CHEMICAL HAZARDS

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A. Hazard Identification and Control Review

My Chemical Song (or Poem)

Detailed information on the legislated requirements for hazard assessment is included in the chapter on legislation. Detailed information on the process for identifying and controlling hazards and sample hazard assessment forms are included in the chapter on health and safety management systems. A brief overview is provided here to reinforce the importance of the basic principles of hazard identification, assessment and control.

What is a Hazard?

A **hazard** is any situation, condition or thing that may be dangerous to the safety or health of workers.

(OHS Code Part 1)

Identifying Hazards

Where's the hazard?

The first step in preventing incidents, injuries or illness in the workplace is identification of all the hazards within the workplace that could cause injury or illness. In Alberta, the employer is responsible for conducting an overall hazard assessment in the workplace (Alberta OHS Code, Part 2); however, all workers should be able to recognize and identify hazards in the workplace on an ongoing basis. As work conditions change, so may the hazards. It is essential that workers be alert and aware of their surroundings at all times.

Controlling Hazards

Hazard Control

The hierarchy of controls applies to all types of hazards and is outlined below.

Whenever possible, hazards should be **eliminated**. If this is not possible, hazards must be controlled. **Control** means reducing the hazard to levels that do not present a risk to worker health. Controls, in order of preference, include:

- Engineering Controls
- Administrative Controls
- Personal Protective Equipment (PPE) (Used only when other levels of control are not possible or if additional protection is required to ensure the health and safety of workers.)

B-Overview.ppt
Slide 1

B. Chemical Hazards Overview

Everything in the physical world around us is made of chemicals. The earth we walk on, the air we breathe, the food we eat, the cars we drive and the houses we live in are all made from chemicals. Living organisms, such as plants, animals and humans are also made of chemicals.

Some of the chemicals we use in our daily lives are man-made. These include some drugs, cosmetics, workplace chemicals and household cleaning products. Many more of the chemicals that we are exposed to each day occur naturally and are found in our food, in the air and in water. There are far more natural chemicals in our environment than man-made ones. Both man-made and natural chemicals can be hazardous but even the most toxic chemicals can be used and handled safely, if the proper controls are in place.

This chapter covers the following topics:

- What are chemical hazards?
- How are we exposed to chemical hazards?
- How can we protect ourselves from chemical hazards?
- How are chemical hazards identified?

C. Types of Chemical Hazards

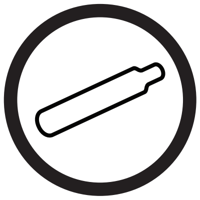
Chemical hazards can be divided into six general types:

- compressed gases
- flammable and combustible chemicals
- corrosive chemicals
- poisons/toxins
- oxidizing chemicals
- dangerously reactive materials

These six general types are consistent with the WHMIS classification of controlled products. More information on WHMIS is found starting on page 50.

While all chemicals have potential hazards associated with them, when proper health and safety procedures are followed, any chemical can be worked with safely.

Compressed Gases



There are three main groups of compressed gases stored in cylinders: liquefied, nonliquefied and dissolved gases. The pressure of the gas in the cylinder is usually given in kilopascals (kPa) or pounds per square inch gauge (psig).

Gauge pressure = total gas pressure inside cylinder – atmospheric pressure

Ballon Air Jack

Atmospheric pressure is usually about 101.4 kPa (14.7 psi) but can vary, depending on elevation. A compressed gas cylinder with a pressure gauge reading of 0 kPa or 0 psig is not really empty. It still contains gas at atmospheric pressure.

Liquefied Gases

Liquefied gases are gases that can become liquids when they are inside cylinders under pressure. They exist inside the cylinder in a liquid-vapour balance or equilibrium. Initially, the cylinder is almost full of liquid and gas fills the space above the liquid. As gas is removed from the cylinder, enough liquid evaporates to replace it, keeping the pressure in the cylinder constant. Anhydrous ammonia, chlorine, propane, nitrous oxide and carbon dioxide are examples of liquefied gases.

Nonliquefied Gases

Nonliquefied gases are also known as compressed, pressurized or permanent gases. These gases do not become liquid when they are compressed at normal temperatures, even at very high pressures. Examples of these are oxygen, nitrogen, helium and argon.

Dissolved Gases

Acetylene, used in oxy-acetylene welding, is the only commonly used dissolved gas. Acetylene is chemically very unstable. Even at atmospheric pressure, acetylene gas can explode. Nevertheless, acetylene is routinely stored and used safely in cylinders at high pressures. This is possible because acetylene cylinders are packed with an inert, porous filler. The filler is saturated with acetone or another suitable solvent. When acetylene gas is added to the cylinder, the gas dissolves in the acetone. Acetylene in solution is stable.

C-Types.ppt
Slide 1

Hazards of Compressed Gases

High Pressure

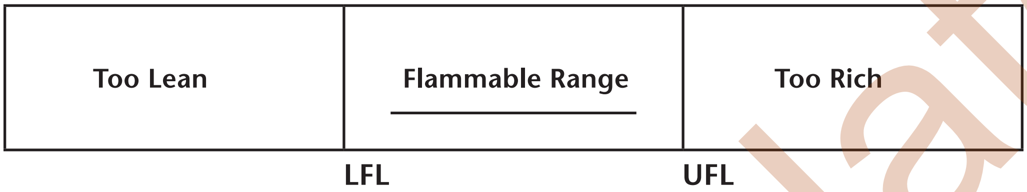
All compressed gases are hazardous because of the high pressures inside the cylinders. Gas can be released deliberately by opening the cylinder valve or unintentionally from a broken or leaking valve. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder.

There have been many cases where damaged cylinders have become uncontrolled rockets or pinwheels and have caused severe injury and damage. This danger has happened when unsecured, uncapped cylinders were knocked over, causing the cylinder to rupture or the cylinder valve to break and allow high-pressure gas to escape rapidly. Most cylinder valves are designed to break at a point with an opening of about 0.75 cm (0.3 inches). This design limits the rate of gas release and reduces cylinder velocity. This limit may prevent larger, heavier cylinders from rocketing but smaller or lighter cylinders might still take off.

Poorly controlled release of a compressed gas in chemical reaction systems can cause vessels to burst, create leaks in equipment or hoses, or produce runaway reactions.

Flammability

Many compressed gases are flammable. If the gas is mixed with air in the correct proportions, the gas will ignite and continue to burn. Each flammable gas has an upper flammable limit (UFL) and a lower flammable limit (LFL). If the concentration of the flammable gas is between its LFL and UFL, it is in the flammable range. For example, the LFL of hydrogen gas in air is 4% and its UFL is 75%. This means that hydrogen can be ignited when its concentration in the air is between 4 and 75%. A concentration of hydrogen below 4% is too "lean" to burn. Hydrogen gas levels above 75% are too rich to burn.



A commonly used flammable gas is propane.

Oxidizers

Oxidizing gases include gases that contain oxygen at higher than atmospheric concentrations (i.e., above 23%), nitrogen oxides and halogen gases, such as chlorine and fluorine. These gases can react rapidly and violently with combustible materials, including:

- organic (i.e., carbon-containing) substances, such as most flammable gases, flammable and combustible liquids, oils, greases, many plastics and fabrics
- metal dusts
- other oxidizable substances, such as hydrazine, hydrogen, hydrides, sulfur or sulfur compounds, silicon and ammonia or ammonia compounds

The normal oxygen content in air is 21%. At higher oxygen concentrations, combustible materials, including clothing fabrics, ignite more easily and burn much faster. Fires in atmospheres enriched with oxidizing gases are very hard to extinguish and can spread rapidly.

Chemical Instability

Some pure compressed gases are chemically unstable. If exposed to slight temperature or pressure increases or mechanical shock, they can readily undergo certain types of chemical reactions, such as polymerization or decomposition. These reactions may become violent, resulting in fire or explosion. Some of these dangerously reactive gases have other chemicals, called inhibitors, added to prevent hazardous reactions.

Common dangerously reactive gases are acetylene (used in welding), 1,3-butadiene (used to make synthetic rubber) and vinyl chloride (used to make PVC plastics).

Toxicity

Many compressed gases are toxic. They can cause health problems that vary depending on the specific gas, its concentration, the length of exposure and the route of exposure.

Asphyxiation

Inert gases, such as argon, helium, neon and nitrogen, are not toxic and do not burn or explode, yet they can cause injury or death if they are present in high enough concentrations. They can displace air, reducing oxygen levels. If oxygen levels are low enough, people entering the area can lose consciousness and possibly die from asphyxiation (suffocation). Low oxygen levels can be a problem in poorly ventilated, confined spaces.

Corrosivity

Some compressed gases are corrosive. They can burn and destroy body tissues on contact. Corrosive gases can also attack and corrode metals. Common corrosive gases include ammonia, hydrogen chloride, chlorine and methylamine.

Cylinders and Fittings for Compressed Gases

Compressed gases are stored in heavy-walled metal cylinders designed, produced and tested for use with compressed gases. Cylinders are made in a wide variety of sizes and shapes. They range from small lecture bottles, often used for classroom demonstration purposes, to large cylinders over 3 m long. Cylinders must comply with the regulations of the Canadian Transport Commission (CTC). CTC regulations require certain permanent markings on every cylinder, including the specifications the cylinder meets, the designed service pressure, a serial number, inspection codes and identification of the cylinder maker or manufacturer. Cylinders for liquefied gases are also marked with the empty (tare) weight. These markings are normally stamped into the cylinder's shoulder or the top surface of its neck.

Cylinders are tested under hydrostatic water pressure when they are made. Usually, cylinders must be retested every five or 10 years. The date of each test must be stamped on the cylinder. Acetylene cylinders are not tested hydrostatically. It is too difficult to remove the water from the porous filler. Instead, they receive careful visual inspections.

Compressed gas cylinders must be connected only to regulators and equipment designed for the gas in the cylinder. Since connecting the wrong equipment can be dangerous, a number of different standard cylinder valve outlets are available for different classes of gas. For example, standard connections prevent the valve connection for a flammable gas from fitting the connections for an incompatible gas, such as an oxidizing gas.

Most compressed gas cylinders have valve caps or some other method of protecting the valve from damage during handling and transportation. A dust cap may be placed over the valve outlet to help keep it clean.

Cylinder Safety Devices

Most cylinders have one or more safety-relief devices. These devices can prevent rupture of the cylinder if internal pressure builds up to levels exceeding design limits. Pressure can become dangerously high if a cylinder is exposed to fire or heat, including high storage temperatures.

There are three types of safety-relief devices. Each relieves excessive gas pressures in a different way:

- Pressure-relief valves: these valves are usually a part of the cylinder. They are normally held closed by a spring. The force holding the valve closed is set according to the type of gas in the cylinder. The valve opens if the cylinder pressure exceeds the set safety limit. Gas is released until the cylinder pressure drops back to the safety limit. The valve then closes and the remaining gas is retained in the cylinder.
- Rupture discs (also known as frangible or bursting discs): these discs are usually made from metal. They burst or rupture at a certain pressure, releasing the gas in the cylinder. The bursting pressure is designed so that the disc ruptures before the cylinder test pressure is reached. These devices cannot be reclosed, so the entire contents of the cylinder are released.
- Fusible plugs (also called fuse or melt plugs): temperature, not pressure, activates fusible plugs. These safety devices are used where heat could initiate an explosive chemical reaction. A pressure-relief valve or rupture disc acts too slowly and too late to prevent rupture of the cylinder if an explosive reaction has already begun. The fusible plug releases the gas before the hazardous reaction can begin. Fusible plugs are made of metals that melt at low temperatures. For example, acetylene cylinders have a fusible plug that melts at about 100°C (212°F). This temperature is below the temperature at which hazardous polymerization may occur.

Not all compressed gas cylinders have safety devices. Some gases are so toxic that their release through a safety device would be hazardous. Cylinders for these gases are built to withstand higher pressures than normal cylinders. When these toxic gas cylinders are involved in a fire, the area must be evacuated.

Flammable and Combustible Materials

Flammable materials are substances that can ignite easily and burn rapidly. There are many commonly used flammable materials at most work sites. They include gases, liquids and solids, such as:

- Gases – natural gas, propane, butane, methane, acetylene, carbon monoxide and hydrogen sulphide. Flammable gases are usually gases with a lower explosive limit of less than 13% in air **or** have a flammable range in air of at least 12%. For example, carbon monoxide has a lower explosive limit of 13% and upper explosive limit of 74% in air; it is flammable over a range of 61%.
- Liquids – gasoline, many solvents (e.g., acetone, alcohols, toluene), oil-base paints, paint thinners, adhesives, degreasers, certain cleaners, waxes and polishes. Flammable liquids have a flashpoint below 37.8°C (100°F). See page 13 for an explanation of flashpoint.
- Solids – some types of coal, pyrophoric metals (i.e., metals that burn in contact with air or water, such as sodium and potassium), solid wastes that are soaked with flammable liquids (e.g., rags, paper, spill clean up products), gunpowder, matches.

Hazards of Flammable and Combustible Chemicals

Fire

The main hazard from flammable and combustible chemicals is fire. For a fire to occur, there are three elements that must come together at the same time and in the right proportions: fuel, heat 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. Fire hazards and prevention are addressed in the chapter on physical hazards.

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

Flashback

Once the vapours from a flammable liquid have ignited, the flames may flashback. 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. Many 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, flame or source of heat.

Flammable and
Combustible Materials
Mix and Match

How to Clean Up
an Oil Spill

C-Types.ppt
Slide 2

Toxicity

Many flammable and combustible chemicals are also toxic. They can be toxic at air concentrations well below those needed to create a fire hazard. For example, the lower explosive limit for acetone is 2.5% acetone in air (about 25,000 ppm) but workers can experience health effects, such as irritation and intoxication, at concentrations of 1000 ppm. Flammable gases, such as carbon monoxide and hydrogen sulfide, are toxic at very low concentrations.

Asphyxiation

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

By-products from Combustion

Toxic gases and vapours can be released when flammable and combustible products burn. Combustion products can include chemicals, such as carbon monoxide, hydrogen cyanide and nitrogen oxides. If the chemical burning contains chlorine, other irritating and toxic chemicals, such as acrolein and hydrogen chloride, can be produced.

Spontaneous Combustion

Spontaneous combustion occurs when a material in contact with air can heat up enough, on its own, to burn. The oils in some wastes can slowly react with oxygen in the air. This reaction creates heat that can build up over time if the wastes are not disturbed. When the heat level in a self-heating material is high enough, i.e., when it reaches the autoignition temperature, a fire may start.

For example, a rag soaked with vegetable oil in the bottom of a pail could heat up enough to cause spontaneous combustion of the rag. However, the same oil-soaked rag would not be expected to heat up on a clothes line because there would be enough contact with moving air to prevent heat from building up. The oil-soaked rag would not heat up if it were in a tight bale because it would not have enough air.

Common Terms Used to Describe Flammability and Combustibility

- *Auto-ignition temperature* – lowest temperature at which a flammable material will ignite on its own and burn without the introduction of a flame or spark; i.e., ignition source. Heating a flammable material to its auto-ignition temperature in a normal atmosphere will cause it to ignite and burn; e.g., splashing a flammable liquid onto a hot surface, such as an exhaust header, can result in a 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 buildup 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 premixed gases to expand on burning will cause a quick rise in pressure in the container that will result in damage to the container unless proper pressure venting occurs.
- *Flammable liquid* – a liquid with a flashpoint below 37°C (100°F). Gasoline, methanol and acetone are examples of flammable liquids.
- *Flammable range* – the concentration range of a flammable vapour or gas in air that can ignite on contact with an ignition source. If there is too much gas/vapour, and not enough air, the mixture is too rich and will not burn. If there is not enough gas/vapour, the mixture is too lean and will not burn.
- *Flashpoint* – the lowest temperature at which a flammable or combustible liquid gives off enough vapour to form an ignitable mixture with air. The lower the value, the more easily the material will burn. It is the vapour, not the liquid, that burns.
- *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; i.e., too little fuel.

- *Pyrolysis* – decomposition or transformation of a compound caused by heat, usually in the absence of oxygen.
- *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; i.e., not enough oxygen.
- *Vapour pressure* – a measure of a liquid's ability to evaporate. The higher the vapour pressure, the higher the evaporation rate, which results in more vapours being produced. Flammable liquids tend to have high vapour pressures.

Corrosive Materials

Corrosive materials are present in almost every workplace. These materials can chemically destroy exposed tissues. Corrosives can also damage or even destroy metal. They begin to cause damage as soon as they touch the surface.

Most corrosives are either acids or bases.

Acid – an acid is a chemical that donates protons or hydrogen ions and/or accepts electrons. Acids are compounds that break into hydrogen (H+) ions and another compound when placed in an aqueous (water) solution. Common acids include hydrochloric acid, sulfuric acid, nitric acid, chromic acid, acetic acid and hydrofluoric acid.

C-Types.ppt
Slides 3–4

Base – a base (or alkaline material) is a chemical that donates electrons or hydroxide ions or that accepts protons. Bases are compounds that break up into hydroxide (OH–) ions and another compound when placed in an aqueous (water) solution. Common bases are ammonium hydroxide, potassium hydroxide (caustic potash) and sodium hydroxide (caustic soda).

Corrosive, Oxidizing
and Reactive Household
Product Poster

pH – the pH scale is used to measure how acidic or basic a liquid is. It is a measure of the number of hydrogen (H+) ions in a solution. If there are a lot of H+ ions, the pH is very low and the material is acidic. If there are a lot of hydroxide ions (OH–), the number of H+ ions is low, the pH is high and the material is basic. The pH scale goes from 0 to 14. Distilled water is neutral and has a pH of 7. Acids have pHs between 0 and 7, bases are from 7 to 14.

Hazards of Corrosive Chemicals

Corrosives can burn and permanently destroy body tissues on contact. The stronger or more concentrated the corrosive material is and the longer it touches the body, the worse the injuries.

Corrosive materials can severely irritate or, in some cases, burn the eyes. This can result in scars or permanent blindness. The stronger or more concentrated the corrosive material is and the longer it touches the eyes, the worse the injury.

Corrosives that touch the skin can severely irritate or even badly burn and blister the skin. Severe corrosive burns over a large part of the body can cause death.

Inhaling corrosive vapours or particles irritates and burns the inner lining of the nose, throat, esophagus (windpipe) and lungs. In serious cases, this results in pulmonary edema, a buildup of fluid in the lungs that can be fatal.

Swallowing corrosive liquids will burn the sensitive lining of the mouth, throat, esophagus and stomach. In nonfatal cases, severe scarring of the throat might occur, which can result in losing the ability to swallow.

Many corrosives corrode metals. Contact with corrosives can damage containers, equipment and building components if they are not compatible. The rate of metal corrosion is greater when the corrosive is stronger and the temperature is higher. When acids attack metals, hydrogen gas is often given off. This is a flammable gas that can burn or explode if an ignition source is present. Common bases, such as sodium hydroxide and potassium hydroxide, can also attack some metals like aluminum, zinc, galvanized metal and tin to produce hydrogen gas.

Some corrosives are toxic and can cause other health problems as well. An example is the acid glutaraldehyde. It is used as a disinfectant and sterilizing agent in medical and dental settings. It is harmful if inhaled or swallowed. Glutaraldehyde can be irritating or corrosive to the respiratory tract, eyes and skin. It may cause permanent eye injury. It is also a skin sensitizer, meaning that it can cause severe allergic skin reactions.

Some corrosives are also flammable or combustible and can easily catch fire and burn or explode.

Corrosives might also be incompatible with other chemicals. They could undergo dangerous chemical reactions and give off toxic or explosive products if they contact each other.

Poisons/Toxins

Toxicity is a measure of the poisoning strength of a chemical. Chemicals that are only weakly toxic need large doses to cause poisoning. Strongly toxic chemicals only need small doses to cause poisoning.

Toxicologists often use animal tests to determine whether small or large doses of a particular chemical cause toxicity. One test measures the dose of a chemical that causes death to 50% of the animals tested. This test is called the Lethal Dose –50% (LD_{50}).

LD_{50} – the amount of a material that causes the death of 50% (one half) of a group of test animals. Toxicologists use many kinds of test animals but, most often, testing is done with rats and mice. LD_{50} is usually expressed as the amount of chemical administered, in milligrams per kilogram of the body weight of the test animal. The LD_{50} can be found for any route of entry or administration but dermal (applied to the skin) and oral (given by mouth) administration methods are the most common; e.g., LD_{50} (oral, rat) – 2 mg/kg.

C-Types.ppt
Slide 5

LC_{50} – LC stands for Lethal Concentration. LC values refer to the concentration of a chemical in air that the test animal inhales. The concentration of the chemical in air that kills 50% of the test animals in a given time (usually four hours) is the LC_{50} value. It is generally reported in ppm (parts of chemical per million parts air); e.g., LC_{50} (rat, 4 hours) – 1500 ppm.

Lethal Dose Hunt

The LD_{50} and LC_{50} give a measure of the immediate or acute toxicity of a chemical in the strain, gender and age group of a particular animal species being tested. Changing any of these variables (e.g., type of animal or age) could result in finding a different value. These acute toxicity tests do not give information on long-term exposure effects of a chemical.

Once you have an LD_{50} or LC_{50} value, it can be compared to other values by using a toxicity scale. A commonly used scale is the Hodge and Sterner Scale.

Refer to Handout 1 – Toxicity Classes: Hodge and Sterner Scale.

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There is a tendency to think of chemicals in terms of those that are poisonous and those that are harmless. This implies that toxicity is an all-or-nothing property of a chemical. This is not the case, since any chemical can cause poisoning if a big enough dose of it is taken into the body. In other words, all chemicals can be toxic. It is the amount or dose taken into the body that determines whether or not a chemical will cause poisonous effects. Poisoning is caused not simply by exposure to a particular chemical but by **overexposure** to it.

Many chemicals that enter the body are excreted unchanged. Others are broken down. The breakdown products may be more toxic or less toxic than the original chemical. Still other chemicals are stored temporarily in body organs and are removed over a period of time. Eventually, most chemicals and their breakdown products are removed as waste in the feces, urine, sweat or exhaled breath. A few chemicals, such as asbestos or silica dusts, can be inhaled into the lungs where they remain for many years and may never be completely removed.

As a general rule, there is less risk of disease from chemical exposure if the body can do one or both of the following:

- break down the chemical into less toxic products
- remove the chemical from the body rapidly

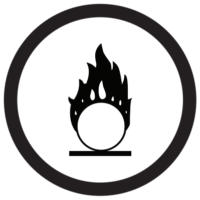
Toxicity versus Hazard

Most people believe that if only small amounts of a chemical are needed to cause poisoning, then the chemical is highly hazardous. This is not necessarily the case. Highly toxic is not the same as highly hazardous. A highly toxic chemical can have a low hazard potential (risk) if it is used with proper precautions and care. On the other hand, it is possible that a chemical of low toxicity may present a high health hazard if it is used carelessly or inappropriately.

Toxicity is a measure of the poisoning strength and is an unchanging characteristic of a chemical. Hazard is a variable feature of a chemical. Hazard is the likelihood that a chemical will cause poisoning, given its poisoning strength and the amounts and manner in which it is used, stored and handled. The toxicity of a chemical cannot be changed but the hazard it presents can be controlled and minimized.

Oxidizers

Oxidizing materials are liquids, gases or solids that readily give off oxygen or other oxidizing substances, such as bromine, chlorine or fluorine. They also include materials that react chemically to oxidize combustible materials. This means that oxygen combines chemically with the other material in a way that increases the chance of a fire or explosion. Oxidizing liquids and solids can be severe fire and explosion hazards.



Corrosive, Oxidizing and Reactive Household Product Poster

Some examples of common oxidizers include:

bromine	nitrous oxide
bromates	nitrites
chlorinated isocyanurates	oxygen
chorates	perborates
chromates	perchlorates
dichromates	perchloric acid
hydroperoxides	periodates
hypochlorites	permanganates
inorganic peroxides	peroxides
ketone peroxides	peroxyacids
nitrates	persulfates
nitric acid	

There are other chemicals that are oxidizing materials. For example, liquid air has been involved in many explosions because of its oxidizing properties. Liquid air contains approximately 30% oxygen, making it a powerful oxidant. (Normal air contains approximately 21% oxygen.)

C-Types.ppt
Slide 6

Hazards of Oxidizers

Oxidizing materials can:

- speed up the development of a fire and make it more intense
- cause substances that do not normally burn readily in air to burn more readily and rapidly
- cause combustible materials to burn spontaneously, without an obvious ignition source

Fire

Although most oxidizing materials do not burn themselves, they can produce very flammable or explosive mixtures when combined with combustible materials like:

- organic (i.e., carbon-containing) materials, such as paper, wood, organic solvents (e.g., kerosene), greases, waxes, many plastics and textiles
- metal dusts
- other oxidizable substances, such as hydrazine, hydrogen, hydrides, sulfur or sulfur compounds, phosphorous, silicon and ammonia or ammonia compounds

Incompatibility

Some oxidizing materials are also incompatible with noncombustible materials. These oxidizers can undergo dangerous reactions with water, inorganic acids or even other oxidizing materials.

Other Hazards

Some oxidizing materials may also be toxic or corrosive. Toxic oxidizers, depending on the material, route of exposure (i.e., inhalation, eye or skin contact, swallowing) and dose, could harm the body. Corrosive oxidizers can attack and destroy human tissues and metal.

Example: ammonium perchlorate

A white or colourless, odourless crystalline material such as:

- explosives and fireworks
- oxidizing agent in solid rocket and missile propellants
- adhesive
- engraving agent
- laboratory (analytical) reagent
- chemical intermediate for alkali and alkaline metal perchlorates
- animal feed supplement
- oxygen-generating devices for life-support systems in submarines, spacecraft, bomb shelters and breathing apparatus

Ammonium perchlorate can cause severe irritation of the skin and eye and is toxic. It can decompose at high temperatures to form toxic gases, such as chlorine, hydrogen chloride and nitrogen oxides. Closed containers or tanks may rupture and explode if they are heated. It is a powerful oxidizer and explosive when mixed with combustible materials. It is highly reactive and impact or high temperatures can cause violent decomposition or explosion. It can form shock-sensitive mixtures with finely powdered metals, metal oxides, strong reducing agents, sulfur and phosphorus. It may also cause eye irritation.

Organic Peroxides

Organic peroxides are a group of oxidizing chemicals. An organic peroxide is an organic (i.e., carbon-containing) compound with two oxygen atoms joined together (-O-O-). This chemical group is called a peroxy group. Organic peroxides can be severe fire and explosion hazards.

The plastics and rubber industries are the heaviest users of organic peroxides. Organic peroxides and mixtures that contain organic peroxides are used as accelerators, activators, catalysts, cross-linking agents, curing agents, hardeners, initiators and promoters.

Organic peroxides can be solids (usually fine powders), liquids or pastes. Some materials, such as water, odourless mineral spirits and some phthalate esters, do not react with organic peroxides and are often used to dilute them. The diluted mixtures or formulations are less likely to explode when exposed to heat or physical shock than the undiluted organic peroxide. Dilution makes the unstable peroxides safer to produce, handle and use.

Hazards of Organic Peroxides

The main hazard of organic peroxides is their fire and explosion hazard. Organic peroxides may also be toxic or corrosive. Toxic organic peroxides, depending on the specific material, route of exposure and dose, could harm the body. Corrosive organic peroxides can attack and destroy human tissue and metals.

It is the double oxygen of the peroxy group that makes organic peroxides both useful and hazardous. The peroxy group is chemically unstable. It can easily decompose, giving off heat at a rate that increases as the temperature rises. Many organic peroxides give off flammable vapours when they decompose. These vapours can easily catch fire.

Most undiluted organic peroxides can catch fire easily and burn very rapidly and intensely. This is because they combine both fuel (carbon) and oxygen in the same compound. Some organic peroxides are dangerously reactive. They can decompose very rapidly or explosively if they are exposed to only slight heat, friction, mechanical shock or contamination with incompatible materials.

Organic peroxides can also be strong oxidizing agents. Combustible materials contaminated with most organic peroxides can catch fire very easily and burn very intensely. Benzoyl peroxide, which was used in science labs, is an example of a more common organic peroxide.

Dangerously Reactive Materials

Generally, dangerously reactive liquids and solids are chemicals that can:

- undergo vigorous **polymerization**, **condensation** or **decomposition**
- become **self-reactive** under conditions of shock or increase in pressure or temperature
- react vigorously with water to release a **lethal** gas

Polymerization

Polymerization is a chemical reaction where many small molecules (i.e., monomers) join together to form a large molecule (i.e., polymer). Often, the reaction produces heat and pressure. Industry carries out these processes under closely monitored conditions. For example, styrene monomer can combine to form polystyrene; i.e., styrofoam.

Vigorous polymerization is potentially hazardous because the reaction may get out of control. Once started, the reaction is accelerated by the heat that it produces. The uncontrolled build up of heat and pressure can cause a fire or an explosion, or can rupture closed containers. Depending on the material, temperature increases, sunlight, ultraviolet radiation, X-rays or contact with incompatible chemicals can trigger such reactions.

Many pure substances (e.g., uninhibited) can undergo vigorous polymerization quite easily by themselves when they are heated slightly or exposed to light. These include:

- acrylic acid
- acrylonitrile
- cyclopentadiene
- diketene
- ethyl acrylate
- hydrocyanic acid
- methacrylic acid
- methyl acrylate
- vinyl acetate

An inhibitor is a chemical that is added to one of these unstable monomers to slow down or prevent the unwanted polymerization. Inhibitors are added to many materials that can polymerize easily when they are pure.

Inhibitor levels in materials may gradually decrease during storage, even at recommended temperatures. At storage temperatures higher than recommended, inhibitor levels can decrease at a much faster rate. At temperatures lower than recommended, the inhibitors may separate out. This can result in some part of the material having little or no inhibitor.

C-Types.ppt
Slide 7

Corrosive, Oxidizing
and Reactive Household
Product Poster

Some inhibitors need oxygen to work effectively. Chemical suppliers may recommend checking oxygen and inhibitor levels regularly in stored materials and adding more if levels are too low.

Monomer vapours escaping from storage containers will not contain an inhibitor. If these vapours condense and form polymers, they could block vents or flame arrestors in process equipment or containers.

Condensation

Condensation is a chemical reaction where two or more molecules join together to form a new substance. Water or some other simple substance may be given off as a by-product. Some polymers, such as nylon, can be formed by condensation reactions.

Vigorous condensation can produce more energy than the surroundings can safely carry away. This could cause a fire or explosion or could rupture closed containers.

Few common pure chemicals undergo vigorous condensation by themselves. Some members of the aldehyde chemical family, including butyraldehyde and acetaldehyde, condense vigorously but bases or, sometimes, strong acids must also be present. Some commercial products sold to be mixed for specialized applications may undergo vigorous condensation if they are not stored, handled and used as directed by the chemical supplier.

Decomposition

Decomposition is a chemical change where a molecule breaks down into simpler molecules. Vigorous decomposition is potentially hazardous because large amounts of energy can be released very quickly. This could result in a fire or explosion or could rupture a closed container, causing the release of dangerous decomposition products. Some pure materials are so chemically unstable that they vigorously decompose at room temperature by themselves. For example, some organic chemicals are relatively safe only when refrigerated or diluted.

Self Reactivity

Some materials are chemically very unstable. They can react vigorously and, in some cases, explosively under conditions of mechanical shock, such as a hammer blow or even slightly elevated temperature or pressure. Materials in this category include:

- ammonium perchlorate
- azo and diazo compounds
- acetylides
- azides
- fulminates
- hydrogen peroxide solutions (91% by weight)
- many organic peroxides
- nitro and nitroso compounds
- nitrate esters
- perchloric acid solutions (over 72.5% by weight)
- picric acid
- picrate salts
- triazines
- some epoxy compounds

Lethal Gas

Some materials can react vigorously with water to produce gases that are extremely toxic at low concentrations in the air. For example, sodium and potassium phosphide release phosphine gas when they contact water. Alkali metal cyanide salts, such as sodium or potassium cyanide, slowly release hydrogen cyanide gas on contact with water. This can result in very hazardous conditions in confined spaces or poorly ventilated areas. Corrosive hydrogen chloride gas is rapidly released when water reacts with aluminum chloride, phosphorous trichloride, tin chloride and chlorosilane compounds.

D-HowExposed.ppt
Slide 1

Mystery Chemical Curator

Lethal Dose Hunt

D. How Are We Exposed to Chemical Hazards?

The hazard from exposure to a chemical is influenced by:

- route of entry into the body
- amount or dose entering the body
- toxicity of the chemical
- the physical form of the chemical
- removal from the body
- biological variation; e.g., gender, age, health

Route of Entry

No chemical can cause poisonous effects without first coming into contact with the body. Breathing of contaminated air is the most common route of entry in the workplace. Some chemicals can be absorbed through the skin; others don't go through the skin but irritate the skin surface. Chemicals may be ingested if food is contaminated or the hands become contaminated. It is also possible for a chemical to be injected into the body through a puncture wound.

Dose

The amount or dose of a chemical entering the body is probably the single most important factor determining the toxic effect from a chemical.

Consider, for example, what happens when you drink water on a warm summer day. The water cools the body and quenches the thirst. Normally, water is considered a harmless chemical. What if, instead of just one glass, many glasses were consumed one after the other, nonstop. A point would be reached where beneficial effects would disappear and harmful effects would start to be noticed. Drinking too much water causes water intoxication. In severe cases, this kind of poisoning causes convulsions and seizures. There are reports of this type of poisoning in small children, endurance athletes and psychiatric patients. The reason water changes from being harmless to being harmful is directly related to the amount of it taken into the body at one time. Drinking too much water causes the toxicity.

Taking too much of any chemical into the body causes toxicity. This relation is true for all chemicals – regardless of their inherent properties and regardless of whether they are natural or man-made. The more toxic a chemical is, the lower the dose needed to cause an effect.

Many chemicals can cause both acute (i.e., immediate) and chronic (i.e., long- term) effects, depending on the conditions of exposure. The adverse health effects caused by the chemical in the two types of exposure are often quite different. It is not usually possible to predict what the chronic toxicity of a chemical might be by looking at its acute toxicity or vice versa.

Acute or Short-term Exposure

A one-time exposure to relatively large amounts of the chemical can overwhelm the body. This may happen by improper handling or because of a spill or a leak. It might also happen during maintenance or cleaning of equipment that normally contains chemicals. The effects caused by a one-time, sudden high exposure are called **acute toxicity** effects. Some examples of acute toxicity effects include:

- inhalation of high concentrations of acid vapours, causing serious burns of the mouth and airways leading to the lungs
- skin contact with certain organic solvents that are absorbed through the skin, causing dizziness and nausea
- inhalation of dusts, causing irritation of the respiratory tract, dryness in the throat and coughing
- inhalation of high concentrations of carbon monoxide (e.g., from a vehicle running in a closed garage), interfering with oxygen uptake and leading to unconsciousness and death

D-HowExposed.ppt
Slide 2

D-HowExposed.ppt
Slide 3

Chronic or Long-term Exposure

Repeated exposure, over a long period of time, to lower doses of a chemical can also produce toxic effects. This occurs because the exposure is repeated day after day over many years. The exposure levels are generally too low to cause acute toxicity. Effects caused by this type of exposure are called **chronic toxicity** effects. Some examples of chronic toxicity include:

- inhalation of certain acid vapours at concentrations that do not cause acute toxicity may, over long periods of time, cause loss of tooth enamel, eventually leading to extensive tooth decay
- inhalation and skin absorption of some organic solvents at concentrations that do not cause acute toxicity may, over long periods of time, cause damage to the central nervous system or liver
- repeated exposure to dusts that contain quartz can cause scar tissue in the lungs that leads to severe and permanent lung damage
- repeated overexposure to carbon monoxide can lead to problems with memory and mental function as well as heart problems

Chronic toxicity is thought to occur by the buildup of a chemical in the body or by the toxicity of the breakdown products from the chemical. For example:

- Sodium fluoride, at very low concentrations, such as in toothpaste or drinking water, causes no noticeable adverse health effects, even after years of exposure. In fact, at these low levels, the effects are considered beneficial for teeth. However, if much higher concentrations of sodium fluoride enter the body repeatedly, they deposit and build up in the bones. At first, the amount of fluoride in the bone may not cause any problems but, after years of repeated high exposure, symptoms of bone disease may appear.
- The chemical n-hexane is not deposited or accumulated in the body; it is broken down in the liver. One of the breakdown products can attack nerve cells in the fingers and toes. These kinds of cells are not replaced easily. With continued exposure for many years, the damage to the cells increases until a point is reached where symptoms appear in the nerves of the fingers and toes.

One special case of chronic toxicity is cancer. Repeated exposure to some chemicals for long periods of time may cause cancer. Often, people express concern about cancer developing after a one-time exposure to a cancer-causing agent. While there is no absolute proof that cancer will not occur from a one-time exposure, all the evidence indicates that repeated exposure, over a long period of time, is necessary before cancer develops.

Toxicity

As was discussed earlier in this chapter, different chemicals have different toxicological properties. One chemical might target the kidneys, another the bones, a third the central nervous system. It is critical to know the specific toxicological properties of any chemicals being handled or used in the workplace.

Physical Form

The physical form of the chemical during normal handling will impact worker exposures. For example, a volatile solvent is more likely to become airborne than a viscous goo. A finely ground powder will be more of a concern than big chunks of the same material.

Removal from the Body

The body has an amazing ability to deal with potentially hazardous materials. In some cases, the body will move the chemical to an area of the body where it can be stored, such as in the bone; e.g., metals. However, this protective process can fail when bone is broken down, e.g., when you are sick, the metal can be released back into the body. If it is released faster than the body can eliminate it in the urine and feces, poisoning can result.

Most organic compounds are converted to forms that can be excreted from the body. Most of this is done by the liver and the kidneys. For example, benzene is converted to phenols, which are further broken down into chemicals that are water soluble and can be removed in urine by the kidneys. Sometimes, the breakdown chemicals are more toxic than the original chemical and the toxic effects from the chemical are actually a result of body metabolism.

The respiratory system and lungs also have an ability to remove particulate matter. Larger particles are trapped in the nose or throat, where they can be removed by coughing, blowing your nose or swallowing. The lungs contain at least three dozen distinct types of cells, each with its special tasks and abilities. Some scavenge foreign matter. Others, equipped with delicate, hair-like cilia, sweep the mucous membranes that line the smallest air passages.

Biological Variation

There are a number of other factors that are specific to each person that influence the hazard from chemicals. These include age, gender, physical fitness and overall health. For example, some people who already have a health problem, such as asthma or liver disease, will be more susceptible to the hazardous effects from chemicals to which they are exposed. Children and the elderly are also more susceptible. But even within the normal, healthy population, there is a very wide range of sensitivity to different chemicals. Some people may have noticeable adverse health effects from a certain dose of a chemical, while others exposed to the same dose show no effect. This can be seen in how different individuals respond to medications, such as pain relievers.

E. Forms of Chemical Hazards

E-Forms.ppt
Slide 1

Fluid Density and
Viscosity

Aerosols (e.g., dusts, mists, fumes)

Aerosols are suspensions of particles or liquids in the air. There are a number of different types:

Dust – solid particles in the air that can be created by grinding or crushing hard materials or through dispersion of powders in the air.

Mist – formed from a material that is a liquid at room temperature; it is a suspension of the liquid's droplets in air. Mists are created by agitation, bubbling, spraying, splashing or otherwise disturbing a liquid.

Fume – a fume forms from the cooling of a hot vapour back into a solid. Fumes are most commonly produced in the air above molten metal; e.g., when metal is welded. Fumes are generally smaller and more easily inhaled than dusts.

Gases and Vapours

Gases and vapours are similar but come from different sources. Most substances that are gases normally take that form at room temperature; e.g., oxygen, nitrogen, argon, carbon dioxide, carbon monoxide. Vapours are gases that are formed from a material that is normally a liquid at room temperature. Most organic solvents form vapours; the amount of vapour formed depends on the volatility of the substance. Materials that are volatile evaporate readily at normal temperature and pressures and, therefore, present more of an inhalation hazard than nonvolatile materials.

Solids

Solids are hard materials because their molecules are packed tightly together. Solids hold their own shape but can form dusts or fumes when they are broken up, cut or heated.

Liquids

Liquids are an in-between state of matter. They can be found in between the solid and gas states. If you have a variety of materials in a dissolved liquid, it is called a solution.

F-ExposeRoutes.ppt
Slide 1

F. Exposure Routes

We are exposed to chemicals in a number of different ways:

- inhalation
- skin contact/skin absorption
- ingestion
- injection

The most common routes of entry are inhalation and skin contact.

Inhalation

Inhalation is the most common way that a chemical can get into the body. The effect on the body depends on the chemical – its physical form, its properties and its concentration in the workplace.

The concentration of a chemical in air is expressed in parts per million (ppm) or milligrams per cubic metre (mg/m^3). Air concentrations from gases and vapours can be expressed both ways but air concentrations of aerosols are only expressed in mg/m^3.

In Alberta, there are standards for worker exposure to airborne chemicals called Occupational Exposure Limits (OELs). These OELs can be found in the Alberta Occupational Health and Safety Code.

Sometimes, the first thing we notice is the smell of a chemical. However, you should never rely on smell as an indicator of a chemical hazard. Every chemical has a different odour threshold.

Some chemicals have very low odour thresholds and we can smell them before they are present in the air at hazardous concentrations. For example, the organic solvent xylene has an odour threshold around 1 ppm and an OEL of 100 ppm. This means that the average person can smell xylene at concentrations well below the OEL.

On the other hand, methylene chloride has an odour threshold around 150 ppm but its OEL is only 50 ppm. Therefore, methylene chloride could be present in dangerous concentrations in the air before we smell it.

When a chemical is in the air, we become used to the smell after a period of time and do not smell it as well. Also, there are some chemicals, like hydrogen sulfide, that, at high concentrations, can overwhelm our sense of smell so we do not smell them at all, even though they are present in the air at very high concentrations. This is called olfactory fatigue.

Skin Contact/Absorption

Many chemicals can react with the skin surface, causing irritation effects, such as drying, reddening and itching. The skin acts as an effective barrier, keeping most chemicals out. However, some fat soluble chemicals are able to penetrate the intact skin and enter the bloodstream. Once in the body, these chemicals can cause other toxic effects.

Work practices involving the handling of chemicals or close contact with chemicals during maintenance, degreasing or cleaning activities can result in significant skin exposure for some chemicals. Even if inhalation exposure is controlled, a significant dose can be achieved from absorption through the skin. Materials with the

potential for significant absorption through the skin are identified with the skin notation in the OELs.

Absorption can be controlled by:

- substitution of a chemical with one that is not absorbed through the skin
- a process change to eliminate skin contact
- the use of appropriate personal protective equipment (PPE)

Ingestion

Sometimes, we can swallow chemicals without knowing it, often simply from not washing our hands before eating after working with chemicals. If we eat or drink in an area where chemicals are used, the materials can inadvertently get into our food or drink.

Lead, for example, is easily ingested. People who work with lead (e.g., people who make stained glass, do certain types of welding, work in a firing range), often have their work area contaminated with lead. If they do not store their food in a clean area or do not wash up thoroughly before eating/drinking/smoking, they will likely ingest lead.

In areas where chemicals, drugs or other materials are used or stored, there must be no drinking, eating or smoking. No food should ever be stored in refrigerators where hazardous chemicals or hazardous biological materials are stored.

Injection

Injection occurs when something sharp punctures the skin and a chemical is brought through the skin and, sometimes, into the blood.

