

Workplace Health and Safety Bulletin



Handling and Storage of Flammable Materials at the Work Site

What are flammable materials

Flammable materials are substances that can ignite easily and burn rapidly. They can be common materials that are at most work sites in gas, liquid and solid forms. Some examples of flammable materials include:

Gases — Natural gas, propane, butane, methane, acetylene, carbon monoxide, hydrogen sulphide. Flammable gases are usually gases with a lower explosive limit of less than 13 percent in air, or have a flammable range in air of at least 12 percent. For example, butane is a flammable gas because its lower explosive limit in air is 20 percent. Carbon monoxide has a lower explosive limit of 13 percent and upper explosive limit of 74 percent in air, it is flammable over a range of 61 percent.

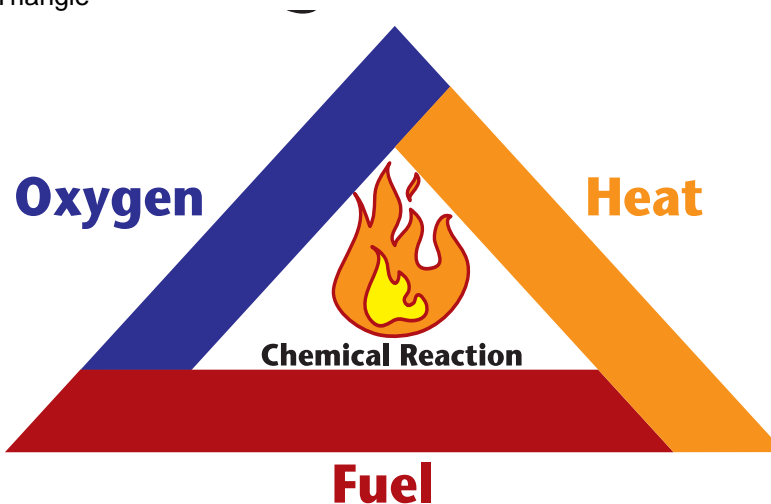
Liquids — Gasoline, many solvents such as acetone, alcohols and toluene, paints and paint thinners, adhesives, degreasers, cleaners, waxes and polishes. Flammable liquids have a flashpoint below 37.8⁰C (100⁰F).

Solids — Some types of coal, pyrophoric metals (metals that burn in contact with air or water, such as sodium and potassium) solid wastes that are soaked with flammable liquids (rags, paper, spill clean up products), gunpowder, matches.

How do fires occur

For a fire to occur, there are three elements that must come together at the same time and in the right proportions, fuel, heat (ignition source) and oxygen. Remove any of the elements and the fire will go out. The “fire triangle” is commonly used as a model to understand how a fire starts and how it can be prevented.

Figure 1 Fire Triangle



Fuel — Fuels are flammable or combustible materials and can be gases, liquids or solids.

Heat — These are ignition sources and include an open flame, lit cigarette and sparks (such as from electrical current and static electricity shorts). A chemical reaction that creates heat can also ignite a fuel and oxygen mixture.

Oxygen — The most common source of oxygen is air, but oxygen can also come from chemicals called oxidizers. Examples of common oxidizers are some types of acids and chemicals such as chlorine, chlorine dioxide, potassium permanganate and potassium chlorate.

The spread or propagation of fire is also dependant on a fourth factor, the chemical chain reactions that occur after the fire is started.

Fire prevention consists of making sure that the three legs of the fire triangle never meet. It is important to note that a fire will not always start even when the legs of the triangle meet unless all three elements are present in right amounts. For example, vapours from a flammable liquid must be mixed with a certain amount of air and exposed to the right amount of heat to ignite and burn.

Once vapours from a flammable liquid have ignited, the flames may “flash-back”. This means the flames travel back, through the vapour-air mixture, to the container or source of the flammable liquid. This can create an explosion. Most flammable liquids produce vapours that are heavier than air. Some flammable gases are also heavier than air. These gases and vapours can spread a considerable distance along the ground or floor and be ignited by a distant spark or flame or source of heat.

Certain chemicals such as organic peroxides (e.g. benzoyl peroxide) contain both fuel and oxygen. Special extra attention is needed for the safe handling and storage of these materials.

