Workplace Health and Safety
Bulletin
WORK SAFE ALBERTA

Solvents at the Work Site

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What are solvents?

A solvent is a liquid chemical that dissolves a solid, liquid or gas, creating a solution. The most common solvent is water. At work sites, the most frequently used solvents are organic (carbon containing) chemicals. They are usually clear, colourless liquids and many have a strong odour. Some examples of solvents include xylene, toluene, kerosene, ethanol, methanol, acetone, turpentine and mineral spirits.

The purpose of this publication is to provide information to employers and workers to help them work safely with solvents at the work site.

Properties of solvents

Because there are so many different types of solvents, their properties are variable. The Material Safety Data Sheet (MSDS) for the solvent should list the chemical's properties. Another useful source of information for chemical properties is the "Pocket Guide to Chemical Hazards" published by the National Institute of Occupational Safety and Health (NIOSH). It is available online at www.cdc.gov/niosh/npg/.

The properties for mixtures of solvents may be different than those for the pure chemicals. Check with the product MSDS or manufacturer for information on the properties of the mixture.

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Some important properties of solvents are:

- autoignition temperature,
- explosive limits,
- flashpoint,
- odour threshold,
- toxicity,
- vapour density, and
- vapour pressure.

Autoignition Temperature

This is the lowest temperature at which a flammable material will ignite on its own without a flame or spark (ignition source) and burn. Heating a flammable material to its autoignition temperature in a normal atmosphere will cause it to ignite and burn (for example, splashing a flammable liquid onto a hot surface such as an exhaust pipe or welding on a part that was just cleaned can result in a fire).

Explosive Limits

The Lower Explosive Limit (LEL) is the minimum concentration of a flammable vapour in air that will burn. Below the LEL, the mixture is too "lean" to burn (too little fuel). The Upper Explosive Limit (UEL) is the maximum concentration of a flammable vapour in air that will burn. Above the UEL, the mixture is too "rich" to burn (not enough oxygen).

Flashpoint

Flashpoint is the lowest temperature at which a flammable or combustible liquid gives off enough vapour to form an ignitable mixture with air, since it is the vapour, not the liquid, which burns. The lower the flashpoint, the more easily the material will burn. Flammable liquids have a flashpoint below 37.8 ^{o}C (100 ^{o}F). Combustible liquids have a flashpoint between 37.8 ^{o}C (100 ^{o}F) and 93.3 ^{o}C (200 ^{o}F).

Odour Threshold

The odour threshold is the lowest concentration of a substance in air that can be detected by smell. People's sensitivity to odours can be very different, so unless the odour threshold is much lower than safe exposure levels, odour should not be relied upon as a warning property.

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Toxicity

Toxicity is a measure of how poisonous a chemical is. Any chemical can cause poisoning if a big enough dose of it is taken into the body. It is the amount, or dose, taken into the body that determines whether or not a chemical will cause poisonous effects.

Scientists often use animal tests to find out whether small or large doses of a particular chemical are toxic. One test, "Lethal Dose 50" (LD_{50}), measures the dose of a chemical that causes death to 50% of the test animals. The LD_{50} is based on how the chemical is given to the test animal. Dermal (applied to the skin) and oral (given by mouth) administration methods are the most common. Another common toxicity parameter used for solvents is LC_{50}. "LC" stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air. For inhalation experiments, 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. Once you have a toxicity value, it can be compared to other values using a toxicity scale. There are several different toxicity scales used, an example of one (Hodge and Sterner Scale) is shown below.