At home you might drop a glass on the floor. What do you do? Sweep it up with a broom? Pick it up with your bare hands? If you are working in a lab and that glass contained a toxic chemical, picking it up with your bare hands could lead to a cut, allowing the chemical to enter your bloodstream.

People who work in hospitals are at a risk of exposure from injection by needles. They can be exposed to the medication as well as to the blood or body fluids of the patient.

G. Exposure to More Than One Chemical

Exposure to one single chemical in the workplace rarely occurs. Exposure to several chemicals can result from complex work processes, breakdown products or from work performed by others in the area. However, standards (e.g., OELs) are usually developed from information, testing or experience resulting from exposure to a single chemical. The effect of exposure to a combination of chemicals is rarely known. However, available data indicates that interactions between chemicals are more likely to occur under conditions of high exposure.

The combined effects of chemicals are described as:

- independent
- additive
- antagonistic
- synergistic
- potentiating

and are explained in the following table.

G-MoreThanOne.ppt
Slide 1

Term	Definition	Model	Example
independent	The toxicity of each compound is produced by independent mechanisms and/or acts upon separate organs or systems. Independent substances exert their own toxicity without influence or interference from one another.	2 + 3 = 2 + 3	silica dust and carbon monoxide
additive	Compounds with similar toxicity produce a response that is equal to the sum of the effects produced by each of the individual compounds acting alone.	2 + 3 = 5	xylene and toluene
antagonistic	Toxicity of one chemical is reduced by exposure to another.	2 + 3 < 5	Selenium and mercury (selenium appears to protect the body from mercury)
synergistic	Two materials act together to produce toxicity greater than that produced by either material administered separately.	2 + 3 > 5	cigarette smoking and asbestos (the risk of lung cancer is drastically increased)
potentiating	One substance does not have a toxic effect on a certain organ but when combined with exposure to a second chemical, it makes the second chemical much more toxic.	0 + 3 > 3	isopropanol and carbon tetrachloride (liver toxicity)

It is not just exposure to more than one chemical at the same time that can enhance toxic effects. For example, people who smoke and are exposed to asbestos have about a 90 times greater chance of getting cancer than those who are only exposed to asbestos. Exposure to some solvents and noise can increase hearing loss more than exposure to noise alone.

There is no model for adjustment of an exposure limit to account for synergistic or potentiating effects. The easiest solutions are to either find a substitute for one of the chemicals to avoid the potential effect or to ensure exposure is maintained as low as reasonably practicable. Note: in the work setting, antagonistic effects are not used as a basis for increasing exposure limits.

H-Limits.ppt
Slide 1

H. Exposure Limits

An occupational exposure limit (**OEL**) is the **airborne concentration of substance for which it is believed that nearly all workers may be repeatedly exposed on a day-to-day basis without suffering adverse health effects**.

OELs are developed, based on review of data from experimental animal and human studies and from industrial experience obtained through clinical and epidemiological studies. (Epidemiological studies are comprehensive statistical studies of disease patterns among known groups of workers.)

While animal and human experimental data are the most useful when determining how the body responds when exposed to chemicals, the studies do not usually represent workplace conditions of exposure. Personal habits, such as smoking, drinking alcoholic beverages and using drugs or medications, may also affect a worker's health profile. The substances involved in these personal habits may have an additive or synergistic action on exposures at the workplace. Well-designed epidemiologic studies can help distinguish between the effects of work-related and non-work-related variables.

There is wide variation in the way people respond to chemical exposure. A small percentage of people may feel discomfort at or below the exposure limit. An exposure limit should not be used as a fine line between safe and unsafe conditions or as an index of relative toxicity. Some people may be affected more seriously due to aggravation of a health condition or by development of an occupational illness. In addition, some individuals are extremely sensitive to certain industrial chemicals due to a previous overexposure, genetic factors, personal habits, such as smoking or alcohol use, or the use of drugs or medications.

A number of organizations and government agencies develop exposure limits. The Occupational Exposure Limits (OELs) in the Alberta health and safety legislation are, for the most part, based on Threshold Limit Values (TLVs) developed by the American Conference of Governmental Industrial Hygienists (ACGIH).

The basis on which exposure limits are established depends on the substance. Protection against health impairment may be a factor for one substance, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form the basis for others. Health impairments that are considered include reduction of life expectancy, compromised physical function of the body, impairment of the capability for resisting other toxic substances or diseases or adverse effects on reproductive capability.

There are several different types of OELs:

- eight-hour
- ceiling
- short term

Eight-hour Exposure Limit

An eight-hour exposure limit is based on the assumption that the exposure occurs for an eight-hour period in the day, five days per week for a total of 40 hours. The exposure periods are followed by a period away from work, after which the body is no longer exposed and is allowed to recover for the next 16 hours.

Nontraditional work schedules are becoming more common in workplaces. There is an increasing trend toward extended work hours with more days off between shifts. Many continuous process operations, such as chemical manufacturing, oil refineries, steel mills, drilling rigs and paper mills, require two or three shifts in a 24-hour period to accommodate continuous production. Shift lengths might be 10 or 12 hours. In addition, workers may work overtime during periods of heavy demand.

When a person is exposed for more than eight hours in a day, the assumptions for eight-hour exposure limits do not necessarily hold true.

In Alberta, the Occupational Health and Safety Code requires that the following model be used to adjust OELs, unless an employer has received approval from the government to use another method. It compensates for unusual work schedules by reducing the permissible concentration in proportion to both the increase in exposure time and the reduction in recovery time.

Adjusted Exposure Limit = 8 hours OEL x daily reduction factor
Daily reduction factor = $(8/h) \times \{(24-h)/16\}$
Where h = hours worked per day

Note: It is unnecessary to adjust exposure limits where they are based on irritation effects alone. Although limits can be adjusted downwards to accommodate longer periods of exposure, standards can never be adjusted upwards to accommodate shorter periods of exposure.

Ceiling Exposure Limit

Ceiling exposure limits may never be exceeded at any time. Ceiling limits are often developed for substances that have **immediate and serious** acute health effects. Formaldehyde and hydrogen sulphide are examples of chemicals with ceiling limits.

Short Term Exposure Limit (STEL)

Short term exposure limits are concentrations of a substance to which it is believed most workers may be exposed for a short period of time without suffering adverse health effects, such as irritation and chronic or irreversible tissue damage. A STEL is not a separate exposure limit. It is in addition to the eight-hour exposure limit. For STELs:

- exposure measured over a 15-minute period must not exceed the 15-minute OEL
- exposure to a substance at a concentration above its eight-hour exposure limit but at or below its STEL must not happen more than four times per day
- there must be at least 60 minutes between successive exposure periods in this concentration range
- the eight-hour OEL may not be exceeded for the work shift

I. Controlling Chemical Hazards

Whenever possible, hazards should be eliminated or controlled at their source, as close to where the problem is created as possible, using engineering controls. If this is not possible, controls should be placed between the source and workers. The closer a control is to the source of the hazard, the better. If this is not possible, hazards must be controlled at the level of the worker.

Administrative controls and personal protective equipment (PPE) control hazards at the level of the worker. These control methods reduce the likelihood of the hazard injuring the worker and lessen the potential seriousness or severity of the injury. They do not eliminate the risk posed by a hazard. A combination of several hazard control approaches may be necessary in some situations. Whatever control method is used, it should attack the **source** of the hazard, not its outward signs; e.g., fumes, exhaust produced. It is better to provide properly designed ventilation to remove a contaminant from the air at the point of generation (i.e., an engineering control) than it is to provide workers with respirators.

Engineering Controls

Engineering controls provide the highest degree of control because they eliminate or control the hazard at its source. They remove the hazard, either by initial design specifications or by applying methods of substitution, minimization, isolation or ventilation. Engineering controls are the most effective hazard control methods, especially when introduced at the conceptual stage of planning when control measures can be integrated more readily into the design. They tend to be more effective than other hazard controls (i.e., administrative controls, personal protective equipment) because they remove the source of the hazard or reduce the hazard rather than lessen the damage that may result from the hazard. They are also less dependent on the user of the protective systems.

I-Controlling.ppt
Slides 1–2

Chemical Control

How to Clean Up
an Oil Spill

Substitution

Substitution refers to the replacement of a hazardous material or process with one that is less hazardous. For example:

- replacing mercury thermometers with alcohol thermometers eliminates potential exposure to mercury
- dip coating materials, rather than spraying them, reduces the amount of mist generation

Substitution is usually the least expensive and the most positive method of controlling hazards. It should always be the first engineering control measure considered.

Ventilation

Ventilation is used to control toxic and/or flammable atmospheres. This is done by exhausting or supplying air to remove hazardous atmospheres at their source or diluting them to a safe level. The two types of ventilation are called **local exhaust** and **general ventilation**. With local exhaust systems, the material, equipment or process is enclosed, as much as possible, and air is withdrawn from the physical enclosure fast enough to ensure that the direction of air movement at all openings is always into the enclosure. A fume hood is an example of a local exhaust system. General ventilation attempts to control hazardous atmospheres by diluting the atmosphere to a safe level by either exhausting or supplying air to the general area.

Local exhaust is always the preferable ventilation method for controlling exposure to toxic substances. For some situations, general ventilation may be enough but only if the following criteria are met:

- Only small quantities of air contaminants are released into the area at fairly uniform rates; there is sufficient distance between the person and the contaminant source to allow sufficient air movement to dilute the contaminant to a safe level.
- Only materials of low toxicity or flammability are used.
- There is no need to collect or filter the contaminant before the exhaust air is discharged into the environment.
- The contaminant will not produce corrosion or other damage to equipment in the area or in any way affect other building occupants outside the general use area.

Isolation

Isolation involves placing a barrier between a material, equipment or process hazard and the persons affected by the hazard; e.g., glove box, blast shield. Isolation is very useful when the material, equipment or process requires minimal contact or manipulations.

I-Controlling.ppt
Slide 3

Modification

There are many ways to modify a process so that either less hazardous materials are used or they are used in lower quantities. By reducing the amounts of hazardous materials used and stored, the potential hazards are lowered. The best time to do this is at the design stage. The process should be evaluated to see how it can be designed to reduce hazards to those who operate it.

An example of a process modification would be to switch from manually pouring drums of a chemical to using an automatic pumping system. This would eliminate direct handling of the chemical and, therefore, reduce exposure. A side benefit would be a reduction in the potential for a musculoskeletal injury.

I-Controlling.ppt
Slide 4

Administrative Controls

If engineering controls cannot eliminate or fully control a hazard, administrative controls are the next level in the hierarchy to consider. Administrative controls manage the hazard or manage how the worker performs his or her work around the hazard. Administrative controls include:

- planning, information sharing and training; e.g., hazard communication
- written policies and procedures
- safe work practices
- environmental and medical surveillance; e.g., workplace inspections, equipment preventive maintenance, exposure monitoring
- work rotation

Because administrative controls address the human aspect of hazard controls, they are of vital importance.

How we work, the care we take and the general practices we put in place are important in the overall protection of people exposed to hazardous substances. It is essential to establish and enforce procedures, such as keeping the work area clean, making sure all spills are properly cleaned up, not eating in contaminated areas and getting training before handling a new chemical for the first time.

Workplaces must have health and safety policies and procedures in place. Workers must be trained in these procedures and follow them at all times. For example:

- Prohibit smoking or open flames where flammables are used.
- Prohibit eating, drinking or smoking in areas where chemical hazards are present.
- Ensure that chemicals are stored properly.
- Use the smallest quantity of chemicals necessary to do the job.

Personal Protective Equipment

As a last resort, workers may need to use personal protective equipment (PPE) to control the potential harmful effects of exposure to a hazard. PPE does not eliminate the hazard. It only protects the worker using it; others in the area are still exposed. The equipment must be used properly and consistently to be effective.

PPE includes a wide variety of items worn by an individual to protect against chemical hazards. PPE is used to protect the eyes, skin and the respiratory tract; e.g., goggles, face shields, coats, gloves, aprons, respirators. In some situations, PPE may be the only practical hazard control option but, for many reasons, it is the least desirable means of controlling chemical hazards. PPE users must be aware of and compensate for these undesirable qualities:

- PPE does not eliminate hazards, it only minimizes damage from hazards; the effectiveness of PPE is highly dependent on the user.
- PPE is often cumbersome and uncomfortable to wear; it can be more awkward to do the work. PPE can sometimes create a hazard to the worker (e.g., heat stress).
- Each type of PPE has specific applications, advantages, limitations and potential problems – those using PPE must be fully knowledgeable of these considerations.
- PPE must match the hazards and the conditions of use and be properly maintained to be effective.
- The equipment must fit properly to be effective.

Making Sure Your Personal Protective Equipment (PPE) Protects You

- Make sure the type of protection is appropriate for the hazards.
- Use PPE that does not create a hazard. Ensure it fits properly and doesn't interfere with the jobs you have to do; e.g., lab coat sleeves hanging over a bunsen burner; gloves too big, preventing a good grip.
- If using more than one type of PPE, make sure one does not interfere with the other; e.g., your respirator does not prevent your eye protection from fitting properly.
- PPE does not work if damaged. Always check before using it to make sure it is in good condition.
- Follow your employer's instruction and training and always properly clean and store the PPE after use or dispose of it if it cannot be reused.

I-Controlling.ppt
Slide 5

Protecting Paulomi

Dissection of a WHMIS and Consumer Product Label

Teacher's Note

Students should be aware that they must remove personal protective equipment (PPE), e.g., lab coats, gloves, eye protection, before leaving the area where it is required. PPE can carry a chemical hazard into a clean work area.

Optional Discussion

You may wish to generate a brief discussion on chemicals that students have been in contact with at home, work or school. Ask them what PPE they should use for:

- liquids like cleaning products, paints, acids and solvents

  (Answer: Eye protection, respirators, impervious gloves)

- dusts and particulates like dust from a grain bin, cleaning a barn, sweeping or cleaning the house
  or raking/mowing/cleaning up the yard

  (Answer: dust mask, eye protection)

I-Controlling.ppt
Slide 6

Respirators

Respirators are used to protect a person from inhaling hazardous substances in the air. Respirators do not remove the hazard, but can reduce the amount you breathe in. There are two types:

- **Air-supplying** – e.g., Self Contained Breathing Apparatus (SCBA), used by fire fighters, and airline respirators.
- **Air-purifying** – rely on disposable cartridges or filters in the respirator unit. The type of cartridge used in the respirator must match the type of containment the worker is exposed to. The wrong cartridge can be worse than no respirator at all because the worker remains in the contaminated environment, believing he or she is protected. These types of respirators do not supply air, so they may not be used in an oxygen-deficient atmosphere.

It is very important that the correct respirator be chosen for the job. There are two steps that need to be taken when choosing a respirator:

- Choose the correct type of respirator for the contaminants.
- Choose the specific model from among the appropriate types available to get the best fit/comfort.

Factors that must be considered when choosing the correct type of respirator include:

- What are the airborne contaminants?
- What is the concentration of the airborne contaminants?
- How much oxygen is present in the environment?
- What is the physical form of the contaminant; e.g., dust, mist, fume, fibre, gas, vapour?
- What is the occupational exposure limit for the contaminant?
- How long will the respirator be used?
- What are the toxic properties of the contaminants? Certain toxic properties of the contaminant will influence the choice of a respirator. For example, choosing a full-face piece, rather than a half-mask respirator is necessary for protection against contaminants that irritate the eye.
- What are the warning properties of the contaminant?
- Is the respirator going to be used in emergencies?

Once the correct type of respirator is chosen, the proper model must be selected. Each type of respirator is available in a number of models. The right model will fit correctly and be comfortable to wear. Fit and comfort vary among individuals, so it is best to test various models before making a selection. There are several factors to be considered in the selection process:

Regulatory approval – respirators chosen to protect workers against health hazards must be approved by the National Institute for Occupational Safety and Health (NIOSH) or by another organization acceptable to Government of Alberta, Occupational Health and Safety.

Facial fit – many models offer face pieces in different sizes. If none of the face pieces on the selected model fits the worker properly, use a different type of equipment.

Comfort – hot, cold or confined working conditions are uncomfortable at the best of times. Wearing respiratory protective equipment may increase this discomfort. Every effort should be made to choose respirators that are as comfortable as possible.

Other factors – choosing the appropriate model of respiratory protective equipment may be influenced by other factors, such as the cost of the basic unit and replacement parts and the availability of service through a local repair centre. Also, what if a full face piece is required and workers wear corrective lenses?

Mystery Chemical Curator

Protective Clothing

Protective clothing includes items like gloves, aprons, chemical resistant shirts, pants and coveralls. The type and material will depend on the type of hazard. It is very important that the correct type of clothing be chosen. For example, chemical resistant gloves are the most common personal protective equipment for the hands. Different types of chemicals require different types of impervious gloves. For example, butyl gloves are better for acetone exposure because the chemical does not penetrate through them as easily as neoprene or latex gloves. All of the materials are chemically resistant but the chemical properties of neoprene and latex do not match well with the properties of acetone.

Depending on the work, the worker may need special safety clothes for extra protection. For example, working with strong chemicals may require impervious aprons, bibs or suits that will be a barrier between skin and the chemical. In some operations, chemical-resistant shoes and boots are required to prevent chemicals from soaking into footwear.

Protective Eyewear

The eyes are vulnerable to damage from airborne particulates and chemicals as well as from splashes by chemicals. The eye has some ability to protect itself:

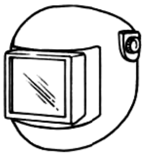
- **Boney structure surrounding the eye** – very large objects are prevented from striking the eye by the strong bony ridges of the eyebrow and cheek.
- **Eyelids** – provided the blink reflex happens in time, the eyelids protect the eye from injury by flashes, liquid splashes, low-speed particles and dust.
- **Cornea** – the cornea is very sensitive to touch, which initiates both the blink reflex and a flow of tears.

These protective functions of the eye are not enough to protect the eye from most chemicals and particles found at work sites. If a worker's eyes may be injured or irritated at a work site, eye protection is needed. In Alberta, this equipment must be CSA approved.

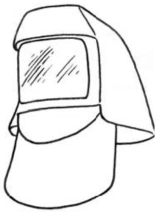
Protective eyewear includes:

spectacles, for impact protection

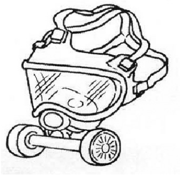
goggles, for protection against impact, dust, splashes



welding helmets and hoods, for protection against UV, impact



face shields, for protection from impacts and splashes



respirator full face pieces, for protection from impact, splashes, dust

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Slide 1

Symbols of Hazard

Chemical Hazards
Response

Recognize WHMIS and
HHPS Symbols

J. Identifying Chemical Hazards

Workplace Hazardous Materials Information System (WHMIS)

WHMIS is a hazard **communication** system. It is a Canada wide system that affects suppliers, importers and distributors of potentially hazardous materials used at work sites as well as employers and workers who use those materials. WHMIS was implemented through coordinated federal, provincial and territorial legislation.

- The federal WHMIS legislation is the *Hazardous Products Act* and Controlled Products Regulations. It covers the legal requirements for **suppliers** of hazardous products to provide hazard information on their products.
- The legislation that covers employers and workers at **work sites** in Alberta is the Alberta Occupational Health and Safety Code, Part 29.

What Is the Purpose of WHMIS?

WHMIS was developed to ensure that workers receive adequate hazard information about chemicals that are used at their work site. The system requires suppliers of controlled products to provide specified hazard information to their work site customers (employers). The employers must provide that hazard information to their workers.

WHMIS has three main elements:

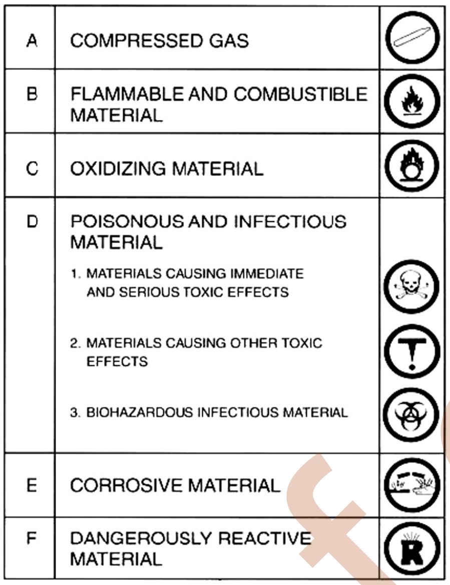
- **Labels** – WHMIS labels provide the basic information that a person needs to know to handle a particular product safely.
- **Material Safety Data Sheets (MSDSs)** – MSDSs provide more technical information about the product's physical characteristics and its hazardous properties.
- **Worker education** – worker education ensures workers have the information they need to safely handle the product.

WHMIS only applies to products that meet certain criteria. These products are called controlled products. There are six classes of controlled products. A product that meets the criteria for any one or more of the six WHMIS classes is a controlled product and is included in WHMIS.

There is no comprehensive list of controlled products. The only way to find out if a product is a controlled product is to compare its properties with the criteria for each of the six classes of controlled products.

Figure 1, the WHMIS classes and hazard symbols, shows the six WHMIS classes and their hazard symbols. The WHMIS classification criteria are contained in the federal Controlled Products Regulations. Suppliers are responsible to assess any products that they manufacture/sell to work sites in Canada and to determine into which hazard classes, if any, those products fall.

J-ChemHazards.ppt
Slide 2



A	COMPRESSED GAS
B	FLAMMABLE AND COMBUSTIBLE MATERIAL
C	OXIDIZING MATERIAL
D	POISONOUS AND INFECTIOUS MATERIAL 1. MATERIALS CAUSING IMMEDIATE AND SERIOUS TOXIC EFFECTS 2. MATERIALS CAUSING OTHER TOXIC EFFECTS 3. BIOHAZARDOUS INFECTIOUS MATERIAL
E	CORROSIVE MATERIAL
F	DANGEROUSLY REACTIVE MATERIAL

Figure 1—WHMIS hazard classes

Suggested Learning Activity

It is recommended that you identify for the students any controlled products stored in the classroom or storage area that they will be using during the semester. Familiarize students with their WHMIS labels and discuss safe methods for handling and storage.

Exclusions

A few types of products have been excluded from the WHMIS requirements because they are covered by other legislation. Note that these products meet the criteria to make them a controlled product but they are specifically excluded from the system.

These products are either totally or partially excluded from the WHMIS requirements.

Totally Excluded Products

Products excluded from all aspects of WHMIS are:

- wood and products made of wood
- tobacco and products made of tobacco
- manufactured articles
  - Manufactured articles means products manufactured to a specific shape, whose function depends on that shape. Manufactured articles do not release controlled products during normal use. Coated pipe is an example of a product that is exempt from WHMIS because of this provision. The coating material may have been a controlled product when it was applied but it is not released during normal use of the pipe. Welding rods, on the other hand, are not exempt, because they release controlled products (as welding fumes) during normal use.
- dangerous goods, while they are covered by transportation of dangerous goods legislation
- hazardous wastes (Except that legislation does require hazardous wastes to be safely stored and handled, which means that employers must ensure hazardous wastes are identified and workers handling them are trained.)

Even though the products listed above are exempt from WHMIS, they could still be harmful. Employers have other responsibilities under the OHS legislation to protect workers who work with harmful substances:

- Ensure that harmful substances or their containers are clearly identified.
- Establish procedures to minimize worker exposure to these substances.
- Train workers in those procedures and in the health hazards associated with exposure to the harmful substance.

Partially Excluded Products

Suppliers are not required to provide WHMIS labels and MSDSs for the following groups of products because there are other labelling and information requirements that already apply. However, the employer must still provide WHMIS training for workers using or working near them:

- explosives, covered by the *Explosives Act*
- cosmetics, devices and foods and drugs covered by the *Food and Drug Act*
- pesticides and herbicides, covered by the *Pest Control Product Act*
- radioactive materials, covered by the *Nuclear Safety and Control Act*
- consumer chemicals (that are restricted products), covered by the *Hazardous Products Act* (HPA)
    - Consumer chemicals mean products packaged in quantities appropriate for and available to the public in retail outlets and labelled with the restricted product label.

WHMIS Labels

The most common types of WHMIS labels are supplier and work site labels.

- supplier labels – the labels that suppliers must apply to containers of controlled products that they sell to work sites
- work site labels – used in the workplace. They are applied to:
    - containers into which controlled products are transferred
    - containers of controlled products that are produced at the work site for use at the work site
    - supplier containers, to replace supplier labels that have been accidentally damaged or defaced, where new supplier labels cannot be obtained

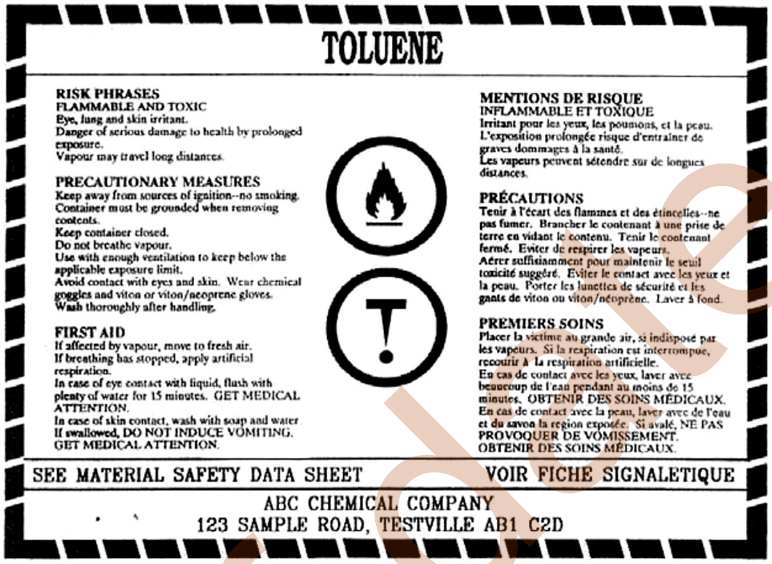
Different information requirements apply to supplier labels and work site labels.

J-ChemHazards.ppt
Slide 3

Dissection of a WHMIS and Consumer Product Label

Supplier Label

Figure 2 illustrates an example of a WHMIS supplier label. Supplier labels are easy to recognize because they have a unique, rectangular slash-marked border.



TOLUENE

RISK PHRASES
FLAMMABLE AND TOXIC
Eye, lung and skin irritant.
Danger of serious damage to health by prolonged exposure.
Vapour may travel long distances.

PRECAUTIONARY MEASURES
Keep away from sources of ignition--no smoking.
Container must be grounded when removing contents.
Keep container closed.
Do not breathe vapour.
Use with enough ventilation to keep below the applicable exposure limit.
Avoid contact with eyes and skin. Wear chemical goggles and viton or viton/neoprene gloves.
Wash thoroughly after handling.

FIRST AID
If affected by vapour, move to fresh air.
If breathing has stopped, apply artificial respiration.
In case of eye contact with liquid, flush with plenty of water for 15 minutes. GET MEDICAL ATTENTION.
In case of skin contact, wash with soap and water
If swallowed, DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION.

MENTIONS DE RISQUE
INFLAMMABLE ET TOXIQUE
Irritant pour les yeux, les poumons, et la peau.
L'exposition prolongée risque d'entrainer de graves dommages à la santé.
Les vapeurs peuvent sétendre sur de longues distances.

PRÉCAUTIONS
Tenir à l'écart des flammes et des étincelles--ne pas fumer. Brancher le contenant à une prise de terre en vidant le contenu. Tenir le contenant fermé. Eviter de respirer les vapeurs.
Aérer suffisiamment pour maintenir le seuil toxicité suggéré. Eviter le contact avec les yeux et la peau. Porter les lunettes de sécurité et les gants de viton ou viton/néoprène. Laver à fond.

PREMIERS SOINS
Placer la victime au grande air, si indisposé par les vapeurs. Si la respiration est interrompue, recourir à la respiration artificielle.
En cas de contact avec les yeux, laver avec beaucoup de l'eau pendant au moins de 15 minutes. OBTENIR DES SOINS MÉDICAUX.
En cas de contact avec la peau, laver avec de l'eau et du savon la region exposée. Si avalé, NE PAS PROVOQUER DE VOMISSEMENT.
OBTENIR DES SOINS MÉDICAUX.

SEE MATERIAL SAFETY DATA SHEET
VOIR FICHE SIGNALETIQUE

ABC CHEMICAL COMPANY
123 SAMPLE ROAD, TESTVILLE AB1 C2D

Figure 2—Example of a supplier label

The supplier label must contain the following seven pieces of information within the rectangular border:

- product identifier – the name of the product (it must be the same as on the MSDS)
- supplier identifier – name of manufacturer or distributor
- hazard symbols – all WHMIS hazard symbols that apply, based on the classification
- risk phrases – brief statements of main risks associated with the product
- precautionary measures – brief statements of main precautions to be taken when using or storing the product
- first aid measures – main first aid measures to be taken in case of acute overexposure
- reference to the Material Safety Data Sheet – for more detailed information on the hazards of the product

Variations on the Basic Supplier Label

In certain situations, the basic requirements are relaxed and less detailed labels may be used. There are five situations when the basic supplier label might vary:

- small containers (less than 100 millilitres)
- products purchased in bulk
- products sold by laboratory supply houses
- products sent to laboratories for analysis
- compressed gas cylinders and grinding wheels (alternative shapes to the rectangular label allowed)

Refer to Handout 2 – Label Checklist.

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Work site Labels

Work site labels are performance-oriented. This means that the content of the label must provide workers with the information they need to handle the product safely. There are no format, language or border requirements. Employers could choose to use the border or hazard symbols, but there are no requirements. Figure 3 illustrates a sample work site label.

J-ChemHazards.ppt
Slide 4

TOLU-SOLV

All Purpose Cleaner

Flammable: Keep away from all sources of heat, sparks and open flames.

Toxic: When handling, use neoprene gloves, goggles and organic vapour respirator.

See MSDS for more information.

Figure 3—Example of a work site label

Variations to the WHMIS Work Site Label

Sometimes, it is more practical to use a placard or sign to draw attention to information about controlled products than to label them. This is permitted in the following situations:

- controlled products that are not in containers
- controlled products that have been produced for sale but have not yet reached the labelling stage of the production process
- controlled products that are destined for export only (remember that WHMIS does not apply in other countries)

A placard must include the same information that a WHMIS work site label includes. The placards must be large enough to be easily read and must be placed so that they are obvious to workers. Placards may be used when a controlled product arrives at the work site without the required supplier label and you store it while you track down the WHMIS supplier label.

Controlled Products that Do Not Require a WHMIS Label

Only two groups of controlled products do not require a WHMIS label:

- controlled products for immediate use
- fugitive emissions

A **controlled product for immediate use** is one that is transferred from a properly labelled container into a transfer container and then into some chemical process vessel where it will be totally used. The transfer container need not have a WHMIS label. An example of this situation is measuring a chemical before adding it to a chemical reaction vessel.

Fugitive emissions are spread through the air or over a surface and, as a result, they cannot be labelled. However, the equipment from which the emissions escape must be appropriately labelled.

Optional Exercise to Reinforce Learning

Have students make up their own WHMIS workplace label for one of the chemicals used in the classroom. Hand out a copy of the MSDS to help the students create their label.

Material Safety Data Sheets (MSDSs)

J-ChemHazards.ppt
Slide 5

What Is a Material Safety Data Sheet?

Material Safety Data Sheets or MSDSs contain information that is more detailed and more technical than the information on WHMIS labels. MSDSs must have at least nine categories of information.

There are no format requirements for WHMIS MSDSs. Any format that includes the required information is acceptable. It does not require the WHMIS border. However, each of the nine categories must be identified by a heading identical or similar to that shown below.

Information Required on a WHMIS Material Safety Data Sheet

- product information
  - product identifier
  - product use
  - manufacturer's name, address and emergency telephone number
  - supplier's name, address and emergency telephone number

- hazardous ingredients
  - required ingredients
  - CAS registry number
  - UN number
  - LD_{50} (species and route)
  - LC_{50} (species and route)

- physical data
  - physical state
  - odour and appearance
  - odour threshold
  - specific gravity
  - vapour pressure
  - vapour density
  - evaporation rate
  - boiling point
  - freezing point
  - pH
  - coefficient of water/oil distribution

- fire or explosion hazard
  - conditions of flammability
  - means of extinction
  - lower flammable limit
  - auto-ignition temperature
  - hazardous combustion products
  - flashpoint and method of determination
  - upper flammable limit
  - explosion data – sensitivity to mechanical impact
  - explosion data – sensitivity to static discharge

- reactivity data
  - conditions of instability
  - substances with which product is incompatible
  - conditions of reactivity
  - hazardous decomposition products

- toxicological properties
  - route of entry
  - effects of acute exposure
  - effects of chronic exposure
  - exposure limits
  - irritancy of product
  - sensitizing properties
  - carcinogenicity

  - reproductive toxicity
  - teratogenicity
  - mutagenicity
  - toxicologically synergistic products
- preventive measures
  - personal protective equipment
  - engineering controls
  - spill/leak procedures
  - waste disposal
  - handling procedures/equipment
  - storage requirements
  - shipping information
- first aid measures
  - specific first aid measures
- preparation information
  - person or group responsible for preparation of the MSDS and telephone number
  - date of preparation of the MSDS

(In Alberta, the internationally recognized 16-section format MSDS may also be used as long as all of the above information categories are included.)

MSDSs must be current. Suppliers must update an MSDS whenever they become aware of new information that outdates the previous version or every three years, whichever comes first. Canadian suppliers should never issue an MSDS that is more than three years old.

Here are some questions a worker should ask when reading an MSDS:

- Do I have the right MSDS for the product?
- Is the MSDS up-to-date? (If it is more than three years old, the answer is probably not.)
- Can the product burn or explode? (Check the fire and explosion section.)
- Is the product reactive with other chemicals? (Check the reactivity section.)

- What harmful health effects are possible? (Check the toxicological properties section.)
- Do I need to wear protective equipment when handling the product? (Check the preventive measures – personal protective equipment section.)
- Are there special handling precautions? Do I know what to do in case the product leaks or spills? (Check the preventive measures section.)
- Do I know what to do in case I come into contact with the product? (Check the first aid section.)

Classroom Activity

Show or tell the students where the MSDSs are kept for the controlled products used or stored for classroom use.

Suggestion: If only a few products will be used during the class, provide copies of the MSDS to each of the students so they can turn to them and review hazards, PPE and safe use procedures each time they use a controlled product in your classroom – great training for life and work!

WHMIS Worker Education

What does WHMIS worker education include?

WHMIS worker education includes generic and work site specific information.

J-ChemHazards.ppt
Slide 6

Generic Worker Education

Generic information includes:

- a general introduction to WHMIS
- training in the required content of WHMIS labels and MSDSs
- training in the purpose and significance of that information to workers' health and safety on the job

Generic WHMIS worker education is extremely important. Labels and MSDSs are the major sources of hazard information for most workers. For this reason, it is very important for workers to know what information to expect on labels and MSDSs and to understand what that information really means. For example, every worker should immediately recognize each WHMIS hazard symbol and understand what it means.

Work Site Specific Education

Site specific worker education goes deeper. It gets into:

- Hazard information on specific products used at the work site. This includes the safety precautions a worker needs to know when working with or producing a controlled product. The site specific worker education must include all the hazard information provided by suppliers **and** all other hazard information of which the employer is aware.
- The different types of product labelling used at the work site (e.g., colour codes, number codes and other ways controlled products are labelled in transfer systems or reaction vessels).
- Procedures for the safe use, storage and handling of controlled products at the work site.
- Procedures for dealing with fugitive emissions and emergencies at the work site.

Generic worker education is transferable from job to job but workers always need to receive site specific education when starting a new job or working with new chemicals.

Do All Workers Require WHMIS Worker Education?

All work site personnel who work with or close to controlled products or who are involved in the manufacture of a controlled product must be provided with WHMIS worker education. All workers who participate in the generic worker education program will receive the same information. The work site specific components of a WHMIS education program will probably vary among groups of workers. The hazard information a person needs to know and the procedures in which a person is trained depend on the work the person performs.

Consumer Chemicals

In addition to its WHMIS requirements, the *Hazardous Products Act* also deals with chemicals that are sold to consumers; i.e., restricted products. These products must have labels that identify their hazards but no MSDS is required. The Consumer Chemicals and Containers Regulations has the details for classifying these products and the information that must be included on the label.

Dissection of a WHMIS and Consumer Product Label

Some examples of consumer chemicals or restricted products are:

- bleaches and cleansers for household use that contain chlorine and chlorine compounds
- products for household use that contain sodium hydroxide, potassium hydroxide, sodium bisulfate, hydrochloric acid or phosphoric acid
- household polishes and cleaning agents that contain petroleum distillates or chlorinated aliphatic hydrocarbons

Consumer chemicals fit into the following categories:

- toxic
- corrosive
- flammable
- explosive

The label must include the following information:

- hazard symbol(s), which are not quite the same as WHMIS hazard symbols
- the signal word Extreme Danger, Danger or Caution
- specific hazard statement(s)
- instructions for use
- cautions about nonintended uses
- first aid treatments

Restricted products are intended primarily for household consumer use rather than workplace use. Because these chemicals are easily bought at retail stores, they often can be found at the work site. When consumer restricted products are poured into another container at the work site, work site labels are required. However, MSDSs are not required and the statement that an MSDS is available would not be used on the label.

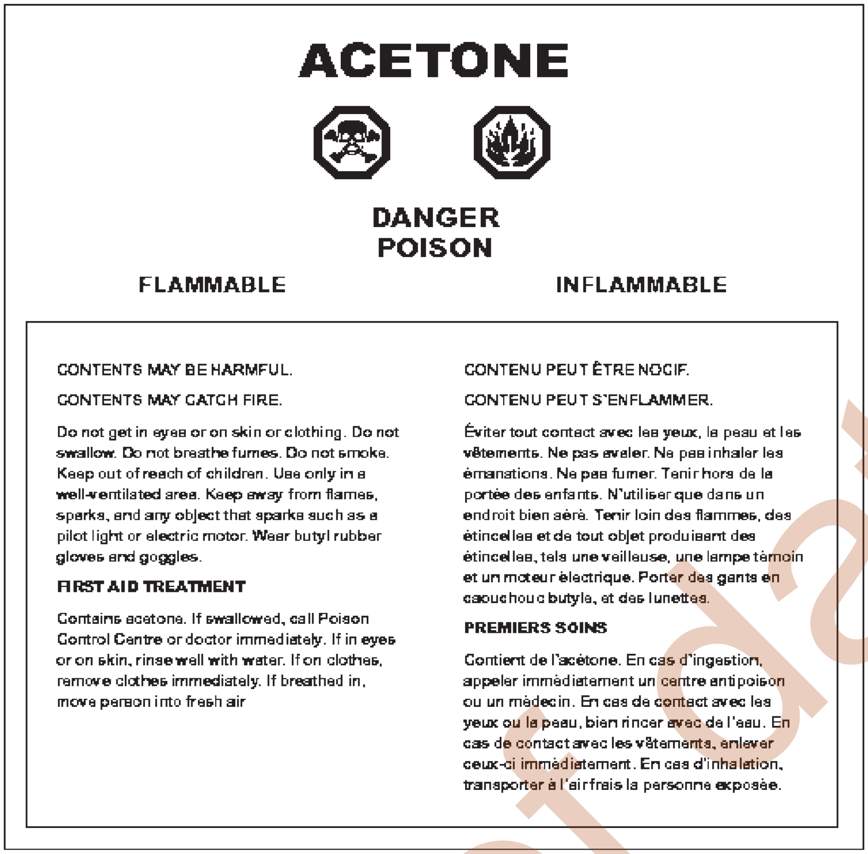
Differences between the labels required on restricted products and on controlled products include the following:

- Restricted product symbols are based on four types of hazard; WHMIS supplier symbols are based on eight.
- WHMIS symbols do not specify degree of hazard.
- Restricted product labels do not require reference to the MSDS.
- WHMIS labels must have a specific border design.

J-ChemHazards.ppt
Slide 7

Consumer Chemical Label Hazard Symbols

Description	Symbol
explosive	
flammable	
poison	
corrosive	



ACETONE

DANGER
POISON

FLAMMABLE

INFLAMMABLE

CONTENTS MAY BE HARMFUL.

CONTENTS MAY CATCH FIRE.

Do not get in eyes or on skin or clothing. Do not swallow. Do not breathe fumes. Do not smoke. Keep out of reach of children. Use only in a well-ventilated area. Keep away from flames, sparks, and any object that sparks such as a pilot light or electric motor. Wear butyl rubber gloves and goggles.

FIRST AID TREATMENT

Contains acetone. If swallowed, call Poison Control Centre or doctor immediately. If in eyes or on skin, rinse well with water. If on clothes, remove clothes immediately. If breathed in, move person into fresh air

CONTENU PEUT ÊTRE NOCIF.

CONTENU PEUT S'ENFLAMMER.

Éviter tout contact avec les yeux, la peau et les vêtements. Ne pas avaler. Ne pas inhaler les émanations. Ne pas fumer. Tenir hors de la portée des enfants. N'utiliser que dans un endroit bien aéré. Tenir loin des flammes, des étincelles et de tout objet produisant des étincelles, tels une veilleuse, une lampe témoin et un moteur électrique. Porter des gants en caoutchouc butyle, et des lunettes.

PREMIERS SOINS

Contient de l'acétone. En cas d'ingestion, appeler immédiatement un centre antipoison ou un médecin. En cas de contact avec les yeux ou la peau, bien rincer avec de l'eau. En cas de contact avec les vêtements, enlever ceux-ci immédiatement. En cas d'inhalation, transporter à l'air frais la personne exposée.

Figure 4—Consumer chemical label

Suggested Learning Activity

This classroom exercise or homework assignment helps students recognize chemical hazards and understand how to work safely with them.

- Have students bring to class empty consumer containers that have warning labels.

For example, a container of white-out, nail polish remover or furniture polish spray would be appropriate. Do not permit filled containers in class due to the risk of spills or splashes.

- Ask students if there is a symbol or picture on the label and ask what it means.
- Could students use this product more safely if they recognize its chemical hazard?
- Ask students to read the handling or storage procedures. Do these procedures make sense, considering the listed hazards of the product?

Hazard Recognition – The World Around You

Students will be able to recognize other chemical hazards (consumer or not) around them.

In a brainstorming exercise, ask them about chemical products they may find in:

- different rooms in their homes; e.g., garage, bathroom, kitchen, workshop
- parts of their school; e.g., art class, science class, furnace room

Once they have identified these hazards, ask them how risky those hazards could be.

For example, ask which is riskier:

- Gasoline or water-based paints and why?
- Window cleaner or oven cleaner and why?

Students need to think about using any hazardous product as safely as possible.

Transportation Labelling

The *Transportation of Dangerous Goods (TDG) Act* and Regulations apply to the handling for transport, offering for transport and transportation of dangerous goods.

TDG requirements apply when goods are:

- **Handled and offered for transport** – refers to activities, such as packing, unpacking, storing, loading and unloading for transport. For example, WHMIS does not apply to products while they are being loaded onto a truck.
- **Stored for transport** – refers to storage in which goods will not be handled at the workplace except to load goods directly onto a transport vehicle for removal from the workplace; i.e., in transshipment.
- **Transported** – generally means **between** workplaces. WHMIS applies when controlled products are transported from one point to another **within** a workplace.
- **Warehoused** – when warehoused, controlled products could be stored for transport, repackaged, used, processed or sold. TDG applies to products stored for transport. WHMIS applies when products in a warehouse are handled; i.e., repackaged, used, processed, sold.

