Workplace Health and Safety
Bulletin
WORK SAFE ALBERTA

Isocyanates at the Work Site

What are Isocyanates?

Isocyanates are chemical compounds identified by the number of -NCO (nitrogen-carbon-oxygen) groups they contain. Mono-isocyanates 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).

In this Safety Bulletin, the term "isocyanates" refers to the di-isocyanates TDI, MDI and HDI.

Properties of isocyanates

Isocyanates are a group of very reactive chemical substances. They react with water and 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.

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If isocyanates are sprayed or heated, droplets of the chemical can be suspended in the air as a mist. Heating isocyanates will increase their volatility.

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.

Industry use of isocyanates

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 used in the manufacture of carbamate pesticides and 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 (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.
- Isocyanates may also be released when polyurethane products, such as paints, foams or adhesives, are heated.

Health effects from exposure to isocyanates

Isocyanates are very irritating to the skin, eyes, nose, throat and lungs.

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Acute exposure

Acute exposure to an isocyanate usually occurs with a single exposure to a high concentration dose of the chemical. The exposure is usually of short duration. The exposure could result, for example, from an unexpected or accidental spill of the liquid chemical, or from the release of high concentrations of the chemical in vapour form.

Exposure to high concentrations of isocyanate vapour or mist causes irritation to the eyes, nose and throat. Symptoms include

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

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

Chronic exposure

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.

Sensitization

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 4 to 8 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 sensitization of the respiratory system. 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.

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Once someone has become sensitized, the person may develop asthmatic reactions to extremely low concentrations of isocyanates, even concentrations 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 percent of workers exposed to isocyanates for one year will develop asthma.

Isocyanates and the risk for cancer

Studies that have looked at workers exposed to isocyanates found no increase in the workers' risk for cancer.

International Agency for Research on Cancer (IARC) classifications of isocyanates

- TDI is classified as 2B, which means that it is possibly carcinogenic to humans. This classification followed studies that indicated exposure to commercial grade TDI (80:20 mixture of 2, 4-TDI and 2, 6-TDI) can cause cancer in rats and mice.
- MDI is classified as 3, which means it is not classifiable in terms of its carcinogenicity to humans.

Health assessment

The baseline health assessment

While there is no regulatory requirement for employers to conduct health assessments of workers exposed to isocyanates, it is good practice to conduct health assessments of workers before they begin work in environments where they could be exposed to isocyanates.

Conducting an initial physical examination and health history for workers provides important baseline information about their health. It may also help identify workers who are at greater risk for having adverse health effects if exposed to isocyanates. A health history should include information on previous isocyanate exposure, allergies, lung and skin disorders, other chemical exposure and smoking history.

The health assessment should include a pulmonary-function test and an assessment of the worker's fitness to wear respiratory equipment.

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For more information about conducting such a health assessment, see

www.hre.gov.ab.ca/documents/WHS/WHS-PUB_mg005.pdf
Medical Assessment of Fitness to Wear a Respirator (MG005)

Who is at greatest risk for developing a sensitization to isocyanates?
It is not yet possible to positively identify workers who will become sensitized to isocyanates. However, individuals with chronic bronchitis, bronchial asthma and allergies may be at increased risk. Individuals who have these conditions may require careful counselling about the effects of isocyanates on health and the use of protective

equipment. They may need closer monitoring than other workers who are exposed to isocyanates.

If there is doubt about whether or not a worker should risk exposure to isocyanates, the worker should consult a medical doctor or medical specialist.

Follow-up health assessments

Besides completing a baseline health assessment, employers should follow-up with periodic health assessments of workers exposed to isocyanates. These assessments should update the worker's health history, including the isocyanate-exposure history, and check the worker for symptoms of irritation or respiratory effects.

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A pulmonary function test should be done regularly on workers exposed to isocyanates. A baseline pulmonary function test should be done at least 48 hours following the last exposure to isocyanates and before the worker is re-exposed. The test should measure forced vital capacity (FVC) and forced expiratory volume in the first second (FEV). Repeat the FEV_1 and FVC measurements during, or at the end of, the same day's work shift, between 4 and 10 hours after the worker resumes exposure to isocyanates.

There are currently no blood or urine tests that can effectively monitor the body's absorption of isocyanates.

Preventative measures

Preventing exposure to isocyanates is the best way to protect health. Consider the following options for reducing workers' exposure (as listed in health and safety legislation).

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(1) Substitute less hazardous substances
(2) Use engineering controls
(3) Change work practices to reduce exposure
(4) Use personal protective equipment

(1) Substitution

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.

(2) Engineering controls

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

- installation of local ventilation hoods
- use of spray booths to apply coatings
- erecting enclosures around work processes.

If engineering controls are working properly, they will eliminate or greatly reduce the potential hazard from exposure to isocyanates. They need be installed only 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.