Other hazards from flammable materials

In addition to the danger of fire, flammable materials may themselves present a health hazard. This can occur at air concentrations well below those needed to create a fire hazard. For example, the lower explosive limit for acetone is 2.5 percent acetone in air (about 25,000 parts per million), however workers can experience health effects such as irritation and intoxication at concentrations of 1,000 parts per million. Flammable gases such as carbon monoxide and hydrogen sulphide are toxic at very low concentrations.

Most vapours from flammable liquids are heavier than air and will accumulate near the ground. They can displace the air. When there is not enough air or oxygen, there is a hazard of asphyxiation (suffocation).

When flammable materials burn, toxic gases and vapours are produced. Combustion products can include chemicals such as carbon monoxide, hydrogen cyanide and nitrogen oxides. If the substance burning contains chlorine, other irritating and toxic chemicals, such as acrolein and hydrogen chloride, can be produced.

Common terms

Autoignition temperature — Lowest temperature at which a flammable material will ignite on its own and burn without the introduction of a flame or spark (ignition source). Heating a flammable material to its autoignition temperature in a normal atmosphere will cause it to ignite and burn (for example, splashing a flammable liquid onto a hot surface such as an exhaust header can result in a fire).

BLEVE — This is a type of pressure release explosion (boiling liquid expanding vapour explosion). It occurs when liquid containers fail (crack or rupture) due to fire.

Combustible liquid — A liquid with a flashpoint between 37°C (100°F) and 93°C (200°F). Kerosene and mineral spirits are examples of combustible liquids.

Endothermic reaction — A chemical reaction that absorbs heat.

Exothermic reaction — A chemical reaction that gives off heat.

Explosion — The very rapid build up and release of pressure resulting from the ignition of flammable gases or flammable liquid vapours in an enclosed container or space. Explosions usually occur in situations where fuel and air have been allowed to mix in the container or space before ignition so the combustion reaction occurs very quickly. The tendencies of the pre-mixed gases to expand on burning will cause a quick rise in pressure in the container which will result in damage to the container unless proper pressure venting occurs.

Flammable range — The minimum and maximum concentration range of a flammable vapour in air that can ignite on contact with an ignition source.

Flashpoint — The lowest temperature at which a flammable or combustible liquid gives off enough vapour to form an ignitable mixture with air, since it is the vapour, not the liquid, which burns. The lower the value, the more easily the material will burn. Hot combustible liquids can generate as much flammable vapour as cold flammable liquids.

Ignition point — The minimum temperature at which a flammable or combustible liquid gives off enough vapour to form a sustained ignitable mixture with air.

Lower Explosive Limit (Lower Flammable Limit) — Minimum concentration of a flammable vapour in air that will burn. Below the LEL, the mixture is too “lean” to burn (too little fuel).

Oxidizer — Oxygen or other substances capable of releasing oxygen. Generally, oxygen levels above 16 percent in air are needed to support combustion. In oxygen rich environments (above 21 percent), burning will be intensified.

Pyrolysis — Decomposition or transformation of a compound caused by heat.

Upper Explosive Limit (Upper Flammability Limit) — The maximum concentration of a flammable vapour in air that will burn. Above the UEL, the mixture is too “rich” to burn (not enough oxygen).


Vapour pressure — A measure of a liquid’s ability to evaporate. The higher the vapour pressure, the higher the evaporation rate resulting in more vapours being produced. Flammable liquids tend to have high vapour pressures.

Work procedures and training

The employer must develop work procedures for the use and storage of flammable materials and ensure workers are trained on these procedures. Because of the potential fire hazard, the employer will also need to have additional procedures in place to deal with fires and spills. Work procedures should address:


- storage
- dispensing
- spill clean up
- incompatible materials
- use and maintenance of engineering controls used in the workplace (such as ventilation)
- required personal protective equipment for handling flammable products
- fire protection and prevention
- special circumstances (e.g. confined spaces, hot work) which may require additional precautions and training

Good references that provide additional information that can be used for training are:

 <http://municipalaffairs.gov.ab.ca/fco/docs/flammableliquids.doc>
Fire Facts: Flammable Liquids

 www.municipalaffairs.gov.ab.ca/mahome/fco/doc/FireFacts/naturalgas.doc
Fire Facts: Propane

These documents are also available from the Alberta Municipal Affairs, Fire Commission's Office at (780) 427-8392 or by email at firecomm@gov.ab.ca

 Alberta Fire Code: Part 4 (Flammable and Combustible Liquids) and Part 5 (Hazardous Processes and Operations) provide some of the specific legal requirements for storage, dispensing, use and handling of flammable liquids and gases in Alberta.

