Isocyanates in industry

Staff members in a school were exposed to isocyanates during the application of roofing foam. Large quantities of polyurethane foam and isocyanate coating materials had been applied to the school roof on several occasions. The staff reported strong odours while the work was being performed. Almost half of the 85 staff members developed asthma as a result of exposure to the isocyanates.

This document explains the health hazards posed by isocyanates and describes the types of products that contain isocyanates. It also describes the dangers of applying isocyanate-based products in the workplace and how to reduce the risk of exposure.

What are isocyanates?

Isocyanates were developed in Germany during World War II as part of a process to replace natural rubber, which became very scarce during the war.

Isocyanates are very reactive chemicals that contain the isocyanate group (-NCO). They react with alcohols to produce polyurethane polymers. Isocyanates are the essential raw materials for polyurethane plastics.

The most commonly used isocyanates are toluene diisocyanate (TDI) and methylene bisphenyl isocyanate (MDI). TDI is used in the production of soft synthetic rubbers. MDI is used in producing foams, hard synthetic rubbers (elastomers), and coatings.

Other isocyanates include

- Naphthalene diisocyanate (NDI)
- Hexamethylene diisocyanate (HDI)
- Isophorone diisocyanate (IPDI)

NDI is used to produce elastomers. HDI and IPDI are both used in paints, coatings, leather finishings, and foams.

Products containing isocyanates have several brand or trade names. Isocyanates also have many different chemical names. Consult the product's material safety data sheet (MSDS) to see if the product contains isocyanates.

Where are isocyanates used?

Isocyanates are used in the production of paints and coatings to create weather-resistant surfaces. They are also used to make building materials (for example, Styrofoam, flexible foams, adhesives, elastomers, and binders) and in the production of manufactured goods (for example, bedding, furniture, clothing, appliances, electronics, tires, and packaging).

In British Columbia, isocyanates are used mainly in the automotive repair, construction, and manufacturing industries.

How does exposure to isocyanates occur?

During the plastic-making process, some isocyanates evaporate into the air and can pose a health risk. Isocyanate mist and vapour can be released into the air by a variety of work activities, including

- Spraying paints or foams containing isocyanates
- Heating polyurethane plastics
- Cutting polyurethane foams using hot wire cutting methods
- Applying varnish
- Manufacturing urethane foam forms
- Hand painting or rolling isocyanate coatings

What are the health effects of isocyanate exposure?

Isocyanates are irritants to the eyes, skin, and respiratory system. Short-term exposure can cause dermatitis and irritation or burns to the eyes, nose, and throat. Even a small amount of isocyanates can produce significant health effects, such as asthma.

It has been estimated that 1 in 20 workers who work with isocyanates will become sensitized to them. Some worker deaths from isocyanate asthma have also been reported.

Sensitization is *permanent*—workers who become sensitized can no longer be exposed to isocyanates without experiencing a reaction—often a severe one.

Symptoms of isocyanate exposure include

- Sore eyes
- Running nose
- Sore throat
- Coughing
- Wheezing (asthma)
- Chest tightness

Isocyanates can have a fruity, musty, or pungent odour. **Do not** use odour to identify hazardous concentrations of isocyanate, because once you can smell it, it is above the permissible concentration. Your sense of smell will not warn you that you are being overexposed to isocyanates until it is too late.

Exposure to airborne isocyanates may cause eye irritation, tearing, and a temporary decrease in sharpness of vision. Direct contact with isocyanates—a splash to the eye, for example—can cause irritation, conjunctivitis (irritation of the membrane lining the eyelids and part of the eyeball), and eye tissue damage.

Direct skin contact with unreacted isocyanates can cause rashes, blistering, and reddening of the skin. In rare cases, the skin can become so sensitized that severe skin reactions will occur through contact with small amounts of isocyanate. Skin exposure can also cause the entire body to become sensitized.

Occupational exposure limits

Employers must ensure workers are not exposed to isocyanate levels above the occupational exposure limits (OELs). The OELs for isocyanates in B.C. are very low—an 8-hour time-weighted average (TWA) of 0.005 parts per million (ppm) and a ceiling value (not to be exceeded) of 0.01 ppm. Isocyanates are ALARA substances, meaning exposure must be kept **a**s **l**ow **a**s **r**easonably **a**chievable. TDI, a type of isocyanate, is listed as a carcinogen.

Employer responsibilities

Employers must develop and implement an effective exposure control plan, which includes training workers and supervisors in relevant sections of the plan.

