HAZARDOUS AREAS TRAINING

Course Pre-Reading Material

Thank you for enrolling with Extend Training. In order to get you thinking a little bit about the course content and how it might relate to your workplace, we've prepared this short booklet, which runs through some of the concepts, definitions and terminology that you'll be spending a lot of time talking about during your course.

We ask that you to please read through the information and attempt the short quiz at the end, *before* your first day of classroom training with us. It shouldn't take you long to get through, and it will help us to ensure that we complete the course in the time available during your training. We've written it to be as easy to read as possible and there might even be a joke or two buried in there somewhere to lighten the load. Hey, you might even enjoy it! (See? Jokes already!) We'll run though the answers to the quiz on the first day of the course and if you have any questions, you can ask them then.

We will briefly review this material in class, but will not be spending much time on it, and there will be questions relating to it in the assessment on the first day of the course. So it will be worth your while to make sure you're across it (or have questions ready if there's anything you don't understand) when you walk in the door to start your training.

Good luck! And as always, if you have any questions please just give us a call.

1 INTRODUCTION

Let's start with a definition, shall we? For the purposes of this training course, a **Hazardous Area** is defined as:

> *"an area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment."*

This definition is actually from AS/NZS 60079.14 Explosive atmospheres - Electrical installations design selection and erection; the "bible" for electrical installations in hazardous areas in Australia. Compliance with this standard is mandatory for hazardous area installations in all states and territories in Australia, so using its definition seems a logical place to start, and it narrows the focus of the subject. The term "hazardous area" in general use would apply to the other hazards that we may encounter in the workplace, like confined spaces, work at heights, moving machinery and so on, but for the purposes of this course (barring a few digressions here and there) these general hazards are not considered – we are interested only in explosions, fire and death… or rather, the prevention of them.

So, armed with this definition, the logical question to ask is, "Where would I find one of these hazardous areas then?" And the answer is of course, "Pretty much everywhere!" Explosive atmospheres can be formed by flammable gases, flammable liquids (or more correctly, the vapours coming from them) or clouds of combustible dusts, and as a result they are common as muck in industry, where these substances are routinely used, processed or stored. Examples of industrial plants where hazardous areas would be present include:

- Oil Refineries (flammable gases and liquids)
- LNG Facilities (flammable gases)
- Gas Pipelines and Compression Stations (flammable gases)
- Coal Mines (flammable gases, combustible dusts)
- Commercial Bakeries (combustible dusts)
- Breweries (combustible dusts)
- Distilleries (combustible dusts and flammable liquids)
- Plastics Factories (flammable gases, liquids and combustible dusts)

Most of us enter hazardous areas regularly in our day to day lives when refuelling our vehicles in service stations, and many of us store sufficient quantities of flammable liquids (mower fuel, paint thinners, turpentine, methylated spirits, jerry cans of petrol) that we would technically have hazardous areas within our garages or sheds; so hazardous areas are commonplace.

Unfortunately, one of the consequences of this ubiquity is that explosions and fires resulting in death, injury and property damage are also commonplace. To recall only a few of the more notorious examples of recent times consider:

- Macondo Well Explosion, Gulf of Mexico – 13 dead
- Pike River Coal Mine Explosion, New Zealand – 29 dead
- Massey Energy Coal Explosion, Virginia – 25 dead

- Pemex Gas Plant Explosion, Reynosa, Mexico – 30 dead

All of these incidents occurred within the last few years, but it would be a mistake to regard hazardous area explosions as a recent phenomenon. Explosions, fire and death have been constant companions to hazardous areas throughout history. In England in 1866 a series of explosions at the Oaks Colliery in England killed 361 miners and 27 rescuers. In 1847 a smaller explosion at the same mine had killed 73. In 1878, the Washburn 'A' Mill in Minneapolis, the largest flour mill in the United States at that time, exploded catastrophically, with the loss of 18 lives and extensive destruction of the surrounding city. More recently, the Piper Alpha oil platform fire in 1988 killed 167 people and remains to this day one of the worst industrial accidents in the offshore oil and gas industry.

Figure 1 - Washburn 'A' Mill explosion in 1878

Since 1980, in the USA alone more than 450 accidents involving combustible dust have killed nearly 130 workers and injured another 800-plus, according to a Center for Public Integrity report, which analysed data compiled by the US Occupational Safety and Health Administration and the US Chemical Safety Board. This represents approximately 1 accident per month just for combustible dusts! If the figures for gas and vapour explosions were included the picture would be even less attractive.

Just in case we are tempted to view hazardous area accidents as an international phenomenon, consider the following relatively recent Australian efforts:

- Longford Gas Plant Explosion, 1998 – 2 dead
- Moura No. 4 Coal Mine Explosion, 1994 - 11 dead
- Myall Creek Gas Explosion, 2003 – 1 dead
- Drayton's Winery Explosion, 2008 – 2 dead.

When one considers that the laundry lists above contain only the more serious or notorious accidents, involving at least one fatality, and that Birds's Triangle suggests many more accidents with less serious (and therefore less newsworthy) consequences will have occurred in amongst these disasters, it is tempting to conclude that explosions, fire and death are an unavoidable fact of life when dealing with hazardous areas.