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Where local ventilation systems or spray booths are used, they must be properly designed. Employers must ensure that

- exhausts are vented to the outside, away from air intakes for the work area
- the ventilation system does not vent back into the work area
- spray booths have a minimum air flow of 100 feet per minute (about 30 metres/second) past the painter
- the system or booth provides sufficient make-up air
- all of the equipment is approved for use in flammable or explosive atmospheres.

(3) Work practices

Various work practices can be implemented in the workplace to reduce potential exposure to isocyanates.

- Educating workers about the hazards associated with isocyanates. Workers should be encouraged to participate in training and monitoring programs in the workplace.

- Using good hygiene practices. Workers should not eat, drink or use tobacco products in areas contaminated by isocyanates. They should 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.

Implementing work practices to reduce exposure is often less expensive than implementing other control measures, but workers must be properly trained and use the safe-work practices. The employer must monitor the safe-practice training and use in the workplace.

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(4) Personal protective equipment (PPE)

If it is not practicable or feasible to substitute less hazardous substances, introduce engineering controls or change work practices to reduce the potential for exposure to isocyanates, the employer must provide workers with appropriate respiratory protective equipment.

Respiratory protective equipment

There are many types of respiratory protective equipment available. It is important for workers to use respirators that will provide the correct level of respiratory protection required. The type of work and the airborne concentrations of isocyanates determine the necessary protection level. (For technical detail, refer to one of the resources below.)

Air-supplying respirators usually provide the most effective type of respiratory protection against isocyanate vapours or mists, as long as the respirators are operating properly.

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Air-purifying respirators with cartridges approved for organic vapours and mists may not provide sufficient protection against isocyanate exposure, particularly during spray painting. It is important to note that wearers are unlikely to know when a cartridge

needs changing and may therefore unknowingly become overexposed. People should not rely on their sense of smell to detect a hazardous concentration of isocyanates in the atmosphere — that is, a concentration over the occupational exposure limit. Therefore, if air-purifying respirators are used to protect against isocyanate exposure, the employer must either

- ensure that the respirator is equipped with an end-of-use indicator (the indicator will show when the cartridge must be changed), or
- use a change-out schedule calculated by someone qualified to calculate the schedule. The person will either use the manufacturer's product information or estimate the change schedule based on knowledge of the effectiveness of the cartridge or canister to remove the contaminant. A change-out schedule must be calculated using the U.S. Occupational Safety and Health Administration (OSHA), or equivalent, method. (The OSHA method may be accessed on line.) The employer must also have written procedures that explain how the calculations are done and confirm the method used for calculations. The employer must ensure that workers understand and use the system for changing cartridges.

For more information about respiratory protective equipment

www.osha.gov/SLTC/etools/respiratory/change_schedule.html

www.hre.gov.ab.ca/documents/WHS/WHS-PUB_ppe004.pdf
Guideline for the Development of a Code of Practice for Respiratory Protective Equipment (PPE004)

www.hre.gov.ab.ca/documents/WHS/WHS-PUB_ppe001.pdf
Respiratory Protective Equipment: An Employer's Guide (PPE001)

CSA Standard Z94.4-02, Selection, Use and Care of Respirators

Protective clothing

Since isocyanates can affect the skin, workers handling materials containing isocyanates should wear

- appropriate solvent-resistant gloves
- coveralls that protect the arms and legs
- Airtight goggles or full-face respirator masks to protect the eyes from irritation or splashes.

Although the use of personal protective equipment may initially seem to be less costly than developing engineering controls, this may not be the case. The costs involved when workers rely on PPE include

- *training*: Workers need to be trained to use the protective equipment
- *monitoring and maintenance*: Employers must monitor use of the PPE and ensure that the protective equipment is properly maintained
- *productivity*: In some cases, personal protective equipment can create a hazard to workers. It could cause heat stress, limited vision or allergic reactions to the equipment material.

Employers should carefully evaluate these considerations before selecting personal protective equipment.

Regulatory requirements

The legislation under the *Alberta Occupational Health and Safety Act* includes general and specific requirements related to isocyanates. It provides Occupational Exposure Limits (OELs) for isocyanates. These limits apply to workers directly involved with tasks using isocyanates, and also to workers in the workplace who may be exposed to the substance indirectly from these operations.

It is important to note that OELs represent standards for the protection of healthy workers who have not been sensitized to isocyanates. Steps must be taken to keep isocyanate levels as low as reasonably practicable, since some workers may become sensitized at levels below the current OELs.

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In addition, the legislation requires employers to

- develop safe-work procedures
- develop procedures for conducting air monitoring to assess worker exposure
- train workers about the health hazards associated with exposure to isocyanates and the organization's safe-work procedures
- properly assess the need for ventilation
- properly design and install ventilation systems, when necessary
- properly maintain installed ventilation systems
- train workers about the operation of installed ventilation systems
- provide appropriate protective equipment, including respirators, where concentrations of isocyanates cannot be controlled below safe limits.

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