The exemption for products being transported means that an employer does not have to provide WHMIS labels, MSDSs or education and training to drivers of vehicles transporting controlled products. However, if the driver is exposed to the controlled product by being actively involved in loading or unloading the product, e.g., the driver of an oil or gasoline truck, the driver should have access to the MSDS at the point of loading or unloading and should undergo training.

Comparison of Hazard Symbols Used in WHMIS and TDG

Pictogram	Use in WHMIS	Use in TDG
	Not applicable	Explosives
	Class A: Compressed Gases	Gases, nonflammable, nontoxic
	Class B: Flammable and Combustible Materials	Flammable gases, liquids and solids
	Class C: Oxidizing Material	Oxidizing substances and organic peroxides
	Class D1: Materials Causing Immediate and Serious Toxic Effects	Toxic substances
	Class D2: Materials Causing Other Toxic Effects	Not applicable
	Class D3: Biohazardous Infectious Material	Infectious substances
	Not applicable	Radioactive materials
	Class E: Corrosive Material	Corrosives
	Class F: Dangerously Reactive Material	Not applicable
	Not applicable	Miscellaneous products, substances or organisms

REVIEW QUESTIONS

Types of Chemical Hazards

1. **The burning process requires three elements, often referred to as the ____________________ _____________________.**

2. **Compressed gases are gases that are contained at greater/less than atmospheric pressure. Circle the correct answer.**

3. **True or False? An empty compressed gas cylinder contains no gas.**

4. **True or False? When working in a medical laboratory, the chemicals that you use to sterilize equipment are safe because they get rid of all the bacteria and biohazardous substances.**

5. **Corrosives are materials that can:**
   a. damage or destroy metals
   b. damage or destroy human tissue
   c. are usually acids or bases
   d. all of the above

6. **Toxicity is:**
   a. the risk of an adverse health effect from exposure to a chemical
   b. a measure of how poisonous a chemical is
   c. not an issue if the dose of a chemical is small
   d. only an issue if the dose of a chemical is large

7. **True or False? All chemicals can be toxic.**

8. **The toxicity of a chemical is related to its ____________________ .**

9. **Oxidizers are chemicals that readily give off ____________________ or other readily oxidizing substances, such as chlorine or bromine.**

10. Oxidizers can:

a. speed up the development of a fire and make it more intense

b. cause substances that do not normally burn readily in air to burn rapidly

c. cause combustible material to burn spontaneously

d. all of the above

11. The main hazard of organic peroxides is:

a. corrosivity

b. carcinogenicity

c. fire and explosion

d. toxicity

12. Dangerously reactive materials can:

a. undergo vigorous polymerization, condensation or decomposition

b. corrode metal

c. oxidize other chemicals

d. all of the above

13. An inhibitor is a chemical that is added to a chemical to

____________________ an unwanted reaction.

14. Which of the following chemicals are flammable materials?

a. sodium hydroxide

b. acetone

c. argon

d. silica

How Are We Exposed to Chemical Hazards

15. The most common route(s) of entry for a chemical to enter the body is (are) through:

a. breathing (inhalation)
b. swallowing
c. skin contact
d. puncture wound
e. a and c

16. In a hair salon, which of the following could be an inhalation hazard or cause irritation?

a. aerosol hairsprays
b. perm solutions
c. nail polish remover
d. all of the above

17. The most significant factor that impacts the potential for a worker's health to be affected is:

a. its form; i.e., gas, liquid, solid
b. how much is used
c. its toxicity and dose
d. the time of day that it is used

18. True or False? Chronic toxicity is caused by a sudden, one-time, high exposure to a chemical.

19. An example of an acute health effect is:

a. burns
b. cancer
c. damage to nerve tissue
d. scarring of the lungs

20. An example of a chronic health effect is:

a. dizziness and nausea

b. burns

c. scarring of the lungs

d. headache

21. A fume is:

a. organic vapour from a liquid

b. a suspension of droplets in the air

c. a suspension of very fine particulates in the air

d. a gas

22. True or False? Smell is a good indicator for how much of a chemical is in the air.

23. True or False? Occupational Exposure Limits are legal limits for exposure to airborne chemicals in workplaces in Alberta.

24. When you work a shift that is longer than eight hours in length in an area where you may be exposed to chemicals:

a. the exposure limit need not be adjusted

b. exposure limits must be adjusted to account for the longer exposure time

c. you must get the following day off to account for the extra exposure time

d. you cannot work more than five consecutive days in a row

25. True or False? When working in a hair salon, you don't need to cover up any cuts that you have when working with clients because, when you are washing their hair or using chemicals, the soap or chemicals will kill any contaminants that may get on your cut.

Controlling Chemical Hazards

26. True or False? Safety glasses must be worn whenever chemicals are used in a classroom experiment.

27. True or False? Never handle chemicals with your bare hands.

28. True or False? To determine the odour of a chemical, always put your head/face directly over the container opening and inhale deeply to get the best sample.

29. True or False? Chemical spills should be left until the end of class before they are cleaned up.

30. True or False? Always return excess chemicals to the original container.

31. True or False? Tasting chemicals is an excellent way to determine a material's physical properties.

32. True or False? When heating chemicals in a test tube, always direct the tube to the centre of the classroom so as not to splash walls and windows.

33. True or False? Never eat, drink or chew gum during a lab.

34. True or False? When diluting acid, always add small amounts of acid to large amounts of water.

35. True or False? The two types of ventilation are general ventilation and local exhaust ventilation.

36. Examples of engineering controls for chemical hazards include:

a. substitution
b. local exhaust ventilation
c. process modification
d. isolation
e. all of the above

37. The last thing you should do before you finish a lab is:

a. wash your hands
b. turn off the lights
c. put away all chemicals and equipment
d. hand in your lab report

38. Which is NOT an administrative control?

a. air monitoring
b. respirator
c. teaching workers about the hazards
d. safe work procedures

39. Which of the following are examples of PPE:

a. respirators
b. gloves
c. eye shields
d. safety clothes
e. all of the above

40. You would use dilution ventilation:

a. in the gym
b. when welding toxic metals
c. in an auditorium
d. a and c

41. You would use local exhaust ventilation:

a. when running a vehicle engine indoors

b. in a general classroom

c. to cool a room

d. a and c

42. If you or someone you know has an allergy to latex, what would be the best advice for them?

a. continue to wear latex gloves because you will get used to them

b. substitute neoprene or nitrile gloves for the latex gloves

c. do not wear any gloves at all – if you are allergic to latex, you will be allergic to all gloves

d. switch between neoprene and latex gloves to give your hands a break

43. In terms of engineering controls, ____________________ means putting up a barrier, like a wall between people and the hazard.

44. What is the term for using an alternative product that is less harmful to one's health and the environment? Give an example.

Identifying Chemical Hazards (WHMIS)

45. True or False? WHMIS stands for Workplace Hazardous Materials Information System.

46. True or False? All products and chemicals have WHMIS symbols.

47. True or False? An MSDS provides less information than a product label.

48. True or False? The main components of WHMIS are labels, MSDSs and worker education.

49. True or False? Materials that contain dangerous bacteria or viruses or the toxins these organisms produce are called infectious materials.

50. MSDS stands for:

a. Material Standards for Dangerous Substances
b. Material Safety Data Sheet
c. Material Safety for Designated Substances
d. Material Safety Description Sheet

51. MSDSs contain information on:

a. physical properties
b. first aid procedures
c. toxic properties
d. all of the above

52. The greatest amount of detailed information about a hazardous material can be found by reading:

a. the MSDS
b. the supplier label on a product container
c. the WHMIS symbol
d. both b and c

53. Before using any chemical for the first time, you should at least read:

a. the MSDS

b. the supplier label on a product container

c. both a and b

54. WHMIS legislation requires that:

a. MSDSs must be no more than three years old

b. MSDSs must be available for workers to review

c. MSDSs must have a red border

d. a and b

e. b and c

55. Name the two most common types of labels.

a.

b.

56. Which of the following is a responsibility of an employer:

a. train workers properly in the safe use of chemicals and equipment

b. maintain a safe working environment

c. take action to correct unsafe working conditions immediately

d. maintain a current file of MSDSs

e. all of the above

57. List three categories of information that must be contained in an MSDS sheet and explain why this information is important.

a.

b.

c.

REVIEW QUESTIONS, WITH ANSWERS

Types of Chemical Hazards

1. **The burning process requires three elements, often referred to as the ____________________ ____________________.**
   Answer: fire triangle

2. **Compressed gases are gases that are contained at greater/less than atmospheric pressure. Circle the correct answer.**
   Answer: greater

3. **True or False? An empty compressed gas cylinder contains no gas.**
   Answer: False

4. **True or False? When working in a medical laboratory, the chemicals that you use to sterilize equipment are safe because they get rid of all the bacteria and biohazardous substances.**
   Answer: False

5. **Corrosives are materials that can:**
   Answer: d. all of the above

6. **Toxicity is:**
   Answer: b. a measure of how poisonous a chemical is

7. **True or False? All chemicals can be toxic.**
   Answer: True

8. **The toxicity of a chemical is related to its ____________________ .**
   Answer: dose

9. **Oxidizers are chemicals that readily give off ____________________ or other readily oxidizing substances, such as chlorine or bromine.**
   Answer: oxygen

10. **Oxidizers can:**
    Answer: d. all of the above

11. **The main hazard of organic peroxides is:**
    Answer: c. fire and explosion

12. Dangerously reactive materials can:
Answer: a. undergo vigorous polymerization, condensation or decomposition

13. An inhibitor is a chemical that is added to a chemical to ______________________ an unwanted reaction.
Answer: slow down or prevent

14. Which of the following chemicals are flammable materials?
Answer: b. acetone

How Are We Exposed to Chemical Hazards

15. The most common route(s) of entry for a chemical to enter the body is (are) through:
Answer: e. a and c

16. In a hair salon, which of the following could be an inhalation hazard or cause irritation?
Answer: d. all of the above

17. The most significant factor that impacts the potential for a worker's health to be affected is:
Answer: c. its toxicity and dose

18. True or False? Chronic toxicity is caused by a sudden, one-time, high exposure to a chemical.
Answer: False

19. An example of an acute health effect is:
Answer: a. burns

20. An example of a chronic health effect is:
Answer: c. scarring of the lungs

21. A fume is:
Answer: c. a suspension of very fine particulates in the air

22. True or False? Smell is a good indicator for how much of a chemical is in the air.
Answer: False

23. **True or False? Occupational Exposure Limits are legal limits for exposure to airborne chemicals in workplaces in Alberta.**
    Answer: True

24. **When you work a shift that is longer than eight hours in length in an area where you may be exposed to chemicals:**
    Answer: b. exposure limits must be adjusted to account for the longer exposure time

25. **True or False? When working in a hair salon, you don't need to cover up any cuts that you have when working with clients because, when you are washing their hair or using chemicals, the soap or chemicals will kill any contaminants that may get on your cut.**
    Answer: False

Controlling Chemical Hazards

26. **True or False? Safety glasses must be worn whenever chemicals are used in a classroom experiment.**
    Answer: True

27. **True or False? Never handle chemicals with your bare hands.**
    Answer: True

28. **True or False? To determine the odour of a chemical, always put your head/face directly over the container opening and inhale deeply to get the best sample.**
    Answer: False

29. **True or False? Chemical spills should be left until the end of class before they are cleaned up.**
    Answer: False

30. **True or False? Always return excess chemicals to the original container.**
    Answer: False

31. **True or False? Tasting chemicals is an excellent way to determine a material's physical properties.**
    Answer: False

32. True or False? When heating chemicals in a test tube, always direct the tube to the centre of the classroom so as not to splash walls and windows.
Answer: False

33. True or False? Never eat, drink or chew gum during a lab.
Answer: True

34. True or False? When diluting acid, always add small amounts of acid to large amounts of water.
Answer: True

35. True or False? The two types of ventilation are general ventilation and local exhaust ventilation.
Answer: True

36. Examples of engineering controls for chemical hazards include:
Answer: e. all of the above

37. The last thing you should do before you finish a lab is:
Answer: a. wash your hands

38. Which is NOT an administrative control?
Answer: b. respirator

39. Which of the following are examples of PPE:
Answer: e. all of the above

40. You would use dilution ventilation:
Answer: d. a and c

41. You would use local exhaust ventilation:
Answer: a. when running a vehicle engine indoors

42. If you or someone you know has an allergy to latex, what would be the best advice for them?
Answer: b. substitute neoprene or nitrile gloves for the latex gloves

43. In terms of engineering controls, ______________________ means putting up a barrier, like a wall between people and the hazard.
Answer: isolation

44. **What is the term for using an alternative product that is less harmful to one's health and the environment? Give an example.**
Answer: substitution! Example: using toothpaste to clean running shoes rather than commercial whitener.

Identifying Chemical Hazards (WHMIS)

45. **True or False? WHMIS stands for Workplace Hazardous Materials Information System.**
Answer: True

46. **True or False? All products and chemicals have WHMIS symbols.**
Answer: False

47. **True or False? An MSDS provides less information than a product label.**
Answer: False

48. **True or False? The main components of WHMIS are labels, MSDSs and worker education.**
Answer: True

49. **True or False? Materials that contain dangerous bacteria or viruses or the toxins these organisms produce are called infectious materials.**
Answer: True

50. **MSDS stands for:**
Answer: b. Material Safety Data Sheet

51. **MSDSs contain information on:**
Answer: d. all of the above

52. **The greatest amount of detailed information about a hazardous material can be found by reading:**
Answer: a. the MSDS

53. **Before using any chemical for the first time, you should at least read:**
Answer: c. both a and b

54. **WHMIS legislation requires that:**
Answer: d. a and b

55. Name the two most common types of labels.

Answer:

a. supplier label

b. work site (or workplace) label

56. Which of the following is a responsibility of an employer:

Answer: e. all of the above

57. List three categories of information that must be contained in an MSDS sheet and explain why this information is important.

Answer: Any 3 of the following:

a. product information (identifies the product and use, supplier/ manufacturer)

b. hazardous ingredients (name, concentration and toxicity of each ingredient)

c. physical data (physical properties)

d. fire or explosion data (potential to ignite or explode)

e. reactivity data (stability and potential to react)

f. toxicological properties (how it enters the body and its effects)

g. preventative measures (measures to protect a worker)

h. emergency and first aid measures (safe evacuation and treatment)

i. preparation information (date of MSDS, by whom and number)

Toxicity Classes: Hodge and Sterner Scale

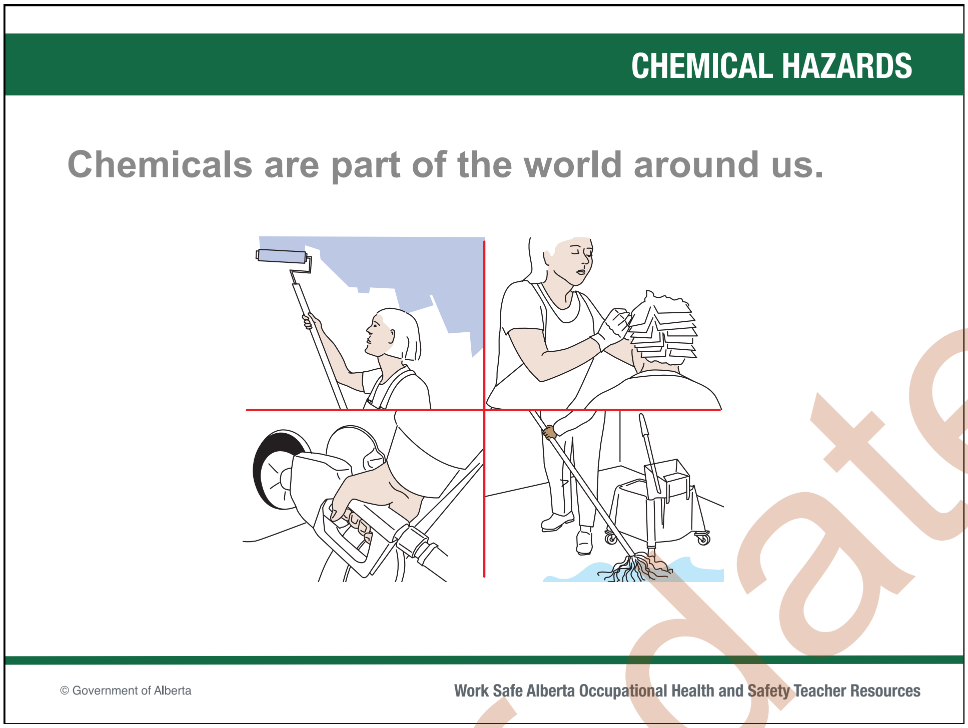
		Routes of Administration			
		Oral LD_{50}	Inhalation LC_{50}	Dermal LD_{50}	
Toxicity rating	Commonly used term ppm	(single dose to rats) mg/kg	(exposure of rats for four hours) ppm	(single application to skin of rabbits) mg/kg	Probable lethal dose for man
1	Extremely toxic	1 or less	10 or less	5 or less	1 grain (a taste, a drop)
2	Highly toxic	1–50	10–100	5–43	4 ml (1 tsp.)
3	Moderately toxic	50–500	100–1000	44–340	30 ml (1 fl. oz.)
4	Slightly toxic	500–5000	1000–10 000	350–2810	600 ml (1 pint)
5	Practically nontoxic	5000–15 000	10 000–100 000	2820–22 590	1 litre (or 1 quart)
6	Relatively harmless	15 000 or more	100 000	22 600 or more	1 litre (or 1 quart)

Label Checklist

WHMIS Labelling Requirements for Controlled Products

Requirements	Supplier Label (> 100 mL)	Supplier Label (< 100 mL)	Laboratory Supply House (<10 kg)	Laboratory Sample* (> 10 kg)
1. Product identifier	✓	✓	✓	✓
2. Chemical identity (i.e., hazardous ingredients)				✓
3. Hazardous symbol(s)	✓	✓		
4. Risk phrases	✓		✓	
5. Precautionary statements	✓		✓	
6. Safe handling procedures				
7. First aid measures	✓		✓	
8. Supplier identifier	✓	✓		✓
9. Reference to MSDS	✓	✓	✓	
10. Emergency telephone number				✓
11. Hatched border	✓	✓		✓
12. English (within hatched border)	✓	✓	✓	✓
13. French (within hatched border)	✓	✓	✓	✓

* where the supplier has opted for the special provisions for by s. 16 of the CPR, the label shall include the statement "Hazardous Laboratory Sample. For hazard information or in an emergency, call [emergency telephone number as per CPR 16 (b)(v)"/ Échantillion pour labortorie de produit dangereaux. Pour obetneir des rensignment sure les danger ou en cas d'urgence, compser [un numéro d'urgence divulgué en vertu du RPC 16(b)(v).



CHEMICAL HAZARDS

Chemicals are part of the world around us.

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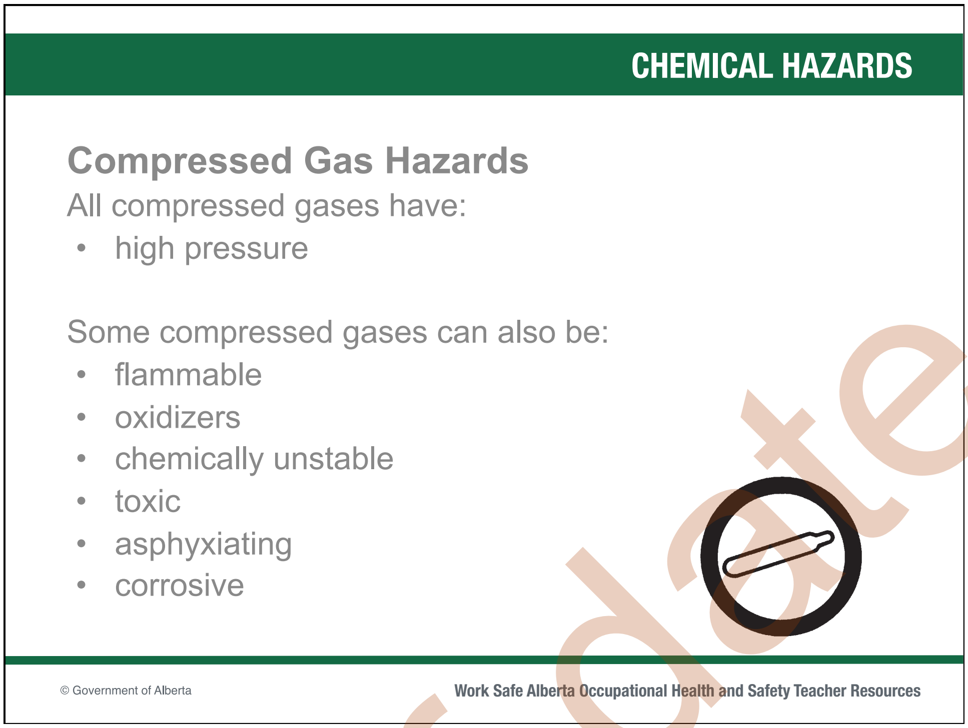
B-Overview.ppt Slide 1



CHEMICAL HAZARDS

Compressed Gas Hazards

All compressed gases have:

- high pressure

Some compressed gases can also be:

- flammable
- oxidizers
- chemically unstable
- toxic
- asphyxiating
- corrosive

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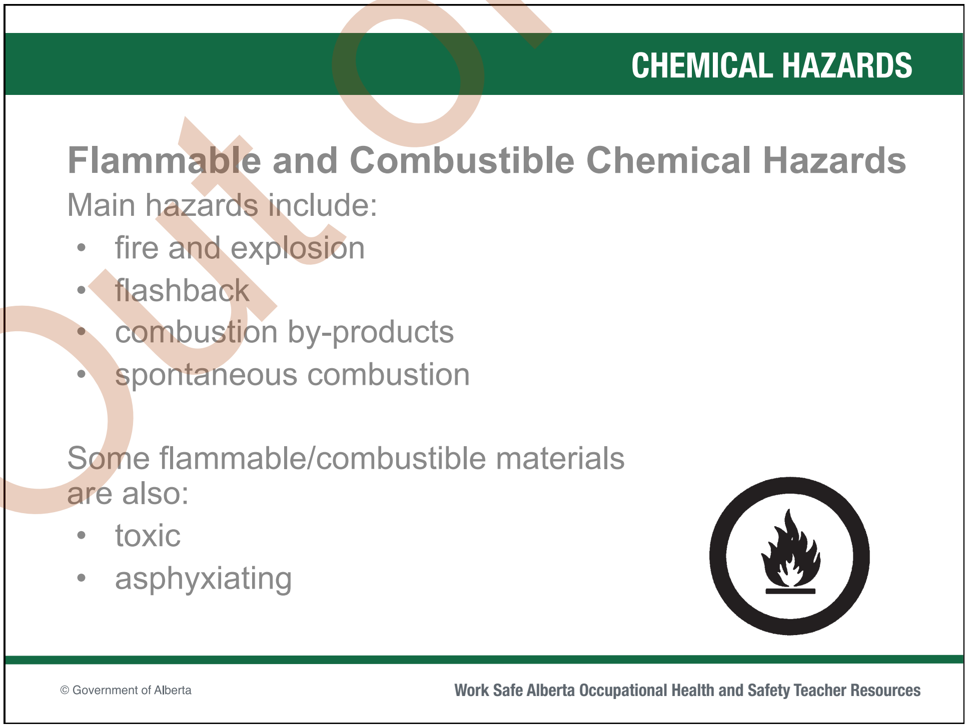
C-Types.ppt Slide 1



CHEMICAL HAZARDS

Flammable and Combustible Chemical Hazards

Main hazards include:

- fire and explosion
- flashback
- combustion by-products
- spontaneous combustion

Some flammable/combustible materials are also:

- toxic
- asphyxiating

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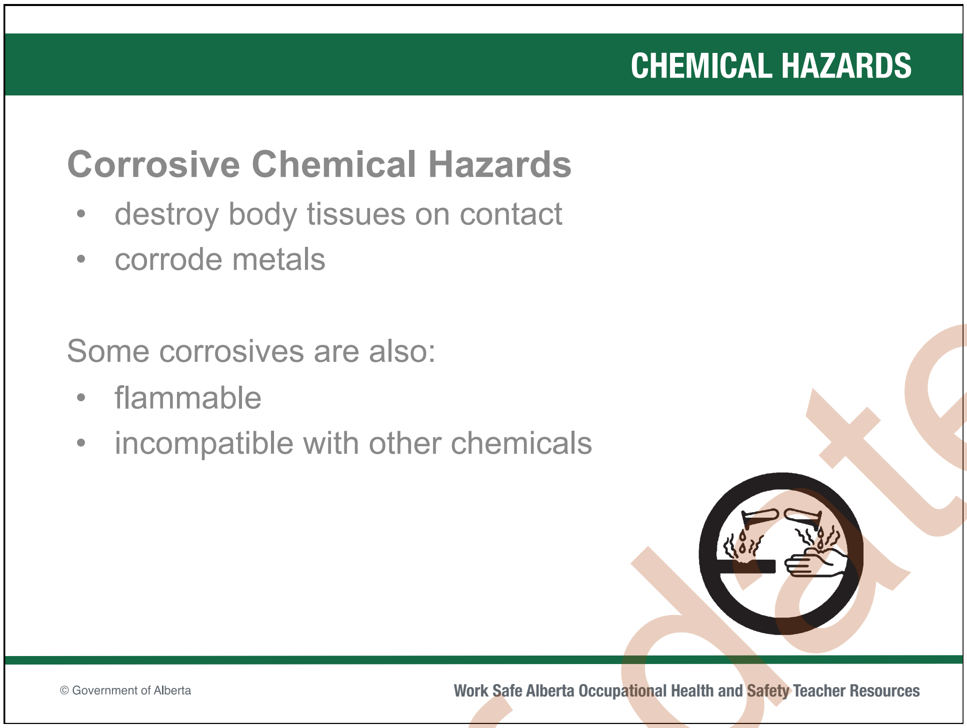
C-Types.ppt Slide 2



CHEMICAL HAZARDS

Corrosive Chemical Hazards

- destroy body tissues on contact
- corrode metals

Some corrosives are also:

- flammable
- incompatible with other chemicals

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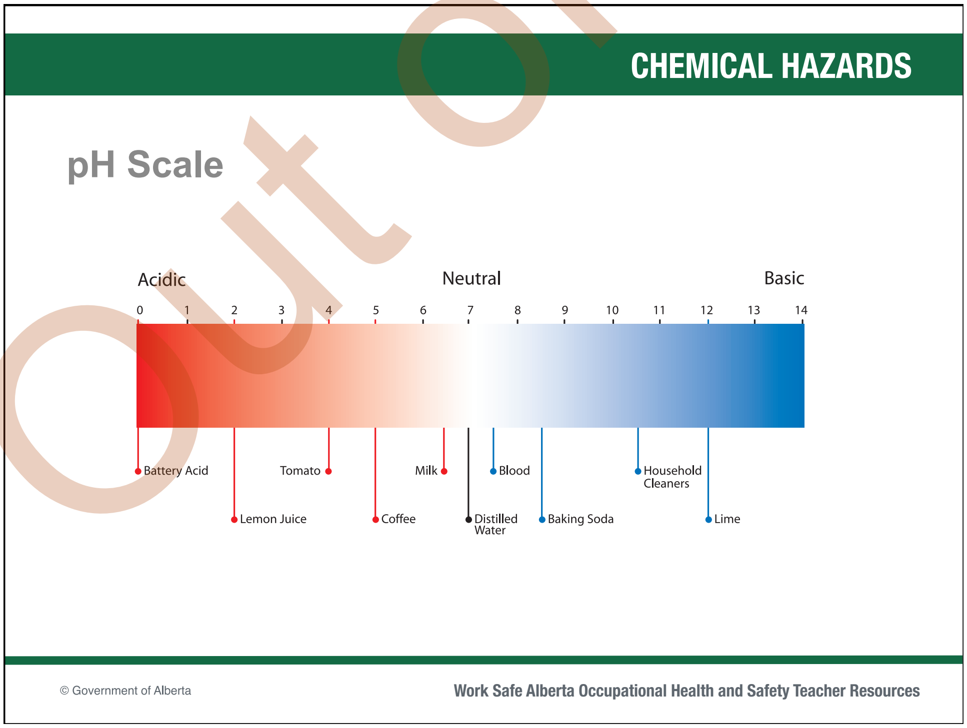
C-Types.ppt Slide 3



CHEMICAL HAZARDS

pH Scale

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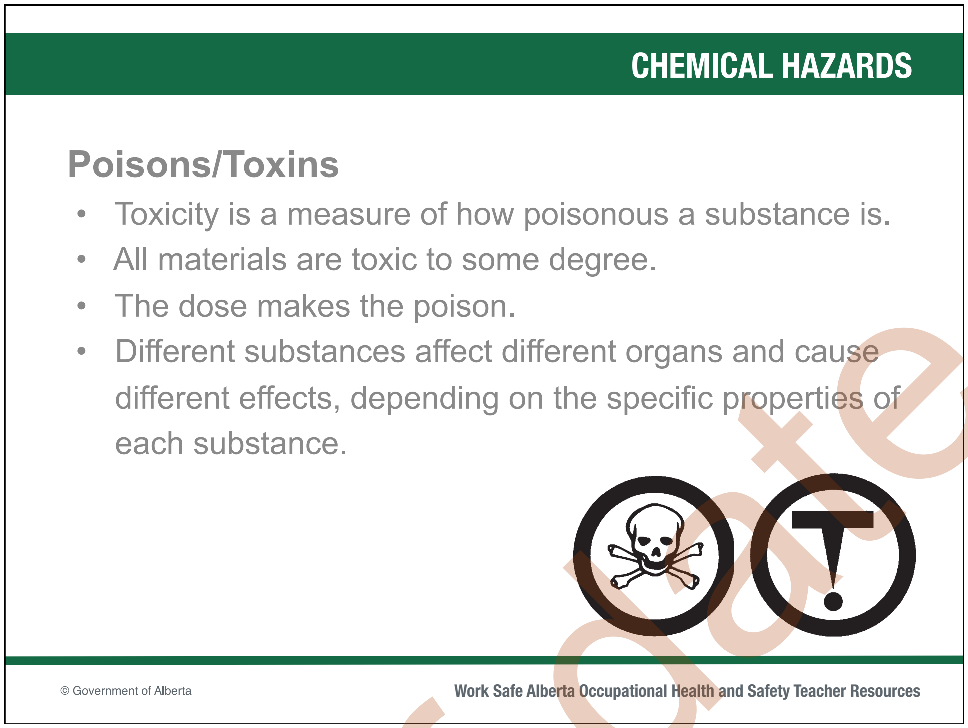
C-Types.ppt Slide 4



CHEMICAL HAZARDS

Poisons/Toxins

- Toxicity is a measure of how poisonous a substance is.
- All materials are toxic to some degree.
- The dose makes the poison.
- Different substances affect different organs and cause different effects, depending on the specific properties of each substance.

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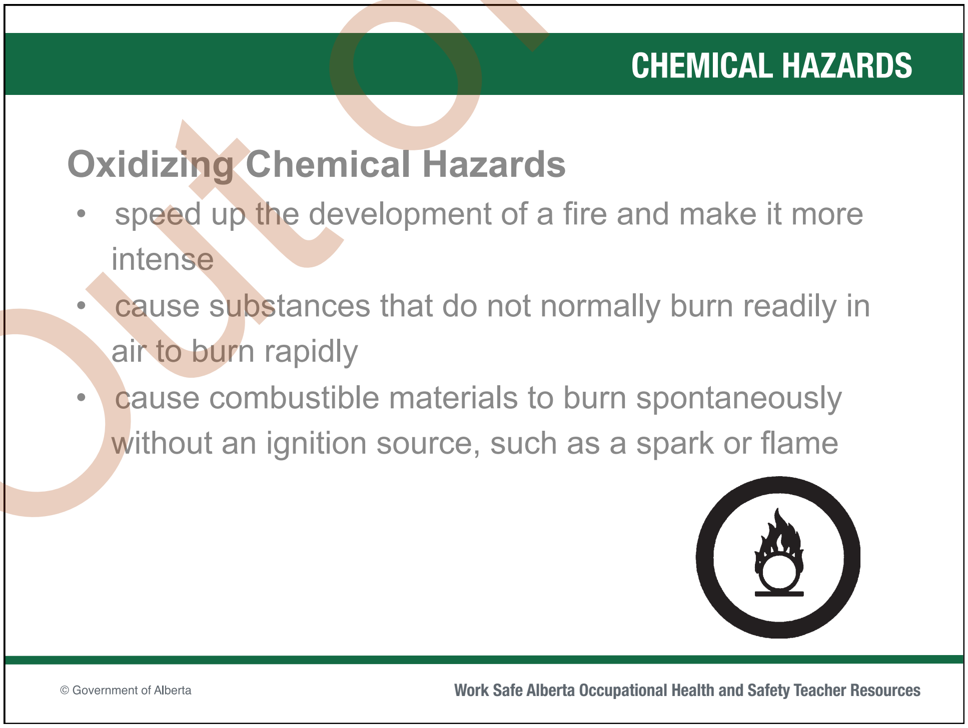
C-Types.ppt Slide 5



CHEMICAL HAZARDS

Oxidizing Chemical Hazards

- speed up the development of a fire and make it more intense
- cause substances that do not normally burn readily in air to burn rapidly
- cause combustible materials to burn spontaneously without an ignition source, such as a spark or flame

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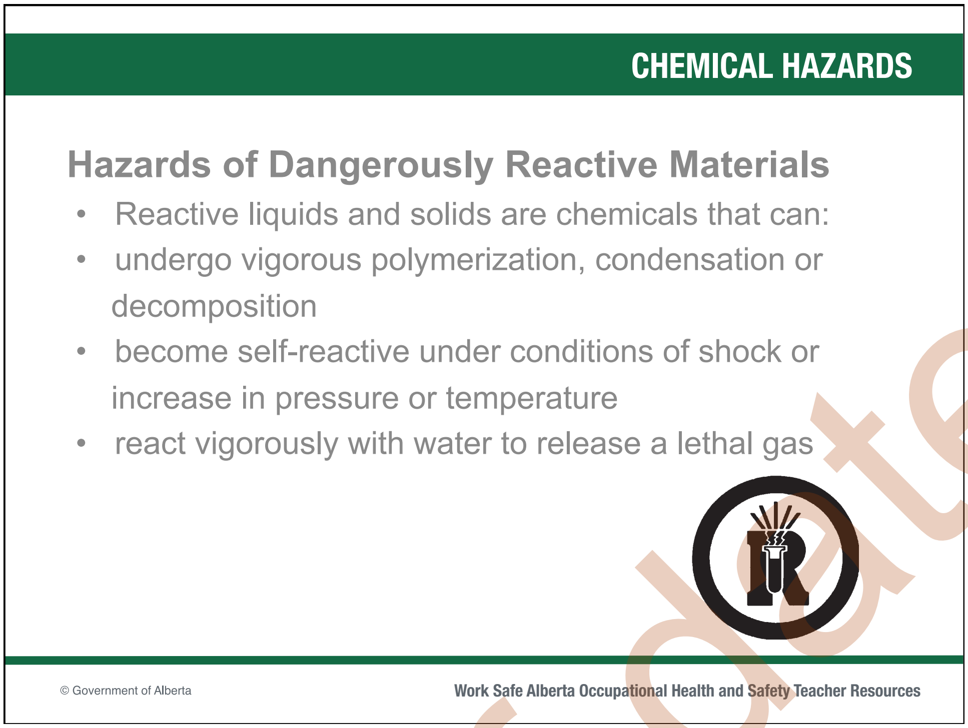
C-Types.ppt Slide 6



CHEMICAL HAZARDS

Hazards of Dangerously Reactive Materials

- Reactive liquids and solids are chemicals that can:
- undergo vigorous polymerization, condensation or decomposition
- become self-reactive under conditions of shock or increase in pressure or temperature
- react vigorously with water to release a lethal gas

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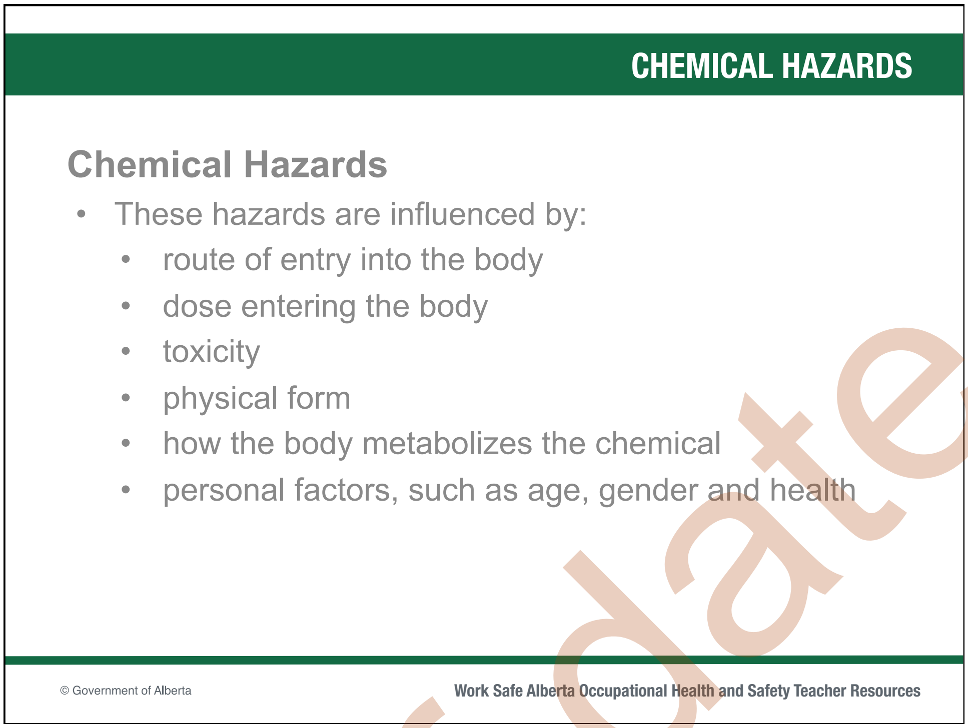
C-Types.ppt Slide 7



CHEMICAL HAZARDS

Chemical Hazards

- These hazards are influenced by:
  - route of entry into the body
  - dose entering the body
  - toxicity
  - physical form
  - how the body metabolizes the chemical
  - personal factors, such as age, gender and health

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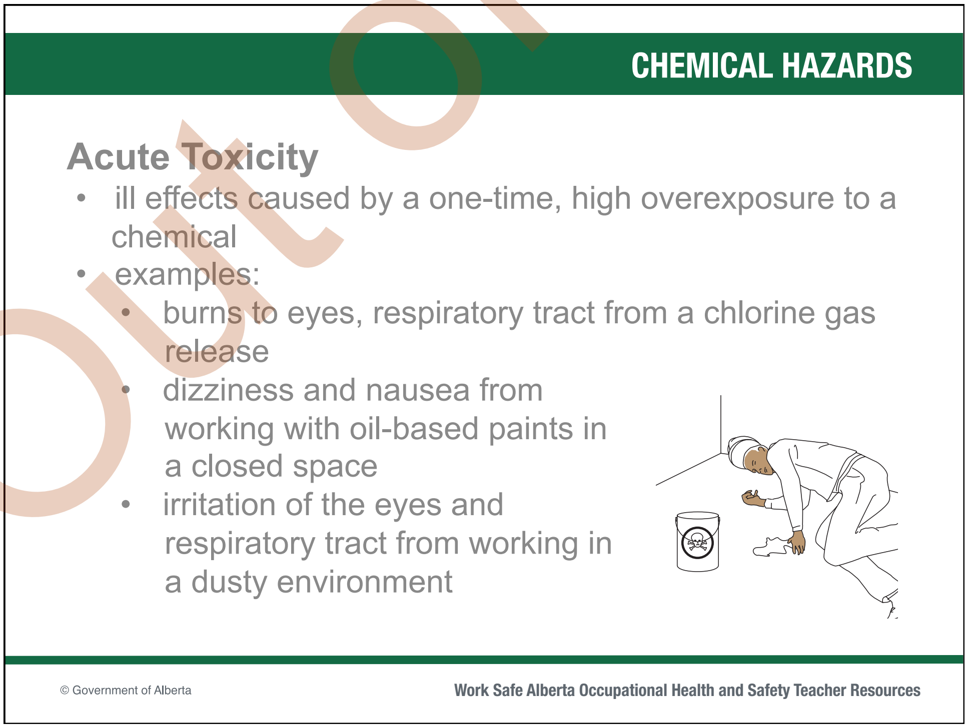
D-HowExposed.ppt Slide 1



CHEMICAL HAZARDS

Acute Toxicity

- ill effects caused by a one-time, high overexposure to a chemical
- examples:
  - burns to eyes, respiratory tract from a chlorine gas release
  - dizziness and nausea from working with oil-based paints in a closed space
  - irritation of the eyes and respiratory tract from working in a dusty environment

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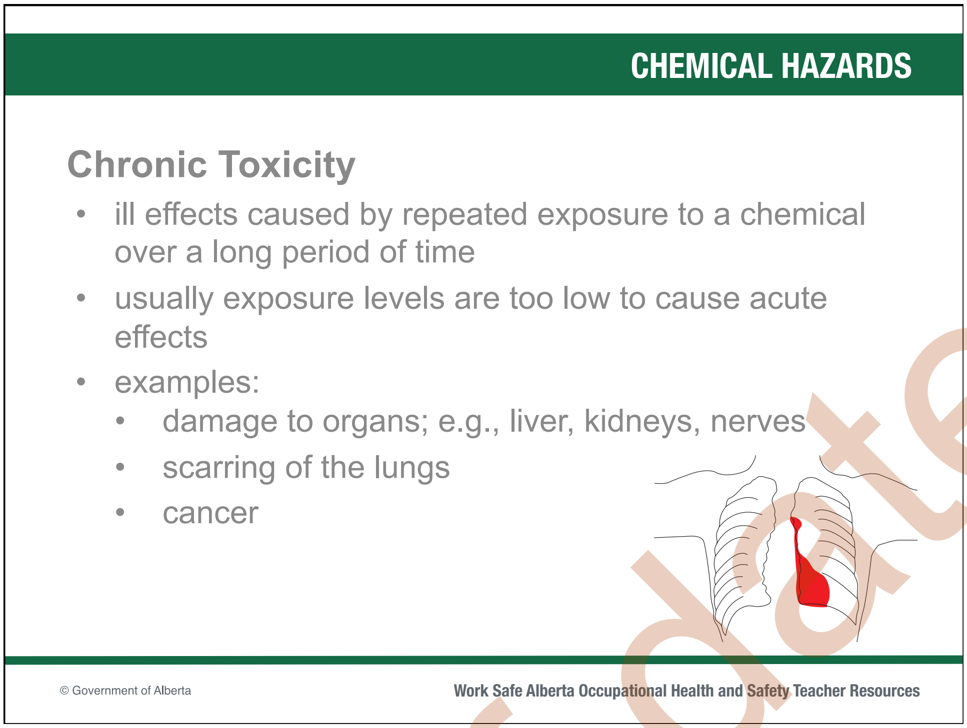
D-HowExposed.ppt Slide 2



CHEMICAL HAZARDS

Chronic Toxicity

- ill effects caused by repeated exposure to a chemical over a long period of time
- usually exposure levels are too low to cause acute effects
- examples:
    - damage to organs; e.g., liver, kidneys, nerves
    - scarring of the lungs
    - cancer