 Canadian Natural Gas Code

 Canadian Propane Gas Code

The above 3 documents are often available at your local fire department or in libraries. Further information on their content and on purchasing copies can be obtained from the Safety Services Branch of Alberta Municipal Affairs at 1-866-421-6929 or by email at safety.services@gov.ab.ca

The Alberta Fire Code can be purchased online from the Learning Resources Centre at www.lrc.learning.gov.ab.ca/pro/resources/item.htm?item-no=362202 or in CR-ROM form from the National Research Council Canada at http://irc.nrc-cnrc.gc.ca/pubs/codes/nrcc41504_e.html

📖 “*Fire Protection, A Health and Safety Guideline for your Workplace*” available from the Ontario Accident Prevention Association online at www.iapa.ca/pdf/firepro.pdf

Storage of flammable materials

In general, flammable materials must not be stored near exits, electrical equipment or heating equipment. They should always be stored in a separate, well-ventilated storage area, away from potential sources of ignition. If the material is removed from its original container, it must be placed into a container that is appropriate for flammable materials.

Portable storage containers for flammable liquids

When flammable liquids are transferred from their original container (one they were purchased in), or from bulk storage such as a drum or tank, it is important that the proper type of portable container be used. Containers that are approved for the use and storage of “portable quantities” are usually made of metal or plastic, are vapour-proof and have:

- welded seams,
- spark or flame arrestors,
- pressure release valves or spring closing lids with spout covers.

At Alberta work sites, portable storage containers for flammable liquids must meet one of these standards:

📖 Underwriter’s Laboratories of Canada, ULC/ORD-C30-1995, *Safety Containers*

- 📖 Canadian Standards Association, B376-M1980-R2003, *Portable Containers for Gasoline and Other Petroleum Fuels*
- 📖 NFPA Standard 30, *Flammable and Combustible Liquids Code*, 2003 Edition

Container volume restrictions are summarized in Table 1.

Table 1 Flammable Liquid Container Sizes

Type	Maximum volume (litres)	Comments
Glass	5	Glass containers may be used for liquids where the purity of the liquid would be affected if it were stored in a metal or plastic container (e.g. laboratory chemicals).
Plastic	25	Container constructed in accordance with ULC or CSA Standards
Metal	25	Container constructed in accordance with ULC or CSA Standards

Section 4 of the Alberta Fire Code has requirements for the storage, handling, use and processing of flammable and combustible liquids in buildings, structures and open areas. Additional information is also provided on the maximum amounts of flammable liquids that may be stored in buildings.

Portable containers must be properly labelled. The labelling should include the following information:

- container contents
- the contents are flammable
- the container should be kept away from ignition sources (heat, spark, open flames)
- the container should be kept closed when not in use
- a reference to the material safety data sheet for the product.

Storage cabinets

When individual containers of flammable liquids are not in use, and are stored inside a building, they should be stored in a storage cabinet. Storage cabinets should meet the requirements in the Standard ULC-C1275-1984, *Guide for the Investigation of Storage Cabinets for Flammable Liquid Containers*. Up to 500 L of flammable and

combustible liquids may be stored in each cabinet, however no more than half of the total volume (up to 250 L) can be flammable liquids. The Alberta Fire Code provides additional restrictions on the total number of cabinets that may be present in a room or area of the work site.