An exposure control plan for a workplace where workers are exposed to isocyanates must include:

- A written policy that
  - — States the employer's commitment to health and safety
  - — States the plan's objectives
  - — Defines the responsibilities and roles of the employer, supervisors, and workers
- An assessment of the workplace hazards (for example, where workers are likely to be exposed to isocyanates)
- Controls used to reduce the hazards (for example, ventilation, barriers, or personal protective equipment)
- Written safe work procedures and emergency response procedures (for example, rescue procedures)
- Training for supervisors and workers
- Records and statistics (for example, first aid records for workers who are exposed to isocyanates)

Worker responsibilities

To help reduce the risk of exposure to isocyanates, workers (including subcontractors) must

- Attend education and training sessions provided by the employer
- Use controls and follow safe work practices outlined in the exposure control plan
- Use available personal protective equipment (for example, airline respirators) as required
- Know how to report exposure incidents

Sampling for isocyanates

Choosing the correct sampling method for isocyanates can be difficult because they may occur as vapours or aerosols of various sizes. Each method has its own potential problems, and most underestimate the amount of isocyanate present. Sampling methods include

- *Air sampling*—Air is passed through a liquid solvent (for example, in glass impingers or bubblers) or a filter (usually made of glass fibre) coated with a reagent. The isocyanates are dissolved in the liquid or adhere to the filter, and are then sent to a laboratory for analysis.
- *Surface/skin sampling*—Skin can be sampled using adhesive tape, which is placed in a reagent and sent to a laboratory for testing. Indicator pads are also available, which change colour (usually to red) in the presence of isocyanates.

Reducing the risk of exposure

The risk of unsafe levels of isocyanates can be reduced with the following controls:

- *Substitution*—If practicable, products that do not contain isocyanates should be used. However, if isocyanates must be used, some are less hazardous than others. For example, MDI is better than TDI because it has a lower vapour pressure and will not vaporize as easily as TDI when applied.
- *Engineering*—Ventilation must be used when applying isocyanates. The type of ventilation (for example, area or local exhaust) and the amount will depend upon the size of the application.
- *Isolation controls*—Unprotected workers must be kept a safe distance from where isocyanates are applied. (See the **Controlling exposure** section on page 3 for safe distances.)
- *Regular inspection and maintenance*—Spray (and other) equipment should be checked regularly to make sure it is operating properly (for example, not clogged). Containers holding liquid isocyanate products should be tightly covered to prevent evaporation.

- *Education*—Workers must be taught how to prevent exposure to isocyanates and how to use protective breathing equipment.
- *Monitoring*—Isocyanate levels in the air must be measured where there is a risk of exposure. Skin and surfaces should also be checked for contamination.
- *Personal protective equipment (PPE)*—Respiratory protection will depend on how isocyanate-containing products are applied. Skin must also be protected from isocyanate exposure. Examples of PPE for applying isocyanate products are given below.

Controlling exposure

When spraying products containing isocyanates, workers in B.C. must use air-supplying respirators such as the following:

- *Self-contained breathing apparatus (SCBA)*—This consists of an air cylinder, which is normally worn on the back, and a full-face mask to protect the eyes and face. A hose connects the face mask to the regulator and the air cylinder.
- *Supplied-air (airline) respirator*—This consists of an airline attached to
  - — A hood- or helmet-style respirator, or
  - — A regulator and full-face mask

Workers who use respirators must be clean-shaven where the respirator seals with the face to ensure a good seal.

PPE should also include a chemical-resistant suit, goggles that seal to the face, and gloves (preferably nitrile or polyvinyl alcohol).

Workers who apply isocyanate products using a roller, brush, or caulking gun should wear a half-face elastomeric respirator with combination HEPA (particulate) and organic vapour/acid gas cartridges.

Used cartridges must be replaced with new cartridges every shift.

The work area should be isolated from unprotected workers. Ideally, the barriers should be as airtight as possible. Unprotected workers should not be allowed within 8 m (25 ft.) of an indoor work zone or within 3 m (10 ft.) of an outdoor work zone. Indoor work zones must be vented to a safe outdoor location.

Ventilation for non-spray applications (paint, caulking, roll-on, etc.)

If practicable, products that contain TDI should be substituted with MDI-based products or other less hazardous products.

The work area should be ventilated. A written ventilation plan (for general or mechanical ventilation) should be prepared and should consider the following:

- General ventilation alone should not be used for controlling isocyanate exposure.
- Fans should be intrinsically safe (for example, non-sparking) and strong enough to provide sufficient air flow.
- Ducting must remain in good shape and be free of holes and tears.
- Intake and exhaust vents should be located in such a way that exhausted air is not brought back into the work area.
- Contaminants must be directed away from workers (and the work area), and there should be no "dead" spots.
- Mechanical ventilation equipment must be located and arranged to adequately ventilate the entire work area.

Personal hygiene

Workers should follow these safety steps to minimize contact with isocyanates:

- Wash hands before eating or smoking.
- Rinse any skin contaminated by isocyanates with diluted rubbing (isopropyl) alcohol to neutralize the isocyanate, and then wash with soap and water.
- Leave contaminated clothing at the workplace to protect family members from exposure.