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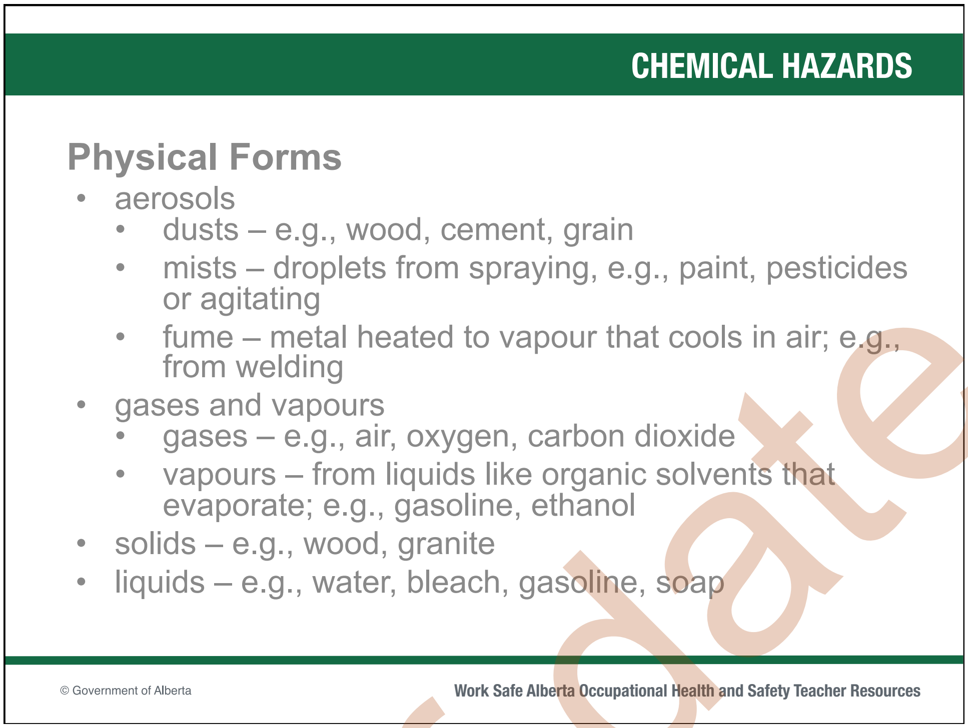
D-HowExposed.ppt Slide 3



CHEMICAL HAZARDS

Physical Forms

- aerosols
  - dusts – e.g., wood, cement, grain
  - mists – droplets from spraying, e.g., paint, pesticides or agitating
  - fume – metal heated to vapour that cools in air; e.g., from welding
- gases and vapours
  - gases – e.g., air, oxygen, carbon dioxide
  - vapours – from liquids like organic solvents that evaporate; e.g., gasoline, ethanol
- solids – e.g., wood, granite
- liquids – e.g., water, bleach, gasoline, soap

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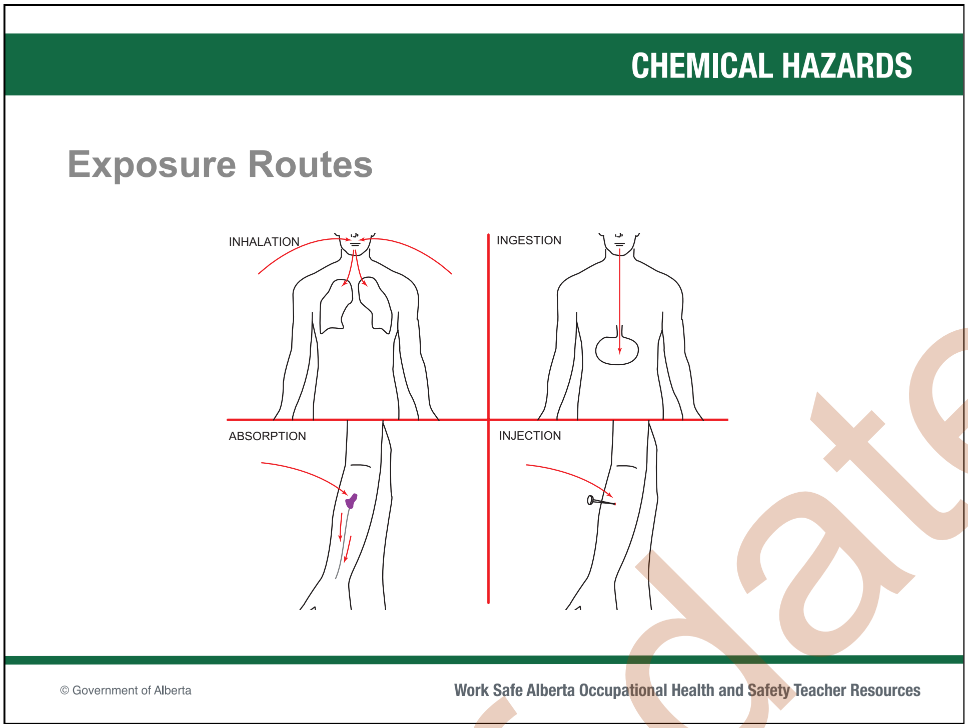
E-Forms.ppt Slide 1



CHEMICAL HAZARDS

Exposure Routes

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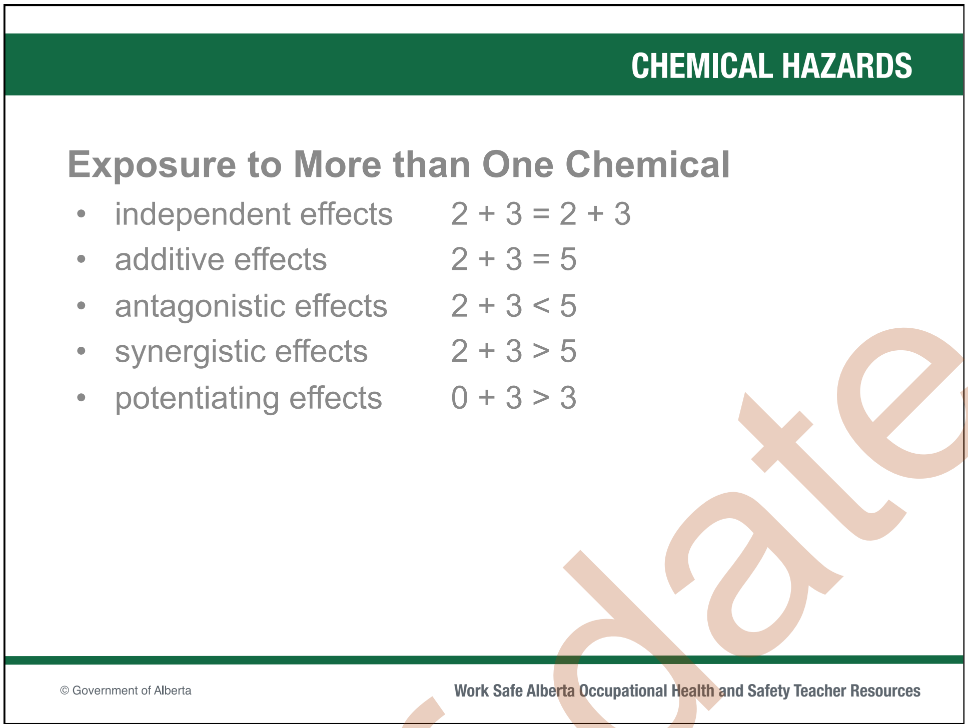
F-ExposeRoutes.ppt Slide 1



CHEMICAL HAZARDS

Exposure to More than One Chemical

• independent effects	2 + 3 = 2 + 3
• additive effects	2 + 3 = 5
• antagonistic effects	2 + 3 < 5
• synergistic effects	2 + 3 > 5
• potentiating effects	0 + 3 > 3

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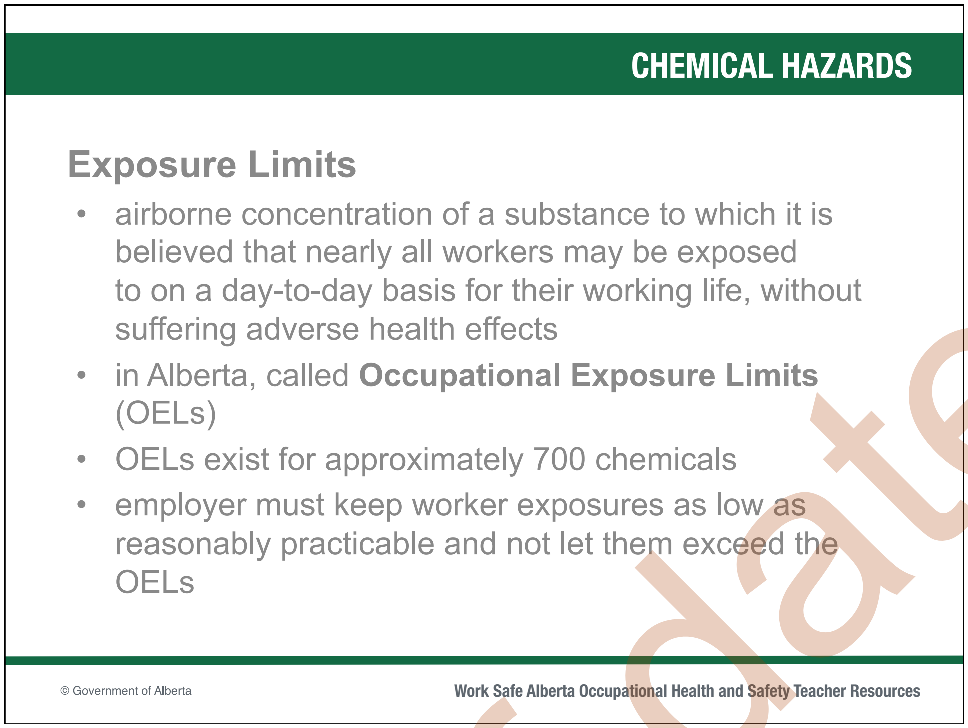
G-MoreThanOne.ppt Slide 1



CHEMICAL HAZARDS

Exposure Limits

- airborne concentration of a substance to which it is believed that nearly all workers may be exposed to on a day-to-day basis for their working life, without suffering adverse health effects
- in Alberta, called **Occupational Exposure Limits** (OELs)
- OELs exist for approximately 700 chemicals
- employer must keep worker exposures as low as reasonably practicable and not let them exceed the OELs

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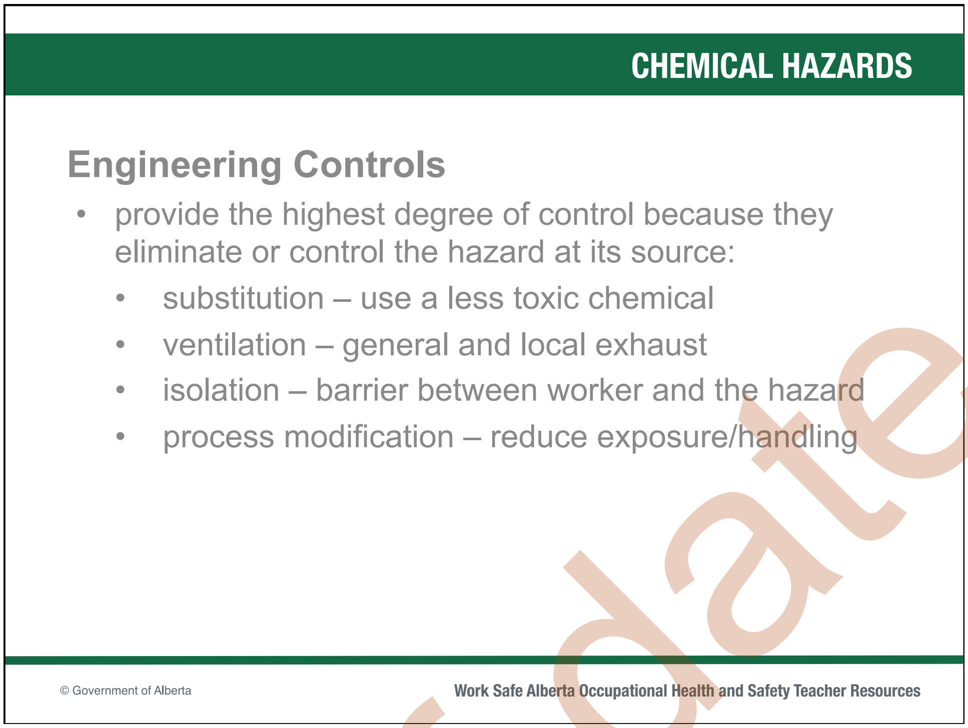
H-Limits.ppt Slide 1



CHEMICAL HAZARDS

Engineering Controls

- provide the highest degree of control because they eliminate or control the hazard at its source:
  - substitution – use a less toxic chemical
  - ventilation – general and local exhaust
  - isolation – barrier between worker and the hazard
  - process modification – reduce exposure/handling

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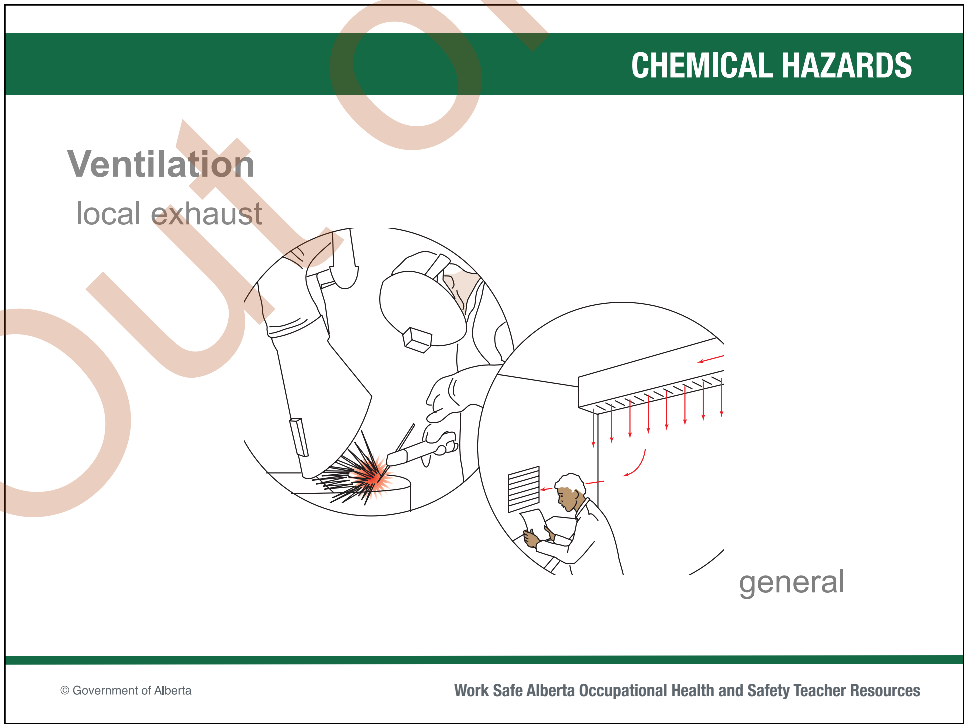
I-Controlling.ppt Slide 1



CHEMICAL HAZARDS

Ventilation

local exhaust

general

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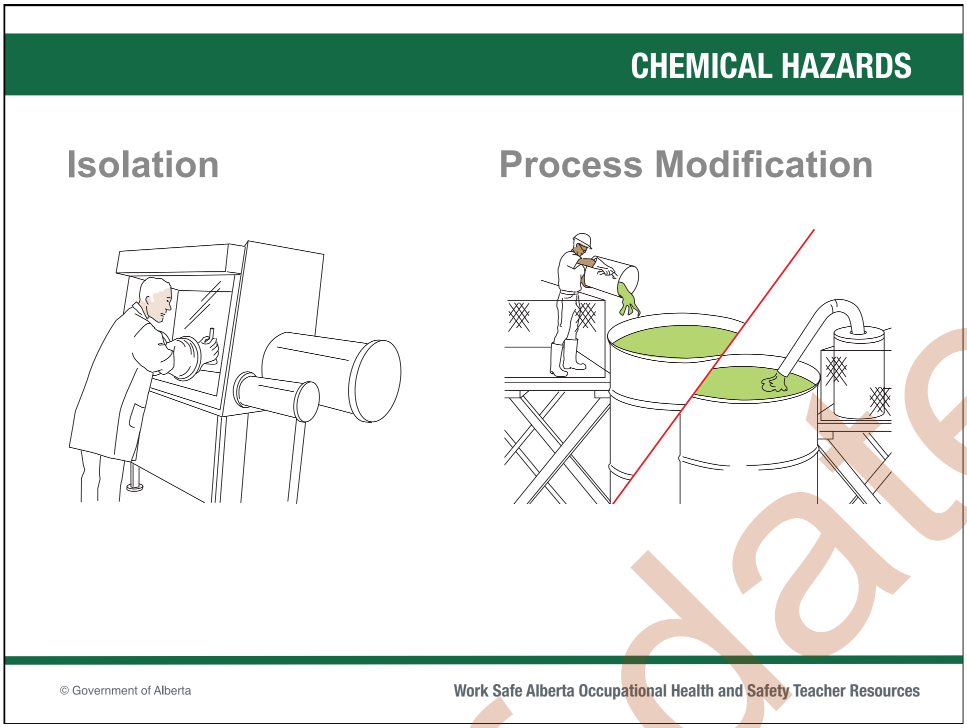
I-Controlling.ppt Slide 2



CHEMICAL HAZARDS

Isolation

Process Modification

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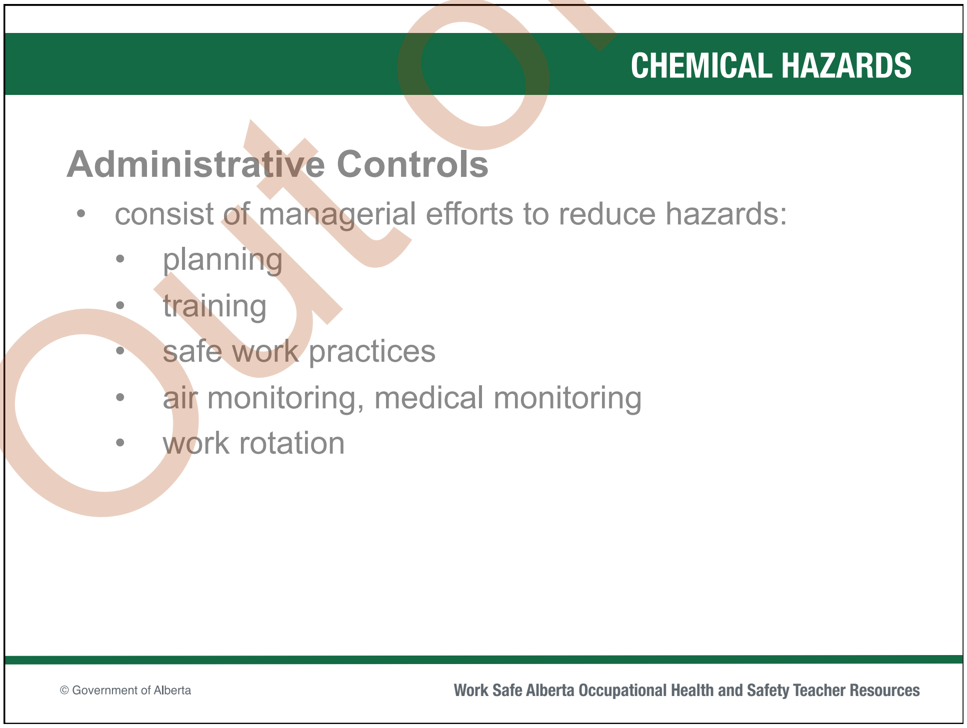
I-Controlling.ppt Slide 3



CHEMICAL HAZARDS

Administrative Controls

- consist of managerial efforts to reduce hazards:
  - planning
  - training
  - safe work practices
  - air monitoring, medical monitoring
  - work rotation

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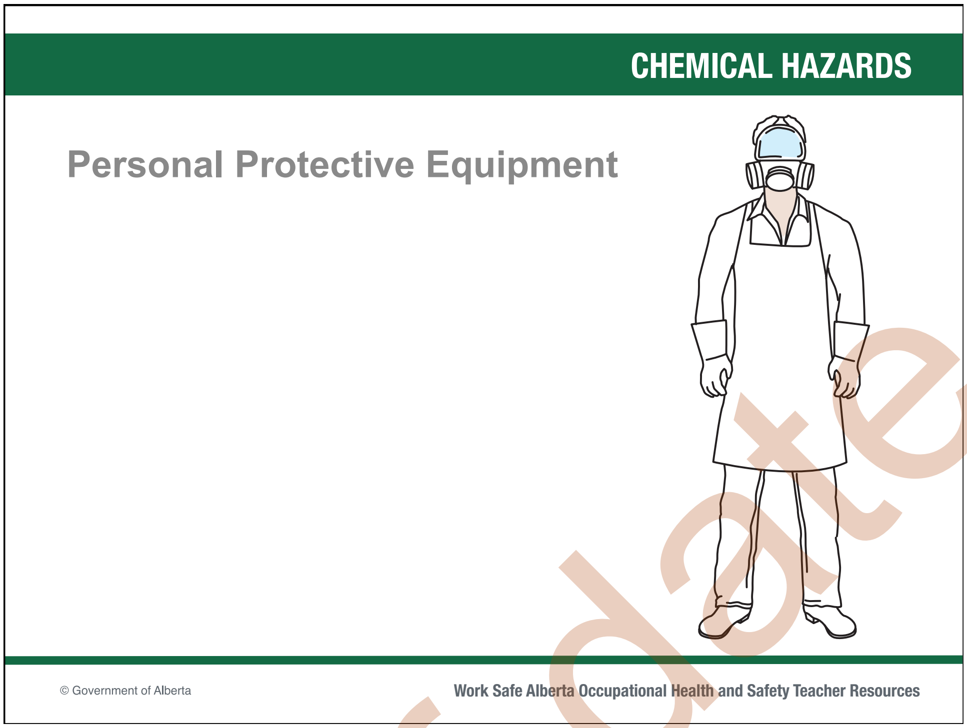

CHEMICAL HAZARDS

Personal Protective Equipment

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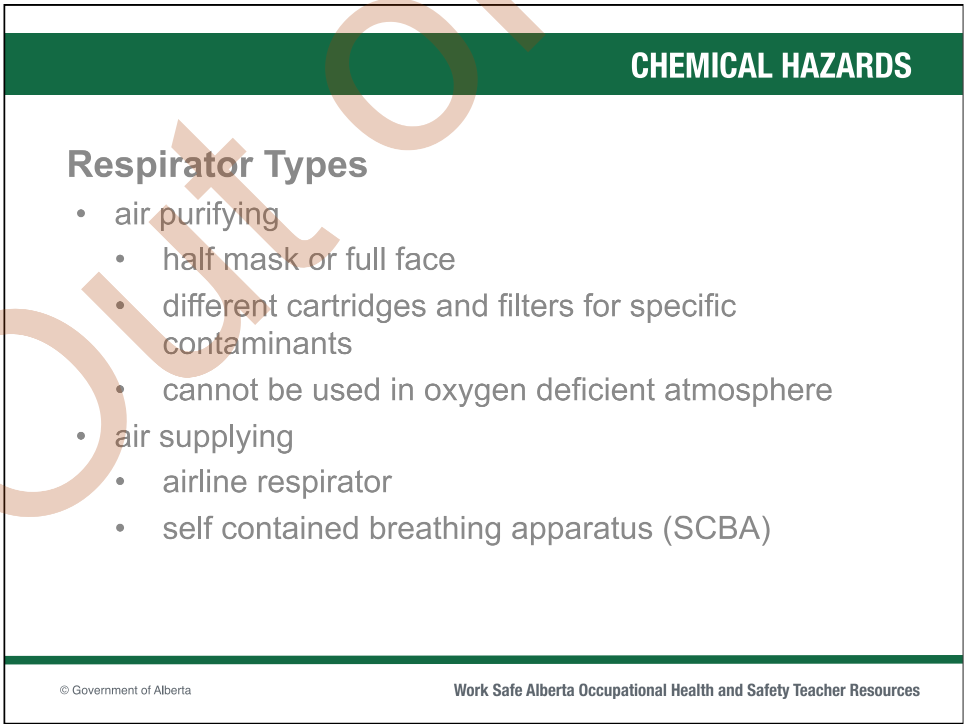

CHEMICAL HAZARDS

Respirator Types

- air purifying
  - half mask or full face
  - different cartridges and filters for specific contaminants
  - cannot be used in oxygen deficient atmosphere
- air supplying
  - airline respirator
  - self contained breathing apparatus (SCBA)

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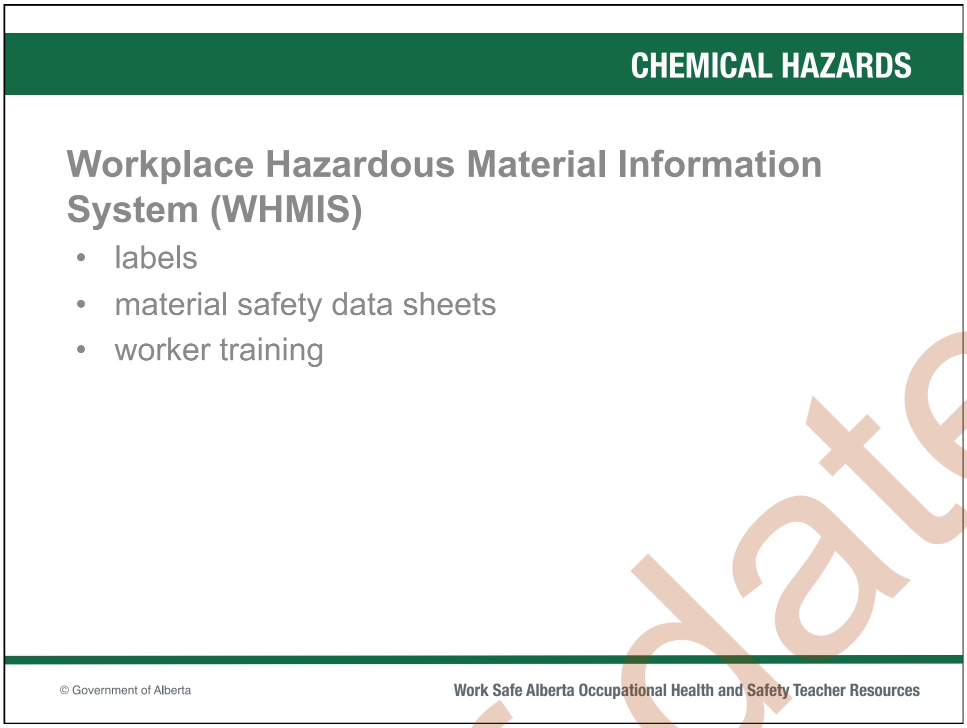

CHEMICAL HAZARDS

Workplace Hazardous Material Information System (WHMIS)

- labels
- material safety data sheets
- worker training

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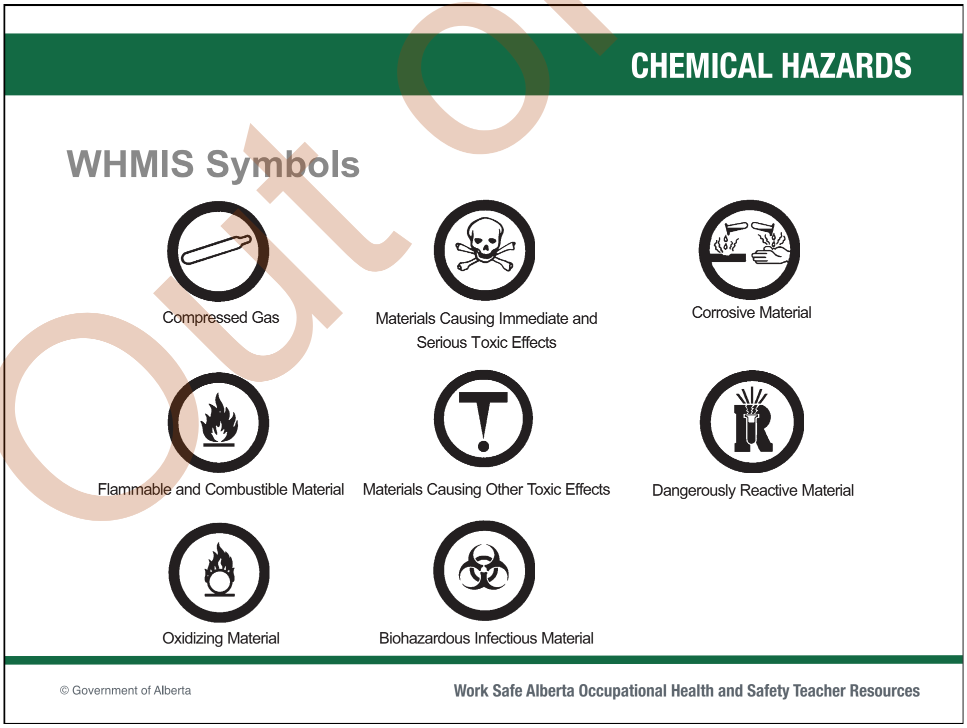
J-ChemHazards.ppt Slide 1



CHEMICAL HAZARDS

WHMIS Symbols

Compressed Gas

Materials Causing Immediate and Serious Toxic Effects

Corrosive Material

Flammable and Combustible Material

Materials Causing Other Toxic Effects

Dangerously Reactive Material

Oxidizing Material

Biohazardous Infectious Material

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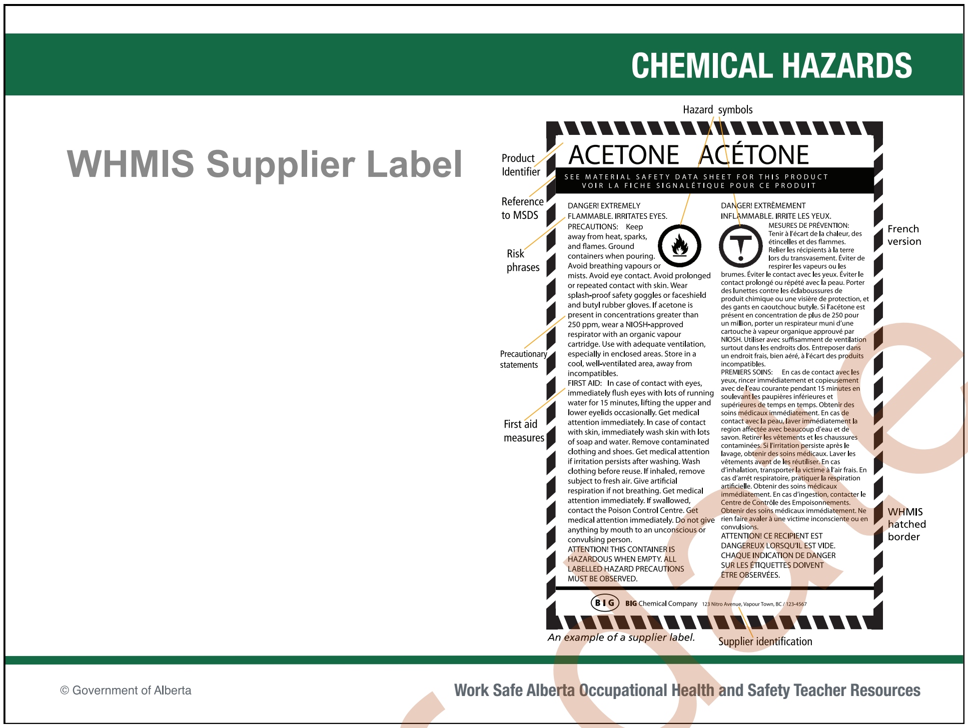
J-ChemHazards.ppt Slide 2



CHEMICAL HAZARDS

WHMIS Supplier Label

ACETONE ACÉTONE

SEE MATERIAL SAFETY DATA SHEET FOR THIS PRODUCT
VOIR LA FICHE SIGNALÉTIQUE POUR CE PRODUIT

DANGER! EXTREMELY FLAMMABLE. IRRITATES EYES.
PRECAUTIONS: Keep away from heat, sparks, and flames. Ground containers when pouring. Avoid breathing vapours or mists. Avoid eye contact. Avoid prolonged or repeated contact with skin. Wear splash-proof safety goggles or faceshield and butyl rubber gloves. If acetone is present in concentrations greater than 250 ppm, wear a NIOSH-approved respirator with an organic vapour cartridge. Use with adequate ventilation, especially in enclosed areas. Store in a cool, well-ventilated area, away from incompatibles.
FIRST AID: In case of contact with eyes, immediately flush eyes with lots of running water for 15 minutes, lifting the upper and lower eyelids occasionally. Get medical attention immediately. In case of contact with skin, immediately wash skin with lots of soap and water. Remove contaminated clothing and shoes. Get medical attention if irritation persists after washing. Wash clothing before reuse. If inhaled, remove subject to fresh air. Give artificial respiration if not breathing. Get medical attention immediately. If swallowed, contact the Poison Control Centre. Get medical attention immediately. Do not give anything by mouth to an unconscious or convulsing person.
ATTENTION! THIS CONTAINER IS HAZARDOUS WHEN EMPTY. ALL LABELLED HAZARD PRECAUTIONS MUST BE OBSERVED.

DANGER! EXTRÈMEMENT INFLAMMABLE. IRRITE LES YEUX.
MESURES DE PRÉVENTION: Tenir à l'écart de la chaleur, des étincelles et des flammes. Relier les récipients à la terre lors du transvasement. Éviter de respirer les vapeurs ou les brumes. Éviter le contact avec les yeux. Éviter le contact prolongé ou répété avec la peau. Porter des lunettes contre les éclaboussures de produit chimique ou une visière de protection, et des gants en caoutchouc butyle. Si l'acétone est présent en concentration de plus de 250 pour un million, porter un respirateur muni d'une cartouche à vapeur organique approuvé par NIOSH. Utiliser avec suffisamment de ventilation surtout dans les endroits clos. Entreposer dans un endroit frais, bien aéré, à l'écart des produits incompatibles.
PREMIERS SOINS: En cas de contact avec les yeux, rincer immédiatement et copieusement avec de l'eau courante pendant 15 minutes en soulevant les paupières inférieures et supérieures de temps en temps. Obtenir des soins médicaux immédiatement. En cas de contact avec la peau, laver immédiatement la region affectée avec beaucoup d'eau et de savon. Retirer les vêtements et les chaussures contaminées. Si l'irritation persiste après le lavage, obtenir des soins médicaux. Laver les vêtements avant de les réutiliser. En cas d'inhalation, transporter la victime à l'air frais. En cas d'arrét respiratoire, pratiquer la respiration artificielle. Obtenir des soins médicaux immédiatement. En cas d'ingestion, contacter le Centre de Contrôle des Empoisonnements. Obtenir des soins médicaux immédiatement. Ne rien faire avaler à une victime inconsciente ou en convulsions.
ATTENTION! CE RECIPIENT EST DANGEREUX LORSQU'IL EST VIDE. CHAQUE INDICATION DE DANGER SUR LES ÉTIQUETTES DOIVENT ÊTRE OBSERVÉES.

BIG Chemical Company 123 Nitro Avenue, Vapour Town, BC / 123-4567

An example of a supplier label.

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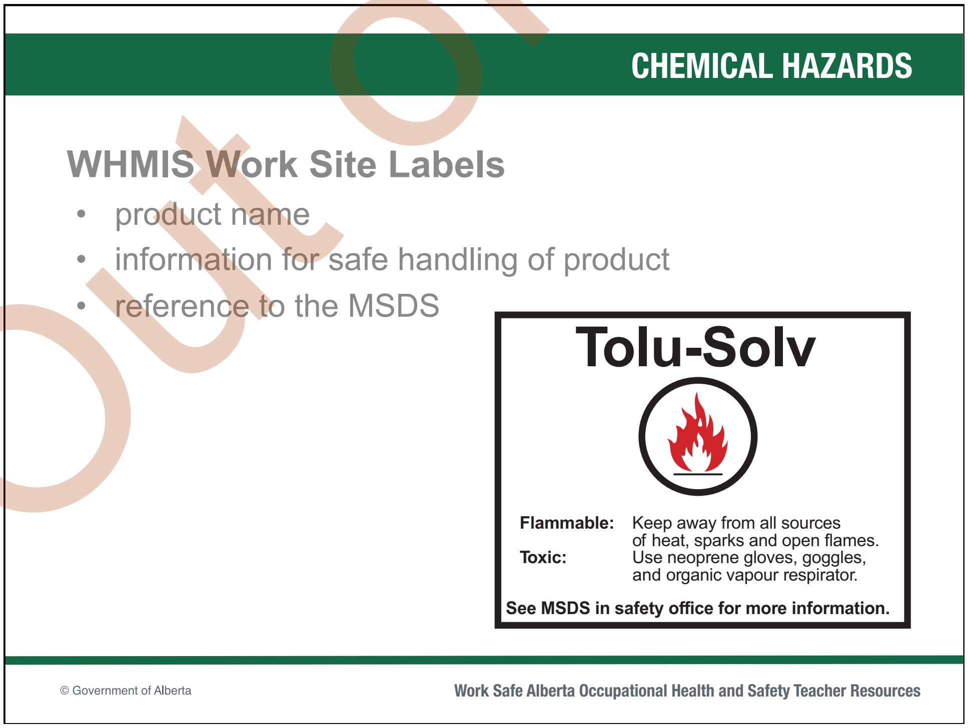
J-ChemHazards.ppt Slide 3



CHEMICAL HAZARDS

WHMIS Work Site Labels

- product name
- information for safe handling of product
- reference to the MSDS

Tolu-Solv

Flammable: Keep away from all sources of heat, sparks and open flames.

Toxic: Use neoprene gloves, goggles, and organic vapour respirator.

See MSDS in safety office for more information.

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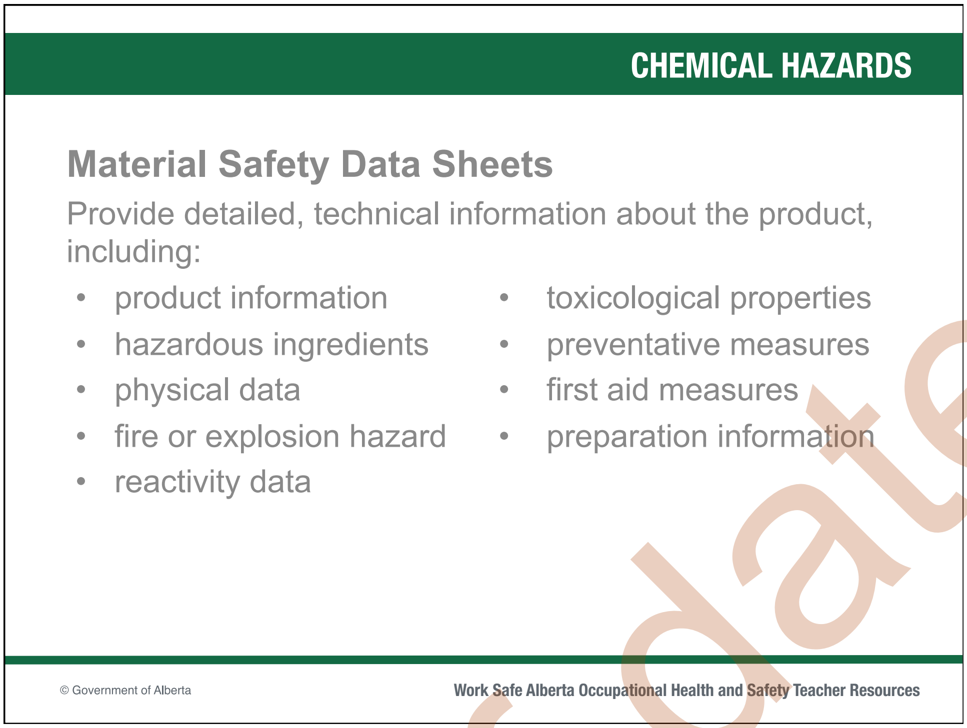

CHEMICAL HAZARDS

Material Safety Data Sheets

Provide detailed, technical information about the product, including:

- product information
- hazardous ingredients
- physical data
- fire or explosion hazard
- reactivity data
- toxicological properties
- preventative measures
- first aid measures
- preparation information

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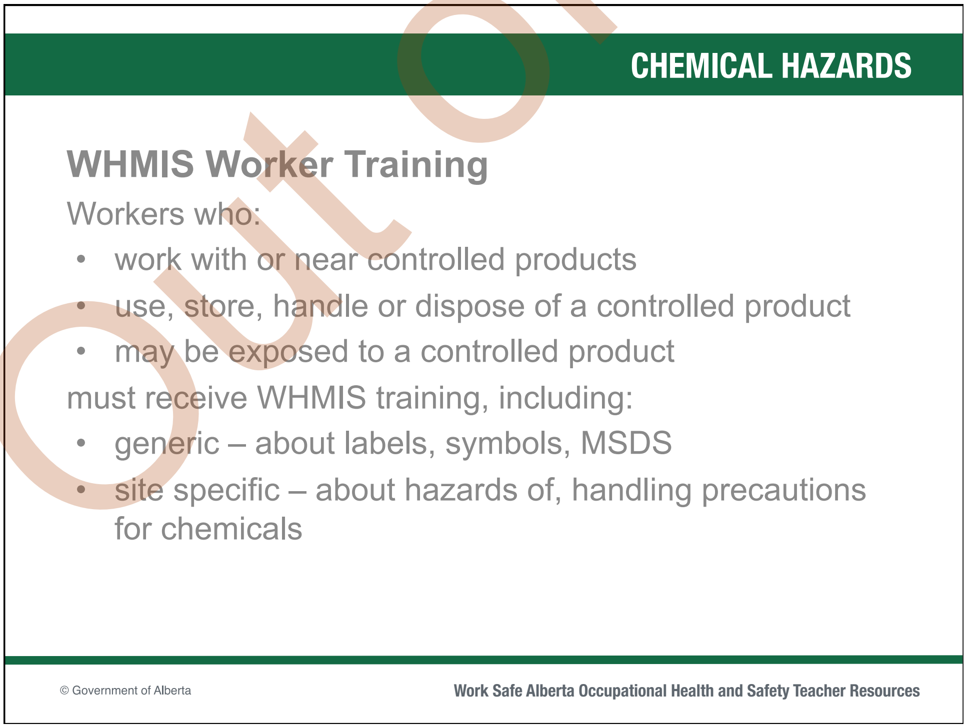

CHEMICAL HAZARDS

WHMIS Worker Training

Workers who:

- work with or near controlled products
- use, store, handle or dispose of a controlled product
- may be exposed to a controlled product

must receive WHMIS training, including:

- generic – about labels, symbols, MSDS
- site specific – about hazards of, handling precautions for chemicals

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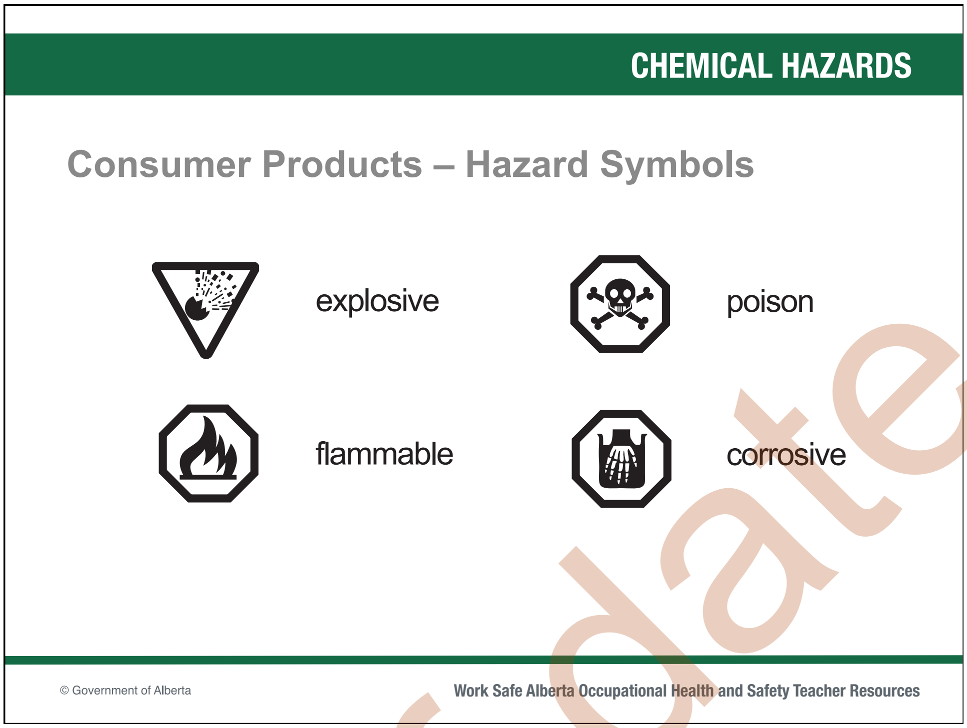

CHEMICAL HAZARDS

Consumer Products – Hazard Symbols

explosive

poison

flammable

corrosive

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J-ChemHazards.ppt Slide 7

TEACHER'S NOTES

A. Chemical Compatibility

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 vapours or gases

In terms of compatibility, chemicals can usually be grouped into five main categories: flammable/combustible, acid, base, oxidizer and reactive. These groups are incompatible with each other and must be stored separately from each other.