Storage tanks and rooms

At some work sites, there are many different types of flammable materials or large volumes of particular materials used. At these sites, flammable materials may be stored in large containers (drums or tanks) or there may be a specific flammable material storage room. The specific requirements for most underground and above ground storage tanks and storage rooms in Alberta are described in the Alberta Fire Code. Facilities, well sites and pipelines approved or licensed by the Alberta Energy and Utilities Board for exploration, production, recovery, handling, processing, treatment, disposal or transmission of hydrocarbons are covered by “*Guide 55: Storage Requirements for the Upstream Petroleum Industry*”. This guide is available online at

 www.eub.gov.ab.ca/bbs/products/guides/g55.pdf

In general:

- Do not store other types of chemicals beside bulk storage containers for flammable materials or in storage rooms for these products.
- Bulk storage containers should be located away from potential ignition sources such as heat, sparks or open flames.
- Do not store compressed gases beside flammable material containers.
- Bulk storage areas should be equipped with spill protection.
- Bulk storage areas and rooms must have appropriate signage or placarding.
- Smoking should never be allowed near flammable material storage areas.
- Drums or large containers of flammable materials should never be stored beside exits or in a way that blocks access.
- Make sure that storage rooms have properly designed ventilation systems that are regularly maintained.

Flammable gases

Flammable gases stored in cylinders are usually at very high pressures, so their uncontrolled release can present both physical and flammability hazards. A small amount of the released gas can fill a large area with a potentially explosive concentration very quickly. This is particularly the case with liquefied gases such as Liquefied Petroleum Gas (LPG).

When storing flammable gas in the workplace:

- store flammable gas cylinders in a separate well ventilated room
- do not store flammable gas cylinders with oxygen cylinders
- ensure that cylinders are properly secured so that they cannot fall over and valves protected from damage
- always use the correct fittings and valves for the specific cylinder, do not mix and match fittings
- protect hoses, connections and containers from damage and inspect them regularly for signs of wear.

Part 3 of the Alberta Fire Code, the Canadian Natural Gas Code and the Canadian Propane Code have additional requirements for the indoor and outdoor storage of compressed flammable gases.

Handling flammable materials

Fire prevention

To prevent fires, flammable materials must be properly managed in the workplace. There are three main ways to prevent fires:

- (1) Limit the amounts of flammable and combustible materials
 - Keep only what you need on-site
 - Purchase materials in the smallest volumes necessary
 - At work locations, keep only those chemicals that are needed for the present task
 - Do not let hazardous wastes accumulate at the work site
 - Store products, including wastes, used at the work site in proper containers
 - Keep flammable materials separate from other processes and storage areas

- (2) Provide proper ventilation to ensure flammable vapours do not accumulate
- Install properly designed ventilation in storage area
 - Ensure that processes that use or make flammable materials do not exhaust back in the work site
 - Ensure that equipment, such as spray booths, where flammable materials are used, are exhausted outside of the building, and away from air intakes
 - Ventilation systems must be properly maintained and comply with the Alberta Building Code
- (3) Control ignition sources
- Ground and bond all work and ignition-proof equipment
 - Ensure that there is no smoking in work areas where flammable materials are stored or used
 - Never store flammable materials near hot equipment or open flames
 - Use intrinsically safe and non-sparking tools

It is important that the employer assess the work site and identify potential fire hazards. This will allow the employer to identify the best ways to control these hazards.

For more information

The Canadian Association of Petroleum Producers (CAPP) has published a document entitled “*Flammable Environments Guideline*” which is available online at:

 www.capp.ca/raw.asp?x=1&dt=NTV&e=PDF&dn=81688

The Industrial Accident Prevention Association has a number of publications on fire safety available online at:

 www.iapa.ca/resources/resources_downloads.asp#fire

Alberta Municipal Affairs provides a number of helpful links for fire safety standards and legislation at:

 http://municipalaffairs.gov.ab.ca/ss_ss-standata.htm

Incompatible materials

Incompatibility is when undesirable and unplanned chemical reactions occur between two or more chemicals or materials. When incompatibility reactions occur, they can produce hazards such as:

- heat or pressure,
- fire or explosion,
- violent reaction,
- toxic dusts, mists, fumes or gases,
- flammable fumes or gases.

Chemicals can usually be grouped into five main categories; flammable/combustible, acid, alkaline or basic, oxidizer and reactive. These groups are incompatible with each other and must be stored separately. Table 2 provides some examples of incompatible materials, that, when mixed together, can create a fire or explosion hazard.