Table 2: Hodge and Sterner Toxicity Scale

Toxicity Rating	Description	Oral LD_{50} (mg/kg)	Inhalation LC_{50} (ppm)	Dermal LD50 (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	1 teaspoon (4 mL)
3	moderately toxic	50-500	100-1000	44-340	1 fluid ounce (30 mL)
4	slightly toxic	500-5000	1000-10,000	350-2810	1 pint (600 mL)
5	practically non-toxic	5000-15,000	10,000-100,000	2820-22,590	1 L or 1 quart
6	relatively harmless	greater than 15,000	greater than 100,000	greater than 22,600	1 L or 1 quart

Source: CCOHS OSH Answers, http://www.ccohs.ca/oshanswers/chemicals/ld50.html

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Vapour Density

Vapour density is the weight of a vapour or gas compared to the weight of an equal volume of air. Vapour that is heavier than air (vapour density greater than 1) will tend to collect near the ground and in confined spaces. In still air, a vapour that is lighter than air (vapour density less than 1) will tend to rise.

Vapour Pressure

Vapour pressure is a measure of a liquid's ability to evaporate. The higher the vapour pressure, the higher the evaporation rate. This results in more vapours being produced. Flammable liquids tend to have high vapour pressures.

Uses of solvents

Solvents are used almost everywhere in the workplace. They are used in products such as varnishes, plastics, thinners, degreasers and cleaners. Solvents can also be an ingredient in a product, for example solvents are used in pesticides, paints and adhesives.

Some commonly used solvents include:

- Acetone
- Benzene
- Dichloromethane (or methylene chloride)
- Ethanol
- Ethyl ether
- Ethylene glycol
- Formaldehyde
- Hexane
- Methanol
- Methyl ethyl ketone
- Mineral Spirits
- Perchloroethylene (or tetrachloroethylene)
- Toluene
- 1,1,1-trichloroethane
- Trichloroethylene
- Xylene

Health effects

Workers can be exposed to solvents by inhalation, skin absorption or ingestion.

Most often, workers are exposed to solvents when solvent vapours get into the air and they are inhaled. Many solvents, in liquid or vapour forms, are easily absorbed by the skin. If the skin is damaged, the exposure can be greater. Solvents can also get into the body when they are accidentally swallowed.

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Solvents can have many different effects on health. Acute health effects occur where there is exposure to a high concentration over a short period of time. Chronic health effects can occur when there are repeated or continuous exposures over a long period of time. Table 1 provides a summary of some of the health effects from solvents often used in the workplace.

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Table 1: Summary of Information on Common Solvents

Chemical Name	Common Synonyms	OEL (ppm)	Flammable	Summary of Health Effects from Exposure
Acetone	Dimethyl Ketone, 2-Propanone	500	Yes	Irritation of eyes, nose and throat; headache; dizziness; central nervous system depression; dermatitis
Benzene	Benzol, Phenyl Hydride	0.5	Yes	Irritation of eyes, skin, nose and respiratory system; dizziness; headache; nausea; loss of appetite; weakness and exhaustion; dermatitis; bone marrow depression; carcinogen
Carbon Tetrachloride	Carbon Chloride, Carbon Tet, Tetrachloromethane	5	No	Irritation of eyes and skin; central nervous system depression; nausea; vomiting; liver and kidney damage; drowsiness; dizziness, incoordination; suspected human carcinogen
Chlorobenzene	Benzene Chloride, Chlorobenzol, MCB, Monochlorobenzene	10	Yes	Irritation of the eyes, skin and nose; drowsiness; incoordination; central nervous system depression; liver damage
Chloroform	Trichloromethane, Methane Trichloride	10	No	Irritation of the eyes and skin; dizziness; mental dullness; nausea; confusion; headache; weakness and exhaustion; anesthesia; liver damage; embryo/fetal damage
Dichloromethane	Methylene Chloride	50	No	Irritation of the eyes and skin; weakness and exhaustion; drowsiness; dizziness; numbness; tingling limbs; nausea
Ethanol	Ethyl Alcohol, Alcohol, Grain Alcohol	1000	Yes	Irritation of the eyes, skin and nose; headache; drowsiness, dizziness; weakness and exhaustion; cough; liver damage; anemia; reproductive and teratogenic effects
Ethyl Benzene	Ethylbenzol	100	Yes	Irritation of the eyes, skin and mucous membrane; headache; dermatitis; drowsiness; dizziness; coma
Ethylene Glycol	Glycol Alcohol, Monoethylene Glycol, 1,2-Ethandiol	C100	No	Irritation of the eyes, skin, nose and throat; nausea; vomiting; abdominal pain; weakness and exhaustion; dizziness, apathy; convulsions; central nervous system depression; skin sensitization
Ethyl Ether	Diethyl Ether, Solvent Ether, Ether, Ethyl Oxide	400	Yes	Irritation of the eyes, skin and upper respiratory system; dizziness; drowsiness; headache; narcosis; nausea; vomiting