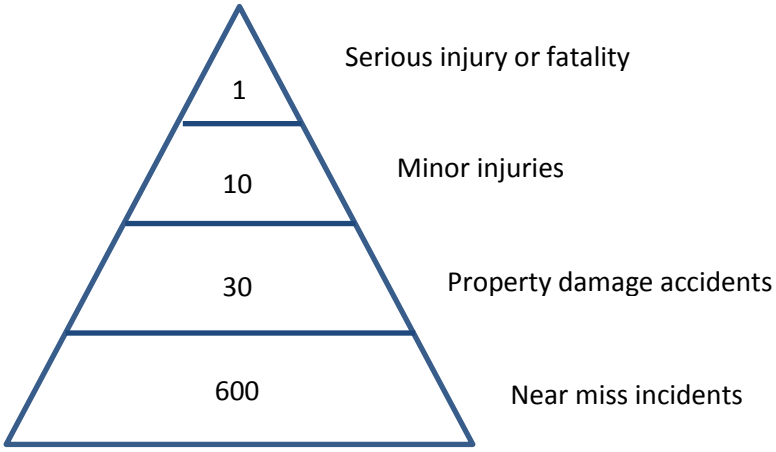

Figure 2 - Bird's Triangle: For every serious injury or fatality there are likely to be many more (less serious) accidents and near misses

Thankfully, this is not true. In fact the technologies and work practices required to ensure the safety of hazardous area facilities are available and well-documented, and have been for many years. Their successful implementation requires attention to detail and ongoing vigilance, but is more than achievable, and the aim of this course is to provide you with the skills and knowledge that are the foundations for achieving safety in your workplace.

We must begin with the attitude that all accidents are preventable, and keeping in mind the horrific consequences of explosions in hazardous areas helps to keep that aim in focus.

Figure 3 - Piper Alpha explosion

2 STANDARDS AND LEGISLATION

As we saw in the introduction, failure to take proper care and attention when working in hazardous areas can have catastrophic consequences. Given the magnitude of the unpleasantness after an accident it's probably not surprising that governments have gotten enthusiastic about regulating the area, and Australian governments have been no different.

Broadly speaking, there are two main areas of legislation with relevance to hazardous areas – electrical safety legislation, which is state based and varies quite significantly in some aspects from state to state; and occupational health and safety legislation, which is also state based, but has recently (not quite finished in the case of some of the more recalcitrant members of the Commonwealth) been harmonised with model legislation produced by the Federal Government (the Work Health and Safety Act 2011 (Cth) and the Work Health and Safety Regulations 2011 (Cth)), so that legislation across the country is essentially the same.

Electrical safety legislation is designed to ensure the safety of electrical installations and establishes such things as the requirement to have an electrical work licence to do electrical work and the requirement that electrical installations comply with a standard. (In the engineering and trades industries in Australia we often focus on compliance with Standards as a means of ensuring safety, however compliance with a standard is only mandatory if the standard is called up in legislation – in an Act or Regulation of parliament that has jurisdiction over the project or installation in question.)

Occupational health and safety legislation establishes a more general duty of care and requires employers to manage risks to workers' health and safety – i.e. to provide a safe workplace. It also places obligations on employees to follow and use the systems and equipment that an employer provides.

2.1 Electrical Legislation - General

In all states and territories of Australia there is an Act or Regulation of parliament that requires electrical installations to comply with AS/NZS 3000 – The wiring rules. Generally it is the obligation of the electrical worker and/or contractor to ensure that the installation does comply and there are serious penalties in place for non-compliance, including loss of licence, fines and jail terms. Although there are often exclusions to the legislated applicability of the wiring rules for places like mines, quarries and petroleum leases, we generally find in such cases that the rules are called up in site safety management plans or contract documents, so compliance is still required, just via a slightly different mechanism.

Section 7.7 of AS/NZS 3000:2007 sets out the requirements for electrical installations in hazardous areas. In addition to devoting approximately four trees' worth of pages to new requirements for recessed downlights, Amendment 2 of AS/NZS 3000:2007 updates the references to the standards governing hazardous area installations. Australia has been progressively aligning its hazardous area standards with the international standards published by the International Electrotechnical Commission (IEC). AS/NZS 3000:2007 Amdt 2 requires compliance with these "harmonised" standards, the AS/NZS 60079 series.

The relevant clauses of Amendment 2 are reproduced below with some commentary:

*"**7.7.2.1 Responsibility** for Classification*

The responsibility for classification of a hazardous area rests with the persons or parties in control of the installation. The requirements are contained in AS/NZS 60079.10.1 for gas or vapour and AS/NZS 60079.10.2 for combustible dust."

So the responsibility for recognising that hazardous areas may exist at a facility and having the area classified (assessed to determine where the hazardous zones are) rests with the owner/occupier of the premises. This is in line with the broad duty of care established under OHS legislation. The person in control of the installation would not generally perform the classification themselves, but would engage a competent person or body to undertake the task.

*"**7.7.2.4** Electrical Equipment*

***7.7.2.4.1** Selection*

Electrical equipment selected for use in hazardous areas shall comply with the appropriate requirements as specified in AS/NZS 60079.14.

***7.7.2.4.2** Installation*

Electrical equipment shall be installed in accordance with the installation requirements of AS/NZS 60079.14.