Refer to Handout 3 – Chemical Compatibility.

A +	B =	C
Acids or bases (corrosives)	Reactive metals such as: • aluminum • beryllium • calcium • lithium • potassium • magnesium • sodium • zinc powder	**Fire**
Solvent or reactive organic materials such as: • 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: • chlorates • chlorine • chlorites • chromic acid • hypochlorites • nitrates • perchlorates • permanganates • peroxides	Flammable liquids Flammable solids Flammable or combustible wastes	**Explosion**

SA-Compatibility.ppt
Slide 1q

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SB-Guidelines.ppt
Slide 1

B. Chemical Hazard Controls – Some General Guidelines

- Obtain and read the material safety data sheets (MSDSs) for all materials with which you work.
- Know which materials are hazardous.
- Be aware of **all** of the hazards (e.g., fire/explosion, health, chemical reactivity) of the materials with which you work.
- Store chemical products in suitable labelled containers away from incompatible materials, in a cool, dry area.
- Keep only the smallest amount of chemical possible (not more than one day's supply) in your work area.
- Store, handle and use chemical products in well-ventilated areas away from potential ignition sources.
- Handle containers safely to avoid damaging them.
- Dispense chemical products carefully, using compatible equipment and containers.
- Keep containers closed when not in use.
- Do not return contaminated or unused chemicals to the original container.
- Handle and dispose of chemical wastes safely.
- Practise good housekeeping, personal cleanliness and equipment maintenance.
- Wear the proper personal protective equipment for each of the jobs you do.
- Know how to handle emergencies, e.g., fires, spills, personal injury, involving the materials with which you work.
- Follow the health and safety rules that apply to your job.

C. Personal Protective Equipment for Chemical Hazards

If chemical hazards cannot be controlled enough with engineering or administrative controls (or a combination of the two), personal protective equipment (PPE) must be worn to protect workers from exposure.

Choosing the right PPE to wear when doing a particular job is essential. The specific hazards of the chemicals worked with must be properly addressed. MSDSs provide general guidance but selecting PPE for a specific job is best done with the help of someone who knows how to evaluate the hazards of the job and how to select the proper PPE.

Avoid Skin Contact

When using materials that are harmful by skin contact, wear protective gloves, aprons, boots, hoods or other clothing, depending on the risk of skin contact. Workers should always try to prevent getting chemical products on the skin when using them. Some will not directly harm the skin but can be absorbed into the body through contact. Choose clothing made of materials that resist penetration or damage by the chemical. The MSDS should recommend appropriate materials. If it does not, contact the chemical supplier for specific information.

Protect Eyes and Face

Always wear eye protection when working with chemical products. Ordinary safety glasses are not good enough; use chemical safety goggles instead. In some cases, workers should also wear a face shield to protect their face from splashes.

Avoid Breathing Dust, Vapour or Mist

If respirators must be used to protect against inhaling airborne contaminants, there should be a written respiratory protective equipment code of practice to follow. Respirators must be properly selected for the hazard and be properly fitted to the wearer.

Know and be familiar with the right PPE for emergencies, as well as for normal operations.

D. Control Options

SD-Options.ppt
Slide 1

Compressed Gases

Substitution

It is not always easy or even possible to find a less hazardous substitute for a particular compressed gas used for a certain job. Speak to the chemical supplier to find out if safer substitutes are available. For example, in some cases, methylacetylene-propadiene (MAPP) gas, propylene, propane or mixtures of liquefied petroleum gas can be substituted for acetylene as fuel gases for cutting, welding and brazing. These gases are more stable and can be stored in normal cylinders. Their flammable limits are much more narrow than those of acetylene (e.g., 3.4 to 10.8% for MAPP versus 2.5 to 82% for acetylene) and, as a result, represent a reduced fire hazard. Obtain MSDSs for all possible substitutes. Find out about all of the hazards, e.g., health, fire, corrosivity, chemical reactivity, of these materials before making any changes.

Ventilation

Well-designed and well-maintained ventilation systems remove gases from the workplace and reduce their hazards. The amount and type of ventilation needed depends on conditions, such as the type of job, kind and amount of materials used and size and layout of the work area.

Assess the specific ways your workplace stores, handles, uses and disposes of its compressed gases. An assessment can reveal if existing ventilation controls and other hazard control methods are adequate. Some workplaces may need a complete system of hoods and ducts to provide acceptable ventilation. Others may require a single, well-placed exhaust fan. Storage facilities for particularly hazardous materials, such as chlorine, may require an additional emergency ventilation system or continuous monitoring with appropriate alarms. Other workplaces, that use small amounts of inert gases may require no special ventilation system.

Make sure ventilation systems are designed and built so that they do not result in an unintended hazard. Ensure that hoods, ducts, air cleaners and fans are made from materials compatible with the gas used. Systems may require explosion-proof (i.e., nonsparking) and corrosion-resistant equipment. Separate ventilation systems may be needed for some compressed gases to keep them away from systems that exhaust incompatible substances.

Modification

Sometimes, process changes or modifications can reduce the hazard. For example, many cylinders of the same gas may be used in different areas of a workplace. Installing fixed pipelines, connected to a central gas supply, in a safe area can often reduce the hazard. It can also reduce the need for many sets of portable equipment supplied through flexible hoses. Also, ordering cylinders equipped with flow limiting restrictors can minimize the hazards of a sudden failure of a process gas line.

Handling Compressed Gas Cylinders

SD-Options.ppt
Slide 2

Inspect all incoming cylinders before storing to ensure they are not damaged and that they are properly labelled. Do not accept delivery of defective cylinders. Be sure they are not giving off odours, visible gas or have hissing sounds. Check that the cylinder was last tested within the required time frame (usually five years). Also check that the cylinder labels are intact and that they match other identifying markings on the cylinder. Do not rely on cylinder colour to identify the gas. Different suppliers may use different colours for cylinders of the same gas. In addition, colours appear different under artificial lights and some people are colour blind.

Call compressed gases by the name on the supplier label. This reduces confusion, promotes recognition of the hazards involved and precautions to take and can prevent accidental use of the wrong gas. If oxygen is called air, someone who wants air to run a tool may use oxygen with possible serious results. Leave the valve cap securely in place until the cylinder is to be used. Inspect the cylinder valve by looking through the ports in the valve cap. Do not accept dirty, rusted or otherwise damaged valves and fixtures.

Always transport cylinders with valve caps or other valve protection in place. Pulling cylinders by their valve caps, rolling them on their sides or dragging or sliding them can cause damage. Rolling cylinders on their bottom edge may be acceptable for short distances. Never lift cylinders with magnets or chain or wire rope slings. Transport cylinders on specially built hand carts, trolleys or other devices designed for this purpose. All these devices should have some way of securing cylinders to prevent them from falling.

Store compressed gas cylinders separately, away from processing and handling areas and away from incompatible materials. Separate storage can minimize injury and damage in case of fires, spills or leaks. Many compressed gases can undergo dangerous reactions if they come in contact with incompatible materials so store them apart from each other. Check the reactivity information and storage requirements sections of the MSDS for details about which materials are incompatible with a particular compressed gas. The Alberta Fire Code addresses requirements for the separation of different gases in storage.

If compressed gas cylinders are stored outside, use a well-drained, securely fenced area. Keep them on a raised concrete pad or noncombustible rack. Protect cylinders from the weather and do not allow them to stand directly on wet soil as this can cause corrosion.

Indoor storage areas must have walls, floors and fittings made of suitable materials. For example, use noncombustible building materials in storage areas for oxidizing gas and corrosion-resistant materials in storage areas for corrosive gas. Make sure floors are level and protect cylinders from dampness.

Always chain or securely restrain cylinders in an upright position to a wall, rack or other solid structure wherever they are stored, handled or used. Securing each cylinder individually is best. Stacking groups of cylinders together offers some protection but, if this is done improperly, the entire group of cylinders could fall.

Store compressed gas cylinders in areas that are:

- well ventilated and dry
- fire-resistant and supplied with suitable fire fighting equipment
- away from electrical circuits and ignition sources, such as sparks, flames or hot surfaces
- accessible at all times but away from elevators, staircases or main traffic routes where cylinders may be dangerous obstacles
- labelled with suitable warning signs
- dry, cool, out of direct sunlight

Always store full cylinders separately from empty cylinders.

Using Compressed Gases

When moving cylinders, securely fasten them to a suitable cylinder transporting device. At the site, chain or otherwise secure the cylinder in place. Remove the valve cap only after the cylinder has been safely installed, then check the cylinder valve and fixture. Remove dirt or rust. Grit, dirt, oil or dirty water can cause gas leaks if they get into the cylinder valve or gas connection. In general, do not lubricate cylinder valves, fittings or regulator threads or apply jointing compounds and tape. Use only lubricants and sealants recommended by the gas supplier. Cylinders stored in cold areas may have frozen valves. Use only warm water to thaw the valve or bring the cylinder into a warm area and allow it to thaw at room temperature.

Never open a damaged valve. Contact your gas supplier for advice.

There are four standard types of cylinder valve outlets to prevent the mixing of incompatible gases. Use only the proper equipment for discharging a particular gas from its cylinder. Never use homemade adaptors or force connections between the cylinder valve outlet and gas handling equipment.

Use only recommended keys or handwheels to open valves. Never use longer keys or modify keys to increase their leverage. Avoid using even the correct key if it is badly worn. Do not use pipe wrenches or similar tools on handwheels. Any of these practices could easily damage the valve seat or spindle.

Always open valves on all gas discharge equipment slowly. Rapid opening of valves results in rapid compression of the gas in the high-pressure passages leading to the seats. The rapid compression can lead to temperatures high enough to burn out the regulator and valve seats. Many accidents involving oxidizing gases result from burned out regulator and valve seats, usually caused by opening valves too quickly.

Do not use excessive force when opening cylinder valves – use no more than three quarters of a turn, if possible. If a problem develops, the valve can then be closed quickly. Leave keys on cylinders when valves are open so the valve can be closed quickly in an emergency. Some cylinder valves, such as oxygen valves, have double seating. These valves should be fully opened; otherwise, they may leak.

Do not use excessive force when opening or closing a cylinder valve. When closing, turn it just enough to stop the gas flow completely. Never force the valve shut.

Close cylinder valves when the cylinder is not actually in use. Do not stop the gas flow from a cylinder by just backing off on the regulator. Regulators can develop seat leaks, allowing pressure to build up in equipment attached to the regulator. Also, if the cylinder valve is left open, foreign matter can enter the cylinder if the cylinder pressure drops lower than the pressure in attached equipment. Close the cylinder valve first and then close the regulator.

When using compressed gases:

- Use the smallest practical cylinder size for a particular job.
- Do not keep cylinders longer than the supplier recommends. Compressed gas cylinders are mainly shipping containers. They are built to be as light as possible while remaining safe and durable.
- Do not drop cylinders or otherwise allow them to strike each other. Rough handling, including using cylinders as hammers or as rollers to move equipment, can seriously damage them.
- Do not strike an electric arc on a cylinder. Arc burns can make the metal brittle and weaken the cylinder.
- Never tamper with cylinders in any way. Do not repaint them, change markings or identification or interfere with valve threads or safety devices.
- Do not refill compressed gas cylinders. Apart from the fact that it is illegal, it can be dangerous for nonspecialists to refill cylinders or to change their contents. Explosions, cylinder contamination or corrosion can result.

Equipment Used with Compressed Gases

Equipment used with compressed gases must be clean, properly designed and maintained. It must be made from materials compatible with the gas used. For example, acetylene forms explosive compounds in contact with copper, silver and mercury or their alloys, including bronze or brass containing more than 65% copper. Ammonia attacks brass and can react with mercury to form an explosive compound. Do not use mercury pressure gauges in ammonia systems.

In general, avoid pressurizing ordinary glass equipment. Use specially designed glass equipment and protective devices. Where cylinders are connected to a manifold or header, make sure specialists properly design and install the system. Use effective flashback arresters on acetylene and other flammable gas systems.

Always follow the correct procedures for assembling and disassembling compressed gas equipment. Check that all the connections are clean and do not leak. Check for leaks, using the gas supplier's recommended method, after assembling and before starting to use equipment. Never use old clips or twisted wire for hose connections. If a hose works loose and flails around, serious injury could result. Poor hose connections are a common cause of incidents and injuries.

Handling Empty Cylinders

- Nonliquefied and dissolved gases
  The amount of material remaining in a nonliquefied or dissolved gas (e.g., acetylene) cylinder is proportional to the cylinder pressure gauge reading. As the gas is used, the reading on the cylinder pressure gauge drops. When the cylinder pressure gauge reads zero, the cylinder is not really empty. The cylinder still contains some gas (at atmospheric pressure).
- Liquefied gases
  The pressure in liquefied gas cylinders remains constant at a given temperature as long as any liquid remains in the cylinder. The only way to know how much material remains in a liquefied gas cylinder is to weigh the cylinder. The empty (tare) weight of the cylinder is stamped on its neck or valve stem. Record the net weight of the cylinder contents on a card attached to it. As with nonliquefied and dissolved gases, never empty the cylinder completely. Keep a small amount of material in the cylinder to maintain a slight positive pressure.

In general:

- Keep a positive pressure in an "empty" compressed gas cylinder to prevent back flow. This back flow is the drawing-back into the cylinder of contaminants or moist air from a higher pressure system or the atmosphere.
- Keep the valves on all "empty" cylinders closed. This practice maintains a positive pressure in them.
- When a compressed gas cylinder is "empty," handle it as though it is full since it does contain gas.
- Close the cylinder valve before removing the gas discharge equipment. Clearly mark or label the cylinder "empty" or "MT."
- Place the cylinder in a storage area separate from that used for full cylinders.
- Keep incompatible materials away from the cylinder.

- Notify the gas supplier if the cylinder or any part of it is damaged or defective, contaminated or may have been exposed to a possibly hazardous condition such as a fire or electric arc.
- Contact the gas supplier for advice on disposing of unserviceable cylinders.

Summary of Specific Safe Work Practices for Compressed Gases

- Know which of the materials you work with are compressed gases and check the label – not the cylinder colour – to identify the gas.
- Store, handle and use compressed gas cylinders securely fastened in place in the upright position. Never roll, drag or drop cylinders or permit them to strike each other.
- Move cylinders in handcarts or other devices designed for moving cylinders.
- Leave the cylinder valve protection cap in place until the cylinder is secured and ready for use.
- Discharge compressed gases safely, using devices, such as pressure regulators approved for the particular gas.
- Never force connections or use homemade adapters.
- Ensure that equipment is compatible with cylinder pressure and contents.
- Check all cylinder-to-equipment connections carefully before use and periodically during use to be sure they are tight, clean, in good condition and not leaking.
- Open all valves slowly, pointed away from you and others, using the proper tools.
- Close all valves when cylinders are not in use.
- Never tamper with safety devices in cylinders, valves or equipment.
- Do not allow flames to contact cylinders and do not strike an electric arc on cylinders.
- Use cylinders in cool well-ventilated areas.
- Handle “empty” cylinders safely. Leave a slight positive pressure in them, close cylinder valves, disassemble equipment properly, replace cylinder valve protection caps, mark cylinders “empty” or “MT” and store them separately from full cylinders.

Flammable and Combustible Chemicals

Substitution

Use chemicals that are less flammable or nonflammable. For example, many cleaning solvents have nonflammable substitutes and water-based latex paints can often be used instead of oil-based paints.

Control Ignition Sources

For a flammable or combustible liquid to burn, a mixture of vapour and air must be ignited. Possible ignition sources include:

- sparks from electrical tools and equipment
- sparks, arcs and hot metal surfaces from welding and cutting
- tobacco smoking
- open flames from portable torches and heating units, boilers, pilot lights, ovens and driers
- hot surfaces, such as boilers, furnaces, steam pipes, electric lamps, hot plates, irons, hot ducts and flues, electric coils and hot bearings
- embers and sparks from incinerators, foundry cupolas, fireboxes and furnaces
- sparks from grinding and crushing operations
- sparks from static electricity from rotating belts, mixing operations or improper transfer of flammable or hot combustible liquids

Eliminate ignition sources by:

- removing open flames
- using nonsparking equipment; e.g., brass
- not smoking around these liquids
- using approved explosion-proof equipment in hazardous areas
- bonding and grounding equipment and containers

Ventilation

Well-designed and maintained ventilation systems remove flammable vapours from the workplace and reduce the risk of fire and health problems. The amount and type of ventilation needed to minimize the hazards of flammable and combustible liquid vapours depends on the:

- nature of the job
- kind and amount of materials used
- size and layout of the work area

SD-Options.ppt
Slide 3

Flammable and
Combustible Materials
Mix and Match

An assessment of the specific ways flammable and combustible liquids are stored, handled, used and disposed of is the best way to find out if existing ventilation controls and other hazard control methods are adequate.

Some workplaces may need a complete system of hoods and ducts to provide acceptable ventilation. If flammable vapours could condense, the ducts should have welded joints. Other workplaces may only require a single, well-placed exhaust fan. Use nonferrous fan blades and shrouds (housing) and explosion-proof electrical equipment in ventilation systems for these liquids. Regular cleaning of the ducts, filters and plenums will decrease the severity of any fires and will reduce the likelihood of spontaneous combustion if some self-heating material is present. Ventilation equipment used to handle solvent vapours must meet the fire code requirements.

If the ventilation keeps vapour levels below the occupational exposure limit of a chemical, usually there is little risk of fire or explosion. Vapour levels harmful to people are, in most cases, well below the lowest concentration of vapour in air that can burn. For example, toluene has a workplace exposure limit of 50 ppm [50 parts of toluene per million parts of air], which is equal to 0.005% toluene in air. This is far below the lower flammable limit (LFL) for toluene, which is 12,000 ppm (1.2%).

Storage of Flammable and Combustible Liquids

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Slide 4

In Alberta, flammable and combustible liquids must be stored in accordance with the Alberta Fire Code. The Fire Code specifies the kinds of storage areas, such as storage rooms and cabinets, allowed for these liquids. It also specifies how to construct these storage areas and the amounts of flammable and combustible liquids in different types of containers that you can store in each kind of storage area. In general:

- Store containers of flammable and combustible liquids separately, away from process and production areas and away from other materials – this separation will reduce the spread of any fire to other materials in storage. It will also protect the stored flammable and combustible liquids from exposure to fires in other areas and unplanned contact with incompatible materials.
- Keep containers closed when not in use.
- Keep the amount of materials in storage as small as possible; it is a good practice to keep no more than one day's supply of flammable and combustible liquids in the immediate work area and to return any leftover material to the proper storeroom or storage cabinet at the end of the day.

- Storage areas should be:
  - well ventilated to reduce vapour concentrations
  - free of ignition sources
  - cool and dry
  - supplied with adequate fire fighting and spill clean-up equipment
  - away from elevators, building and room exits or main aisles leading to exits
  - accessible by fire fighters
  - labelled with suitable warning signs; e.g., "No Smoking"

Drums of flammable liquids should have pressure- and vacuum-relief venting installed. Normally, this is done as soon as the drum is opened for dispensing. If a stored drum will be exposed to heat sources or large temperature changes, relief venting may be needed.

Storing a full drum in direct sunlight or near other heat sources can increase vapour levels in the drum. This leads to an increase in pressure that could, in extreme cases, cause the drum to rupture. A buildup in pressure can also result in vapour shooting out into the face or onto the clothing of the person opening the drum. A pressure-relief vent prevents this increase in pressure.

Vacuum-relief vents are also useful. If a drum of flammable liquid is subjected to sudden cooling, a partial vacuum can form inside it. This could, in extreme cases, cause the drum to collapse and leak. Also, for proper dispensing of liquids, the space left behind by the liquid in the drum must be replaced with air so that no vacuum forms. There are different kinds of pressure-relief and vacuum-relief devices, including combination types, available from safety equipment retailers.

Dispensing Flammable and Combustible Liquids

Take care when dispensing or transferring flammable and combustible liquids from one container to another. Dispense from only one container at a time. Finish dispensing one material before starting to dispense another. Be sure containers are closed after dispensing to control hazardous vapours and to avoid accidental spills. Approved transfer pumps and drum faucets that cannot be inadvertently left running are available. Check these devices periodically to be sure that they work properly and do not leak.

Use an approved safety drip can below each drum faucet to catch spills or drips from worn or damaged faucets.

Never dispense flammable and combustible liquids near ignition sources. Always make sure that metal containers are bonded and grounded when dispensing.

Never transfer liquids by pressurizing their usual shipping containers with air. The pressure may damage ordinary drums and barrels or create a flammable atmosphere inside the containers.

Mark dispensing areas with suitable warning signs.

Using Flammable and Combustible Liquids

When using flammable and combustible materials in your work area, use approved safety containers. Approved containers are containers that have been approved by testing laboratories acceptable to government enforcement agencies. These laboratories include Underwriters Laboratories of Canada (ULC), Canadian Standards Association (CSA) and Factory Mutual Research (FM). There are many different kinds of approved containers available from safety equipment retailers.

Safety Cans

Portable safety cans for carrying, storing and dispensing flammable and combustible liquids are widely used. They are available in different shapes and in capacities from 0.5 to 25 litres. Approved safety cans are made from metal or very low conductivity plastic. Safety cans have spring-mounted spout caps. These automatically open when the vapour pressure builds up inside to allow vapours to escape and prevent rupture or explosion, in the event of fire. The cap-operating mechanisms also cause the spout cap to close automatically when you finish filling or pouring from the safety can or if the can is dropped. This safety feature could create a hazard under some conditions. In a warm enclosed space, such as a car trunk, vapours venting from a safety can may reach flammable levels and a spark could cause an explosion. For temporary transport of small amounts (normally less than 25 litres) of flammable liquid, use an approved pressure-resistant and nonventing container. Eliminate ignition sources and ensure good ventilation.

Other Approved Containers

Other types of approved containers include:

- tanks for dipping or washing parts in liquid
- plunger cans for moistening cleaning rags
- bench cans for dipping and rinsing small parts
- dispenser or benzine cans for dispensing small amounts of liquid directly on work or cloths
- containers for disposal of flammable and combustible liquids and oily rags and waste

These approved safety containers also have different kinds of safety devices, such as self-closing lids or flame arresters. Containers like some rinse or dip tanks or oily rag and waste cans with lids that are not self-closing are held open by fusible link devices. In the event of a fire in an open container, the fusible link melts, closing the lid and smothering the fire.

In certain cases, flammable and combustible liquids may be stored, handled and used in approved, nonreusable glass or plastic containers (usually the ones they are shipped in), holding no more than 1 gallon (U.S.) or 3.8 L. This may be acceptable if the required liquid purity, such as analytical reagent grade or higher, is affected by storage in metal containers or if the liquid causes excessive corrosion of metal containers.

Follow the WHMIS requirements for proper labelling of all containers used for flammable and combustible liquids. This helps prevent inadvertently mixing one chemical with another and reduces the chances of mistaking one liquid for another. Plainly mark the name of the liquid on the container, along with information for safe handling and a reference to the MSDS. Keep the label clean so that it can be easily seen at all times. Never use a container for any liquid except the one that is marked on the label.

Using unsuitable containers, such as open cans, buckets or pails, is a dangerous practice. Open containers allow hazardous vapours to escape. Breakable containers increase the chance of serious spills.

Waste Disposal

Store waste flammable and combustible liquids in the same way as unused flammable and combustible liquids. Clean drums made of compatible material can be used to store waste liquids if they are vented, grounded and bonded similarly to dispensing drums. Approved safety disposal cans are also available for waste liquids.

Place cloth, paper and other solid materials that are soaked with flammable and combustible liquids in approved oily waste disposal cans. These are made of metal and have self-closing lids. Do not overfill them and empty them at least at the end of every workday to reduce the chance of spontaneous combustion.

Clearly label all waste containers with their contents.

Be careful with "empty" flammable and combustible liquid containers. They may contain enough vapours to create an explosion hazard. Only about 14 ml (1/2 fluid ounce) of liquid are needed to give enough vapour to form an explosive atmosphere in a 182-litre (40-gallon) drum. This amount can easily be trapped in a seam or be present as a very thin film on the inner surface of the drum.

Do not perform any work, e.g., welding, cutting, drilling, soldering, on an "empty" container until all liquid and vapours have been properly cleaned out. Contact the chemical manufacturer or supplier for the best way to do this.

Never pour waste flammable liquids down sinks or drains. Dispose of them through hazardous waste collection and disposal companies, according to the environmental laws. Contact Alberta Environment for advice.

Controlling Static Electricity

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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 become 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:

- nonpolar liquid (e.g., hydrocarbons) flowing through a pipe or hose
- spraying
- blending or mixing
- filling containers or tanks
- movement (friction) between materials
- movement of dry powdered material through chutes or conveyors
- movement of nonconductive 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 creates 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 is also used when parts of equipment and containers are electrically separated; e.g., by gaskets or caulking compounds. Bonding does not eliminate the static charge and must be 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% at 21°C 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 nonconductive 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.

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Corrosive, Oxidizing
and Reactive Household
Product Poster

Corrosive Chemicals

Ventilation

Well-designed and well-maintained ventilation systems are able to remove corrosive vapours, fumes, mists and dusts from the workplace and reduce their hazard. The amount and type of ventilation needed to minimize the hazards of airborne corrosive chemicals depends on the:

- kind of job
- kind and amount of materials used
- size and layout of the work area

An assessment of the specific ways corrosives are stored, handled, used and disposed of is the best way to find out if existing ventilation controls are adequate.

Some workplaces may need a complete system of hoods and ducts to provide acceptable ventilation. Others may require a single, well-placed exhaust fan. Use corrosion-resistant construction in ventilation systems for corrosive materials. No special ventilation system may be needed when working with small amounts of corrosives that generate minimal airborne contaminants.

Storage of Corrosive Chemicals

Corrosive chemicals can destroy containers made of incompatible materials. Ensure that corrosive materials are stored in the type of containers recommended by the manufacturer or supplier. Protect containers against damage when storing, transferring or using them. Keep them tightly closed when they are not in use.

Corrosives should be stored separately, away from processing and handling areas and from other materials. Separate storage can reduce the amount of damage caused in case of fires, spills or leaks. If totally separate storage is not possible, store corrosives away from incompatible materials.

Some corrosives are incompatible with each other. For example, acids and bases react together, often violently.

Walls, floors and shelving in corrosive storage areas should be made from materials that resist attack by corrosives. Floors in areas where liquid corrosives are stored should not allow liquids to penetrate. Since many corrosive liquids flow easily, store them in corrosion-resistant trays to contain spills or leaks. For large containers, such as 250-litre (55-gallon) drums, provide dikes around liquid storage areas and sills or ramps at door openings.

Store containers at a convenient height for handling, below eye level. High shelving increases the risk of dropping containers and the severity of damage if a fall occurs.

Store corrosives in areas that are:

- well ventilated
- cool, dry, out of direct sunlight and away from sources of heat, such as steam pipes or boilers
- supplied with adequate fire fighting equipment
- supplied with suitable spill clean-up equipment and materials
- labelled with proper warning signs

At all times:

- Allow only trained, authorized people into storage areas.
- Keep the amount of corrosive material in storage as small as possible.
- Make sure that containers of corrosives are kept tightly closed, except when the materials are actually being used.
- Check that all corrosive containers are properly labelled.
- Inspect storage areas regularly for any deficiencies, including corrosion damage, leaking containers or poor housekeeping. Correct all deficiencies as soon as possible.

Follow the chemical manufacturer or supplier recommendations for storage temperature. Where appropriate, store corrosive liquids at temperatures above their freezing (melting) points. Acetic acid, for example, has a freezing point of about 17°C (63°F) and can freeze in an unheated room. As it freezes, it expands and can crack a glass container.

Avoid rapid temperature changes in corrosive liquid storage areas. If a tightly-sealed corrosive liquid container is cooled suddenly, a partial vacuum could form inside it. In extreme cases, the container might collapse and leak.

Acid containers, such as drums and carboys, can cause particular problems if they are not handled and stored safely. Injuries have resulted from the rupture of sealed acid drums.

There are many reasons why these containers rupture:

- Heat can cause vapour levels inside a sealed container to build up to the point where the container bursts. This is more likely to happen if the drum is overfilled.
- Chemicals stored in a metal drum might react with the metal and form hydrogen gas that could ignite when the drum is opened.
- The drum may not have been cleaned thoroughly before it was filled. If the previously stored chemical is incompatible with the corrosive, chemical reactions could cause the drum to explode.
- Air or inert gas pressure used to empty the drum may cause weakened or damaged drums to burst.

To avoid bursting or rupturing, acid drums may need to be vented periodically. This is done by carefully loosening a closure plug to relieve pressure buildup. The MSDS may say whether drums of a particular liquid need to be vented and, if so, how often. To be sure whether drums of acids must be vented and for specific directions about how to vent, contact the chemical manufacturer or supplier. Venting should only be done by trained people, using the right tools and wearing the proper personal protective equipment. If swollen drums of chemicals are seen, contact the chemical manufacturer or supplier immediately for assistance.

Handling swollen chemical drums is a very hazardous job that often requires special procedures and equipment to be done safely.

Handling Corrosive Chemicals

Take care when dispensing or transferring corrosives from one container to another. Dispense from only one container at a time. Finish all the dispensing of one material before starting to dispense another. Be sure containers are closed after dispensing.

Handle corrosives so that dusts, mists, vapours or fumes do not get into the air. Be very careful when transferring from larger containers into smaller ones. Many injuries have been caused by spillage from open, unstable or breakable containers during material transfer.

If liquid corrosives are stored in drums, use a corrosion-resistant drum pump for transferring liquids into other containers. Pumps are also available for dispensing corrosive liquids from most sizes and types of the supplied containers. Do not transfer liquids by pressurizing their usual shipping containers with air or inert gas. Ordinary drums and barrels may be damaged by the pressure. Never pipette corrosive liquids by mouth. Use a pipette bulb or aspirator instead. Transfer corrosive solids using tools like scoops or shovels that are corrosion resistant.

Sometimes, a job requires mixing corrosives with water. Many corrosive materials, both liquid and solid, generate large amounts of heat when they are mixed with water. This can cause the solution to froth and boil or erupt violently from the container. For example, a glass of water thrown into a bucket of concentrated sulfuric acid is converted instantly to steam, which will eject the entire contents of the bucket into the air. For this reason, always add corrosives to water slowly, in small amounts, with frequent stirring. Always use cold water. Never mix them the other way around; i.e., never add water to a corrosive.

Corrosive wastes are hazardous and must always be handled safely. Containers for corrosive wastes must be made from corrosion-resistant materials. Identify the contents of these containers with suitable labels. "Empty" drums, bottles and other containers often have hazardous corrosive residues inside them. Never use these "empty" containers for anything else, no matter how clean they seem to be. Treat them as corrosive wastes.

Never dispose of corrosives down sinks or drains that connect to sanitary or storm sewers. Dispose of them according to the manufacturer or supplier's directions or through hazardous waste collection and disposal companies. In all cases, dispose of corrosive wastes according to the environmental laws. Contact Alberta Environment for details about the disposal laws that apply for specific corrosives.

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Corrosive, Oxidizing
and Reactive Household
Product Poster

Oxidizing Chemicals

Substitution

Substitution can be the best way to avoid or reduce a hazard. However, finding a suitable non-oxidizing or less powerful oxidizing substitute to do the job effectively and safely is not always easy or even possible. Ask chemical suppliers if safer substitutes are available. Obtain Material Safety Data Sheets (MSDSs) for possible substitutes. Find out about all of the hazards, e.g., health, fire, corrosivity, chemical reactivity, of these materials before making changes.

Choose the least hazardous material and process that can do the job effectively and safely.

Ventilation

Well-designed and well-maintained ventilation systems remove airborne oxidizing materials from the workplace and reduce their hazards. The amount and type of ventilation needed depends on the:

- type of job
- kind and amount of materials used
- size and layout of the work area

An assessment of the particular ways a workplace stores, handles, uses and disposes of its oxidizing materials is the best way to find out if existing ventilation is adequate.

Some workplaces may need a complete system of hoods and ducts to provide acceptable ventilation. Others may only require a single, well-placed exhaust fan. No special ventilation system may be needed for work with small amounts of oxidizers that give off minimal amounts of airborne contaminants.

Organic materials, such as wood, should not be used in ventilation systems for oxidizing materials. Systems should be free of ignition sources and separate from other systems that might be exhausting incompatible substances. The system may also need to be corrosion-resistant if the material is also corrosive. Air cleaning devices, such as dust collectors, should be made from noncombustible materials. Ensure that hoods, ducts, fans and air-cleaning devices, such as dust collectors, are made from materials compatible with the oxidizing agents.

Laboratories that use perchloric acid need special fume hoods and fume exhaust systems to prevent explosions. These are available from laboratory equipment suppliers.

Modification

Sometimes, changing or modifying a process can reduce the hazards from an oxidizing material. In some cases, it may be possible to:

- reduce dust levels by using solutions of oxidizers instead of dry, solid forms
- reduce dangerous reactivity by diluting solutions with water

Other modifications could include the installation of alarms or automatic shut-off switches on equipment to warn of equipment failure, high temperatures or high pressures.

Storage of Oxidizing Materials

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Before storing, inspect all incoming containers to ensure that they are undamaged and properly labelled. Do not accept delivery of defective containers.

Store oxidizing materials in containers that the chemical supplier recommends. Normally, these are the same containers in which the material was shipped. Repackaging can be very dangerous, especially if contaminated or incompatible containers are used. Protect containers against damage when storing, transferring or using them. Do not use wooden pallets or other combustible pallets for storing containers of oxidizing materials.

Make sure containers are suitably labelled. For oxidizing materials that require temperature control, the recommended storage temperature range should be plainly marked on the container. It is also a good practice to mark the date that the container was received and the date it was first opened.

Keep containers tightly closed when storing, unless the supplier's instructions state otherwise. This helps to avoid contamination of the material or evaporation of solvents used to dilute oxidizers to safer concentrations.

Some oxidizing agents, such as solutions of 8% or higher hydrogen peroxide in water, must be stored with specially vented caps. Hydrogen peroxide gradually decomposes at room temperature to produce oxygen and water. The properly working vent will prevent the buildup of pressure inside containers. The normal buildup of pressure could rupture an unvented container. Check vent caps regularly to ensure they are working properly. Keep vented containers in the upright position. **NEVER** stack vented containers on top of each other.

Store oxidizing materials separately, away from processing and handling areas and away from other materials. Separate storage can reduce the risk of personal injury and damage in case of fires, spills or leaks. If totally separate storage is not possible, ensure oxidizing materials are stored away from incompatible materials – especially organic or other oxidizable materials (sometimes called reducing materials or reducing agents). Some oxidizing materials are incompatible or may react with each other, sometimes violently. Do not store them beside each other. Check the reactivity data and storage requirements sections of the MSDS for specific details about incompatibility.

Walls, floors, shelving and fittings in storage areas should be constructed of noncombustible materials. Wood impregnated with a fire-retardant material is not fully protected against the increased fire hazard caused by contact with oxidizers. Protect metal construction materials against corrosion by painting them with a compatible coating.

Ensure that floors in areas where oxidizers are stored are watertight and do not have cracks where these materials can lodge. Contain spills or leaks by storing in trays made from compatible materials. For larger containers, such as drums or barrels, provide dikes around storage areas and sills or ramps at door openings.

Store oxidizer containers at a convenient height for handling, below eye level, to reduce the risk of dropping containers. Avoid overcrowding in storage areas. Do not store containers in out-of-the-way locations where they could be forgotten.

Store containers away from doors. Although it is convenient to place frequently used materials next to the door, they could be bumped by people going by, or could cut off the escape route if an emergency occurs.

Store oxidizing materials in areas that are:

- labelled with suitable warning signs
- well ventilated
- dry, cool, out of direct sunlight and away from heat sources, such as steam pipes or boilers
- supplied with adequate fire fighting equipment, including sprinklers, where appropriate
- supplied with suitable spill clean-up equipment and materials
- free of ignition sources
- accessible at all times

At all times:

- Allow only trained, authorized people into storage areas.
- Keep the amount of oxidizing materials in storage as small as possible.
- Inspect storage areas regularly for any deficiencies, including damaged or leaking containers and poor housekeeping.
- Correct all deficiencies as soon as possible.

Dispensing and Using Oxidizing Materials

Be very careful when dispensing oxidizers from storage containers into other containers. Avoid spilling material and contaminating your skin or clothing. Spills from open, unstable or breakable containers during material transfer have caused serious injuries.

Dispense from only one container at a time. Finish all the dispensing of one material before starting to dispense another. Dispense the smallest amount possible, preferably only enough for immediate use. Keep containers closed after dispensing to reduce the risk of contaminating their contents.

Take care that oxidizing materials do not contact combustible or other incompatible materials when dispensed. Use containers and dispensing equipment, such as drum pumps, scoops or spatulas, that the chemical supplier recommends. These items must be made from materials that are compatible with the oxidizing materials used. Keep them clean to avoid contamination.

NEVER transfer liquids by pressurizing their usual shipping containers with air or inert gas. Ordinary barrels or drums may be damaged by the pressure. NEVER pipette oxidizing liquids or other chemicals by mouth. Use a pipette bulb or aspirator instead.

Since some solid oxidizers may be shock sensitive, do not chip or grind lumps to break them up. If crystals have precipitated in containers of an oxidizing agent, contact the supplier about their safe handling and disposal. Avoid sliding or skidding heavy metal containers, such as drums or barrels, across floors.

Follow the chemical supplier's directions for mixing oxidizers with water. Some oxidizers, including nitric acid and perchloric acid, generate large amounts of heat when they are mixed with water. This reaction can cause the solution to froth and boil or even erupt violently from the container. For this reason, always add these oxidizers to cold water slowly, in small amounts, with frequent stirring.

Make sure that all areas where oxidizing materials are used are free of combustible and other incompatible materials. Do not allow smoking or any other ignition sources around oxidizing materials.

Ensure that temperatures do not become high enough to cause rapid decomposition of the materials. Hydrogen peroxide decomposes gradually at room temperature but decomposes almost twice as fast for every 5.6°C (10°F) increase in temperature.

In laboratories, do not use corks, rubber stoppers or stopcock grease to seal containers of strong oxidizing materials. Use fibreglass heating mantles or sand baths instead of oil baths to heat reaction vessels that contain significant amounts of oxidizing materials.

Follow the chemical supplier's instructions, with regard to handling oxidizing agents. Always:

- Inspect containers for damage or leaks before handling them.
- Handle containers of oxidizers carefully to avoid damage.
- Keep containers of oxidizers tightly closed, except when actually using the material, to help avoid spillage or contamination of the container contents.
- Keep only the smallest amounts possible (i.e., not more than one day's supply) of oxidizers in work areas.
- Return unopened containers to the proper storage area and opened containers to a dispensing area at the end of the day.
- Check that all containers are properly labelled and handle the containers so that the label remains undamaged and easy to read.
- Never return used or unused oxidizers to original containers of uncontaminated material. Trace amounts of contaminant might cause a dangerous decomposition.

Disposal

Waste oxidizing materials are hazardous. Always handle them safely. Treat any oxidizing materials inadvertently mixed with an unknown or foreign material as contaminated and do not use it. Dispose of contaminated material immediately.

"Empty" drums, bottles, bags, sacks and other oxidizing agent containers usually have hazardous oxidizing residues inside them. **NEVER** use these containers for anything else, no matter how clean they seem. Treat them as hazardous wastes.

Store waste oxidizing materials, including contaminated empty containers, in the same way as unused oxidizing materials. Only use compatible containers for waste material. Identify their contents with suitable labels.

NEVER dispose of oxidizers in ordinary garbage or down sinks or drains that connect to sanitary or storm sewers. Dispose of them according to the supplier's directions or through hazardous waste collection and disposal companies. In all cases, dispose of oxidizing wastes according to the environmental laws that apply. Contact Alberta Environment for details.

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Dangerously Reactive Materials

Substitution

Substitution can be the best way to avoid or reduce a hazard. But it is not always easy or even possible to find a suitable, less hazardous substitute for a particular dangerously reactive material used for a certain job. Speak to the chemical supplier to find out if safer substitutes are available. For materials that polymerize easily, use a product that contains a polymerization inhibitor instead of a pure product, whenever possible. Check for any limitations associated with the inhibitor.

Obtain MSDSs for possible substitutes. Find out about all of the hazards, e.g., health, fire, corrosivity, chemical reactivity, of these materials before making changes.

Ventilation

Well-designed and maintained ventilation systems remove airborne, dangerously reactive materials from the workplace and reduce their hazards. The amount and type of ventilation needed depends on the:

- type of job
- kind and amount of materials used
- size and layout of the work area

An assessment of the specific ways a workplace stores, handles, uses and disposes of its dangerously reactive materials is the best way to find out if existing ventilation is adequate.

Some workplaces may need a complete system of hoods, ducts and fans to provide acceptable ventilation. Others may require a single, well-placed exhaust fan. No special ventilation system may be needed to work with small amounts of dangerously reactive materials that do not give off airborne contaminants.

Make sure ventilation systems for dangerously reactive materials are designed and built so that they do not result in an unintended hazard. Ensure that hoods, ducts, air cleaners and fans are made from materials compatible with the dangerously reactive substance. Systems may require explosion-proof electrical equipment.

Ensure that the system is designed to avoid the buildup of dusts or condensation of vapours. The vapours of inhibited liquids are not inhibited. When the vapours condense back into a liquid, the liquid could polymerize or decompose easily.

Keep systems for dangerously reactive materials separate from other systems that exhaust incompatible substances. Regular, scheduled inspections of ventilation systems will help maintain them in good operating condition.