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Chemical Name	Common Synonyms	OEL (ppm)	Flammable	Summary of Health Effects from Exposure
Formaldehyde	Methanal, Methyl Aldehyde, Methylene Oxide	0.75	Yes	Irritation of the eyes, nose, throat and respiratory system; tearing of eyes; cough; wheezing; suspected human carcinogen
n-Hexane	Hexane, normal-Hexane	50	Yes	Irritation of the eyes and nose; nausea; headache; damage to the nerves in the extremities; muscle weakness; dermatitis; dizziness; chemical pneumonitis with aspiration of liquid
Isopropanol	Isopropyl Alcohol, IPA, 2-Propanol, sec-Propyl Alcohol, Rubbing Alcohol	200	Yes	Irritation of the eyes, nose and throat; drowsiness; dizziness; headache; dry cracked skin
Methanol	Methyl Alcohol, Carbinol, Wood Alcohol, Wood Spirits, Wood Naphtha	200	Yes	Irritation of the eyes, skin and upper respiratory system; headache; drowsiness; dizziness; nausea; vomiting; visual disturbance; optic nerve damage (blindness); dermatitis
Methyl Ethyl Ketone	MEK, 2-Butanone, Methyl Acetone, Ethyl Methyl Ketone	200	Yes	Irritation of the eyes, skin and nose; headache; dizziness; vomiting; dermatitis
Mineral Spirits	Stoddard Solvent, Petroleum Solvent,	100	Yes	Irritation of the eyes, nose and throat; dizziness; dermatitis; chemical pneumonitis with aspiration of liquid; kidney damage
Petroleum Distillates (Naphtha)	Petroleum Naphtha, Rubber Solvent, Naphtha	400	Yes	Irritation of the eyes, nose and throat; dizziness; drowsiness; headache; nausea; dry cracked skin; chemical pneumonitis with aspiration of liquid
Tetrachloroethylene	Perchloroethylene, Perk, Perc	25	No	Irritation of the eyes, skin, nose, throat and respiratory system; nausea; flushed face and neck; dizziness; incoordination; headache; drowsiness; skin redness; liver damage
Toluene	Methyl Benzene, Methyl Benzyl, Toluol, Phenyl Methane	50	Yes	Irritation of the eyes and nose; weakness and exhaustion; confusion; euphoria; dizziness; headache; dilated pupils, tearing of the eyes; anxiety; muscle fatigue; insomnia; itching or tingling sensation in the skin; dermatitis; liver, kidney damage, reproductive effects; ototoxic

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Chemical Name	Common Synonyms	OEL (ppm)	Flammable	Summary of Health Effects from Exposure
1,1,1-Trichloroethane	Chloroethene, Methyl Chloroform	350	No	Irritation of the eyes and skin; headache; weakness and exhaustion; central nervous system depression; loss of balance; dermatitis; irregular hear beat; liver damage
Trichloroethylene	TCE, Ethylene Trichloride, Trilene, Trichloroethene	50	No	Irritation of the eyes and skin; headache; visual disturbance, weakness and exhaustion; dizziness; tremors; drowsiness; nausea; vomiting; dermatitis; irregular heart beat; itching or tingling sensation in the skin; liver injury; suspected human carcinogen
Turpentine	Gum Spirits, Spirits of Turpentine, Turps, Wood Turpentine	20	Yes	Irritation of the eyes, skin, nose and throat; headache; dizziness; convulsions; skin sensitization; blood in the urine; protein in urine; kidney damage; abdominal pain; nausea; vomiting; diarrhea; chemical pneumonitis with aspiration of liquid
VM & P Naphtha	Ligroin, Painters' Naphtha, Petroleum Ether, Petroleum Spirit	300	Yes	Irritation of the eyes and upper respiratory system; dermatitis; central nervous system depression; chemical pneumonitis with aspiration of liquid
Xylene	Xylenes, m,p,o-Xylenes	100	Yes	Irritation of the eyes, skin, nose and throat; dizziness; excitement; drowsiness; incoordination; staggering gait; corneal vacuolization (formation of small spaces in the cornea); loss of appetite; nausea; vomiting; abdominal pain; dermatitis