Employers should do the following:

- Provide washroom and changing facilities that have separate lockers for work clothes and street clothes.
- Provide a separate area for storing and eating food, away from the work area.

First aid

Washing and eyewash facilities must be available near areas where isocyanates are handled, and all workers must know how and when to use these facilities. Soap and water should be available at these facilities to treat contaminated skin.

If isocyanates enter the eyes, follow these steps:

1. Flush the eyes with lukewarm water immediately, for at least 30 minutes.
2. Remove contact lenses after the eyes have been irrigated with water for a few minutes, and then resume irrigation.
3. See a doctor.

If isocyanates contact the skin, follow these steps:

1. Remove contaminated clothing. Contaminated clothing can be treated with a neutralizing mixture (10% isopropyl alcohol and 1% ammonia in water) and sent for laundering.
2. Wash skin with soap and water. Shower if necessary.
3. Discard contaminated items such as leather watch straps and shoes.
4. See a doctor if there is a chemical burn.

If isocyanates are swallowed, follow these steps:

1. Do not induce vomiting.
2. Have the worker drink water or milk to dilute the material in the stomach.
3. Transport the worker to the nearest hospital as soon as possible.

If a worker is overcome by inhaling isocyanates, follow these steps:

1. Move the worker to fresh air, and give the worker oxygen, if available.
2. If the worker is having trouble breathing or is not breathing, start assisted ventilation using a pocket mask. Add oxygen to the mask, if available.
3. Transport the worker to the nearest hospital as soon as possible.

Emergency procedures

Emergency procedures should be posted wherever there is a risk of exposure to isocyanates. Workers must be trained in emergency procedures for the following:

Spills—A written spill-response plan should be created for the worksite. Workers should be trained in spill response before a spill occurs. The MSDS for the product used should contain information on how to contain and clean up a spill.

Isocyanate spills must be cleaned up immediately by workers wearing the proper PPE. Follow these steps:

1. Evacuate anyone in the area who is not involved in the cleanup.
2. Immediately cover the isocyanate spill with a dry absorbent such as vermiculite or sand. Do not use sawdust or shredded paper because of the fire hazard.
3. Shovel the waste into a metal container, cover it, and place the container outside in a shaded, dry area prior to disposal.
4. Make sure that the container is not sealed tightly so any pressure buildup can escape.

Chemical reactivity—Isocyanates react vigorously with water, ammonia, or strong bases to produce heat and carbon dioxide (CO_2) gas. If this reaction occurs in a sealed container, the container may rupture or explode, releasing isocyanate vapour and CO_2.

Before disposing of empty isocyanate containers, they must be decontaminated by filling them with water and leaving them uncovered (for at least 48 hours) to allow CO_2 gas to escape. The containers must be pierced to prevent reuse.

Fires—Isocyanates, and most substances containing them, are flammable. They will burn and release toxic gases such as carbon monoxide, nitrogen oxides, and hydrogen cyanide. Burning polyurethane products made with isocyanates may release a number of hazardous substances, including benzene, toluene, carbon monoxide, nitrogen oxides, and hydrogen cyanide.

Isocyanates should be treated as a Class C fire hazard—do not use water or foam-containing fire extinguishers. Use a CO_2 or dry chemical extinguisher to put out flames. In the case of a major fire, firefighters must wear self-contained breathing apparatus (in positive-pressure mode) to protect them from toxic fumes.

Medical monitoring

If you think a worker has been exposed to isocyanates (and the worker has persistent or recurring eye irritation, nasal congestion, dry or sore throat, cold-like symptoms, cough, shortness of breath, wheezing, or chest tightness), the worker should see a physician knowledgeable in work-related health problems. If sensitivity is present or developing, the worker should not be exposed further to isocyanates.

Lung function tests should be conducted on a regular basis (for example, as part of a yearly physical examination). If workers develop symptoms of isocyanate overexposure, a pulmonary specialist can determine whether or not they have become sensitized.

Workers should report any suspected health damage to their employer and a physician. Workers should act on medical advice and comply with any medical instructions a doctor gives them.

For more information

For more information on isocyanates, refer to the following web pages:

- U.S. Occupational Safety & Health Administration (OSHA). Safety and Health Topics—Isocyanates. www.osha.gov/SLTC/isocyanates/index.html
- Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST). Polyurethane foam spraying—Good practices guide. www.irsst.qc.ca/en/_publicationirsst_100503.html
- U.S. National Institute for Occupational Safety and Health (NIOSH). Isocyanates. http://www.cdc.gov/niosh/topics/isocyanates/
- Canadian Urethane Foam Contractors Association (CUFCA). www.cufca.ca/home_e.php