Modification

Sometimes, process changes or modification can improve control of the hazards from working with a dangerously reactive material. These could include the installation of alarms or automatic shut-off switches on equipment to warn of equipment failure, high temperatures or high pressures.

Choose processes that minimize worker exposures and the potential for uncontrolled reactions.

Storage of Dangerously Reactive Materials

Inspect all incoming containers before storing to ensure that they are undamaged and properly labelled. Do not accept delivery of defective containers.

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Store dangerously reactive materials in containers that the chemical supplier recommends. Normally, these are the same containers in which the material was shipped. Repackaging can be dangerous, especially if contaminated or incompatible containers are used. For example, strong hydrogen peroxide solutions can decompose explosively if placed in a container with rusty surfaces. Bottles for light-sensitive materials are often made of dark blue or brown glass to protect the contents from light. Containers for water-sensitive compounds should be waterproof and tightly sealed to prevent moisture in the air from reacting with the material.

Make sure containers are properly labelled. For materials that require temperature control, the recommended storage temperature range should be plainly marked on the container. It is also a good practice to mark the date that the container was received and the date it was first opened.

Keep stored containers tightly closed. This helps to avoid contamination of the material or evaporation of solvents used to dilute substances, such as some organic peroxides, to safer concentrations.

Some dangerously reactive liquids, such as strong hydrogen peroxide solutions or certain organic peroxide products, gradually decompose at room temperature and give off gas. These liquids are shipped in containers with specially vented caps. These vent caps relieve the normal buildup of gas pressure that could rupture an unvented container. Check vent caps regularly to ensure that they are working properly. Keep vented containers in the upright position. NEVER stack vented containers on top of each other.

Store dangerously reactive liquids and solids separately, away from processing and handling areas. Protect containers from damage that might cause shock. Some dangerously reactive materials are incompatible with each other. Do not store these beside each other. Separate storage can minimize personal injury and damage caused by fires, spills or leaks.

Check the reactivity data and storage requirements sections of the MSDS for details about what substances are incompatible with a specific dangerously reactive material.

Construct walls, floors, shelving and fittings in storage areas from suitable materials. For example, use noncombustible building materials in storage areas for dangerously reactive oxidizers. Use corrosion-resistant materials for dangerously reactive corrosives.

Ensure that floors in storage areas are watertight and without cracks in which spilled materials can lodge. Contain spills or leaks by storing smaller containers in trays made of compatible materials. For larger containers, such as drums or barrels, provide dikes around storage areas and sills or ramps at door openings.

Store smaller containers at a convenient height for handling, below eye level, to reduce the risk of dropping them and of splashes to the face. Avoid overcrowding in storage areas. Do not store containers in out-of-the-way locations where they could be forgotten.

Store containers away from doors. Although it is convenient to place frequently used materials next to the door, they could cut off the escape route if an emergency occurs and could be inadvertently jarred by the traffic.

Store dangerously reactive materials in areas that are:

- well ventilated
- dry, cool, out of direct sunlight and away from heat sources, such as steam pipes and boilers
- supplied with adequate fire fighting equipment (Sprinklers should not be used in areas where materials that react dangerously with water are present – another fire suppression material/system would be required.)
- supplied with suitable spill clean-up equipment and materials
- free of ignition sources, such as sparks, flames, burning tobacco or hot surfaces
- accessible at all times
- labelled with suitable warning signs

Follow the chemical supplier's recommendations for maximum and minimum temperatures for storage and handling. Higher temperatures can be hazardous since they can start and speed up hazardous chemical reactions. In many cases, inhibitors can be rapidly depleted at higher-than-recommended storage temperatures. Loss of inhibitor can result in dangerous reactions.

Some dangerously reactive materials must be kept at low temperatures in refrigerators or freezers. Use only approved or specially modified units. These are generally known as laboratory safe. Standard domestic refrigerators and freezers contain many ignition sources inside the cabinet.

It can also be hazardous to store dangerously reactive materials at less than the recommended temperature. For example, acrylic acid is normally supplied with an inhibitor to prevent polymerization. Acrylic acid freezes at 13°C (55°F). At temperatures less than this, it will partly solidify. The solid part contains little or no inhibitor; the inhibitor remains in the liquid portion. The uninhibited acrylic acid can be safely stored below the freezing point but it may polymerize violently if it is heated to warmer temperatures.

Some organic peroxides are sold dissolved or dispersed in solvents, including water, to make them less shock-sensitive. If these are cooled to below their freezing points, crystals of the pure, very sensitive organic peroxide may be formed.

Do not keep a material for longer than the chemical supplier recommends.

At all times:

- Allow only trained, authorized people into storage areas.
- Keep the amount of dangerously reactive materials in storage as small as possible.
- Inspect storage areas regularly for any deficiencies, including damaged or leaking containers and poor housekeeping.
- Correct all deficiencies immediately.

Dispensing and Using Dangerously Reactive Materials

Corrosive, Oxidizing and Reactive Household Product Poster

There should be specific written procedures for handling dangerously reactive materials – follow them! Open and dispense containers of dangerously reactive materials in a special room or area outside the storage area. Do not allow any ignition sources in the vicinity. Take care that the dangerously reactive materials do not contact incompatible substances. Use containers and dispensing equipment, such as drum pumps, scoops or spatulas, that the chemical supplier recommends. These items must be made from materials compatible with the chemicals. Keep them clean to avoid contamination.

When transferring materials from one container to another, avoid spilling material and contaminating your skin or clothing. Spills from open, unstable or breakable containers during material transfer have caused serious injuries.

NEVER transfer liquids by pressurizing their usual shipping containers with air or inert gas. The pressure may damage ordinary drums and barrels.

Glass containers with screw-cap lids or glass stoppers may not be acceptable for friction-sensitive materials. Avoid using ordinary screw-cap bottles with a cardboard liner in the cap for moisture-sensitive chemicals. Airborne moisture can diffuse slowly but steadily through the liner. **NEVER** transfer materials stored in a vented container into a tightly sealed, nonvented container. The buildup of vapour pressure could rupture it.

Dispense from only one container at a time. Finish dispensing and labelling one material before starting to dispense another. Dispense the smallest amount possible, preferably only enough for immediate use. Keep containers closed after dispensing to reduce the risk of contaminating their contents. **NEVER** return any unused material, even if it does not seem to be contaminated, to the original container.

If a dangerously reactive material freezes, do not chip or grind it to break up lumps or heat it to thaw it out. Follow the chemical supplier's advice.

Never drop, slide or skid heavy metal containers, such as drums or barrels of friction- or shock-sensitive material.

Always:

- Inspect containers for damage or leaks before handling them.
- Handle containers carefully to avoid damage.
- Keep containers tightly closed, except when actually using the material.
- Avoid returning used chemicals to containers of unused materials.
- Keep only the smallest amounts possible (i.e., not more than one day's supply) of dangerously reactive materials in the work area.
- Return unopened containers to the proper storage area and opened containers to a dispensing area at the end of the day.
- Check that all containers are properly labelled and handle containers so that the label remains undamaged and easy to read.

Safe Work Procedures for Dangerously Reactive Materials

Ensure that processing equipment is clean, properly designed and made from materials compatible with the dangerously reactive material used. Find out from the chemical supplier what materials are suitable for the specific chemical. For example, some steels and aluminum alloys, zinc and galvanized metal can cause rapid decomposition of certain organic peroxides.

Some jobs require that dangerously reactive materials be diluted prior to use. Always strictly follow the chemical supplier's advice. Using the wrong solvent or a contaminated solvent could cause an explosion. Using reclaimed solvents of unknown purity is risky. They might contain contaminants that are incompatible with the dangerously reactive material.

Some operations involving dangerously reactive materials can be especially hazardous. Many incidents have occurred during distillation, extraction or crystallization because these processes involve concentrating reactive substances. Sieving dry, unstable materials can result in static electricity sparks that could cause ignition.

Procedures to follow:

- Follow the chemical supplier's advice on maximum and minimum temperatures for storage and use.
- Follow the chemical supplier's advice on checking and maintaining inhibitor and dissolved oxygen levels, where appropriate.
- Handle containers carefully to avoid damaging them or shocking their contents.
- Dispense dangerously reactive materials carefully into acceptable containers, using compatible equipment.
- Do not subject dangerously reactive materials to any type of friction or impact.
- Be careful when performing operations, such as separations or distillations, that concentrate dangerously reactive materials. Follow safe work procedures exactly.

Disposal of Dangerously Reactive Materials and their Containers

Waste dangerously reactive materials are hazardous. Dispose of unwanted or contaminated reactive chemicals promptly, using a method the chemical supplier recommends. Consider any reactive materials accidentally mixed with an unknown or foreign material as contaminated and dispose of them. **NEVER** attempt to salvage spilled or contaminated dangerously reactive materials.

"Empty" drums, bottles, bags and other containers usually contain hazardous residues. **NEVER** use these "empty" containers for anything else, no matter how clean they seem to be. Treat them as hazardous wastes.

Store reactive waste in the same way as unused dangerously reactive materials. Use only compatible containers for wastes. Identify their contents with suitable labels.

NEVER dispose of these wastes in ordinary garbage or down sinks or drains. Dispose of them according to the supplier's advice or through hazardous waste collection and disposal companies. In all cases, dispose of dangerously reactive wastes according to the environmental requirements. Contact Alberta Environment for details.

E. Health Hazards of Common Chemicals

In this section, supplemental information is provided for the following chemicals:

- asbestos
- silica
- lead
- carbon monoxide
- isocyanates
- hydrogen sulfide
- benzene

Asbestos

What is Asbestos?

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Slide 1

Asbestos is a naturally occurring mineral. The most commonly used types of asbestos are named chrysotile, amosite and crocidolite. Asbestos has been and continues to be used in a variety of materials due to its strength and unique fire and chemical resistance properties. Asbestos containing products may be friable (i.e., easily crumbled by hand pressure) or nonfriable (i.e., the asbestos fibres are bound into the product). Since asbestos is a fibrous material, it can be spun and woven like yarn into fabric.

How Is Asbestos Used?

In the past, asbestos containing materials were used in a variety of building applications. They were applied to structural steel and concrete for fire protection and as insulation. Asbestos containing products were also used as boiler and pipe insulation. Asbestos was used in many other building materials, including wall board, caulking compounds, floor tiles, vinyl floor sheeting, ceiling tiles, plaster, drywall joint compound and decorative texturing products. Asbestos is still used in some products, such as cement board and sewer pipe.

Asbestos has also been used in a wide variety of other products. These include gaskets, plastics, duct tape, fire curtains and other textile products; e.g., clothing, rope, gloves, wire insulation. Some brake pads, clutch plates and automotive and industrial gaskets and valve packing materials can still contain asbestos. The use of asbestos in these products continues to decline.

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Slides 2–3

Health Effects from Asbestos Exposure

Asbestos can affect the body if the fibres are inhaled. Once inhaled, the fibres settle in the airways and lung tissues. Three diseases that may be caused by inhaling asbestos fibres are asbestosis, lung cancer and mesothelioma.

Asbestosis is a lung disease caused by overexposure to asbestos over a long period of time. It takes from 10 to 30 years after exposure begins for the disease to develop. The main effect is scarring of the lung tissues, which causes shortness of breath. This laboured breathing, in turn, strains the heart, causing further health concerns for the individual. These effects develop slowly and can worsen as the disease progresses, even after asbestos exposure stops.

Workers exposed to asbestos have an increased risk of developing lung cancer. Workers who smoke and are exposed to asbestos have a much greater risk (90 times greater) of developing lung cancer than nonsmokers who are exposed to the same concentrations of fibres. Lung cancer takes about 15 to 25 years to develop, depending on the amount of exposure.

Mesothelioma is a rare cancer of the chest cavity or abdominal cavity linings, associated almost exclusively with asbestos exposure. This disease has no cure and is almost always fatal. The time period between exposure and the onset of disease can range from 15 to 55 years.

Controlling Exposure to Asbestos

Asbestos fibres must be inhaled to cause disease. Asbestos containing products in good condition and that are not disturbed are not a direct health hazard. These products become a potential health hazard only if fibres are released. Workers currently having the highest risk of asbestos exposure are those involved in asbestos abatement projects (i.e., removal, enclosure, encapsulation of asbestos containing products), those doing maintenance on equipment or buildings that use asbestos containing products or those who may work in an area where asbestos is being disturbed by others.

Where asbestos containing products must be disturbed, four principles must be followed during any work procedures:

- isolate the work area
- protect workers
- minimize the release of asbestos fibres
- ensure that the area is properly cleaned up after the work is completed

There are very specific requirements to be followed when handling asbestos. These include requirements for education, personal protective equipment, decontamination (of the site and of workers) and more. Any worker who regularly works with asbestos must take an approved asbestos abatement course and be certified. Detailed recommended work practices for projects involving asbestos containing materials are provided in the Alberta Asbestos Abatement Manual. The Manual can be downloaded from the Occupational Health and Safety website at www.worksafe.alberta.ca.

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Slide 4

Silica

What Is Silica?

Silica is the scientific name for a group of minerals made of silicon and oxygen. Silica is found in most mineral deposits in the world, in both crystalline and noncrystalline (amorphous) forms. Crystalline silica has its oxygen and silicon atoms arranged in a three-dimensional repeating pattern. Amorphous forms of silica have a random pattern.

Crystalline silica occurs in several forms, including quartz, cristobalite and tridymite. Quartz is the most common form of crystalline silica. It is the crystalline forms of silica that are the main concern when considering health effects.

How Is Silica Used?

Silica's many uses include:

- moulds and cores used to make metal castings
- refractory brick used in foundries, power plants and cement plants
- filter media for water filtration systems
- sports and recreational uses, such as sand traps on golf courses and sand in playgrounds
- sandblasting abrasives
- building materials, such as concrete, grout and plaster
- glass and fibreglass
- ceramics and fine china
- plastics and paints
- dental materials
- components for electronics, fibre-optics, lasers and time keeping devices
- aid for hydraulic fracturing in oilfield applications

Silica dust is produced during construction-related activities, such as bricklaying, stone setting, demolition and repair of concrete materials. It is also produced during rock drilling, dry sweeping, abrasive blasting, quarrying and mining.

Health Effects from Exposure to Crystalline Silica

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Slides 5–6

Crystalline silica dust particles that are small enough to be inhaled into the lungs can cause a number of health problems, including silicosis and lung cancer.

Silicosis is caused when small crystalline silica particles (i.e., respirable silica) are inhaled and deposited in the lungs. The lung tissue reacts by developing lumps and scarring around the trapped silica particles. If the lumps and scar tissue grow too large, breathing becomes difficult. The effects can continue to worsen even after exposure to crystalline silica stops. The disease can be fatal.

Crystalline silica is considered carcinogenic or cancer causing to humans. Workers exposed to high concentrations of respirable dust who have developed silicosis also have an increased risk of developing lung cancer.

Other health problems that have been linked to silica exposure include:

- Chronic obstructive pulmonary disease – smoking may increase the risk of getting this disease.
- Autoimmune related diseases, such as scleroderma, lupus, rheumatoid arthritis, sarcoidosis – these diseases have been reported in many studies of workers exposed to crystalline silica – the cause(s) of these diseases remains unclear.

Controlling Exposure to Silica

Preventing exposure to crystalline silica is the best way to protect workers' health. Options that should be considered include:

- using less hazardous substitutes
  For many products that use silica as an ingredient, there are no substitute materials. However, a wide variety of materials can, where practical, be used as substitutes to silica in abrasive blasting. A number of factors need to be considered when looking at substitutes. These include the hardness of the material, cost, coverage and health effects. Some of the alternatives to silica contain heavy metals for which there are health concerns. As well, some of the substitutes can cause damage to the lungs when they are inhaled or are more toxic than silica sand. Some substitutes that are natural products, such as staurolite and garnet, can contain small amounts of crystalline silica. If they are used in uncontrolled abrasive blasting operations, enough airborne respirable crystalline silica can be generated to exceed occupational exposure limits.

- engineering controls
  - wet processes, such as wet abrasive blasting or wet cutting
  - local ventilation hoods
  - dust collection systems on machines or equipment
  - dust control additives
  - enclosures around the work process
  - automated processes; e.g., robotics
  - use of alternative equipment; e.g., use of vacuums instead of compressed air lances or dry sweeping to remove debris from cracks in road repair
- administrative controls
  - educating workers to understand the hazards associated with crystalline silica; workers should be encouraged to participate in training and monitoring programs
  - using good hygiene practices – workers should not eat, drink or use tobacco products in areas contaminated by crystalline silica; hands and face should be washed before eating, drinking or smoking
  - ensuring that engineering controls and other equipment used to reduce exposure are used and maintained properly
  - using signage to warn workers of the hazards and informing them about the required protective equipment needed in areas where crystalline silica is used
  - conducting monitoring for silica dust in the air
- personal protective equipment
  - providing respiratory protective equipment if the above controls are not feasible or do not control exposure well enough
  - ensuring workers have a change of clothing at the work site to avoid contamination of street clothes
  - protecting eyes to prevent silica particles from entering them and causing irritation or damage

Lead

SE-HealthHazards.ppt
Slide 7

What Is Lead?

Lead is a bluish-grey metal that has been used since ancient times. It has a low melting point, is pliable and corrosion resistant. Lead is naturally present in the earth, usually combined with other elements, such as zinc, silver and copper. The most common lead ore is galena (lead sulfide).

How Is Lead Used?

In ancient times, lead was used to construct water pipes and storage vessels and white lead was used as a coating. Lead has continued to be used in many ways. Until the 1980s, the main sources of lead exposure for Canadians were lead paint and emissions from cars using leaded gasoline. The use of lead in gasoline was stopped in Canada in 1990, except for some specific types of vehicles like race cars and farming equipment.

Today, lead is used in many of the following products:

- batteries
- lead shielding for X-rays
- crystal
- ceramics and pottery glazes
- stained glass
- lead solder – used in water pipes in older homes, electronics, radiator shops
- cosmetics – many of the pigments and other substances used in cosmetics contain lead
- pesticides; e.g., lead arsenate
- ammunition
- lead weights and tools

Exposure to lead can occur in battery recycling facilities, firing ranges, radiator shops (e.g., lead contamination in the radiator fluid, soldering activities) and during welding activities (due to lead paint on the metals being welded). Wood products, such as furniture, that have been chemically stripped of lead paint, can continue to contain lead in the pores of the wood. Even though the wood looks uncoated, airborne lead dust can be released when surfaces are cut or sanded. Lead may also be produced as a by-product in metal smelting operations and at brass or copper foundries.

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Slides 8–9

Health Effects from Lead Exposure

The most common ways that workers are exposed to lead at the work site are inhalation of airborne lead dust or fumes and unintended ingestion. Workers ingest lead by handling cigarettes or food when their hands are contaminated with lead. Most of the lead entering the body will leave the body in the urine, feces, sweat and as dead skin cells slough off. Lead may also be found in breast milk. The lead that remains in the body tends to accumulate in bone where it can be stored for decades. Lead in bones can be released back into the blood long after the original exposure.

Many of the health effects from lead take a long time to develop. Workers with lead in their bodies may not notice immediate health effects.

The nervous system is one of the main targets of lead. Early symptoms of lead exposure include headaches, irritability, memory problems and difficulty sleeping. Over time, the nerve-muscle system can be damaged, leading to muscle weakness, decreased feeling in the hands and feet and a metallic taste in the mouth.

Long-term exposure to high doses of lead is also linked to high blood pressure and cardiovascular disease. However, these effects are rarely seen at the typical levels of lead exposure today.

Pregnant women exposed to lead can suffer stillbirths and miscarriages. Even low level exposure can effect a pregnancy by shortening the term or affecting the mental development of the fetus. In men, sperm can be affected, which may result in lowered fertility.

Controlling Exposure to Lead

To determine if lead poses a hazard in the workplace, it is important to find out where and how lead is used. Lead may be found in places that are not immediately obvious. Tools, weights, solder and old paint may contain lead. Ask the following questions:

- Where is lead present in this workplace?
- What tasks or products involve the use of lead?
- How do workers come into contact with lead?

In work sites where workers can be exposed to lead, the OHS Code requires the employer to develop a "lead exposure control plan". The purpose of the plan is to minimize worker exposure to lead. This plan must have the following elements:

- statement of purpose and responsibilities
- worker education about the hazards of lead and safe work procedures
- written safe work procedures to control the hazard
- procedures for worker decontamination
- health monitoring, including blood tests for lead
- documentation and record-keeping
- follow-up to evaluate how well the program is working and determine if changes are needed

The health of a worker's family may also be at risk if lead dust is taken home on clothes, boots or in the hair. Children are much more susceptible to the effects of lead than adults.

Preventing exposure to lead is the best way to protect health. Options that should be considered include:

- use of less hazardous substitutes
  Where possible, less hazardous substances should be substituted for lead. This can be done with paints and glazes, batteries and solder materials.
- engineering controls
  - installation of local exhaust ventilation to remove the lead dust/fumes at the source
  - installation of dust collection systems onto machines or equipment
  - enclosures around work process
- administrative controls
  - educating workers so that they understand the hazards associated with lead
  - using good hygiene practices; e.g., do not eat, drink or use tobacco products in areas contaminated by lead, wash hands and face before eating, drinking or smoking
  - ensuring that engineering controls and other equipment used to reduce exposure are used and maintained properly

- personal protective equipment
  - selecting protective clothing (e.g., respirator, gloves, aprons) appropriate to the type of work being done, work conditions and the presence of other contaminants in the workplace
  - removing any protective clothing used in a lead contaminated environment before the worker leaves the workplace (Otherwise, the worker may take the lead contamination home, resulting in family members being exposed. This is one of the most common ways that children are exposed to lead. Lead contaminated clothes should **not** be laundered at home.)

Carbon Monoxide

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Slides 10–11

What Is Carbon Monoxide?

Carbon monoxide is a colourless, odourless gas. It is usually formed from the incomplete combustion of fuels, such as coal, coke, wood, oil, gasoline, natural gas and propane. Most of the carbon monoxide released into the atmosphere comes from internal combustion engines.

In addition to being toxic, carbon monoxide is a flammable gas. Mixtures of 12 to 75% carbon monoxide in air can catch fire and explode when there is a source of ignition present. Also, when heated to high temperatures, carbon monoxide can react violently with oxidizing agents, such as oxygen, ozone, peroxides and chlorine.

Where Is Carbon Monoxide Found?

There are many potential sources of carbon monoxide at the work site. These include emissions from:

- internal combustion engines
- kilns
- furnaces and boilers
- welding
- moulding of plastics
- forging, ceramic, petroleum, steel and waste management industries
- gas-fired space heaters and improperly adjusted oil or gas burners
- fires and explosions
- cigarette smoking

Health Effects from Exposure to Carbon Monoxide

Carbon monoxide enters the body through the lungs. Since it has no colour or odour and is not irritating, workers may be unaware for some time that they have been exposed.

Carbon monoxide is eventually exhaled. Within four hours after exposure stops, about half the carbon monoxide present in the body will be exhaled. The amount of carbon monoxide taken up by the body depends on the:

- concentration of the gas in the air that is inhaled
- length of time the person is exposed
- person’s rate of breathing

The health effects of carbon monoxide may be greater in persons:

- with certain health conditions, such as heart disease
- performing physically demanding work
- working in high temperatures
- working at high altitudes

Carbon monoxide affects a person because it reduces the amount of oxygen available to the body. After carbon monoxide enters the body, it quickly combines with hemoglobin in the blood. Hemoglobin is a compound that usually carries oxygen. However, hemoglobin takes up carbon monoxide much more readily than it takes up oxygen, forming a compound called carboxyhemoglobin (COHb). The more COHb that is formed, the less oxygen the blood will be able to carry, resulting in an oxygen deficiency for the body, although there is plenty of oxygen in the air.

Smokers should be aware that smoking a pack of cigarettes a day, with no other carbon monoxide exposure, creates a level of 5 to 6% of COHb in the blood. Heavy cigar smokers can reach up to 20%.

A pregnant worker who could be exposed to carbon monoxide should consult her physician. Carbon monoxide crosses the placenta to the fetus and is eliminated from the fetus' blood at a much slower rate. As a result, a fetus is at a higher risk of injury/illness than the mother.

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Slide 12

Controlling Exposure to Carbon Monoxide

Preventing exposure to carbon monoxide is the best way to protect health. The most effective way to prevent exposure is to identify the sources of the carbon monoxide and eliminate them. When this is not possible or practicable, sources of carbon monoxide must be controlled to prevent exposure. To control exposure to carbon monoxide, employers may choose:

- engineering controls
  - installation of local or general ventilation that is properly designed for the space
  - substituting electrical battery or air-powered equipment/tools/vehicles for ones that use fuels, such as gasoline or propane
  - providing enclosures and exhaust systems for work processes that produce carbon monoxide
  - providing properly designed and located air-supply and exhaust systems for fuel-burning appliances, such as furnaces, hot water boilers and heaters

- administrative controls
  - educating workers about the hazards associated with carbon monoxide and the warning signs of overexposure
  - ensuring that engineering controls and other equipment used to reduce exposure are used properly
  - ensuring regular inspection, maintenance and tuning of fuel-powered equipment and tools
  - use of personal or area carbon monoxide monitoring equipment, where there are potential sources of carbon monoxide (This equipment should have audible alarms that warn workers when carbon monoxide concentrations are too high. These instruments should alarm at a level below the Occupational Exposure Limit for carbon monoxide.)
- personal protective equipment
  - use of a supplied-air system (Note that because carbon monoxide has no odour or other warning properties, air purifying respirators cannot be used.)

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Isocyanates

What Are Isocyanates?

Isocyanates are chemical compounds that contain a number of NCO (nitrogen- carbon-oxygen) groups. Monoisocyanates contain one group, di-isocyanates contain two and so on. The most commonly used isocyanates in Alberta are di-isocyanates, such as toluene di-isocyanate (TDI), methylene diphenyl isocyanate (MDI) and hexamethylene di-isocyanate (HDI).

Isocyanates are a group of very reactive chemical substances. They react with water, other industrial compounds and even with themselves, unless carefully controlled. Once isocyanates have reacted, the resulting product is usually less harmful than the chemical itself. In the manufacture of polyurethane foam, for example, isocyanates are combined and react with other chemicals. Exposure to the foam, however, is far less harmful than to the isocyanate itself.

Most isocyanates are liquid at room temperature and can evaporate and become airborne as vapours. TDI and HDI are quite volatile at room temperature and can easily become vapours. MDI is much less volatile. Both isocyanate vapour and mist will burn in the presence of a flame, spark or other ignition source. When heated or burned, isocyanates can break down and release toxic gases, such as carbon monoxide, hydrogen cyanide and nitrogen oxides.

How Are Isocyanates Used?

Industry uses many different isocyanates. Methyl isocyanate, one of the most toxic of the isocyanate compounds, killed thousands in Bhopal, India, when it leaked out of a pesticide production facility in 1985. This chemical is not a significant issue for Alberta work sites.

TDI, MDI and HDI are used mainly in the manufacture of polyurethanes, which appear in a very wide range of products, such as:

- synthetic rubber
- synthetic textile fibres
- glues and adhesives
- anti-corrosive chemicals
- wire and cable insulation
- paints, lacquers, ink and varnishes
- leather finishes
- foundry cores; e.g., binders
- bathtub and sink finishes
- ornamental plaques and frames

- packaging materials
- plastics and artificial limbs
- flexible foam in upholstery
- rigid foam and high-density resins, used as insulation materials for homes, vehicles and around tanks and piping
- flotation materials

Exposure to isocyanates can also occur:

- In the application of surface coatings – primers, urethane paints or lacquers containing isocyanates are often used in spray painting vehicles or other surfaces. Isocyanates are used in these products to improve surface durability.
- In the manufacture of various foam products – isocyanate foams are usually two-component products that are mixed before they are applied. One of the components contains isocyanates.

When polyurethane products, such as paints, foams or adhesives, are heated.

Health Effects from Exposure to Isocyanates

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Slide 14

Isocyanates are very irritating to the skin, eyes, nose, throat and lungs. Symptoms of exposure to isocyanate vapours/mists include:

- itchy, watery eyes
- a sensation of burning in the eyes
- a runny nose
- sneezing
- hoarseness
- coughing
- chest tightness
- fever
- fatigue

Symptoms may not appear for six to 10 hours following exposure and usually clear up within 12 to 24 hours. Often, because symptoms are delayed, workers don't connect these symptoms with workplace exposure to the chemical.

Isocyanates splashed directly on the skin or eyes cause a severe inflammatory reaction that produces pain, redness and swelling.

Repeated exposure to isocyanates at low concentrations over a long period of time will affect the skin and lungs, as in acute exposures but the symptoms and signs may be different. For some workers, exposure to isocyanates can sensitize the skin or respiratory system. This response can be caused by one acute exposure or repeated exposure at low concentrations. Skin sensitization is not as common as respiratory sensitization. It results in a rash similar to eczema. Skin rashes may not appear until four to eight hours after exposure. These skin changes are not permanent and will go away once exposure to isocyanates stops.

The most troubling health effect from isocyanates is respiratory sensitization. Respiratory sensitization appears as asthma-like symptoms, such as a wheeze, cough, chest tightness and shortness of breath. It is believed that respiratory sensitization occurs mainly from inhaling isocyanate vapour or mist. However, there is also evidence to suggest that respiratory sensitization can occur from skin exposure.

Once someone has become sensitized, the person may develop asthmatic reactions to extremely low concentrations of isocyanates – concentrations well below the occupational exposure limit (OEL). Sometimes, the asthma-like reaction occurs immediately after exposure. More commonly, sensitized individuals experience symptoms several hours after exposure. Studies of exposed workers show that roughly 1% of workers exposed to isocyanates for one year will develop asthma. Some sensitized workers also develop sensitivity to other hydrocarbons.

Controlling Exposure to Isocyanates

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Preventing exposure to isocyanates is the best way to protect health. Consider the following options:

- substitute less hazardous substances
  One of the easier ways to control isocyanate exposure is to substitute less hazardous substances for products containing isocyanates. This has been done successfully by substituting latex paint and coating products, for example, for polyurethane products.
- engineering controls
  - installation of local ventilation hoods
  - use of spray booths to apply coatings
  - erecting enclosures around work processes

- administrative controls
  - educating workers about the hazards associated with isocyanates
  - using good hygiene practices; e.g., do not eat, drink or use tobacco products in areas contaminated by isocyanates, wash hands and face before eating, drinking or smoking
  - ensuring that engineering controls and other equipment used to reduce exposure are used properly
  - ensuring that isocyanates are stored properly
  - ensuring that unprotected workers are not in an area where products containing isocyanates are mixed or sprayed
  - ensuring that spills are cleaned up quickly and properly and that appropriate protective equipment and clothing is used when spills are cleaned up
  - ensuring that product containers are kept tightly sealed when not in use
  - conducting air monitoring in areas where isocyanates are used or stored
- personal protective equipment
  - using respirators that provide the correct level of respiratory protection (Air-supplying respirators provide the most effective type of respiratory protection against isocyanate vapours or mists. Isocyanates have poor warning properties (i.e., workers cannot smell the product until the concentration is too high). Air-purifying respirators may not provide sufficient protection against isocyanate exposure because the wearer is unlikely to know when a cartridge needs changing and may, therefore, unknowingly become overexposed.)
  - wearing appropriate solvent-resistant gloves, coveralls that protect the arms and legs and airtight goggles or full face respirator masks to protect the eyes from irritation or splashes

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Hydrogen Sulfide

What Is Hydrogen Sulfide?

Hydrogen sulfide is a colourless and poisonous flammable gas with a strong smell of rotten eggs. It is also known as sewer gas, sour gas and stink damp. It can be detected by smell at concentrations that range from 0.01–0.3 parts per million (ppm). However, relying solely on its odour is not a good idea because, at higher concentrations, it deadens a person's sense of smell within a few minutes. The pure gas is heavier than air and can collect in low areas, such as sewers, pits, tunnels and gullies.

Hydrogen sulphide gas is corrosive to metals and can cause metal fatigue, leading to sulphide stress cracking. High concentrations (between 4.3% and 46% of gas by volume in air) can catch fire and explode if there is a source of ignition. When the gas is burned, other toxic gases, such as sulfur dioxide, are formed. Hydrogen sulfide is incompatible with strong oxidizers, such as nitric acid or chlorine trifluoride, and may react violently or ignite spontaneously. When hydrogen sulfide is released into the air, it will form sulfur dioxide and sulfuric acid in the atmosphere.

Where Is Hydrogen Sulfide Found?

Hydrogen sulfide (H_2S) occurs naturally in the earth in crude petroleum, natural gas reservoirs, volcanic gases and hot springs. Hydrogen sulfide is also produced from:

- the breakdown of human and animal wastes by bacteria
- industrial activities, such as food processing
- coke ovens
- kraft paper mills
- rayon textile manufacturing
- wastewater treatment facilities
- sulfur production
- tar and asphalt manufacturing plants
- tanneries
- refineries

In Alberta, most worker exposure to hydrogen sulfide occurs during drilling and production of natural gas, crude oil and petroleum products. Hydrogen sulfide can also accumulate in sewers and sewage treatment plants, as well as in hide storage pits in the tanning industry. Well drillers, tunnel workers and miners may be exposed when underground pockets of hydrogen sulfide are encountered. Hydrogen sulfide is also a raw material used to manufacture inorganic sulfides, sulfuric acid and thiols (also known as mercaptans).

Health Effects from Exposure to Hydrogen Sulfide

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Hydrogen sulfide is extremely toxic. Workers are exposed when they inhale hydrogen sulfide in air and the gas is absorbed by the lungs. It is believed that exposure to hydrogen sulfide prevents the brain from using oxygen by inhibiting the enzyme, cytochrome oxidase.

Short-term (acute) exposure to hydrogen sulfide can cause irritation to the nose, throat, eyes and lungs. Exposure to higher concentrations can cause very serious health effects and even death. It is important to note that the symptoms of pulmonary edema (i.e., buildup of fluid in the lungs), such as chest pain or shortness of breath, can be delayed for up to 72 hours after exposure.

Workers who survive a serious hydrogen sulfide exposure (concentrations above 500 ppm) may recover completely or suffer long-term health effects. In some cases, there can be permanent nervous system effects, such as fatigue, anxiety, irritability, impaired learning and memory. Some of these effects may be the result of oxygen deprivation during a severe hydrogen sulfide exposure. Workers who experience knockdown or unconsciousness tend to have a greater chance of having permanent effects to the respiratory system, with symptoms that include shortness of breath on exertion, wheezing, chest tightness, hypersensitive airways and permanent lung damage.

Hydrogen sulfide does not accumulate in the body. Repeated or prolonged exposure has been reported to cause low blood pressure, headache, nausea, loss of appetite, eye inflammation and chronic cough.

The following health effects due to long-term (i.e., chronic) exposure to hydrogen sulfide have also been reported in the scientific literature:

- reduced lung function (Smoking together with hydrogen sulfide exposure may worsen this effect.)
- neurological effects, such as headaches, nausea, depression, weakness, personality changes (Exposure to other reduced sulfur gases, such as dimethyl sulfide and thiols (mercaptans), at the same time, may contribute to this effect.)
- eye irritation
- irritation to the mucous membranes
- damage to the cardiovascular system

More research is needed to confirm the human health effects from chronic exposure.

SE-HealthHazards.ppt
Slide 18

Controlling Exposure to Hydrogen Sulfide

Avoiding exposure to hydrogen sulfide is the best way to protect health. Options that should be considered include the use of:

- engineering controls
  - – ventilation to control hydrogen sulfide concentrations in the air
  - – closed systems that vent to a flare
  - – treatment methods to remove hydrogen sulfide from liquid and gas streams

  Flaring is the controlled burning of gas. It is a technique that is used by the petroleum industry to remove waste gases from crude oil. However, when hydrogen sulfide is burned, another toxic gas, sulfur dioxide, is produced. Flaring can also contribute to emissions of greenhouse gases. For these reasons, flaring is becoming a less popular way of dealing with waste gases in petroleum products.

  Chemical treatment can be used to remove hydrogen sulfide from crude oil, gas and water streams. Hydrogen sulfide treatment for crude oil is used to reduce overall sulfur levels in the product. The most common method is called the Claus Process, where hydrogen sulfide is separated from the gas stream by extraction and then converted to less toxic substances using combustion and chemical reaction. When hydrogen sulfide is present in off- gases from wastewater treatment or other industrial processes, there are a variety of scrubbers and filters that can be used. In water, hydrogen sulfide can be treated by chlorination, manganese greensand filters, aeration, ozonation, activated carbon and biofilters.

- administrative controls
  - educating workers about the hazards associated with hydrogen sulfide and symptoms of overexposure (Courses, such as H_2S Alive, are recommended for workers who may be exposed to hydrogen sulfide at the work site.)
  - developing safe work procedures for activities in environments that may contain hydrogen sulfide and training workers in these procedures
  - conducting air monitoring where there are potential sources of hydrogen sulfide (This equipment should have audible alarms that will warn workers when concentrations are too high. These instruments should be set to alarm at a level no higher than the occupational exposure limit for hydrogen sulfide.)
- personal protective equipment
  - wearing appropriate respiratory protective equipment when it is not practicable or feasible to use engineering or administrative controls to reduce the potential for exposure to hydrogen sulfide or if these measures are not sufficient (There are many types of respirators available and it is important to select the correct level of respiratory protection, depending on the type of work being done and the airborne concentrations that may be encountered. A full face piece positive pressure supplied air respirator is needed in areas where hydrogen sulfide concentrations exceed the occupational exposure limit.)
  - wearing air-tight goggles or full face respirator masks

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Slide 19

Benzene

What Is Benzene?

Benzene is a flammable liquid made from hydrocarbons or coal. Synonyms for benzene include benzol, carbon oil, coal naphtha, cyclohexatriene and phenyl hydride.

Benzene is a clear, colourless liquid with a sweet odour. The odour threshold of benzene is around 60 parts per million (ppm), although there is a sizeable range in the reported values (i.e., 0.78 to 160 ppm). Because the odour threshold of benzene is well above its OEL, it is considered to have poor warning properties. Benzene is extremely flammable. Its flashpoint (the temperature where an ignition source can ignite benzene vapours) is -110°C. Its flammable range is from 1.2 to 7.8% in air. The vapour is heavier than air, so it can spread long distances and ignite far from the source and flash back. The liquid is lighter than water and it floats on top of water if mixed. Mixing or contact with strong oxidizers, such as peroxides, chlorine, ozone, nitric acid and perchlorates, can cause spontaneous combustion and, in some cases, explosions.

How Is Benzene Used?

Before the First World War, benzene was used mostly as a solvent or in gasoline to enhance the octane number. Today, benzene is used mostly as a raw material to manufacture:

- ethyl benzene, which, in turn, is used to make styrene (an important ingredient in plastics and synthetic rubber)
- cumene, used to make phenol (an ingredient in adhesives and dyes)
- cyclohexane, used to make nylon
- chlorobenzenes, used in pesticides
- alkybenzene, used in detergents
- aniline, used in dyes and plastics

Crude oil and natural gas condensate contain benzene naturally, although the concentration varies considerably, depending on the geology and location of the well site. Drilling fluids may contain benzene and can also become contaminated with benzene when they are recirculated down well. Benzene and other hydrocarbons may be released from stacks, flares, hydrocarbon storage facilities, glycol dehydrators and other operations that involve crude oil or fuels.

A small amount of benzene, usually less than 1% by weight, is still present in gasoline sold in North America. Workers may be exposed to benzene when gasoline is used or handled or from vehicle exhaust. Benzene is still used as a solvent and reagent in laboratories. Benzene is also a compound found in cigarette smoke.

Health Effects from Exposure to Benzene

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Slide 20

Workers are usually exposed to benzene by inhaling the airborne vapours or by skin contact with the liquid chemical. The vapours in air can also be absorbed through the skin. This occurs to a much lesser extent than by direct contact with the liquid and is unlikely to be a significant route of exposure when benzene concentrations in the air are less than 25 ppm.

Short-term (acute) exposure to benzene at high concentrations can cause central nervous system depression, causing drowsiness, dizziness, headache, nausea, vomiting, sleepiness, fatigue, slurred speech, loss of balance and disorientation. These effects are not usual at concentrations below 25 ppm; they are more common at 50 to 150 ppm. As concentrations of benzene vapours in the air increase, the health effects become more severe (e.g., vertigo, confusion, loss of consciousness). Exposure to about 20 000 ppm for five to 10 minutes can cause death.

Nose and throat irritation have also been reported after short-term overexposure. Prolonged or repeated contact of benzene with the skin causes redness, drying and cracking because benzene dissolves and removes the protective natural oils from the skin. The most significant health effect of benzene is its impact on the blood system. Benzene can be metabolized in the liver and bone marrow and its metabolites can damage the bone marrow where new blood cells are produced. At high concentrations, these metabolites can cause a serious condition where the number of red blood cells, white blood cells and clotting cells is reduced (i.e., pancytopenia). In the initial stages, this effect is thought to be reversible but, with continued exposure, it may progress to aplastic anemia (a rare blood disorder that results from the failure of the bone marrow to produce blood cells) or leukemia (a cancer that starts in blood cells). Benzene can weaken the immune system by lowering the number of white blood cells produced.

Benzene is considered carcinogenic to humans. Long-term exposure to benzene may increase the incidence of a specific type of leukemia (i.e., acute myelogenous leukemia) and may (although the results are not consistent) be associated with other forms of leukemia and lymphomas (i.e., cancers that develop from cells in the lymphatic system).

Studies have shown that benzene can cross the placenta but there is no conclusive evidence that it affects the fetus. Benzene can cause mutation of cells, usually when there is exposure to concentrations that are high enough to also cause blood changes.

Exposure to ethanol and benzene together can increase the effects to the blood system. Exposure to toluene and benzene can reduce the body's ability to remove benzene since the two chemicals are metabolized in a similar way.

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Slide 21

Controlling Exposure to Benzene

Preventing exposure to benzene is the best way to protect health. Options that should be considered include:

- use of less hazardous substitutes
  One option to control exposure to benzene is to use other solvents when this is practicable. For example, some alcohols and cyclohexane can be substituted for benzene as a solvent in laboratory procedures. Toluene, which has a similar chemical structure to benzene, is also often used as a substitute. However, substitution may not always be possible when benzene is the raw material for the manufacture of another product. In addition, the substitutes may have their own health hazards.
- engineering controls
  - installation of local ventilation hoods
  - enclosures around work processes; e.g., fume hoods, glove boxes
  - use of automatic systems to pump benzene or substances containing benzene from storage containers to process containers

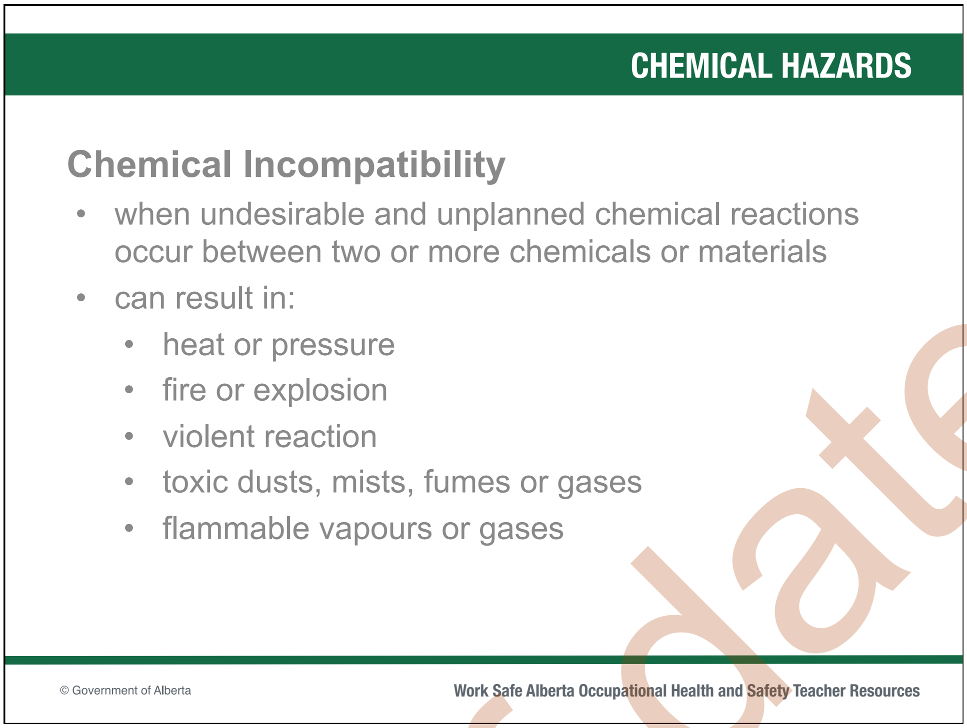
Notes:

- Fuels that contain benzene must be handled carefully. Even though they contain only a small amount of benzene, enough benzene vapours can be released during product handling to exceed occupational exposure limits.
- Benzene presents a fire hazard as well as a health hazard to workers. Many of the products that contain benzene (e.g., gasoline) are also flammable. Particular attention must be paid to fire safety and potential sources of ignition in areas where benzene is used and stored. Benzene should be stored in a cool, dry, well-ventilated area, out of direct sunlight and in a part of the work site that is separate from the production area. Benzene should never be stored with oxidizing chemicals.