Notes:
OEL: Alberta 8-hour Occupational Exposure Limit
C denotes a ceiling limit
For more detailed information, refer to the NIOSH Pocket Guide for Chemical Hazards, http://www.cdc.gov/niosh/npg/

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Respiratory Tract

Solvent vapours can be irritating to both the upper and lower respiratory tract. Some solvents, such as propylene oxide, can cause respiratory sensitization. Workers who become sensitized may have asthma-like symptoms when exposed to very low concentrations of the solvent.

Skin

When solvents come into direct contact with the skin, they can cause drying, cracking, reddening and blistering (dermatitis). If the skin is damaged, solvents are more easily absorbed, increasing exposure. Some solvents such as methyl methacrylate and glutaraldehyde can cause skin sensitization. Workers who become sensitized may have dermatitis-type symptoms even when exposed to very low concentrations of the solvent.

Eyes

Direct contact with solvent vapours or liquids can cause eye irritation.

Liver and Kidneys

Many solvents are toxic to the liver or kidneys, either by themselves, or in combination with other chemicals. For example, liver damage is associated with exposure to carbon tetrachloride and other chlorinated hydrocarbons and ethanol. The kidney is another target organ that can be damaged by exposure to a number of solvents, for example trichloroethane, petroleum distillates, gasoline and turpentine. Consumption of alcoholic drinks following exposure to many solvents can increase their effects in the body.

Cardiovascular System

Exposure to some chlorinated solvents such as methylene chloride, trichloroethane and trichloroethylene can damage the heart. Chronic exposure to some solvents such as carbon disulfide can worsen coronary heart disease. Workers with a pre-existing heart condition can be more sensitive to the effects from solvent exposure.

Nervous System

Exposure to solvents can have a number of serious effects on the central nervous system (brain and spinal cord) and peripheral nervous system (nerves supplying the rest of the body). Acute effects range from drowsiness, headache, dizziness and nausea to alcohol-like intoxication and narcosis. This can lead to unconsciousness and

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eventually death from respiratory failure if the worker is not removed from exposure. These effects usually wear off once exposure stops. Chronic central nervous system effects from long term repeated exposures to organic solvents include fatigue, mood disturbance, difficulty in concentrating, memory loss and personality changes. This damage can eventually become permanent. Some solvents, such as n-hexane and methyl n-butyl ketone cause damage to the nerve cells in the peripheral nervous system. Common symptoms include restless legs, muscle cramps, pains and weakness in the limbs and loss of feeling in the limbs.

Cancer

Some solvents such as benzene and vinyl chloride can cause (or are suspected to cause) cancer in humans or animals. Agencies such as the International Agency for Research on Cancer (IARC) and the American Conference of Governmental Industrial Hygienists (ACGIH) classify a variety of chemicals as to their carcinogenicity.

For more information

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans
http://monographs.iarc.fr/ENG/Classification/index.php

ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, available for purchase from ACGIH at: http://www.acgih.org/store/.

Reproductive Effects

Some solvents are teratogens (materials that cause birth defects in a fetus at exposures that would cause no damage or injury to the mother, for example methyl mercury) or are embryotoxic (toxic to the fetus at concentrations that are not toxic to the mother, for example xylene). Injuries to the fetus can be particularly severe between the two and eight week stage of development.