NOTES:

1 AS/NZS 60079.14 includes requirements for the competency of persons.

2 Inspection and maintenance requirements for electrical installations in hazardous areas are given in AS/NZS 60079.17."

Therefore, in order to comply with AS/NZS 3000:2007 in a hazardous area installation, the electrical equipment must be selected and installed with AS/NZS 60079.14, which thereby becomes mandatory. There will be a transition period before compliance with Amendment 2 becomes mandatory, but after it has elapsed compliance with the older Australian Standards for hazardous area installations (the 2381 series), will no longer be recognised. This course therefore focuses on AS/NZS 60079.14. (We often refer to it as "the bible," for hazardous areas).

Note 1 to clause 7.7.2.4.2 refers to competency requirements in AS/NZS 60079.14. The relevant clause in that standard is 4.4, reproduced below:

*"**4.4.** Competency of personnel*

The design of the installation, the selection of equipment and the erection covered by this Standard shall be carried out only by persons whose training has included instruction on the various types of protection and installation practices, relevant rules and regulations and on the general principles of area classification. The competency of the person shall be relevant to the type of work to be undertaken.

Appropriate continuing education or training shall be undertaken by personnel on a regular basis.

Competency may be demonstrated in accordance with AS/NZS 4761, Competencies for working with electrical equipment for hazardous areas (EEHA), or equivalent training and assessment framework."

This clause clearly establishes the requirement for all persons working with EEHA to undertake appropriate training and to be able to demonstrate competency. The competency must be relevant to the type of work to be undertaken, so if you are installing you need to be competent to install, if you're designing you need to be competent to design. The clause also requires that personnel continue to educate themselves in order to keep up with changing standards and technologies in the field. The intent of these requirements is to prevent persons who do not understand how explosion-protected electrical equipment works from inadvertently compromising the protection during design, installation and maintenance.

The training and assessment in this course is in accordance with AS/NZS 4761 and the UEE11 national package. The units of competency covered are listed on the first page of this manual.

Remember, the competency requirement, just like all the other requirements of AS/NZS 60079.14, is mandatory wherever state electrical legislation applies. Non-compliance is not a legally acceptable option.

2.2 Electrical Legislation – State by State

Although all Australian states and territories have enacted legislation that generally requires compliance with the wiring rules, there are exceptions, variations and additional requirements particular to each jurisdiction. The following sections detail the relevant Acts and Regulations for each state, the scope of the legislation (i.e. the areas that the legislation has no jurisdiction over and any excluded areas such as mines or oil and gas leases) and any additional requirements particular to hazardous areas in that state.

2.2.1 Queensland

Electrical Legislation: Electrical Safety Act 2002, Electrical Safety Regulation 2002

Purpose and Operation: The purpose of the Act and Regulation is to promote electrical safety and prevent death and injuries caused by unsafe electrical installations and work practices. It does this by creating obligations on various parties, including electrical workers and their employers, as well as designers and suppliers of electrical equipment, to ensure that their activities are conducted in an electrically safe way and their electrical installations are safe.

To ensure installations are safe, section 66 of the Regulation requires electrical workers to ensure that electrical installations that they perform electrical work on are (to the extent that the installation is affected by the work), in accordance with the wiring rules.

Additional Requirements for Hazardous Areas: There are several additional requirements for hazardous areas installations under the Act:

- All new installations in hazardous areas must be audited by an accredited auditor before energisation (section 153 of the Regulation). Auditors are appointed by the Electrical Safety Office (the regulator created by the Act) and charge a fee for conducting the audit, as compensation for assuming some of the liability in the case of an accident. This requirement can be inconvenient when maintenance or repairs are conducted on an installation – if anything other than "like-for-like" replacement of equipment occurs the installation is deemed to be new, and an audit is required.
- The definition of *"electrical equipment"* usually excludes equipment supplied at extra-low voltage (ELV). However, ELV equipment in a hazardous area is included, which means that the requirement for audit applies to ELV installations. This is intended to ensure that intrinsically safe installations, which are usually ELV, are covered by the audit requirements, but has the unfortunate side effect of making work on them fall under the definition of *"electrical work,"* which requires a licence. This can cause difficulties for instrumentation technicians, who often don't have one.

Scope and Exclusions: The Electrical Safety Act and Regulation apply to all electrical installations in Queensland, except for:

- Mines and Quarries (which are covered under the Mining and Quarrying Safety and Health Act 1999
- Underground coal mines (which are covered under the Coal Mining Safety and Health Act 1999)
- Petroleum and gas leases (which are covered under the Petroleum and Gas (Production and Safety) Act 2004)

The only section of the Act that applies to the above areas is Section 4, which covers the requirements for licensing – i.e. the requirement to have an electrical work licence in order to perform electrical work still applies to electrical installations in these places, but the obligations to ensure electrical safety under the Act do not. This is because there are safety obligations established under each of the industry specific acts, and having parallel obligations under the Electrical Safety Act would create a conflict.

Although the Electrical Safety Act requirement to comply with the wiring rules does not apply to mines and petroleum leases, the industry specific legislation still requires the lease operators to identify hazards and control their risks, which will include the risk associated with the electrical installation. How might an operator control that risk, you ask? How about by stipulating in the safety management plan for the site that the electrical installation shall comply with a recognised standard? Sounds reasonable – how about AS/NZS 3000? So we often end up in the same, legally binding place, with the wiring rules mandated, just via a different legislative mechanism.

