
Workplace Health & Safety

Chemical Hazards
April 2003

Isocyanates at the Work Site

Isocyanates are a group of chemicals that are identified by the number of $-NCO$ (nitrogen-carbon-oxygen) groups they contain. Mono-isocyanates contain one group, di-isocyanates contain two, and so on. There are many different types of isocyanates used in industry. Methyl isocyanate, one of the most toxic of the isocyanate compounds, was the chemical involved in the release in Bhopal, India in 1985. This chemical is used in the manufacture of carbamate pesticides and is not a significant issue for Alberta work sites.

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). These chemicals 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

In this Safety Bulletin, where the term “isocyanates” appears, it refers to all of the types of di-isocyanates noted above (TDI, MDI and HDI).

Isocyanates are included in some coatings because they increase durability. Primers, urethane paints and lacquers containing isocyanates are often used for spray painting of vehicles or other surfaces. Exposure to isocyanates can also occur during the manufacture of various foam products. Isocyanate foams are usually two-component products that need to be mixed before they are applied. One of the components contains isocyanates. Isocyanates may also be released when polyurethane products like paints, foams or adhesives are heated, such as during welding, cutting or grinding.

Isocyanates are a group of very chemically reactive substances. They react with water and other industrial compounds and even with themselves unless carefully controlled. Once isocyanates have reacted, they are usually less harmful.

Most isocyanates are liquid at room temperature. They 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. If isocyanates are sprayed or heated, droplets of the chemical can be suspended in the air as a mist. Heating of 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.

Health effects

Because isocyanates are very reactive, they are very irritating to the skin, eyes, nose, throat and lungs.

Acute exposure

Acute exposures are usually single dose, high concentration exposures over a short period of time. These occur from an unexpected or accidental spill of the liquid chemical or release of high concentrations of vapour.

Exposure to high concentrations of isocyanate vapour or mist causes irritation to the eyes, nose and throat. Symptoms of exposure include itchy, watery eyes, a sensation of burning in the eyes, a runny nose, sneezing, hoarseness, coughing, chest tightness, fever and fatigue. These symptoms can be delayed 6 to 10 hours following exposure and usually clear within 12 to 24 hours. Often, workers do not connect these symptoms with workplace exposure because of the delay.

Splashes of isocyanates directly on the skin or eyes cause a severe inflammatory reaction, producing pain, redness and swelling.

Chronic exposure

Repeated exposure 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 cause sensitization of the skin or respiratory system. This can be caused by one acute exposure or repeated exposure at low concentrations. Skin sensitization is not as common as respiratory sensitization and 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. Once someone has become sensitized, they may develop asthmatic reactions to extremely low concentrations of isocyanates, below the Occupational Exposure Limits. Sometimes the asthma-like

reaction occurs immediately after exposure. More commonly, sensitized individuals experience symptoms several hours after isocyanates exposure. The amount of exposure needed to become sensitized varies from a few weeks to a few years. It has been estimated that among workers exposed to isocyanates for one year, roughly 1 percent will develop asthma due to isocyanates.

Cancer

In studies that looked at workers exposed to isocyanates, no increase in cancer risk was found. The International Agency for Research on Cancer (IARC) has classified TDI as 2B, possibly carcinogenic to humans. MDI has the designation 3, not classifiable as to its carcinogenicity to humans.


Some studies have indicated that exposure to commercial grade TDI (80:20 mixture of 2, 4-TDI and 2, 6-TDI) can cause cancer in rats and mice.

Health assessment

While there is no regulatory requirement of a health assessment, it is recommended that a worker exposed to isocyanates have a health assessment.

An initial physical examination and health history for workers who are starting to work with isocyanates will provide important information. This may help identify workers who are at greater risk and will provide baseline information on the worker's health. The 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.

For more information

 <http://www3.gov.ab.ca/hre/whs/publications/pdf/mg005.pdf>
Medical Assessment of Fitness to Wear a Respirator (MG005)



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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 counseling about the effects of isocyanates on health, the use of protective equipment and may need closer monitoring than other workers who use isocyanates. Where there is doubt about whether a worker should risk exposure to isocyanates, they should consult with their medical doctor or specialist.

At each periodic assessment, the health history including isocyanate exposure history should be updated, the worker checked for irritation effects, and symptoms of respiratory effects. A pulmonary function test should be conducted regularly.

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. This will include measurement of forced vital capacity (FVC) and forced expiratory volume in the first second (FEV₁). A repeat of the FEV₁ and FVC measurements during or at the end of the same day's work shift, between four and ten hours after resuming exposure to isocyanates.

