities for storage of rubbish, e.g. skips.

Keep flammable rubbish, such as contaminated rags, in a closed-top, fire-resisting container, e.g. a metal dustbin.

Situate rubbish skips outside (placing it so if it does catch fire it does not put at risk the site or other properties nearby). Store empty bulk fibre bags, sacks and wooden pallets in a safe place until they can be removed from site.

If a skip is less than 3 m away from other structures, precautions to prevent skip fires spreading to the structure include: situating the skip against a fire-resisting wall that is high enough to prevent fire from reaching other flammable parts of the structure, e.g. brick; avoid placing skips beneath canopies or overhanging eaves;

F. Good Housekeeping

Good housekeeping minimises the risk of: a fire starting and helping a fire spread. In most cases of fire prevention, it involves simple measures. And having knowledge of how fires start allows you to take precautions. It's as basic as keeping fuel sources and ignition sources apart. So store things that burn easily away from things which create heat. One example is not stacking cardboard boxes next to the heater. That decreases the chances of a fire starting, and then quickly spreading.

Also, ensure that rubbish and waste products are not allowed to build up. One thing is that they can cause a slip hazard when people are rushing out in the event of a fire. But it also makes for a good fuel source. It is important to prevent it from piling up inside, and store outside away from buildings.

Rubbish bins and skips are common methods which arsonists use to start a fire. So keeping them well away reduces the risk. Good housekeeping reduces the risk of:

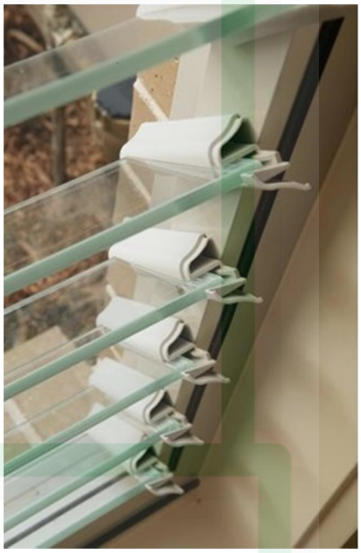
- hindering a safe evacuation,
- obstructing access to firefighting equipment or alarm call points,
- making signs and notices difficult to see.

It will enable everyone to locate fire extinguishers, blankets, and hoses. This could mean that a fire gets extinguished in its early stages and limits the risk to life and property. It can also make signs easier to see and read. These give a variety of important information. How

to use the equipment, not to smoke, keep a fire door shut, and where the fire exit is. Signs can help prevent and protect in the event of a fire, so keeping them seen is vital.

Having a housekeeping program will also ensure that fire exits and routes are not blocked. Storing items in the emergency exit route will limit the width of the passageway. But stored items can also get knocked over in an evacuation and prevent the safe exit of everyone. Fire and smoke can spread much quicker than many people expect, so having a quick and safe means of exit is compulsory.

3.2.3. Control of sources of oxygen



There are few options in trying to remove this side of the fire triangle, however there are still a few options available including:-

- closing doors and windows
- shutting off ventilation/air conditioning systems/ducting
- safe use and storage of oxidising materials

Self-closing fire doors can minimise or stop the spread of fire for 30 minutes up to 2 hours. They may have intumescent strips or blade type smoke seals. If a fire door cannot be kept shut permanently it can be held open electromagnetically, this can be connected to the fire alarm which will release the door when the alarm is activated.

Picture: Automatic door closer

3.2.4 PROCEDURES TO MINIMISE RISK OF FIRE

A. Inspections

Workplace tours or inspections should be undertaken to ensure fire standards are maintained. This may include daily checks to ensure all fire exits are clear to monthly checks of fire extinguishers or full workplace inspections looking at anything which could cause a fire or increase its severity. A more formal audit should be undertaken annually to ensure any systems and procedures in place are actually up to date and working well. Fire may be one of the specific topics reviewed during internal and external H&S audits.

B. Safe systems of work

"The integration of personnel, equipment, materials and the environment to ensure an acceptable level of health and safety" "A step by step procedure to carry out a task taking into account all the hazards and controls required"

The safe system of work (SSOW) may be written or verbal; if it is a complicated procedure or process it must be written down. The need for safe systems may be identified as the result of a risk assessment, they need to include the steps taken in each task to prevent and control the risks of fire or explosions.

C. Permits to Work

Permits to work are a means of authorising work and controlling it, they are not just safe systems; they set out a regime of checks to ensure that a task is completed safely, they normally operate in conjunction with a SSOW. They should be used when entering high risk areas or when completing a high risk task including hot work and work with explosives.

"A formal system is to operate a planned procedure which is designed to protect personnel working in hazardous environments. Usually for non-routine work which requires special training and precautions. With written signed authority given to carry out the task"

A permit to work will:

- set out the work to be done, the location and precautions to be taken;
- predetermine a safe method of work;
- provide a clear record that all foreseeable risks have been considered;
- define the precautions to be taken and their sequence.

A permit to work procedure mainly involve maintenance activities which could create a fire risk including:

- Hot work
- Work on electrical systems or work on high voltage equipment/working with live electricity
- Repairing unguarded machinery/machinery maintenance
- Entry into confined spaces
- Work being undertaken in flammable or explosive atmospheres

Permit No: HW……..