The requirement for audit of hazardous area installations is also excluded for mines and petroleum leases, but some operators have their installations audited anyway, to increase confidence in the safety of their operations.

2.2.2 New South Wales

Electrical Legislation: The New South Wales Electricity (Consumer Safety) Act 2004 No 4, Electricity (Consumer Safety) Regulation 2006.

New South Wales legislation is not particularly coherently organised. In addition to the Act and Regulation noted above, parts of the Fair Trading Act 1987 apply to electrical installations, and the requirement for an electrical work licence comes from the Home Building Act 1989 (where else?)

Purpose and Operation: The legislation is intended to ensure electrical installations are safe. Regulation 32 of the regulation requires that installations comply with the wiring rules, and states that a new installation cannot be energised without authorisation by the network service provider.

Additional Requirements for Hazardous Areas: Any additional requirements are at the discretion of the network service provider. They are required to have a Customer Installation Service Plan, which may require inspection of hazardous area installations by an authorised inspector (for example) before the authorisation to energise will be given.

NSW has recently restructured the electricity supply sector to have only three network service providers. Requirements for hazardous area installations should be checked with the provider servicing the area of the installation as they may vary between the three.

2.2.3 Victoria

Electrical Legislation: Electrical Safety Act of 1998 and amendment 2010, Electrical Safety (Installations) Regulation 1999.

Purpose and Operation: The purpose of the Act and Regulation is to promote electrical safety and prevent death and injuries caused by unsafe electrical installations and work practices. Compliance with the wiring rules is mandated by the Regulation. Energy Safe Victoria is the regulator (formerly known as the Office of the Chief Electrical Inspector.).

Additional Requirements for Hazardous Areas: Regulation 406 from Electrical Safety (Installations) Regulation 1999 deems all electrical work at or above low voltage in hazardous areas to be *prescribed electrical work.* Prescribed work must be inspected by a licensed "H" class inspector before it can be bought into service. Similar to auditors in Queensland, H-class inspectors will charge a fee for their services. There are some specific types of electrical work in hazardous areas which are defined as non-prescribed and therefore do not require inspection prior to energisation but may be subject to an inspection at a later date. These exceptions are listed in table 8 of the "Guidelines to the Certificate of Electrical Safety" published by Energy Safe Victoria (ESV).

2.2.4 Tasmania

Electrical Legislation: Occupational Licensing (Electrical Work) Regulations 2008

Purpose and Operation: The regulation requires compliance with the wiring rules, with work carried out by a licensed tradesperson to ensure the safety of installations.

Additional Requirements for Hazardous Areas: Regulations 19 requires (as far as practicable) an authorised officer to inspect, or cause to be inspected, hazardous area installations. Regulation 20

makes it an offence to energise any new electrical work in a hazardous area without approval from an authorised officer. The approval is not required for work that involves repairs effected by replacement of a part with another part performing substantially the same function.

2.2.5 South Australia

Electrical Legislation: Electricity Act 1996, Electricity (General) Regulations 2012

Purpose and Operation: As for the other states, the purpose of the legislation is to ensure the safety of electrical installations.

Section 56 of the Electricity (General) Regulations 2012 requires compliance with the wiring rules:

> "56—Certain electrical installation work and certificates of compliance
>
> (1) The following provisions apply for the purposes of section 61(1) of the Act:
>
> (a) work on an electrical installation or proposed electrical installation that is work of any kind referred to in AS/NZS 3000 or another Australian Standard or Australian/New Zealand Standard called up by AS/NZS 3000 must be carried out, and the installation must be examined and tested—
>
> (i) in accordance with AS/NZS 3000 and any Australian Standard or Australian/New Zealand Standard called up by AS/NZS 3000 and so that the installation complies with any other technical and safety requirements under these regulations; and
>
> (ii) in accordance with the technical installation rules of the operator of the distribution network to which the installation is or is to be connected;"

Additional Requirements for Hazardous Areas: Connection of supply, including any inspection requirements for the installation (hazardous area or otherwise) prior to connection are at the discretion of the network operator – a similar arrangement to NSW. In addition the following is from the FAQs section in the SA government web site (sa.gov.au)

"Anyone working on or near hazardous areas must be adequately trained, be competent to perform the work and hold an appropriate license. "

2.2.6 Western Australia

Electrical Legislation: The Electricity Safety Act 1947, The Electricity Safety Regulations 1947, The Electricity (Licensing) regulations 1991

Purpose and Operation: The WA legislation has been updated and amended frequently since its original enactment in 1947, so there's no need for alarm. It mandates compliance with the wiring rules to promote safety, in essentially the same way as the other states.

It places the responsibility for inspection of installations on the network operator, in a similar manner to NSW.

2.2.7 Northern Territory

Electrical Legislation: The Electricity Reform Act, Electricity Reform (Safety and Technical) Regulations

Purpose and Operation: The purpose of the legislation is the same as the other states, but the NT system establishes a joint responsibility for safety, shared between the owner of an installation and the electrical contractor(s) working on it. The contractor has the responsibility for ensuring compliance with the wiring rules and must supply a certificate of compliance to the owner and ensure his employees working on the site are appropriately qualified and competent, while the owner has a duty of care to ensure that the contractor is appropriately licensed, qualified and competent.