There are currently no chemical tests for blood or urine to effectively monitor for isocyanate absorption in the body.

Preventative measures

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

- use of less hazardous substitutes
- use of engineering controls
- changes in work practices to reduce exposure
- use of personal protective equipment

Substitution

One of the easier options to control exposure is to substitute isocyanates containing products with less hazardous substances. This has been done successfully with some paint and coating products (for example the use of latex products instead of polyurethane products). The considerations that will be important will include the properties needed in the product, whether the substitute products are equivalent, cost and ease of use.

Engineering controls

Engineering controls are mechanical 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 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
- enclosures around the work process

Where local ventilation systems or spray booths are used, they must be designed properly and not vent back into the work area. Exhausts from these systems should be ventilated to the outside, away from air intakes for the work area. Spray booths will require a minimum air flow of 100 feet per minute (about 30 m/s) past the painter. When designing spray booths, ensure that there is sufficient make-up air and that the equipment is approved for use in flammable or explosive atmospheres.

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.

Work practices

Work practices that can be implemented in the workplace to reduce potential exposure to isocyanates include:

- 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. The hands and face should be washed 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 are often less expensive than other control measures, but workers must be properly trained and use the safe work practices. The employer must monitor this in the workplace.

Personal protective equipment

If it is not practicable or feasible to use substitutes, engineering controls or change work practiced to reduce the potential for exposure, the employer must provide workers with appropriate respiratory protective equipment. 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 of isocyanates that may be encountered.

Properly operating air-supplying respirators are usually the most effective type of respiratory protection against isocyanate vapours or mists. Air purifying respirators with cartridges approved for organic vapours and mists may not provide sufficient protection against isocyanate exposure, particularly during spray painting. The concentration of isocyanates detectable by most people by smell is higher than the occupational exposure limits. Because of this, the wearer will not be able to detect when a cartridge is in need of changing and may unknowingly become overexposed.


If air purifying respirators are used for isocyanates, the employer must either:


- ensure that the respirator is equipped with an end-of-use indicator (the indicator will show when the cartridges must be changed), or
- use a change-out schedule that has been calculated by a qualified person who uses the manufacturer's product information or makes estimates based on knowledge of the effectiveness of the cartridge or canister to remove the contaminant. If calculated change out schedules are used, the U.S. Occupational Safety and Health Administration (OSHA) method, or an equivalent method, must be used. The employer should also have written procedures that address how the calculations are done and confirm the


method used for calculations and also ensure that workers understand and use the system for cartridge change out. The OSHA method may be accessed on line.

For more information

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

 <http://www3.gov.ab.ca/hre/whs/publications/pdf/ppe004.pdf>
Guideline for the Development of a Code of Practice for Respiratory Protective Equipment (PPE004)

 <http://www3.gov.ab.ca/hre/whs/publications/pdf/ppe001.pdf>
Respiratory Protective Equipment: An Employer's Guide (PPE001)

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



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Books
Manuals

Since isocyanates can affect the skin, appropriate solvent resistant gloves should be worn. The worker directly using the product should also wear coveralls that protect the arms and legs. Air-tight goggles or full-face respirator masks should be worn to protect the eyes from irritation or splashes.

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

Regulatory requirements

The regulations under the Alberta Occupational Health and Safety *Act* have general and specific requirements related to isocyanates. Occupational Exposure Limits (OELs) for isocyanates are provided. 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, unsensitized workers. Steps must be taken to keep isocyanates level as low as reasonably practicable since some workers can become sensitized at levels below the current OELs.

Additional requirements include:

- Development of safe work procedures
 - Training of workers on the health hazards associated with exposure to isocyanates and the safe work procedures developed by the employer.
 - Ensuring that the need for ventilation is properly assessed and systems that are installed are properly designed and maintained. Workers also need to be trained on the proper operation of these systems.
 - Provision of appropriate protective equipment, including respirators, where concentrations of isocyanates cannot be controlled below safe limits.
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How to contact us:

Province-Wide Call Centre


 1- 866-415-8690



Deaf or hearing impaired

- Edmonton (780) 427-9999
- Other locations 1-800-232-7215


Internet Web Site

 www.whs.gov.ab.ca

Getting copies of regulations:

Queen's Printer

 www.qp.gov.ab.ca

 Edmonton (780) 427-4952
Calgary (403) 297-6251

Workplace Health and Safety

 www.whs.gov.ab.ca/law/index.html

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