Hearing Loss

Some chemicals are ototoxic, which means that they can cause or increase the likelihood of hearing loss when a person is exposed to them. Exposure to these chemicals and noise together can increase the potential effect. Some examples of ototoxic solvents are toluene and xylene.

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Other Hazards

Fire

Many solvents are flammable or combustible. A fire can result when solvent vapours are mixed with the right amount of air and an ignition source is present. For more information on these hazards, refer to the bulletin Handling and Storage of Flammable Materials at the Work Site, available online at:

http://employment.alberta.ca/documents/WHS/WHS-PUB_fex002.pdf

Decomposition

Solvents can produce toxic gases and vapours when they burn or chemically react with other substances. Combustion and decomposition products can include chemicals such as carbon monoxide, hydrogen cyanide and nitrogen oxides. If the solvent contains chlorine, other irritating and toxic chemicals, such as acrolein and hydrogen chloride, can be produced.

Incompatibility

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

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

Solvents tend to be chemically incompatible with strong acids, bases and oxidizers (oxygen or other substances capable of releasing oxygen.)

Preventative measures

Preventing exposure to solvents is the best way to protect health. Options that should be considered include the following (listed in order of preference):

- Substitute with a less hazardous material
- Use of engineering controls
- Changes in work practices to reduce exposure (administrative controls)

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- Use of personal protective equipment

Substitution

Substituting a less hazardous solvent can reduce the hazard in the workplace. For example, where solvents are used for cleaning or degreasing, consider instead:

- Abrasive methods (compressed air, water pressure, steam) or abrasive materials (sand, steel grit, sodium bicarbonate, etc.)
- Water-based cleaners
- Detergents
- Biodegradable "solvents" (limonene, terpenes, etc.), products are usually derived from a natural source

It is important to consider that the substitutes may have their own hazards. Some considerations to look at when selecting a substitute are:

- Effectiveness: will the substitute meet the technical requirements
- Compatibility: the substitute must be compatible with the process, equipment and other materials used in the workplace
- Control measures: will existing control measures be adequate? For example, some alcohols are less toxic than chlorinated solvents, but tend to be flammable.
- Waste disposal: will the system used be adequate and appropriate for the new chemical

A hazard assessment must be done when considering a substitute chemical. Compare properties such as the vapour pressure, short and long term health effects and physical hazards (e.g. flammability) to make sure that the substitute will be a better choice.

A tool that may be useful to identify alternatives is the Solvent Alternates Guide (SAGE). It is available on line at
http://www.p2pays.org/ref/19/18161/index.cfm.htm

Engineering controls

Engineering controls are processes used to eliminate exposure to a substance. Engineering controls remove the substance from the air or provide a barrier between the worker and the substance. Examples of engineering controls that can be used to prevent exposure to solvents include:

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- Installation of local ventilation hoods
- Enclosures around work processes (fume hoods, glove boxes)
- Use of automatic or closed systems to pump solvents from storage containers to process containers

Where ventilation systems are used at the work site, they must be properly designed and not vent back into the work area.

If engineering controls are working properly, they will eliminate or greatly reduce the potential hazard. They only need to be installed once and do not place a physical burden on workers. However, an initial investment is required and the systems must be properly operated and maintained once installed.

Administrative controls

Work practices that can be used in the workplace to reduce exposure to solvents include:

- Using and maintaining engineering controls and other equipment used to reduce exposure properly.
- Storing solvents properly.
- Educating workers about the hazards of the solvents they work with. Workers should be encouraged to participate in training and monitoring programs in the workplace.
- Using good hygiene practices.
- Ensuring that unprotected workers are not in areas where solvents are used.
- Cleaning up spills are quickly and properly and using appropriate spill kits and personal protective equipment.
- Keeping product containers tightly sealed when they are not in use.