The regulator has the power to inspect installations at their discretion.

2.3 Occupational Health and Safety Legislation

OHS legislation in Australia has recently been harmonised, meaning that all States and Territories (a few stragglers aside) have passed Acts and Regulations based on "Model" legislation produced by the Commonwealth (Federal) Government. This means that legislation across the country is almost the same.

The essential features of the legislation are the establishment of duties of care on employers (referred to as a Person Conducting a Business or Undertaking, which includes everything from sole traders through to multinationals employing thousands of people), their officers and employees. A person may have more than one duty and more than one person can have the same duty. However, in that case each person must discharge the duty to the extent the person has the capacity to influence and control the matter.

Duties imposed on a person to ensure health or safety require the person:

- to eliminate risks to health and safety, so far as is reasonably practicable, and
- if it is not reasonably practicable to eliminate risks to health and safety, to minimise those risks so far as is reasonably practicable.

Health and safety duties must be discharged so far as is 'reasonably practicable', which means that which is reasonably able to be done in relation to ensuring health or safety, taking into account and weighing up all relevant matters including:

- the likelihood of the hazard or risk occurring
- the seriousness of the risk
- what the person concerned knows, or ought reasonably to know, about the hazard or the risk, and ways of eliminating or minimising the risk, and
- the availability and suitability of ways to eliminate or minimise the risk.

After assessing these matters the cost of ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk, may also be taken into account.

The main duties placed on employers and workers are summarised below:

Primary duty

The duty of a person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of:

- workers engaged, or caused to be engaged by the person, and
- Workers whose activities in carrying out work are influenced or directed by the person, while the workers are at work in the business or undertaking.

A person conducting a business or undertaking must also ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking. This primary duty encompasses the provision and maintenance of a work environment without risks to health or safety, safe plant and structures and safe systems of work. It also includes the safe use, handling, storage and transport of plant, structures and substances, the provision of and access to adequate facilities for the welfare of workers, the provision of information, training, instruction or supervision, and monitoring of the health of workers and the conditions at the workplace.

Workers' duties

Workers must:

- take reasonable care for their own health and safety,
- take reasonable care that their acts or omissions do not adversely affect the health and safety of other persons, and
- comply, so far as the worker is reasonably able with any reasonable instruction given by a person conducting a business or undertaking to allow the person conducting the business or undertaking to comply with the model WHS Bill, and
- cooperate with any reasonable policy or procedure of the person conducting the business or undertaking which relates to work health or safety and that has been notified to workers.

Essentially the legislation places an obligation on employers to eliminate workplace hazards, or where they cannot be eliminated (eliminating the flammable materials in an oil refinery would be somewhat counter-productive for example), to manage the risks to workers' health and safety. This generally leads to the establishment of a safe system of work - a set of procedures or work instructions, equipment (including PPE), and training that allow work to be carried out safely. There is a parallel obligation placed on workers to comply with the requirements of the system and follow instructions to ensure their own safety and that of others.

We will examine some the specific hazards associated with working in hazardous areas, along with typical elements of safe systems of work employed to control the risks and ensure a safe workplace in the coming chapters.

3 FIRES AND EXPLOSIONS

A fire and an explosion are examples of the same chemical process – oxidation. Oxidation is the process that causes metals to corrode, but this obviously occurs very slowly. When the oxidation is occurring quickly enough that heat and light is released, we have a fire, or combustion. An explosion is simply a very rapid fire that causes a large increase in volume of the exploding material, releasing a lot of energy very quickly.

The speed at which a fire moves through a substance is called the rate of propagation. As a fire propagates it pushes ahead of it a pressure wave. The faster the propagation speed the bigger the pressure wave. If the speed of flame propagation is subsonic the fire or explosion is called a deflagration and propagates thermally, by the transfer of heat. If the speed of propagation is supersonic the explosion is called a detonation and propagates by shock (pressure).

3.1 The Fire Triangle

For a fire or explosion to take place, we require three elements: fuel, oxygen and a source of ignition to initiate the combustion process. The three elements are commonly represented as the fire triangle, below.