- administrative controls
  - educating workers about the hazards of benzene
  - using good hygiene practices; e.g., not eat, drink or use tobacco products in areas where benzene or products containing benzene are used or stored, wash hands and face before eating, drinking or smoking
  - using and maintaining engineering controls and other equipment used to reduce exposure properly
  - storing benzene properly
  - ensuring that unprotected workers are not in areas where products containing benzene are used
  - cleaning up spills quickly and properly, using appropriate protective equipment and clothing
  - keeping product containers tightly sealed when they are not in use
- personal protective equipment
  - wearing properly operating air-supplying respirators (Because benzene has poor warning properties, air purifying respirators generally are not adequate for benzene exposure. The wearer will not be able to detect when a cartridge is in need of changing and may unknowingly become overexposed.)
  - wearing solvent resistant gloves and other protective clothing when workers handle the chemical or may be exposed to airborne vapours (Different protective clothing and glove materials will be needed, depending on whether the worker will be exposed to pure benzene or benzene as a component in a mixture (e.g., gasoline). For mixtures containing benzene, choose a material that has been tested for similar mixtures. For example, a material with resistance to gasoline will provide protection for condensate and crude oil as well.)
  - wearing protective clothing that covers and protects the arms and legs (Close fitting goggles or full face respirator masks should be worn to protect the eyes from irritation or splashes. Where skin contact with liquids containing benzene occurs, the area should be thoroughly washed immediately.)

Chemical Compatibility

A +	B =	C
Acids or bases (corrosives)	Reactive metals such as: • aluminum • beryllium • calcium • lithium • potassium • magnesium • sodium • zinc powder	**Fire**
Solvent or reactive organic materials such as: • 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: • chlorates • chlorine • chlorites • chromic acid • hypochlorites • nitrates • perchlorates • permanganates • peroxides	Flammable liquids Flammable solids Flammable or combustible wastes	**Explosion**



CHEMICAL HAZARDS

Chemical Incompatibility

- when undesirable and unplanned chemical reactions occur between two or more chemicals or materials
- can result in:
  - heat or pressure
  - fire or explosion
  - violent reaction
  - toxic dusts, mists, fumes or gases
  - flammable vapours or gases

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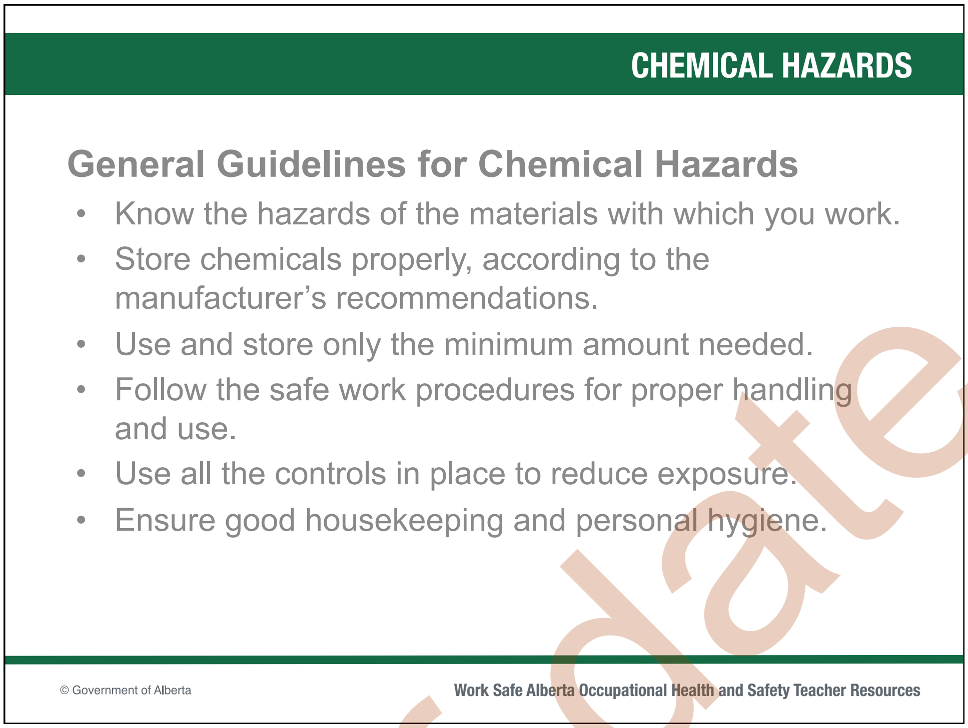

CHEMICAL HAZARDS

General Guidelines for Chemical Hazards

- Know the hazards of the materials with which you work.
- Store chemicals properly, according to the manufacturer's recommendations.
- Use and store only the minimum amount needed.
- Follow the safe work procedures for proper handling and use.
- Use all the controls in place to reduce exposure.
- Ensure good housekeeping and personal hygiene.

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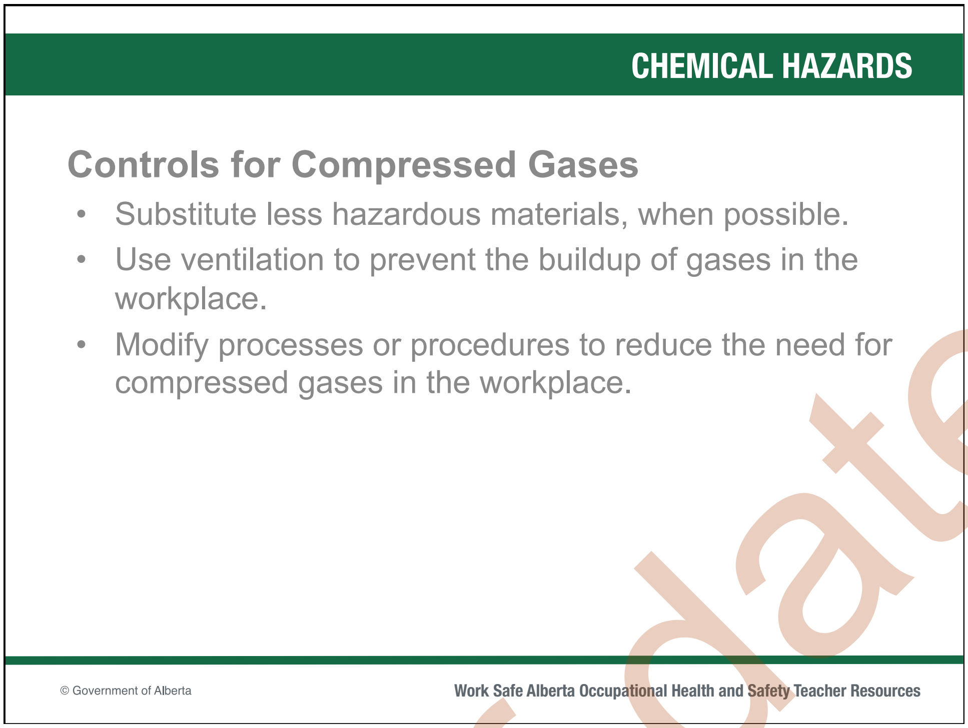
SB-Guidelines.ppt Slide 1



CHEMICAL HAZARDS

Controls for Compressed Gases

- Substitute less hazardous materials, when possible.
- Use ventilation to prevent the buildup of gases in the workplace.
- Modify processes or procedures to reduce the need for compressed gases in the workplace.

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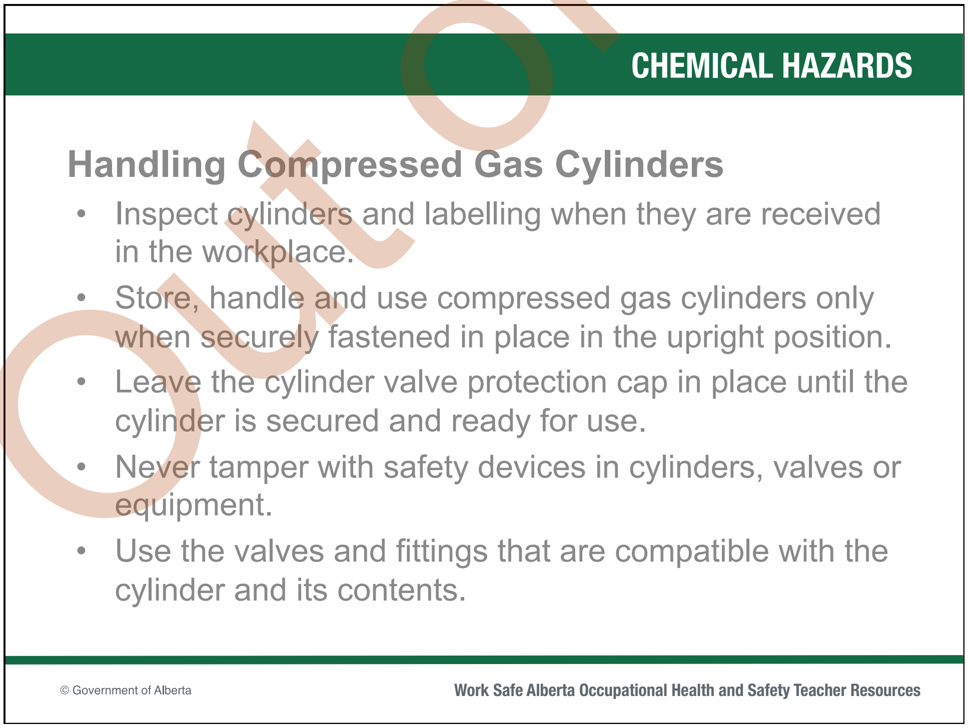

CHEMICAL HAZARDS

Handling Compressed Gas Cylinders

- Inspect cylinders and labelling when they are received in the workplace.
- Store, handle and use compressed gas cylinders only when securely fastened in place in the upright position.
- Leave the cylinder valve protection cap in place until the cylinder is secured and ready for use.
- Never tamper with safety devices in cylinders, valves or equipment.
- Use the valves and fittings that are compatible with the cylinder and its contents.

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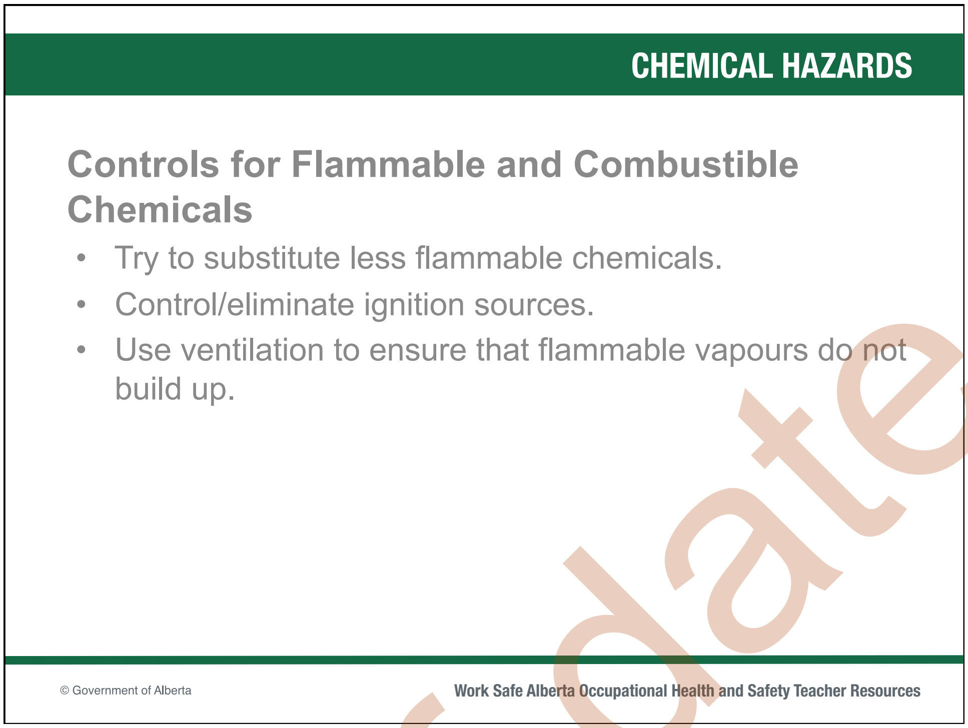

CHEMICAL HAZARDS

Controls for Flammable and Combustible Chemicals

- Try to substitute less flammable chemicals.
- Control/eliminate ignition sources.
- Use ventilation to ensure that flammable vapours do not build up.

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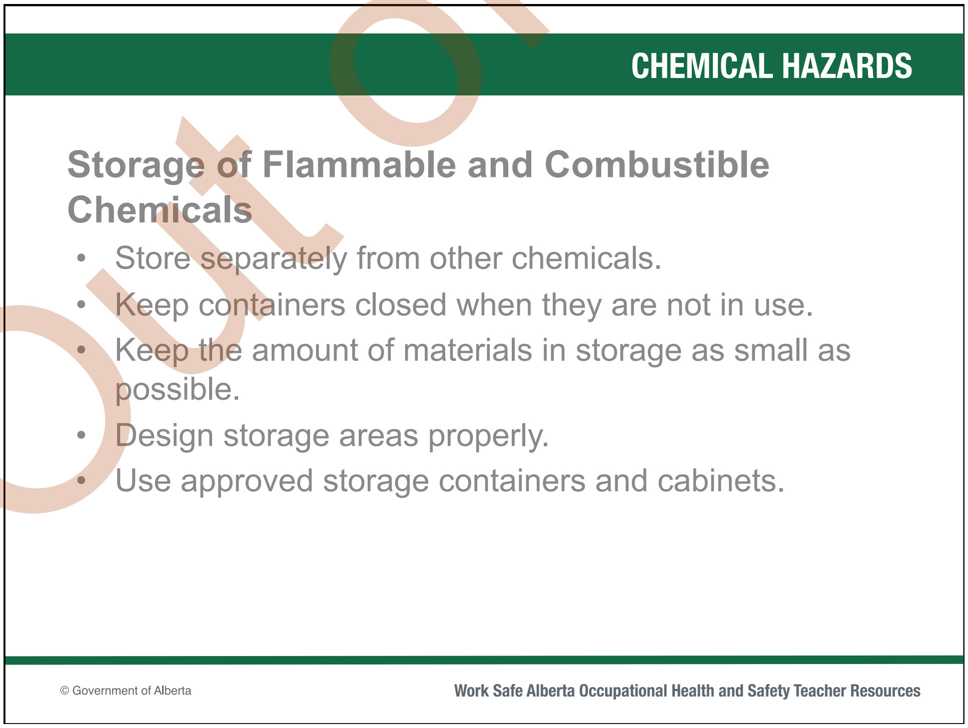

CHEMICAL HAZARDS

Storage of Flammable and Combustible Chemicals

- Store separately from other chemicals.
- Keep containers closed when they are not in use.
- Keep the amount of materials in storage as small as possible.
- Design storage areas properly.
- Use approved storage containers and cabinets.

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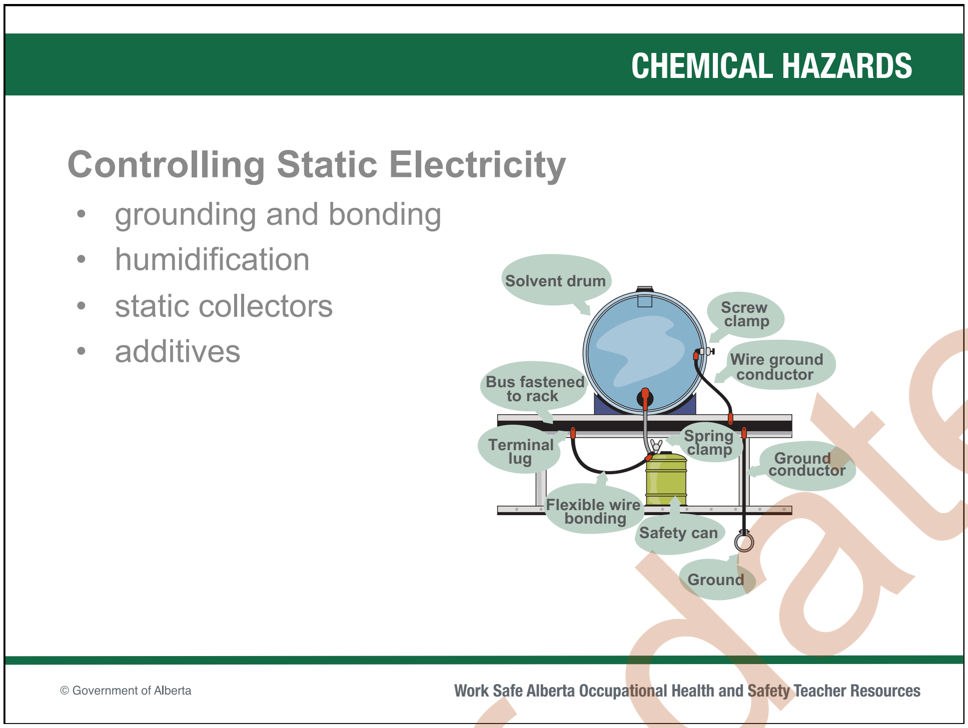

CHEMICAL HAZARDS

Controlling Static Electricity

- grounding and bonding
- humidification
- static collectors
- additives

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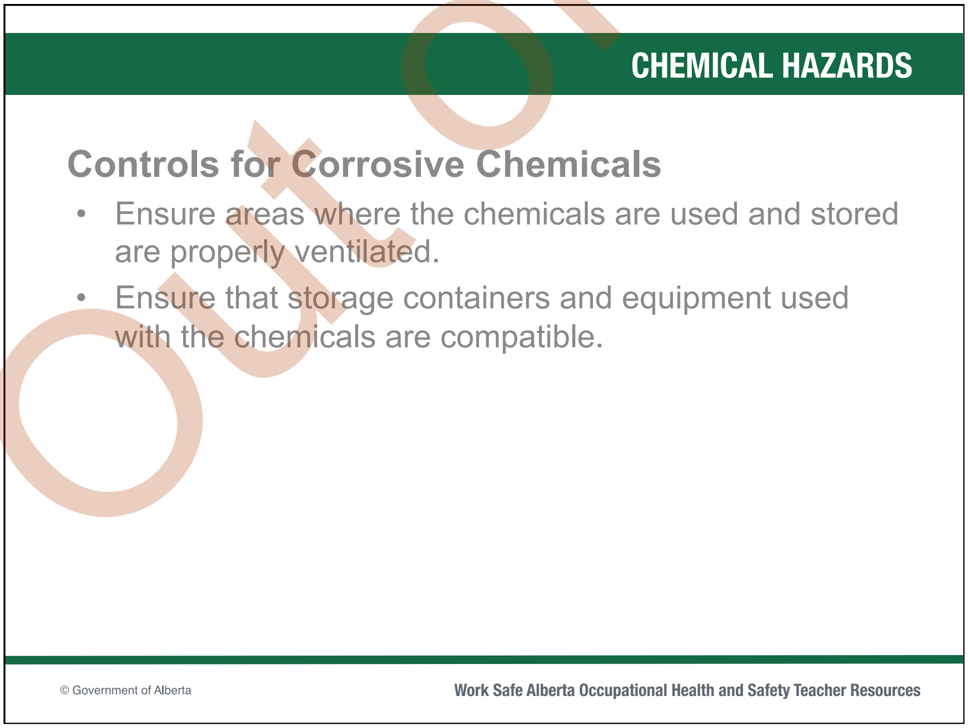

CHEMICAL HAZARDS

Controls for Corrosive Chemicals

- Ensure areas where the chemicals are used and stored are properly ventilated.
- Ensure that storage containers and equipment used with the chemicals are compatible.

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CHEMICAL HAZARDS

Storage of Corrosive Chemicals

- Ensure that walls and shelving will resist corrosion.
- Store away from incompatible materials.
- Store products at temperatures above their freezing point.
- Do not use empty containers to store other chemicals or items.

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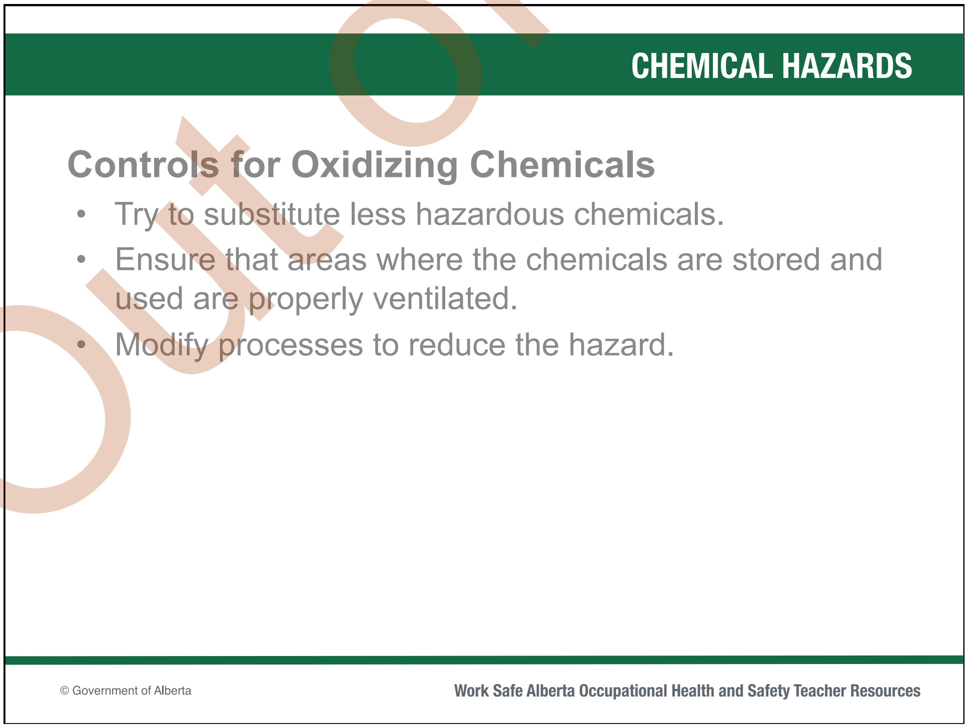

CHEMICAL HAZARDS

Controls for Oxidizing Chemicals

- Try to substitute less hazardous chemicals.
- Ensure that areas where the chemicals are stored and used are properly ventilated.
- Modify processes to reduce the hazard.

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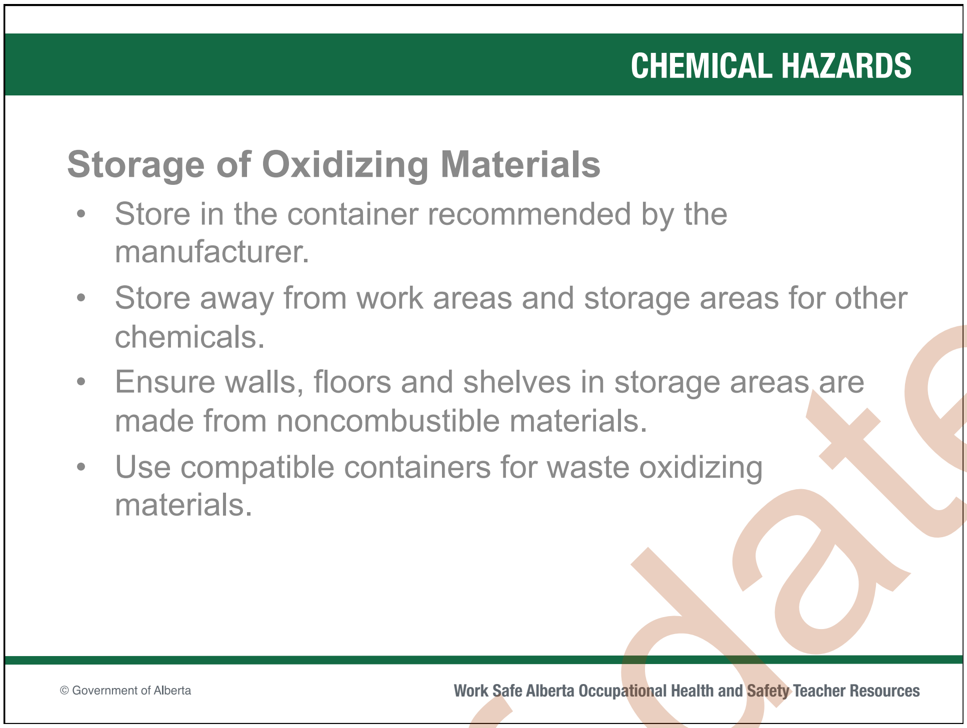

CHEMICAL HAZARDS

Storage of Oxidizing Materials

- Store in the container recommended by the manufacturer.
- Store away from work areas and storage areas for other chemicals.
- Ensure walls, floors and shelves in storage areas are made from noncombustible materials.
- Use compatible containers for waste oxidizing materials.

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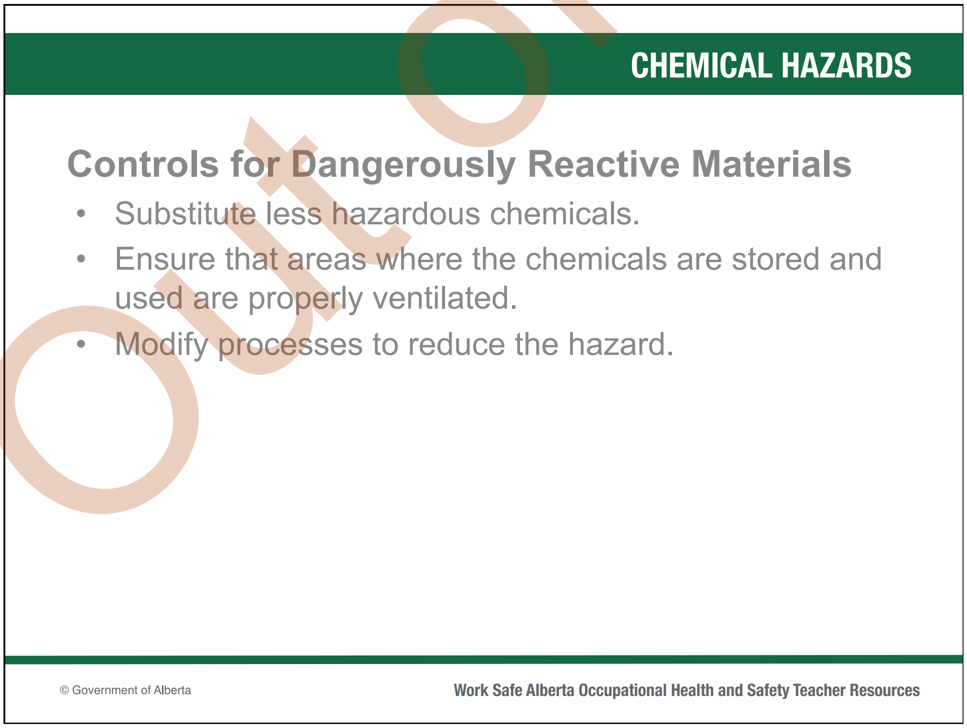

CHEMICAL HAZARDS

Controls for Dangerously Reactive Materials

- Substitute less hazardous chemicals.
- Ensure that areas where the chemicals are stored and used are properly ventilated.
- Modify processes to reduce the hazard.

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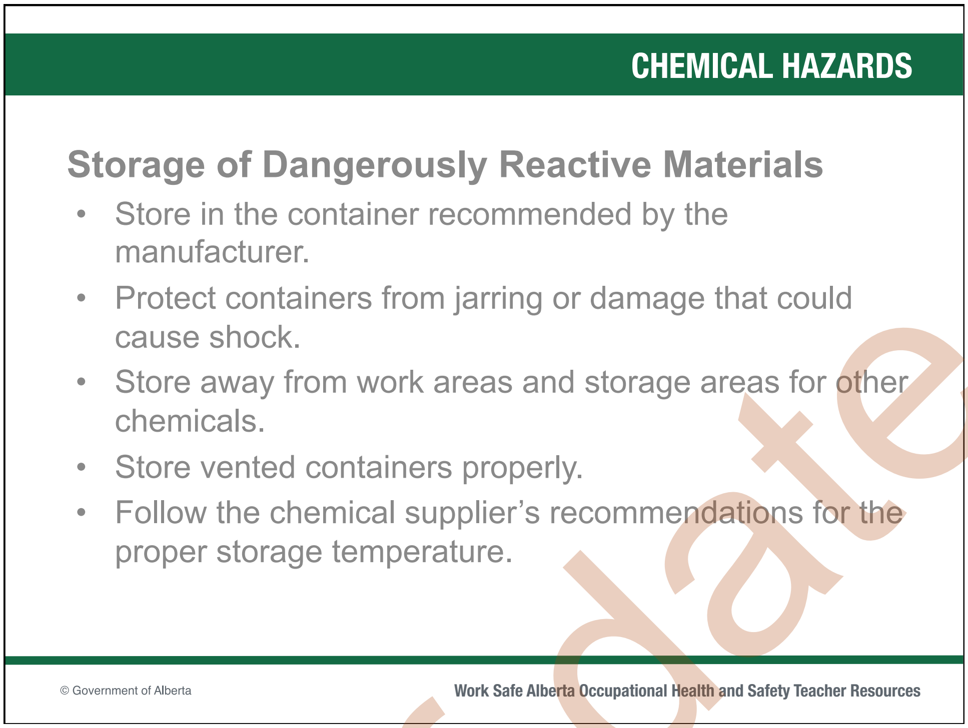

CHEMICAL HAZARDS

Storage of Dangerously Reactive Materials

- Store in the container recommended by the manufacturer.
- Protect containers from jarring or damage that could cause shock.
- Store away from work areas and storage areas for other chemicals.
- Store vented containers properly.
- Follow the chemical supplier’s recommendations for the proper storage temperature.

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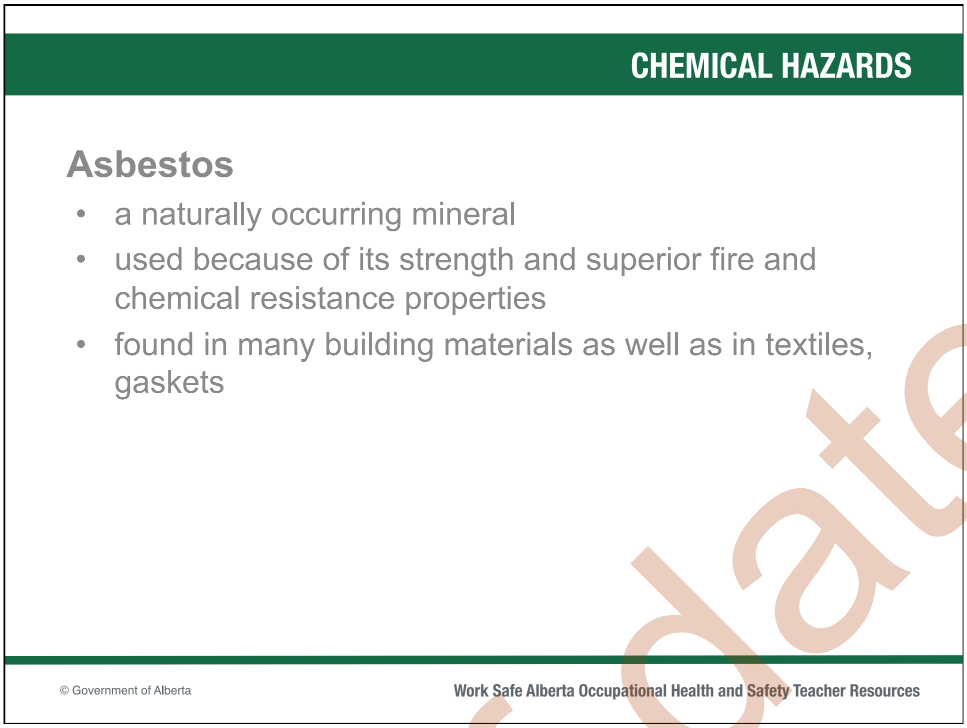

CHEMICAL HAZARDS

Asbestos

- a naturally occurring mineral
- used because of its strength and superior fire and chemical resistance properties
- found in many building materials as well as in textiles, gaskets

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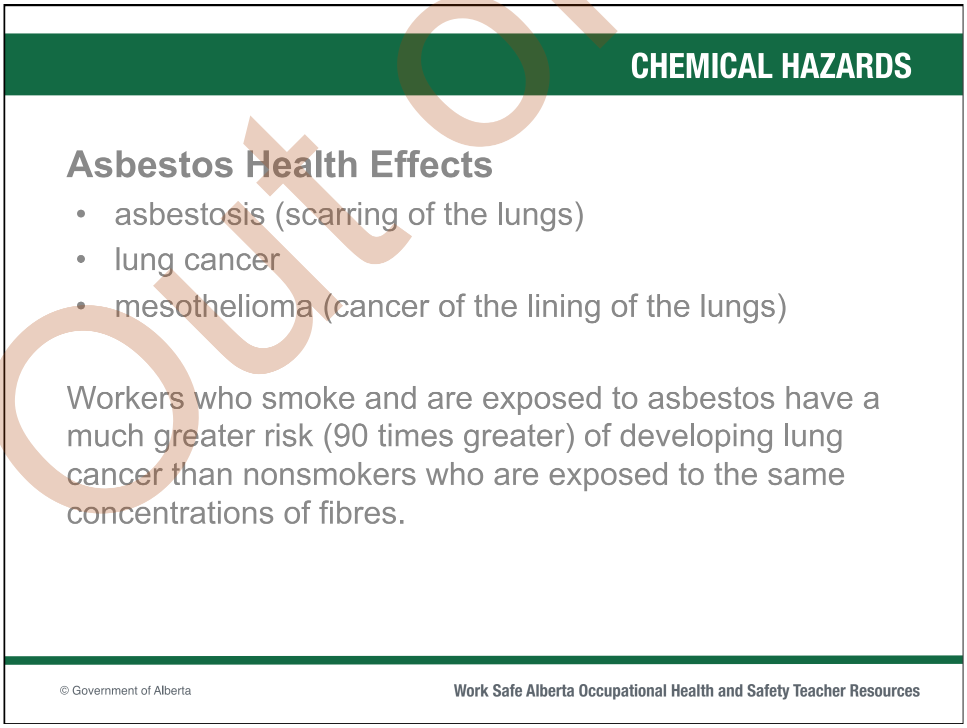

CHEMICAL HAZARDS

Asbestos Health Effects

- asbestosis (scarring of the lungs)
- lung cancer
- mesothelioma (cancer of the lining of the lungs)

Workers who smoke and are exposed to asbestos have a much greater risk (90 times greater) of developing lung cancer than nonsmokers who are exposed to the same concentrations of fibres.

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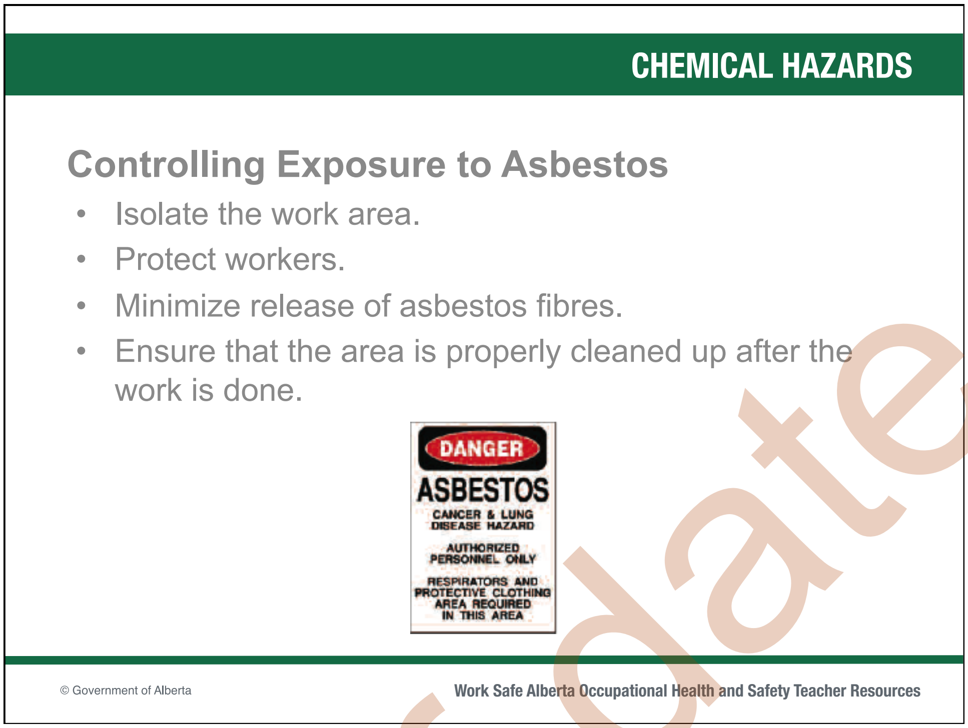

CHEMICAL HAZARDS

Controlling Exposure to Asbestos

- Isolate the work area.
- Protect workers.
- Minimize release of asbestos fibres.
- Ensure that the area is properly cleaned up after the work is done.