Table 2 Examples of Incompatible Materials

A	+	B	=	C
Acids or bases (Corrosives)		Reactive metals such as <ul style="list-style-type: none"> ▪ aluminum ▪ beryllium ▪ calcium ▪ lithium ▪ potassium ▪ magnesium ▪ sodium ▪ zinc powder 		Fire
Solvent or reactive organic materials such as <ul style="list-style-type: none"> ▪ alcohols ▪ Aldehydes ▪ nitrated hydrocarbons 		Acids Bases Reactive metals		Explosion
Flammable liquids		Acids Bases Oxidizers Poisons		Fire Explosion or Violent reaction
Flammable compressed gases		Oxidizers		Fire Explosion or Violent reaction
Cyanide and sulphur mixtures		Acids		Fire
Oxidizers such as <ul style="list-style-type: none"> ▪ chlorates ▪ chlorine ▪ chorites ▪ chromic acid ▪ hypochlorites ▪ nitrates ▪ perchlorates ▪ permanganates ▪ peroxides 		Flammable liquids Flammable solids Flammable or combustible wastes		Explosion

Static electricity

Static electricity is an electric charge that cannot move. It is created when two objects or materials that are in contact with each other are separated. While the objects are in contact, the surface electricity charges try to balance each other. When the objects are separated, they are left with either an excess or shortage of electrons, causing them both to become electrically charged. If these charges do not have a path to the ground, they are unable to move and becomes “static”. If static electricity is not quickly removed, the charge will build up. Eventually, it will develop enough energy to jump as a spark to some nearby less highly charged object. In an explosive or flammable atmosphere, the spark can set off an explosion or fire. The danger is greatest when flammable liquids are being poured or transferred.

Static electricity can be produced by:

- non-polar liquid flowing through a pipe or hose (e.g. hydrocarbons)
- spraying
- blending or mixing
- filling containers or tanks
- movement (and friction) between materials
- movement of dry powdered material through chutes or conveyors
- movement of non-conductive conveyor belts or drive belts
- appliances that are plugged into electrical outlets
- flipping a light switch on or off.

Static electricity can be controlled by:

- bonding and grounding
- humidification
- static collectors
- additives

Bonding and grounding

Bonding and grounding are techniques that are used to prevent sparks (a source of ignition) from being created when liquids are transferred between containers.

Bonding is when there is an electrical connection between two or more conductive containers. Bonding ensures that the containers have the same electrical charge. Without a difference in charge or “electrical

potential”, a spark cannot be created that jumps from one container to another. Bonding also includes when parts of equipment and containers that are electrically separated (for example, by gaskets or caulking compounds) are connected. Bonding does not eliminate the static charge which is why it is used in combination with grounding.

A container is grounded when there is an electrical connection between the container and the earth. Grounding quickly drains away the static charge.

Humidification

Keeping relative humidity between 60 and 70 percent at 21⁰C may stop paper or layers of cloth and fibres from sticking together. However, high humidity may not prevent the accumulation of static electricity and should not be relied upon solely where there are flammable liquids, gases or dusts present.

Static collectors

These are devices that are used on moving equipment parts and non-conductive materials such as plastic film. Some examples include metallic tinsel bars and spring copper brushes. They work by capturing the static discharge. To work properly, these devices must be properly grounded.

Additives

Anti-static additives can be added to some flammable liquids. The additive changes the electrical properties of the liquid.

For more information

The Ontario Industrial Accident Prevention Association has a guide on static electricity online at:

 www.iapa.ca/pdf/2004_feb_Static%20Electricity.pdf

The Department of Labour, New Zealand has also published a document entitled “Guideline for the Control of Static Electricity in Industry” available online at:

 www.osh.govt.nz/order/catalogue/pdf/staticelectricity.pdf

Inerting

An “inert” atmosphere usually refers to an environment where there is little or no oxygen and which contains mostly non-reactive gases. Nitrogen, argon, helium and carbon dioxide are commonly used to create an inert atmosphere. An inert atmosphere protects against fire or explosion by removing or reducing the amount of oxygen present. Inerting is often used to remove flammable vapours and gases from tanks or other confined spaces before workers enter.