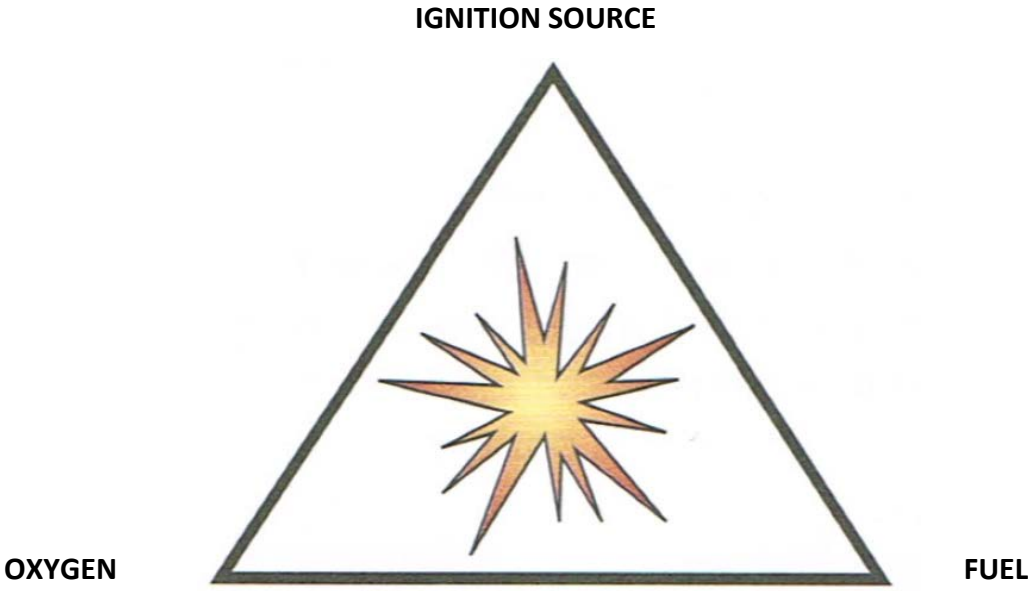

Figure 4 - The fire triangle

Let's examine the three elements of the triangle in a little more detail:

Oxygen

Oxygen makes up 21% of the air that we breathe, so it is readily available and although eliminating it would prevent a fire or explosion from taking place it would cause significant other difficulties in most cases. This approach is used sometime in the interior of flammable liquid tanks, where the vapour space of the tank is "inerted" by filling it with an inert gas such as nitrogen to remove the oxygen.

Limitations to the scope of this course: This course does not deal with oxygen enriched atmospheres, such as oxygen tents in medical facilities. The higher levels of oxygen in these places make them particularly dangerous and hence they are beyond the scope of this course. Similarly the course does not cover electrical safety for high explosives, such as TNT. These substances incorporate oxygen into the chemical compound itself and they therefore do not need any atmospheric oxygen to explode. TNT will detonate quite happily in the vacuum of space.

Fuels

Fuels for fires come in many forms, but not all of them are capable of forming an explosive atmosphere – firewood for example will clearly burn, but is not capable of causing an explosion. Explosive atmospheres may be formed by fuels in the following forms (note again that explosives are excluded):

- Flammable Gases

A flammable gas is a substance that is in its gaseous phase at ambient temperature and pressure that will burn when mixed with oxygen in the correct proportions and ignited. Examples include Hydrogen (H_2), Methane (CH_4) and Propane (C_3H_8).

Propane is the main component in the gas that we use for barbeques. When we purchase it in cylinders it has been highly compressed, to the point that it becomes a liquid. This is done because in its liquid phase it takes up much less space and is easier to transport. When we allow the propane to return to ambient pressure by opening the valve at the top of the cylinder the liquid rapidly evaporates and escapes as a gas. We therefore consider propane to be a gas, not a liquid – we store it in its liquid form for convenience by keeping it under pressure.

- Flammable Vapours

Flammable vapours are the vapours given off by flammable liquids. When a flammable liquid such as petrol burns, it is the vapours that the liquid gives off that burn, not the liquid itself. The amount of vapour that a liquid gives off depends on the temperature of the liquid – as a liquid is heated it gives off more vapour. The lowest temperature at which a liquid gives off enough vapour for the vapour to form an explosive mixture is called the Flashpoint of the liquid. A flammable liquid is defined as a liquid that has a Flashpoint of 61 ^{o}C or lower. Examples include petrol, methylated spirits, turpentine and ethanol.

Liquids that have Flashpoints of above 61 ^{o}C do give off flammable vapours, but at typical ambient temperatures they are unlikely to give off sufficient vapours to form an explosive atmosphere, so we don't generally find that they cause hazardous areas (unless they are being heated to within six degrees of their Flashpoint, or are dispersed as a mist – see below). They are called combustible liquids. Examples include diesel and fuel oil.

- Flammable Mists

A mist is a spray of fine droplets. A mist of flammable liquid will be explosive, which is not surprising, but an interesting effect is observed with mists of combustible liquids. When a combustible liquid (i.e. a liquid with a Flashpoint of greater than 61 ^{o}C) is atomised, forming a

mist, the increased surface area of all the tiny droplets of liquid may allow sufficient vapour to evolve for the mist to become explosive, even though its temperature may be below flashpoint. If there is a process condition that could create such a mist then the area may be considered hazardous, even though the liquid itself would not normally give rise to an explosive atmosphere.

- Combustible Dusts

A dust is defined as a substance having a particle size of less than 500 microns (0.5mm). If such a dust can burn or glow in air, is capable of being suspended in the air as a cloud and will settle out of the air under its own weight then it is a combustible dust. Such dusts will form explosive atmospheres if raised into clouds with sufficiently high concentrations. Examples of substances that will form combustible dusts if finely ground include, flour, sugar, coal and most metals.

- Combustible Fibres and Flyings

Combustible flyings are substances, including fibres, having a nominal particle size of greater than 500 microns that can burn or glow in air, are capable of being suspended in the air as a cloud and will settle out of the air under their own weight. Fibres are characterised by a high ratio of length to thickness, or, to put it in English, they are long and thin. Most organic and synthetic fibres are combustible and will form explosive atmospheres if dispersed in air in sufficient quantities. Examples of combustible fibres and flyings include cotton, wool, nylon, jute, cocoa fibre and polypropylene.