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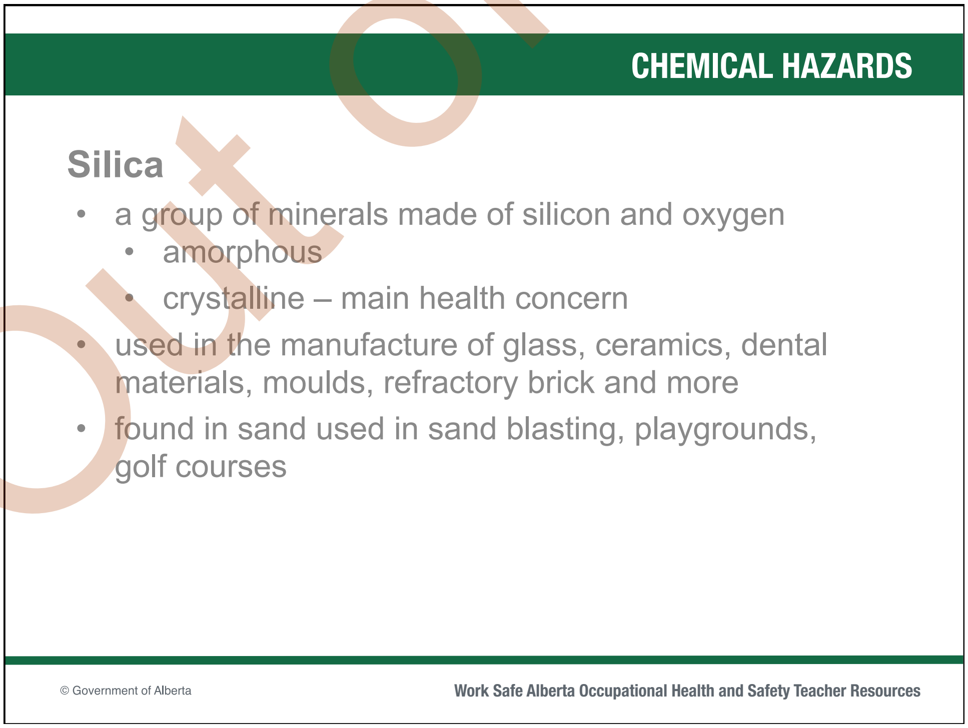

CHEMICAL HAZARDS

Silica

- a group of minerals made of silicon and oxygen
  - amorphous
  - crystalline – main health concern
- used in the manufacture of glass, ceramics, dental materials, moulds, refractory brick and more
- found in sand used in sand blasting, playgrounds, golf courses

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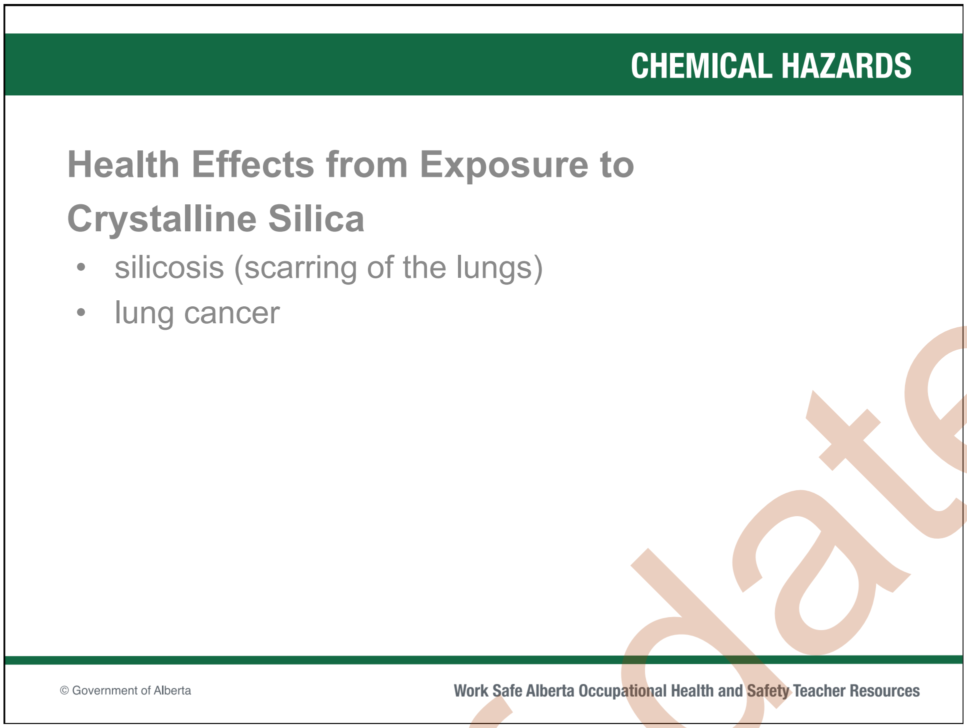

CHEMICAL HAZARDS

Health Effects from Exposure to Crystalline Silica

- silicosis (scarring of the lungs)
- lung cancer

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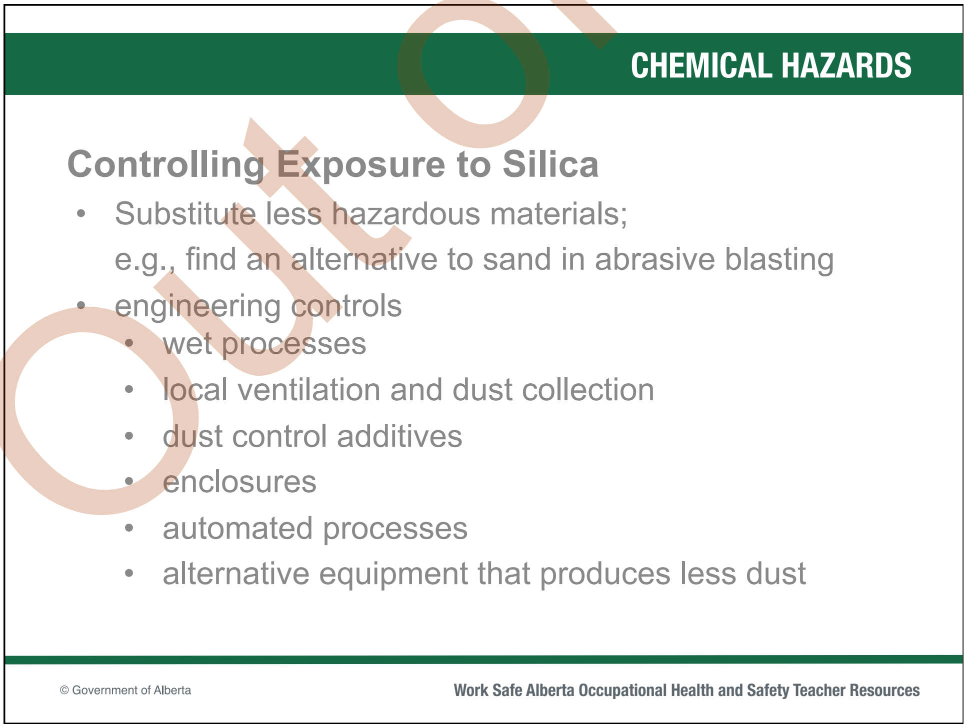

CHEMICAL HAZARDS

Controlling Exposure to Silica

- Substitute less hazardous materials;
  e.g., find an alternative to sand in abrasive blasting
- engineering controls
  - wet processes
  - local ventilation and dust collection
  - dust control additives
  - enclosures
  - automated processes
  - alternative equipment that produces less dust

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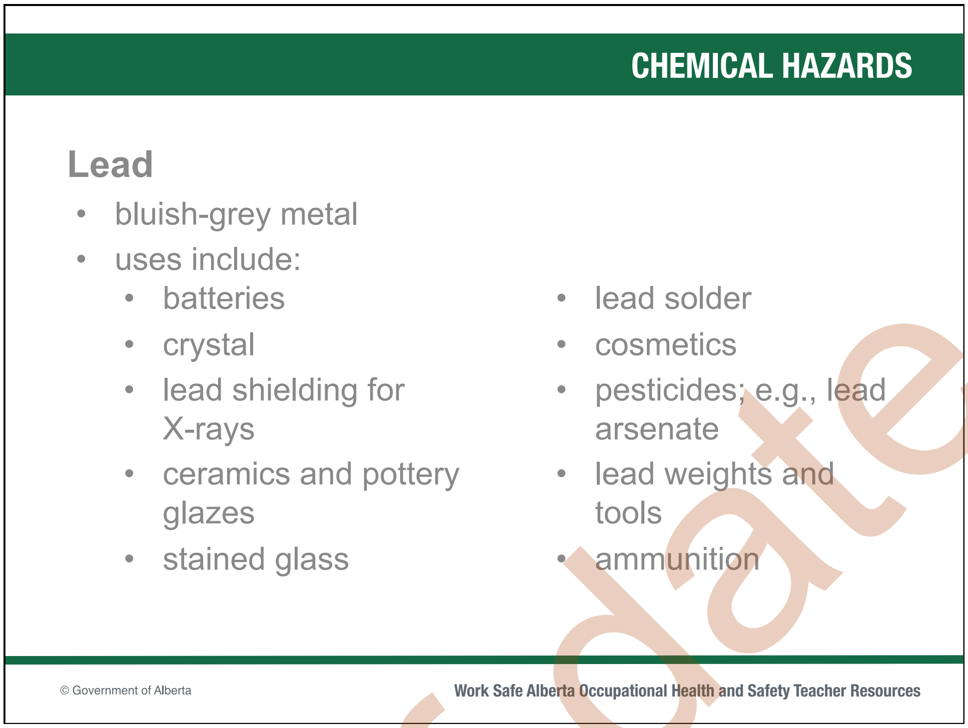

CHEMICAL HAZARDS

Lead

- bluish-grey metal
- uses include:
  - batteries
  - crystal
  - lead shielding for X-rays
  - ceramics and pottery glazes
  - stained glass
  - lead solder
  - cosmetics
  - pesticides; e.g., lead arsenate
  - lead weights and tools
  - ammunition

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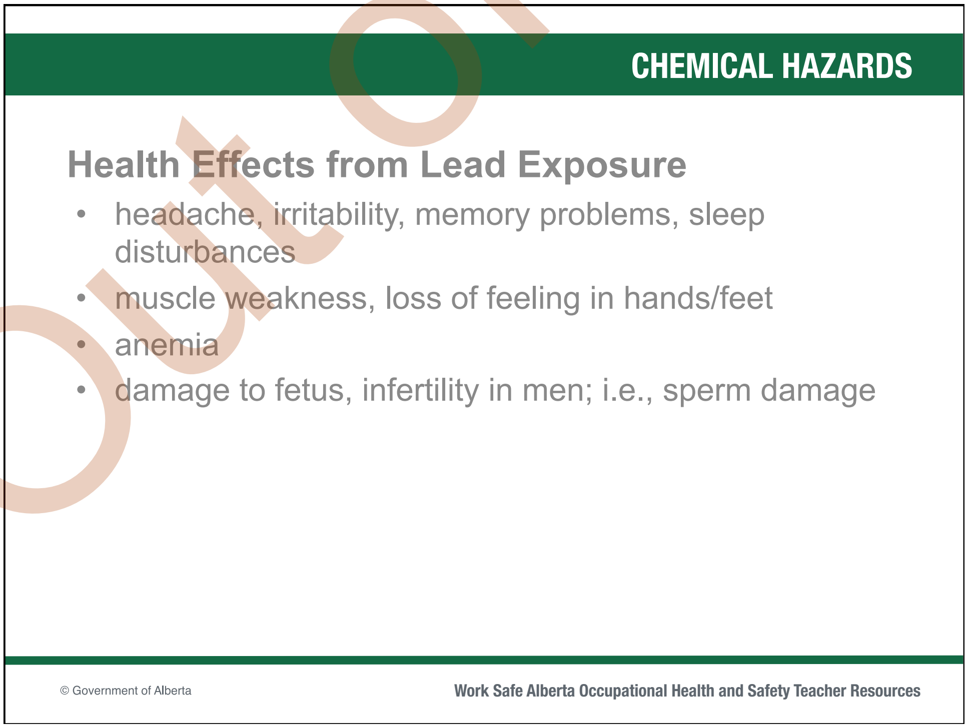

CHEMICAL HAZARDS

Health Effects from Lead Exposure

- headache, irritability, memory problems, sleep disturbances
- muscle weakness, loss of feeling in hands/feet
- anemia
- damage to fetus, infertility in men; i.e., sperm damage

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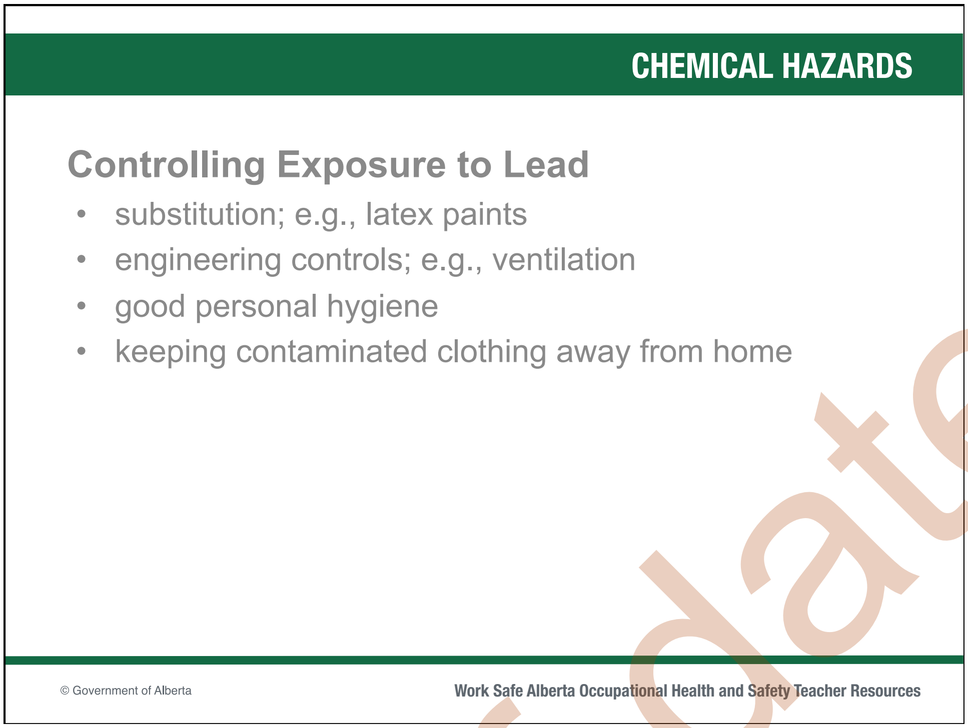

CHEMICAL HAZARDS

Controlling Exposure to Lead

- substitution; e.g., latex paints
- engineering controls; e.g., ventilation
- good personal hygiene
- keeping contaminated clothing away from home

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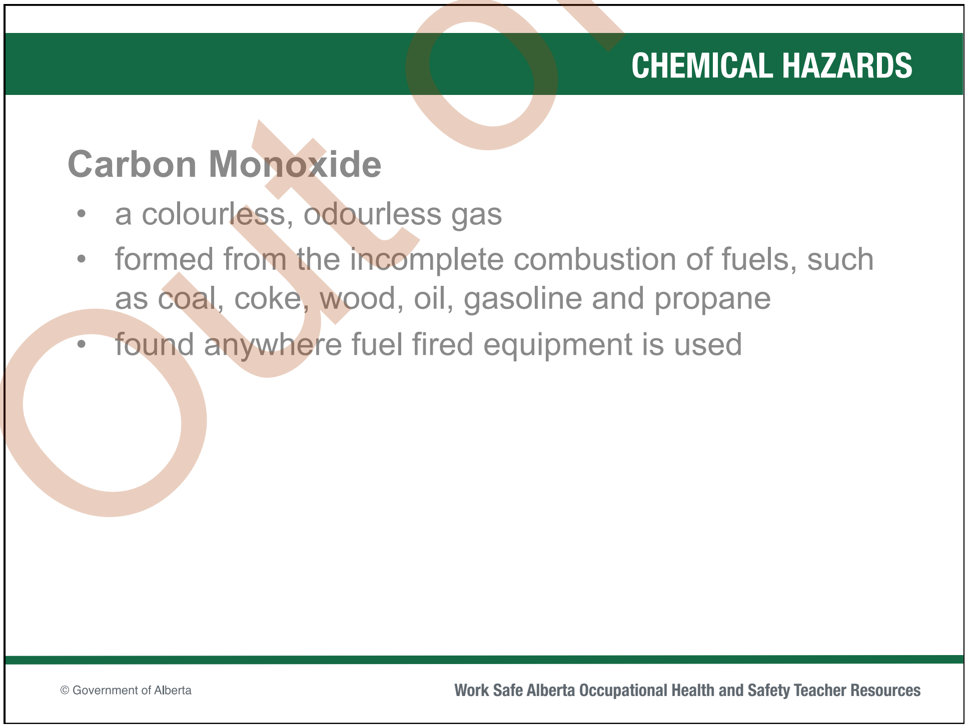

CHEMICAL HAZARDS

Carbon Monoxide

- a colourless, odourless gas
- formed from the incomplete combustion of fuels, such as coal, coke, wood, oil, gasoline and propane
- found anywhere fuel fired equipment is used

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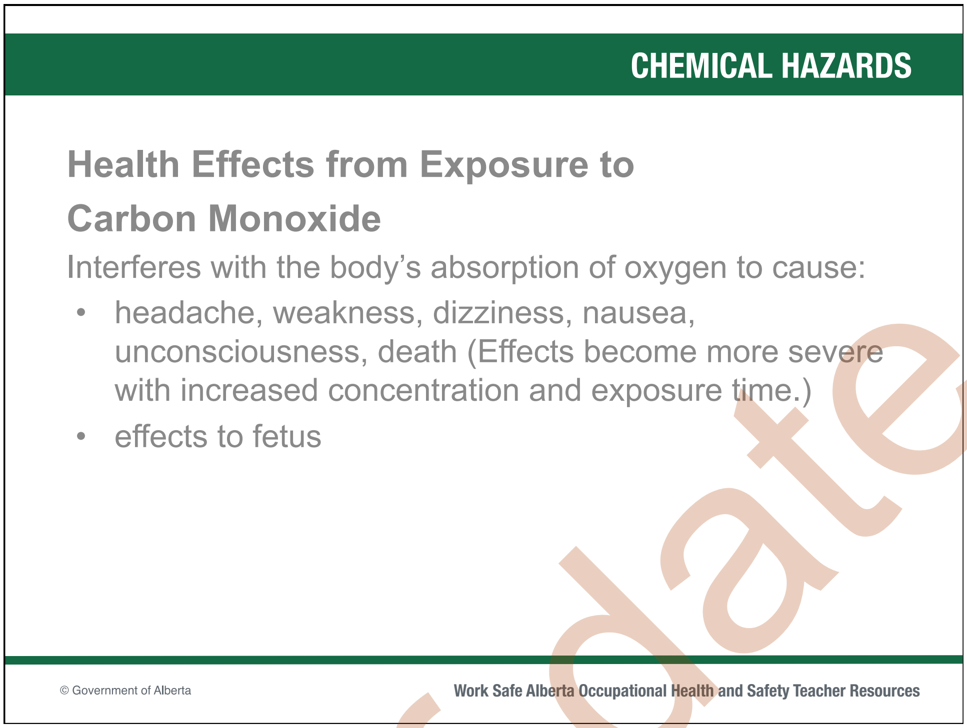

CHEMICAL HAZARDS

Health Effects from Exposure to Carbon Monoxide

Interferes with the body’s absorption of oxygen to cause:

- headache, weakness, dizziness, nausea, unconsciousness, death (Effects become more severe with increased concentration and exposure time.)
- effects to fetus

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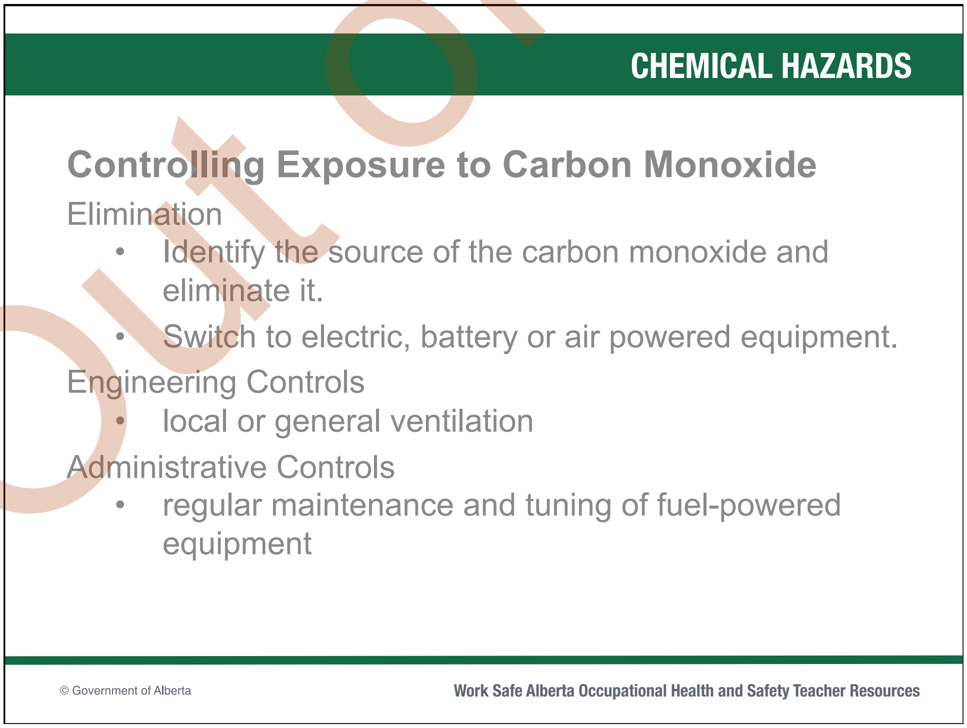

CHEMICAL HAZARDS

Controlling Exposure to Carbon Monoxide

Elimination

- Identify the source of the carbon monoxide and eliminate it.
- Switch to electric, battery or air powered equipment.

Engineering Controls

- local or general ventilation

Administrative Controls

- regular maintenance and tuning of fuel-powered equipment

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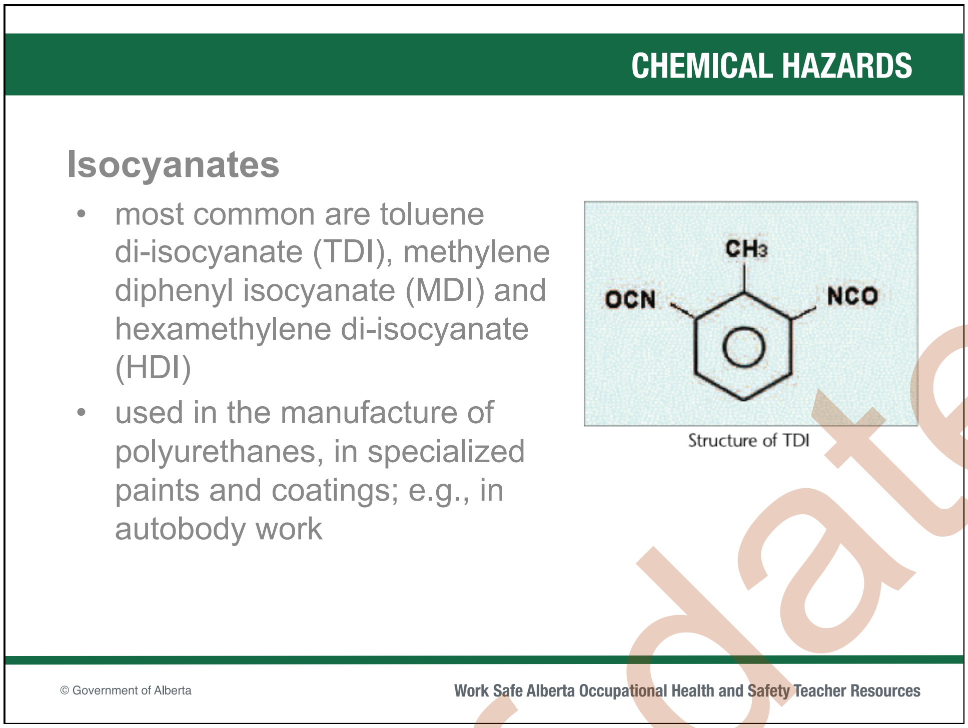

CHEMICAL HAZARDS

Isocyanates

- most common are toluene di-isocyanate (TDI), methylene diphenyl isocyanate (MDI) and hexamethylene di-isocyanate (HDI)
- used in the manufacture of polyurethanes, in specialized paints and coatings; e.g., in autobody work

Structure of TDI

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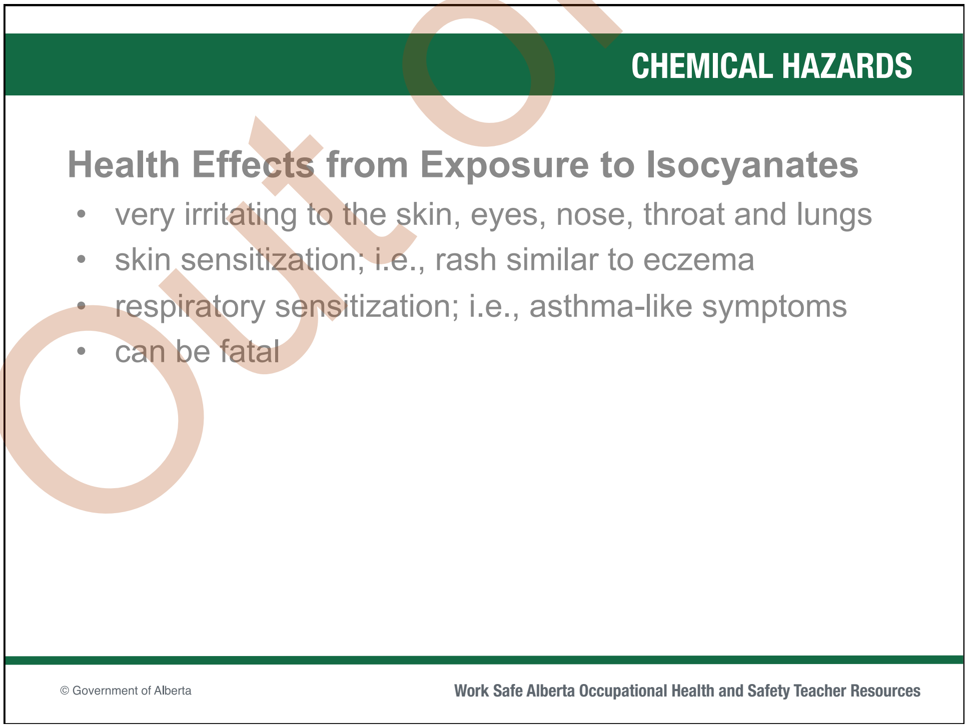

CHEMICAL HAZARDS

Health Effects from Exposure to Isocyanates

- very irritating to the skin, eyes, nose, throat and lungs
- skin sensitization; i.e., rash similar to eczema
- respiratory sensitization; i.e., asthma-like symptoms
- can be fatal

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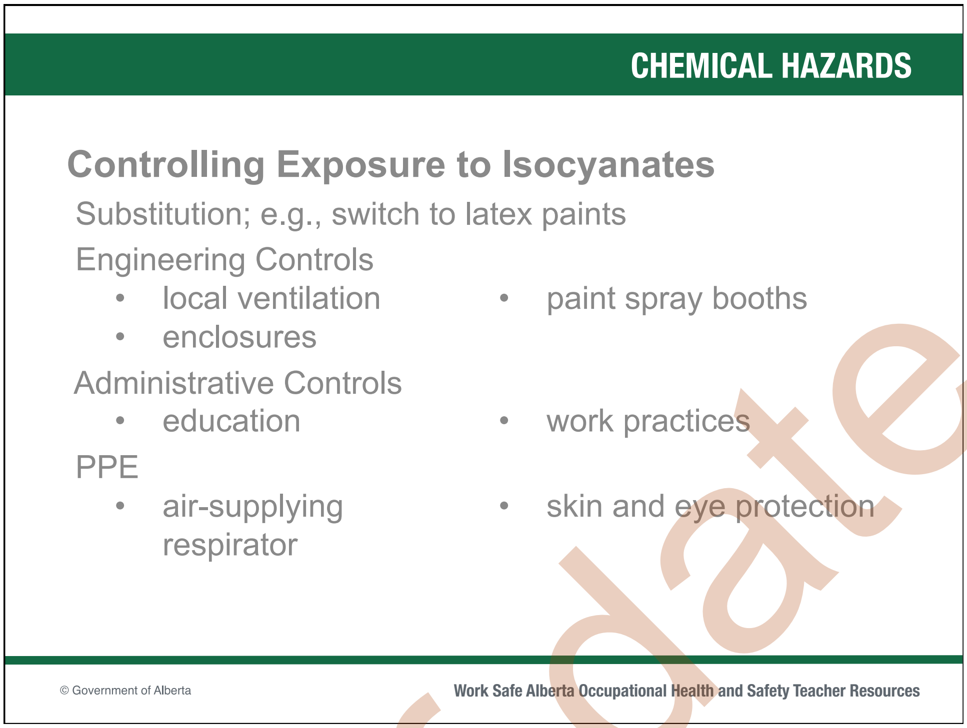

CHEMICAL HAZARDS

Controlling Exposure to Isocyanates

Substitution; e.g., switch to latex paints

Engineering Controls
- local ventilation
- enclosures
- paint spray booths

Administrative Controls
- education
- work practices

PPE
- air-supplying respirator
- skin and eye protection

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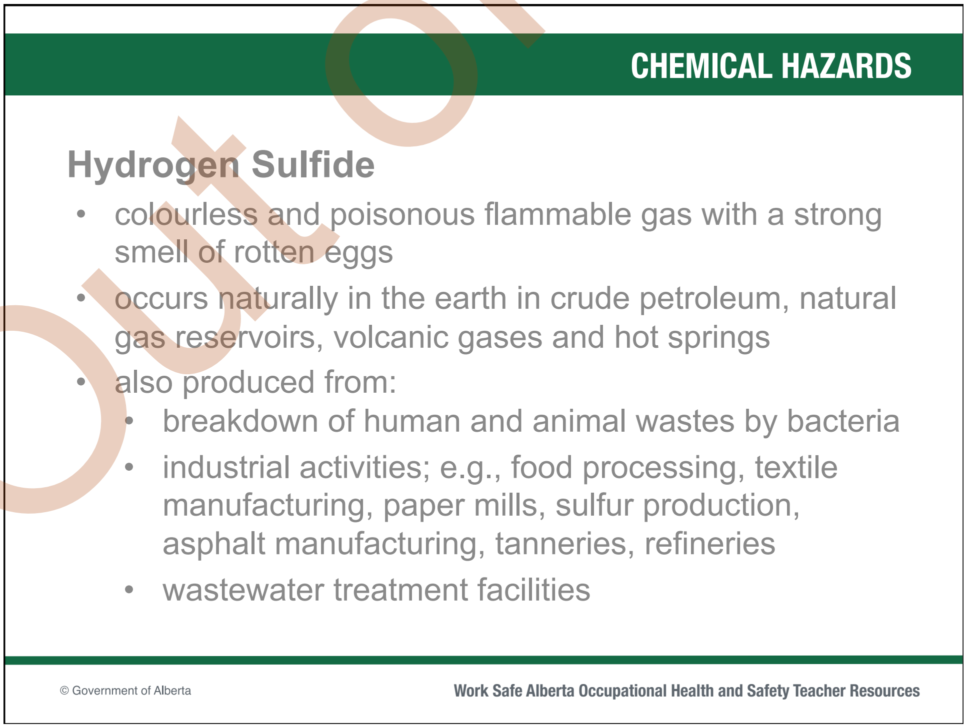

CHEMICAL HAZARDS

Hydrogen Sulfide

- colourless and poisonous flammable gas with a strong smell of rotten eggs
- occurs naturally in the earth in crude petroleum, natural gas reservoirs, volcanic gases and hot springs
- also produced from:
  - breakdown of human and animal wastes by bacteria
  - industrial activities; e.g., food processing, textile manufacturing, paper mills, sulfur production, asphalt manufacturing, tanneries, refineries
  - wastewater treatment facilities

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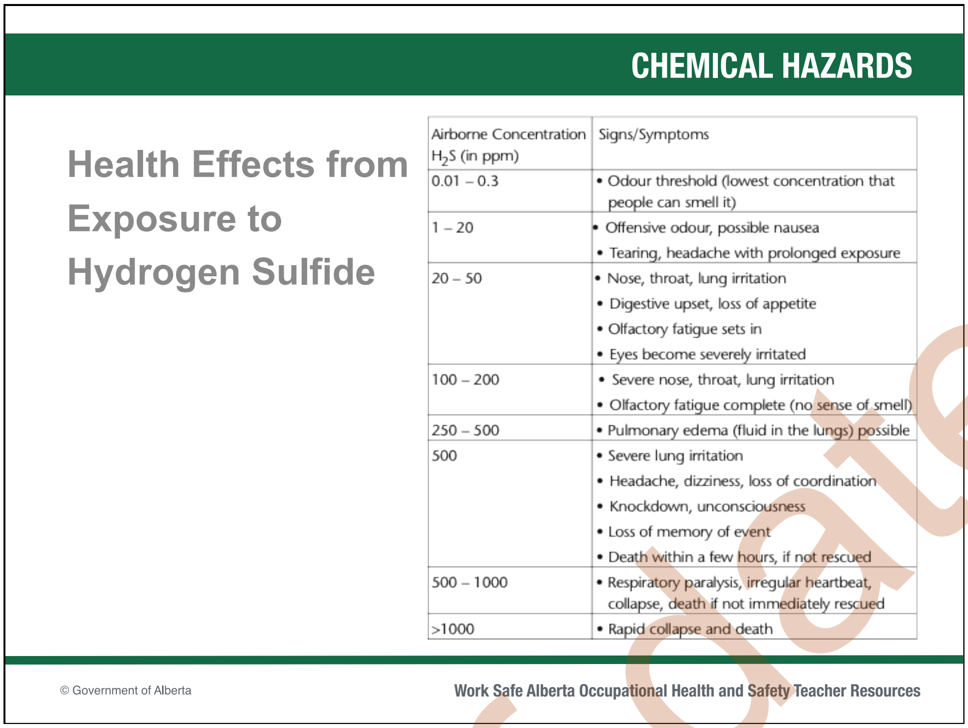

CHEMICAL HAZARDS

Health Effects from Exposure to Hydrogen Sulfide

Airborne Concentration H_2S (in ppm)	Signs/Symptoms
0.01 – 0.3	• Odour threshold (lowest concentration that people can smell it)
1 – 20	• Offensive odour, possible nausea • Tearing, headache with prolonged exposure
20 – 50	• Nose, throat, lung irritation • Digestive upset, loss of appetite • Olfactory fatigue sets in • Eyes become severely irritated
100 – 200	• Severe nose, throat, lung irritation • Olfactory fatigue complete (no sense of smell)
250 – 500	• Pulmonary edema (fluid in the lungs) possible
500	• Severe lung irritation • Headache, dizziness, loss of coordination • Knockdown, unconsciousness • Loss of memory of event • Death within a few hours, if not rescued
500 – 1000	• Respiratory paralysis, irregular heartbeat, collapse, death if not immediately rescued
>1000	• Rapid collapse and death

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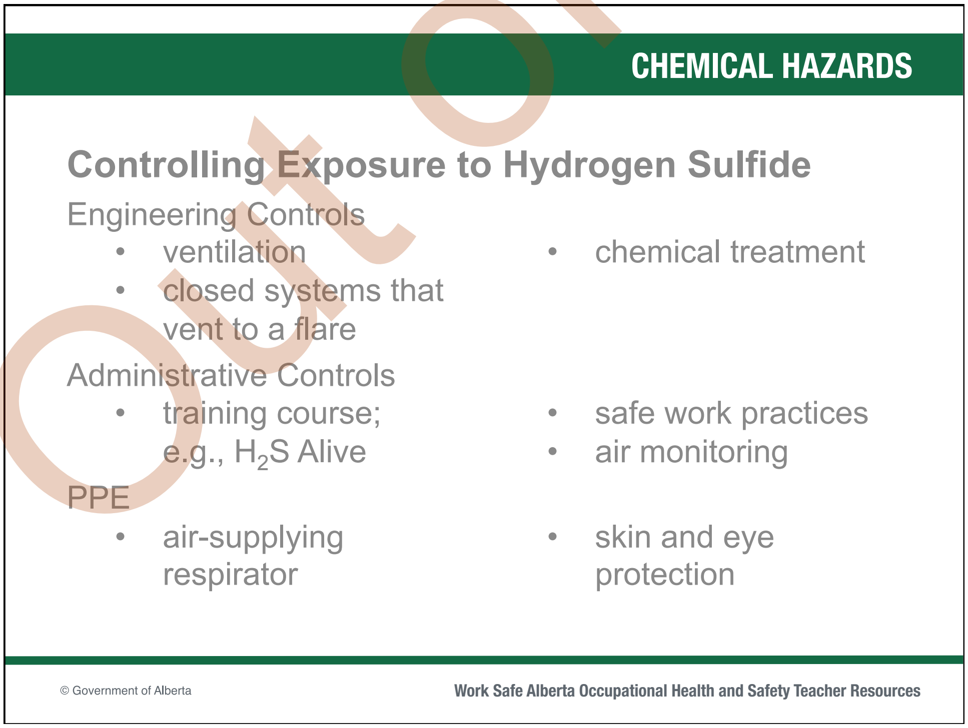

CHEMICAL HAZARDS

Controlling Exposure to Hydrogen Sulfide

Engineering Controls
- ventilation
- closed systems that vent to a flare
- chemical treatment

Administrative Controls
- training course; e.g., H_2S Alive
- safe work practices
- air monitoring

PPE
- air-supplying respirator
- skin and eye protection

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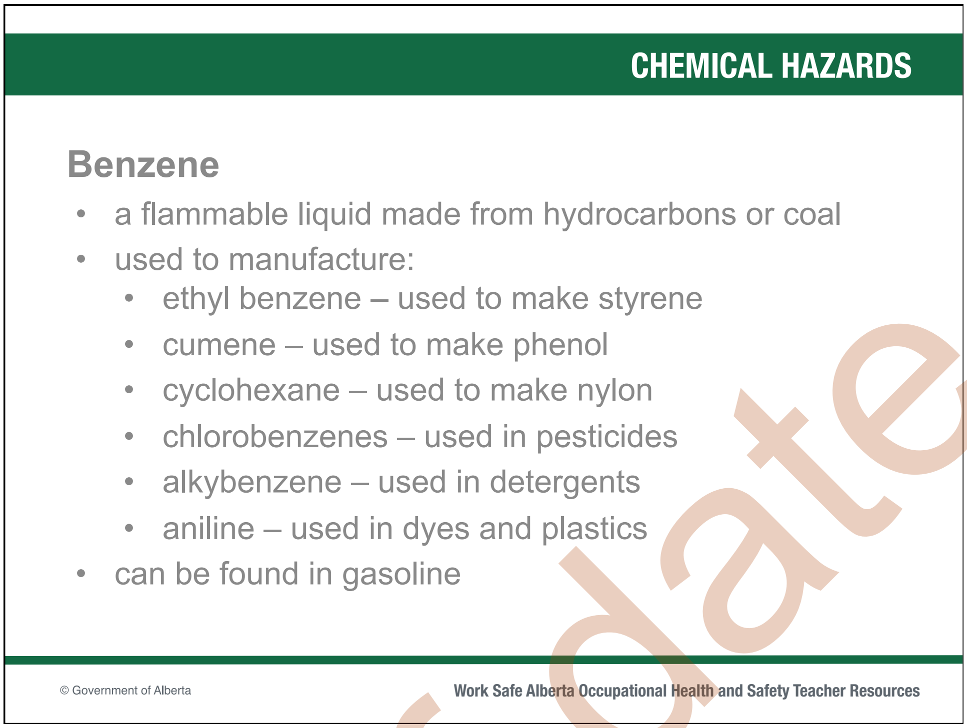

CHEMICAL HAZARDS

Benzene

- a flammable liquid made from hydrocarbons or coal
- used to manufacture:
  - ethyl benzene – used to make styrene
  - cumene – used to make phenol
  - cyclohexane – used to make nylon
  - chlorobenzenes – used in pesticides
  - alkybenzene – used in detergents
  - aniline – used in dyes and plastics
- can be found in gasoline

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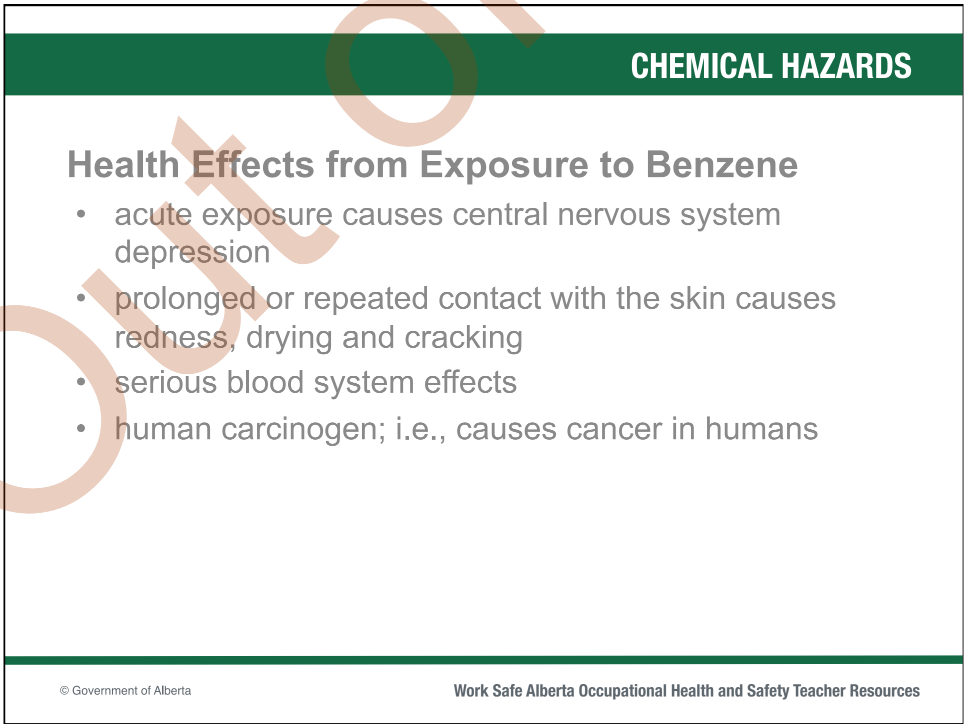

CHEMICAL HAZARDS

Health Effects from Exposure to Benzene

- acute exposure causes central nervous system depression
- prolonged or repeated contact with the skin causes redness, drying and cracking
- serious blood system effects
- human carcinogen; i.e., causes cancer in humans

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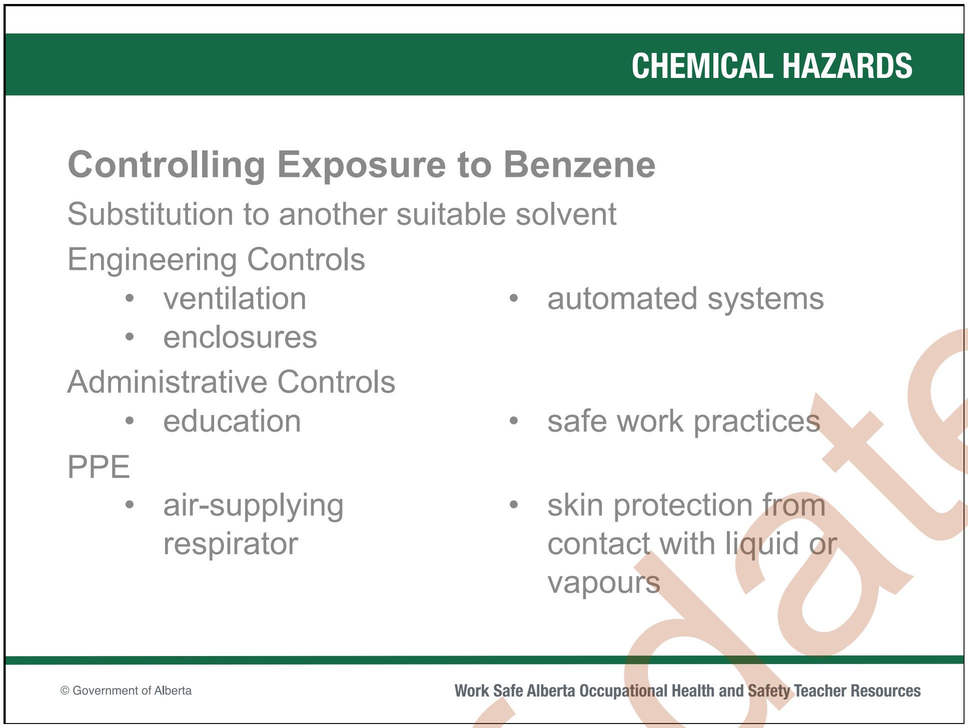

CHEMICAL HAZARDS

Controlling Exposure to Benzene

Substitution to another suitable solvent

Engineering Controls
- ventilation
- enclosures
- automated systems

Administrative Controls
- education
- safe work practices

PPE
- air-supplying respirator
- skin protection from contact with liquid or vapours

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What if I want to find out more?

RESOURCES

Respiratory Protection

Canadian Standards Association (CSA)
Standard Z94.4-02, *Selection, Use and Care of Respirators*,
Rexdale, Ontario, 2002.

National Institute for Occupational Safety and Health
NIOSH Guide to the Selection and Use of Particulate Respirators
Publication no. 96-101, NIOSH, Cincinnati, Ohio, 1996.
www.cdc.gov/niosh/userguid.html

Alberta Occupational Health and Safety
"Respiratory Protective Equipment—An Employer's Guide"
www.humanservices.alberta.ca/ppe001

Protective Clothing

National Institute for Occupational Safety and Health (NIOSH)
"Pocket Guide to Chemical Hazards"
www.cdc.gov/niosh/npg/npg.html

National Institute for Occupational Safety and Health (NIOSH)
"Recommendations for Chemical Protective Clothing"
www.cdc.gov/niosh/ncpc/ncpc2.html

National Institute for Occupational Safety and Health (NIOSH)
"A Guide for Evaluating the Performance of Chemical Protective Clothing"
www.cdc.gov/niosh/docs/90-109/

Canadian Centre for Occupational Health and Safety (CCOHS)
"OSH Answers, Chemical Protective Clothing, Glove Selection"
www.ccohs.ca/oshanswers/prevention/ppe/gloves.html

Canadian Centre for Occupational Health and Safety (CCOHS)
"OSH Answers Safety Footwear"
www.ccohs.ca/oshanswers/prevention/ppe/footwear.html

Canadian Centre for Occupational Health and Safety (CCOHS)
"OSH Answers Headwear, Care"
www.ccohs.ca/oshanswers/prevention/ppe/headwear.html

Protective Eyewear

Canadian Centre for Occupational Health and Safety (CCOHS)
"OSH Answers: Safety Glasses and Face Protectors"
www.ccohs.ca/oshanswers/prevention/ppe/glasses.html

WHMIS

Alberta Occupational Health and Safety

- "WHMIS – Information for Employers"
  www.humanservices.alberta.ca/ch008
- "WHMIS – Information for Workers"
  www.humanservices.alberta.ca/ch007
- "WHMIS Hazard Symbols" (poster)
  www.humanservices.alberta.ca/ch006

Flammable

Alberta Municipal Affairs
"Propane Safety"
www.municipalaffairs.alberta.ca/documents/ss/propane.pdf

Canadian Association of Petroleum Producers
"Flammable Environments Guideline"
www.capp.ca/raw.asp?x=1&dt=NTV&e=PDF&dn=81688

Industrial Accident Prevention Association

- "Fire Protection: A Health and Safety Guideline for Your Workplace"
  www.iapa.ca/pdf/firepro.pdf
- "Guide on Static Electricity"
  www.iapa.ca/pdf/2004_feb_Static%20Electricity.pdf