Example Hot Work Permit

Project:	
Task or work operation:	Duration of permit:
This permit to Work is issued for the following work. No work other than that detailed must be carried out:	
Location of work:	
Precautions: • Ensure hot work equipment is suitable for use and in good order. • Check location and means of raising alarm. • Ensure location extinguishers/hose reels. • Inspect nearby areas. • Remove any combustible material from work area. • Remove any flammable liquid containers from work area (whether full or empty). • Provide suitable and adequate protections against sparks and hot particles. • Follow-up inspection (…… Hours …….. mins… later) Additional Precautions:	
Extra precautions to be taken if plant, machinery or systems are in operation:	
SECTION 1 - AUTHORISATION (CLIENT):	
Name of person issuing Permit:	
Designation:	Signature:
Time:	Date:
SECTION 2 - RECEIPT:	
I hereby declare that no work other than that stated above will be carried out, and all precautionary measures will be adhered to:	
Name:	
Designation:	Signature:
Company:	
SECTION 3 - CLEARANCE:	
I hereby declare that the work stated above has/has not been completed.	
Details if not completed:	
Name:	SECTION 4 - CANCELLATION:
Designation:	All copies of this permit to work are hereby cancelled.
Signature:	Name:
Company:	Signature

D. Planned preventive maintenance programmes

Effective maintenance should ensure that equipment can function fully, ensuring it does not over heat or have any electrical faults which could lead to a fire. There are many types of maintenance; some reactive, some proactive.

The term maintenance includes a wide variety of work activities such as the repair, cleaning, adjustment and renovation of equipment as well as activities designed to improve the working environment such as cleaning, painting etc. Equipment and the workplace should be maintained in a state to ensure they are in good working order, equally measures must be taken to ensure those completing any maintenance activities are protected from the hazards they may face.

This is a programme of operation covering inspection, adjustment, rectification of faults and periodic overhauls with the aim of taking action before breakdowns occur. As well as the programme there must be an effective system for ensuring the correct frequency of maintenance is actually undertaken. Records of any repairs and safety issues should be logged and recorded.

E. Management of contractors

Companies need to ensure they only employ competent contractors, for some this is developed into an Approved Contractors List. All such contractors must meet stringent health and safety standards and checks.

Competence Checks May include

- References and Evidence of similar work & experience
- Qualifications (skills & knowledge)
- Membership of trade or professional bodies
- Enforcement Actions
- Accident record
- H&S policy
- Method statements or safe systems of work
- Sample risk assessments
- Sample plans from other jobs
- Evidence of health, safety and fire management – audits, inspections etc.
- Training provision

Information will need to be provided from site owner on fire safety arrangements, this may include rules on the classification of electrical equipment to be used, arrangements for smoking on site, storage and use of highly flammables. Fire alarm arrangements and the location of the assembly point.

Liaison meetings need to be held for long term projects to ensure any issues and problems are identified and rectified.

Full co-operation and consultation will be maintained with the contractor at all times during any project or undertaking. No work will be permitted where the employer is satisfied with the health and safety arrangements planned or implemented by the contractor. Spot checks and inspections to check that the rules are being adhered to e.g. keep the fire exits clear and store items in the designated area.

Housekeeping & Disposal of waste - the contractor needs to be aware of what the specific arrangement are for the site for housekeeping and the correct disposal of any waste generated**.** Typical procedural measures that an organisation should take to help

reduce the risk to the health and safety of their own employees whilst the contractors are carrying out this work.

F. Provision of information and training to employees and others

As part of the RFRO employers must ensure are all employees given information, instruction, and training by a competent person on:

- fire risks and precautions to be taken to avoid fire
- what to do if they discover a fire,
- raising the alarm, including location of alarm call points
- recognising the fire alarm and what to do when it is raised
- calling the fire brigade
- evacuation procedures, including arrangements for members of the public, and people with disabilities, and - escape routes, fire exits, and assembly areas;

• some employees will need additional training about special risks in their workplace, for example staff in: - kitchens and laboratories, or electrical and maintenance engineers;

• employees designated in emergency plans to supervise evacuations and fire drills or nominated as persons to use firefighting equipment will need additional special training for these roles, including:

- the location, choice, and use of firefighting equipment,

- the means of ensuring that everyone has left the building.