Sources of Ignition

Ignition sources are many and varied and impossible to entirely eliminate in industrial plants. They include:

- Electrical arcs and sparks (including welding arcs)
- Mechanical sparks (impact and frictional)
- Flames, such as oxy-acetylene cutters
- Hot surfaces (e.g. process heat and unintended frictional heating, particularly heat produced by failed bearings or worn components)
- Static electricity (particularly static charges produced frictionally by the motion of materials inside pipework at high velocity)
- Lightning

It is interesting to note that although the focus of this course is on ensuring the safety of the electrical equipment in the hazardous area, in the majority of industrial incidents the ignition source is of mechanical origin. Unintended frictional heat produced by failed or worn bearings, conveyor belt idlers, gearboxes and the like is one of the most common causes of fires in industry. Standards for electrical equipment for hazardous areas have been in widespread use for many years now, so electrical risks (provided we follow the standards' recommendations) are generally well controlled. In recent years there has been a push to develop similar standards for mechanical equipment. These have been adopted in Europe and the intent is that they will be adopted in Australia in due course.

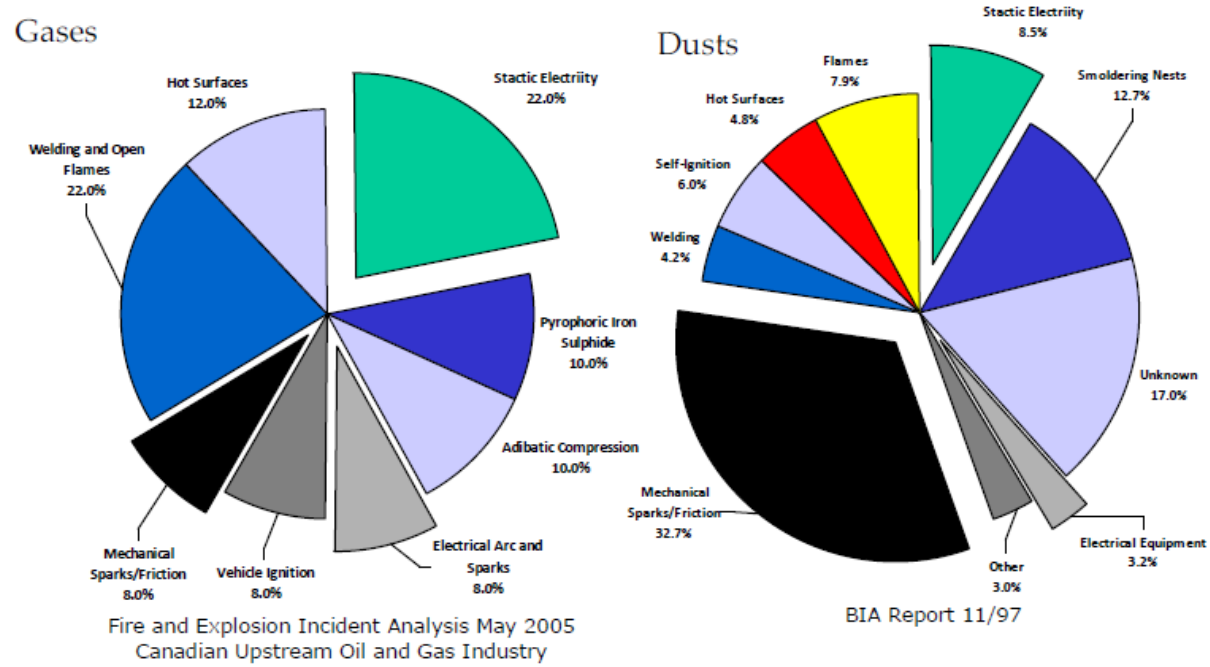

Figure 5 - Breakdown of ignition sources for fires and explosions in industry

3.2 Control Measures for Fire and Explosion Risk

All three elements of the fire triangle are required for a fire to occur, so it follows with an elegant inevitability that if we prevent the three elements from coming together at the same place and time, we will prevent fires and explosions in our facilities. By definition, in a hazardous area there is a likelihood that an explosive atmosphere (i.e. fuel and oxygen) will exist from time to time. There are also a great variety of ignition sources (electrical spark, mechanical sparks, frictional and process heating etc.) present in a typical industrial plant, so we must put control measures in place to mitigate the risk – to prevent the ignition sources and the explosive atmosphere from coinciding.

Figure 6 - Hierarchy of controls

Let's consider the control measures that are available to mitigate the explosion risk in a typical hazardous area facility, using the hierarchy of controls that is commonly used in risk management,

where the most effective controls are at the top of the pyramid and the least effective at the bottom:

Elimination:

- Eliminate fuel (not often practical in plants where the fuel is the product, e.g. Refinery)
- Eliminate ignition sources (also difficult)

Substitution:

- Substitute flammable materials for ones that are less flammable

Engineering Controls:

- Design plant to limit releases of flammables(reduce the size of the hazardous areas)
- Use explosion-protected equipment, correctly installed and maintained

Administrative controls:

- Permit systems to control introduction of ignition sources to the hazardous area
- Access controls to prevent unauthorised persons inadvertently compromising safety

Personal Protective Equipment:

- The last line of defence and not particularly effective against an explosion – better to concentrate on the higher levels of the hierarchy!