It is important to remember that this technique can itself create hazards to workers. Workers who enter a confined space that has been inerted can be quickly overcome by simple asphyxiation due to lack of oxygen unless they are provided with supplied air respirators. In addition, LEL meters will not read properly when oxygen levels are less than about 10 percent. Without enough oxygen, these meters can give an incorrect low reading even if flammable vapours and gases still remain.


Personal protective equipment

If it is not practicable or feasible to use engineering or administrative controls to reduce the potential for exposure, or if these measures are not sufficient, the employer must ensure that workers have appropriate protective equipment. This may include a respirator to protect from airborne vapour concentrations above occupational exposure limits, fire retardant clothing, protective gloves, chemical goggles to prevent injury to the eyes from chemical splashes or protect from fire or airborne vapours, and personal gas detectors.

For more information on respirators:


 http://industry.alberta.ca/documents/WHS/WHS-PUB_ppe004.pdf
Guideline for the Development of a Code of Practice for
Respiratory Protective Equipment – PPE004

 http://industry.alberta.ca/documents/WHS/WHS-PUB_ppe001.pdf
Respiratory Protective Equipment: An Employers' Guide – PPE001

 http://industry.alberta.ca/documents/WHS/WHS-PUB_mg005.pdf
Medical Assessment of Fitness to Wear a Respirator – MG005

Employers should also refer to the CSA Standard Z94.4-02, *Selection, Use and Care of Respirators*.

For more information on protective eyewear:

 www3.gov.ab.ca/hre/whs/publications/pdf/eyeinja.pdf
Eye Injury Prevention in Industry

More information on protective clothing materials recommended for various flammable solvents is available from the National Institute of Occupational Safety and Health (NIOSH) database “Recommendations for Chemical Protective Clothing”. The database is available online at:

 www.cdc.gov/niosh/ncpc/ncpc2.html

Although the use of personal protective equipment may initially seem to be less costly, there will be ongoing maintenance and training costs. Workers need to be trained on the protective equipment they are using. Employers need to monitor use and ensure the protective equipment is properly maintained. In some cases, personal protective equipment can create a hazard to workers, e.g. heat stress, limited vision, allergic reactions to the equipment material. These issues need to be evaluated when personal protective equipment is selected.

Occupational Health and Safety (OHS) legislation

Section 15 of the Alberta *Occupational Health and Safety (OHS) Regulation* requires an employer to ensure that procedures are established to minimize worker exposure to “harmful substances” at the work site. A harmful substance is defined in Section 1 of the Regulation as “*a substance that, because of its properties, application or presence, creates or could create a danger, including a chemical or*

biological hazard, to the health and safety of a worker exposed to it.” Flammable substances are included under the definition of a harmful substance. Workers must be provided with training on the procedures developed by the employer and apply that training at the work site. Workers must participate in the training and follow the procedures established by the employer.

Part 2 of the Alberta OHS Code requires an employer to assess the hazards at the work site. Hazards that are identified must be eliminated or controlled.

If there may be emergencies at the work site that involve fires or explosions, the employer must develop an emergency response plan that includes the elements specified in Part 7 of the OHS Code.

Specific health and safety requirements for fire and explosion hazards can be found in Part 10 of the OHS Code. At a work site no person may:

- work or enter a work area where the LEL is greater than 20 percent, except for competent workers responding to an emergency,
- smoke or use an open flame in an area of the work site where a flammable material is stored, handled or processed,
- mix, clean with or use a flammable or combustible liquid at a temperature above its flashpoint in an open vessel if there is a potential ignition source nearby, and
- use a flammable or combustible liquid at a temperature above its flashpoint for washing or cleaning except in cleaning equipment specifically designed and manufactured for this purpose.


Part 10 of the OHS Code, also includes additional requirements that address:

- storage container standards,
- contamination of clothing or skin with a flammable substance,
- protection in locations that are hazardous locations as described in the *Canadian Electrical Code*,
- use, location and operation of internal combustion engines and industrial furnaces,
- hot work and hot taps,
- spray operations,
- storage of compressed and liquefied gas, and
- welding services.

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Workplace Health and Safety



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