Particular attention must be paid to fire safety and potential sources of ignition in areas where solvents are used and stored. They 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. Storage containers must be compatible with the chemical. Solvents should never be stored with oxidizers or other incompatible chemicals. The product's MSDS and the manufacturer should be consulted for more information on proper storage and handling.

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For more information o

http://employment.alberta.ca/documents/WHS/WHS-PUB_fex002.pdf
Handling and Storage of Flammable Materials at the Work Site

Enform Industry Recommended Practice Volume 8: Pumping of Flammable Fluids, available online at:
www.enform.ca/pdf/irp8_final_mar2009.pdf

Personal Protective Equipment

If it is not practicable or feasible to use substitutes, engineering controls or administrative controls to reduce the potential for exposure, or if they are not sufficient, the employer must provide workers with appropriate protective equipment.

Respiratory protective equipment is used to protect workers from inhaling airborne vapours. There are many types of respirators available. It is important to select the correct level of respiratory protection based on the type of work being done and the airborne concentrations of solvents at the work site.

For more information:

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

http://employment.alberta.ca/documents/WHS/WHS-PUB_ppe001.pdf
Respiratory Protective Equipment: An Employer's Guide – PPE001

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

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

Workers who handle solvents, items contaminated by solvents or may be exposed to airborne solvent vapours must wear appropriate solvent-resistant gloves and other protective clothing. Workers should wear protective clothing that covers and protects the arms and legs. Workers

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should also wear airtight goggles or full-face respirators to protect the eyes from irritation or splashes. Some types of chemicals and protective clothing materials are not compatible, or the clothing will not offer sufficient protection. For example, methylene chloride will cause latex gloves and many other kinds of materials to break down. Information about protective clothing materials recommended for various solvents is available from the NIOSH database "Recommendations for Chemical Protective Clothing". The database is available online at: www.cdc.gov/niosh/ncpc/ncpc2.html.

Although the use of personal protective equipment may initially seem less costly, workers need to be trained in the use and maintenance of the protective equipment they use. Employers need to monitor the use and ensure that the protective equipment is properly maintained. In some cases, personal protective equipment can create a hazard to the worker (heat stress, limited vision, allergic reactions to the equipment material). These issues need to be evaluated when personal protective equipment is selected and used.

Regulatory Requirements

The health and safety legislation has general and specific requirements related to solvents. Most solvents have Occupational Exposure Limits (OELs). These limits apply to workers directly involved with tasks using solvents and also to other workers in the workplace who may be exposed to solvents indirectly from these operations. It is important to note that OELs represent standards for the protection of most healthy workers. Steps must be taken to keep exposure levels as low as reasonably practicable.

The employer must also:

- Conduct a hazard assessment related to solvent use and storage at the work site
- Train workers on the health hazards from exposure to solvents and the safe work procedures developed by the employer.
- Conduct an exposure assessment where workers may be exposed to solvents.
- Have appropriate emergency procedures in place in case of spills or fires.
- Comply with requirements for handling and storage of flammable materials.

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- Ensure that the need for ventilation is properly assessed and that systems installed are properly designed and maintained. Workers also need to be trained on the proper use and maintenance of the ventilation systems.
- Provide appropriate personal protective equipment (including respirators) where concentrations of solvents cannot be controlled below safe limits. Workers must use the required protective equipment and must be trained on its proper use and care.
- Ensure that up-to-date MSDSs are available for solvents used at the work site.

Additional regulatory requirements for the handling and storage of flammable materials in the workplace are in Part 4 of the Alberta Fire Code. More information on these requirements can be found on the Alberta Municipal Affairs website at:

 www.municipalaffairs.alberta.ca/cp_fire_codes_&_standards.cfm

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- **1-800-232-7215** throughout Alberta

Web Site

www.worksafely.org

Getting copies of OHS Act, Regulation & Code:

Queen's Printer

www.qp.gov.ab.ca

Edmonton 780-427-4952

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http://employment.alberta.ca/whs-ohs

Call any Government of Alberta office toll-free
Dial 310-0000, then the area code and telephone number you want to reach

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