As many control measures as possible should be employed to ensure safety in hazardous area facilities, but engineering and administrative controls usually provide the most options.

3.3 Explosion-Protected Electrical Equipment Introduction

One of the most commonly employed control measures in hazardous area facilities is the use of explosion-protected electrical equipment. This is electrical equipment that has been specially designed to ensure that the three elements of the fire triangle do not come together (in most cases) in the course of the operation of the equipment.

This is achieved by the use of one or more recognised Equipment Protection Types. The protection types are indicated by a letter, used in conjunction with the prefix “Ex,” for example “Ex d” indicates a flameproof enclosure. The table below gives a brief overview of the most common types and a brief description of how they work (i.e. how they achieve separation between the elements of the fire triangle).

Method of Protection	Symbol	Name
Exclusion – excluding the fuel/air mixture so it cannot come into contact with any ignition sources present in the equipment.	Ex t	Protection by Enclosure
	Ex m	Encapsulation
	Ex q	Sand Filling
	Ex p	Pressurisation
	Ex o	Oil Filling
Explosion Containment – allowing an explosion to take place within the enclosure but preventing it from being transmitted to the outside	Ex d	Flameproof Enclosure
Energy Limitation –ensuring that any sparks produced will not have enough energy to ignite the explosive atmosphere.	Ex i	Intrinsic Safety
Avoidance of Ignition Source – equipment is designed to avoid electrical arcs and hot surfaces.	Ex e	Increased Safety
	Ex n	Non-Sparking
Dilution – adding fresh air to dilute the concentration of fuel to the point that the atmosphere is non-explosive.	Ex v	Protection by Ventilation

Obviously the explosion protected equipment will only provide protection if it is properly installed and maintained. The installation and maintenance requirements, along with the techniques for working safely in the hazardous area while carrying out the job, are the primary subject of this course.

4 QUIZ

1. Which of the following is the correct definition for a “Hazardous Area” according to AS/NZS 60079.14?

   a) An area in which there are, or could be expected to be, toxic chemicals in quantities sufficient to require protective equipment for personnel.

   b) An area in which danger to personnel is present for an average of 5 hours or more over a 40 hour working week.

   c) An area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

   d) An area in which confined spaces are present.

   /1 mark

2. Which of the following facilities would you expect to contain hazardous areas?

   a) Commercial bakery

   b) Service station

   c) Plastics manufacturing plant

   d) All of the above

   /1 mark

3. Where hazardous areas exist, who is *responsible* for ensuring that the area is properly classified?

   a) A competent person or body

   b) The employees at the site

   c) The site owner/occupier

   d) None of the above

   /1 mark

4. Compliance with AS/NZS 3000, “The wiring rules,” is mandatory in -

a) All states and territories of Australia

b) All states and territories of Australia, but with exemptions for mines, quarries and petroleum leases in some states

c) All states of Australia, but not its territories

d) All states and territories of Australia except Tasmania

/1 mark

5. For electrical installations in hazardous areas, AS/NZS 3000 Amendment 2 requires compliance with:

a) AS/NZS 60079.14

b) AS/NZS 60079.17

c) AS/NZS 2381.1

d) AS/NZS 61241.14

e) Both a) and b)

f) Both c) and d)

/1 mark

6. According to AS/NS 60079.14, what is required of persons working with electrical equipment in hazardous areas?

a) They must hold an electrical licence.

b) They must be responsible.

c) They must be competent to do the work required of them.

d) They must comply with safe work and permitting procedures in force at the sites they are working on.

/1 mark

7. Which of the following is NOT required for a fire or an explosion to take place?

a) Oxygen

b) Fuel

c) Ignition Source

d) None of the above (i.e. they are all required)

/1 mark

8. Which of the following sources of fuel could create an explosive atmosphere (assuming standard ambient conditions)? Circle all that apply.

a) Flammable liquids (Flashpoint < 61^{o}C)

b) Combustible liquids (Flashpoint > 61^{o}C)

c) Flammable gases

e) Combustible dusts

/1 mark

9. Which of the following is true of flammable vapours, but NOT true of flammable gases?

a) They are lighter than air.

b) They must be pressurised to liquefy them at room temperature.

c) They may be toxic.

d) They can exist in contact with their liquid phase at ambient temperature and pressure.

/1 mark

10. Match the method for constructing explosion protected electrical equipment with the description of how it works (draw lines to connect the term to its description).

Exclusion	Allowing an ignition to take place inside an enclosure but preventing it from escaping to ignite an external explosive atmosphere.
Explosion Containment	Providing sufficient fresh air to ensure that the concentration of flammable gas/vapour is kept below the explosive range.
Energy Limitation	Ensuring that the equipment does not produce any arcs, sparks or hot surfaces.
Avoidance of Ignition Source	Preventing a fuel/air mixture from entering the enclosure.
Dilution	Ensuring that there is not enough energy available in a circuit to produce a spark big enough to ignite the explosive atmosphere.

/1 mark