3.2.5 CONSTRUCTION RELATED CONTROL MEASURES TO REDUCE THE RISK OF FIRE AND EXPLOSION

a. Construction Work On An Existing Building - Fire Prevention Techniques

- Reduce the amount of fuel available to a fire by limiting stocks of combustible building materials and the accumulation of rubbish close to sources of ignition or inside buildings
- Consider moving to the use of substances which are flame retardant / fire resistant
- Volatile flammable materials such as LPG cylinders are stored in a suitably secure external store. Access to be limited so as to control distribution/use around the site.
- Cylinders to be returned to the store after use/ at end of the working day.
- Initiate a system where electrical equipment (and cabling) is checked on a regular
- basis particularly in relation to usage and the conditions in which it is being used
- Portable appliance testing is carried out on a regular basis
- Ensure that any electrical equipment or plant being employed in areas where solvents are being used or dusts are being generated is appropriately protected and will not overheat
- Initiate a Permit to Work systems for hot work (i.e. welding) Limit such work to trained competent staff only.
- Before hot work is started clear area of combustible items. Where this not possible erect suitable protection. Check the areas around and under where hot work has taken place up to an hour after the work has been completed
- Enforce a No Smoking policy or designate specific safe areas for smoking
- Ensure good security arrangements are in place, with no gaps in fencing and flammables appropriately locked away.
- Maintain plant and equipment in safe working condition

- If refuelling of vehicles or plant takes place on-site ensure a safe system is employed which takes place in the open air and away from potential sources of ignition
- Ensure portable lamps are appropriately secured so as not to fall over. Keep halogen lamps which generate large amounts of heat away from combustible materials
- Ensure temporary electrical installations are correctly installed. Any modifications or alterations to electrical systems are carried out by trained and competent staff
- Do not allow bonfires on site. Initiate a regular system for the disposal of waste so that bonfires are only used in exceptional circumstances. If used they must be at least 10 metres away from buildings and other combustible materials. The use of accelerants such as petrol should not be employed and the bonfire must be attended at all times

b. Construction Work On An Existing Building - Fire Protection/Mitigation Measures

- Means of escape: Provide suitable exit doors / points from buildings and the site. Provide adequate escape routes. Be aware there may be a need for additional temporary stairs to be formed from scaffolding and platforms in certain circumstances Update arrangements as construction progresses
- Develop a plan for the actions to be taken in the event of fire and ensure all staff understand it
- Where necessary appoint and train fire wardens to supervise and take a lead in a fire emergency
- Arrange specific fire assembly points where staff can be checked off
- Carry out fire drills to test the effectiveness of all of the above
- Provide a suitable fire alarm system to alert all staff
- Emergency lighting
- Make specific and suitable arrangements for calling the Fire Service, meeting and advising them on site
- Provide fire extinguishers and other firefighting equipment appropriate to need particularly for hot work situations
- Utilise existing sprinkler systems in buildings being modified / renovated
- Provide or utilise existing fire resisting doors and fit with/maintain intumescent strips to prevent spread of smoke and gases

- Provide fire action notices exit signs and emergency lighting and be aware of the need to update and relocate as work progresses
- Install heat and smoke detectors or ensure those in existing buildings remain operational. Make requirements for reactivation of detectors following hot work part of the PTW
- Ensure regular maintenance and inspection of the means of escape
- Intumescent coatings reduce the spread of heat along metal girders. Strips of the same material can be found around the edges of some fire doors.

If skips are near to structures i.e. less than 3 metres away they should be located against fire resisting walls and consideration should be given to using non-combustible chutes if they are required. It is important to restrict the amount of flammable materials placed in the skip and to arrange for it to be emptied before it contains a substantial fire load which could constitute a major hazard.

c. Demolition

Demolition work can involve a high risk of fire and explosion. In particular: dismantling of tank structures causing ignition of flammable residues; and/or disruption and ignition of buried gas services.

Buried and other service pipes should always be assumed to be present on a site unless it is positively confirmed that they are not. Identify the location of gas service pipes before any demolition work begins. The client or local supply company will often be able to provide indications of where pipes and cables are located, but this should always be accompanied by a survey of the site.

A competent person should do the survey using service pipe-locating devices. Once the locations of all service pipes are identified, make arrangements to ensure that they are disconnected from the mains supply by a competent person and purged of any residual gas. It is extremely dangerous to merely assume that this has been done. It needs to be confirmed by a formal process in which a competent person, usually a representative of the local supply company, gives authoritative assurance of disconnection and clearance. Further information is contained in HSE publication HSG47 Avoiding danger from underground services.

Even if removal of the pipe services is not an intended part of the demolition job, it is still important to locate and isolate services to avoid damaging them. In some cases, it may be necessary for supply systems to remain charged. In such cases, particular care will be needed in implementing systems of work to minimise the risk of contact.

Storage tanks and drums often contain residues of flammable materials even tiny amounts of which can result in flammable and explosive concentrations. This is especially dangerous when hot work dismantling methods – including oxyacetylene cutting or methods generating ignition sources such as angle grinding – are used. Such methods should only be used after the tank has been thoroughly cleaned and certified gas and residue free by those who specialise in such work. This work is potentially extremely dangerous and specialised. Those doing it must be competent. (Consideration should be given to mass filling with concrete and leaving in situ.)

d. Actions to minimise risks from arson

- Fencing and hoarding – temporary for construction sites and permanent for other businesses
- Secure storage of highly flammables, lockable compounds for LPG and other flammables
- Secure storage for other combustibles
- Anti-climbing paint
- Security lighting, security checks and patrols & CCTV
- Regular collection of waste, covering waste skips & keep skips away from buildings and fences
- Securing costly plant away from view and isolating the power
- Liaison with local schools to try and deter children from gaining access
- Automatic fire detectors linked to an alarm system