



Isocyanates: Control measures guideline

Control measures to eliminate or reduce exposure of
employees to isocyanates in spray-painting operations

GUIDELINE

October 11, 2018

The purpose of this guideline is to assist federally regulated workplace parties manage and control exposure to isocyanates during spray-painting operations. This guideline will be particularly useful for industrial hygiene specialists and health and safety professionals who may be recommending or installing different control measures that are appropriate to meet legislative and regulatory requirements for work places that fall under the federal jurisdiction. The purpose of this guideline is to support the Labour Program's mandate of fostering healthy and safe work place environments.

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1. Introduction

Isocyanates are reactive, low molecular weight chemical compounds which contain one or more $-N=C=O$ functional groups. In reaction with polyalcohols, isocyanates polymerize and form macromolecular compounds, the so-called polymers. Isocyanates are commonly used in manufacturing of foams and fibers, paints, varnishes and in the automobile industry for repair and insulation materials. They are also a component of polyurethane products and other chemicals that are used in various commercial and industrial processes¹.

Isocyanates are usually present as combination of two isocyanate groups (diisocyanates) or multiple isocyanate groups (polyisocyanates). Some examples of isocyanates include methylene diphenyl diisocyanate (methylene bisphenyl isocyanate) (MDI), toluene diisocyanate (TDI), and hexamethylene diisocyanate (HDI).

Hexamethylene diisocyanate (HDI) is the most common isocyanate and it is an aliphatic isocyanate which is almost exclusively used in the production of paints and surface coatings. The monomer of HDI possesses such properties that make the isocyanate effectively irreplaceable. It gives the product excellent durability, colour stability, resistance to chemicals and light, as well as resistance to extreme temperatures. In spraying isocyanate paints and primers, HDI is present in two forms, monomer and polymer. The monomer content is usually very low - less than 1%.

A common characteristic of all isocyanates used in work places is that they are very toxic. Work place exposure to them before they cure must be tightly controlled or serious health effects will occur.

The following guideline document gives a summary of the control and preventive measures that should be used at a work place to keep the occupational exposure levels to isocyanates below the limits as prescribed by the *Canada Occupational Health and Safety Regulations (COHSR)*^{2,3,4} and, by reference the American Conference of Government Industrial Hygienist (ACGIH[®]) *Threshold Limit Values (TLVs[®]) for Chemical Substances and Physical Agents & Biological Exposure Indices (BEIs[®])* booklet.

2. Health effects

Potential health effects associated with exposure to free/unreacted isocyanates include skin, eye, gastrointestinal tract and respiratory tract irritation. Very serious skin and respiratory sensitization can occur, which will increase the person's susceptibility to asthma attacks. It is important to note that fully cured paints contain no free isocyanates and are therefore innocuous and do not present any danger.

Some of the most common symptoms experienced by employees exposed to isocyanates are:

- Excessive tear secretion;
- Dry throat;
- Dry cough;
- Chest pains and tightness;
- Difficulty in breathing;

- Cold-like symptoms; and
- Eye irritation.

Direct skin contact may cause rashes, blistering, hardening and reddening of the skin. If the liquid splashes into the eyes, damage to the cornea can occur. Isocyanates are considered to be one of the main causes of occupational asthma worldwide, Health effects due to isocyanates are chronic and often permanent to the employees' health.

The most recent edition of the American Conference of Governmental Industrial Hygienists (ACGIH[®]) *Threshold Limit Values (TLVs[®]) for Chemical Substances and Physical Agents & Biological Exposure Indices (BEIs[®])* booklet must be used for exposure limit values for isocyanates². The booklet is referenced in COHSR Part X under the Part II of the *Canada Labour Code*³.

Currently, the booklet includes only the HDI monomer TLVs[®] along with TLVs[®] of other isocyanate types, but does not include TLVs[®] for the HDI polymer.

Isocyanates are also included in the Biological Exposure Indices (BEIs[®]) list in the ACGIH[®] booklet. Hence, while determining exposure concentrations of employees, the BEIs[®] should also be consulted to take into account the human intake level of the isocyanates in addition to the exposure levels.

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3. Occupational exposure limits

The most recent edition of the American Conference of Governmental Industrial Hygienists (ACGIH[®]) *Threshold Limit Values (TLVs[®]) for Chemical Substances and Physical Agents & Biological Exposure Indices (BEIs[®])* booklet must be used for exposure limit values for isocyanates². The booklet is referenced in COHSR Part X under the Part II of the *Canada Labour Code*³.

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4. Regulatory requirements

In addition to the most recent edition of the ACGIH[®] *Threshold Limit Values (TLVs[®]) for Chemical Substances and Physical Agents & Biological Exposure Indices (BEIs[®])* booklet referenced in the COHSR, it is necessary that the federally regulated workplace parties follow the entire COHSR Part X, *Hazardous Substances* as it includes hazard investigation, storage/handling, medical examination, ventilation, hazard control measures, employee training, hazard control regulations and warning signs. Below are examples of relevant sections³:

- Part X, Section 10.4, the employer must appoint a qualified person to carry out the necessary hazard investigation;
- Part X, Subsection 10.17 (1) requires that every ventilation system installed on or after January 1, 1997, to control the concentration of an airborne hazardous substance shall be so designed, constructed, installed, operated and maintained that
 - (a) The concentration of the airborne hazardous substance does not exceed the values and levels prescribed in subsections 10.19(1) and 10.20(1) and (2); and
 - (b) It meets the standards set out in:
 - (i) Part 6 of the *National Building Code*, as referenced in Section 1.2 of the COHSR;
 - (ii) the most recent publication of the American Conference of Governmental Industrial Hygienists (ACGIH[®]) entitled *Industrial Ventilation Recommended Practices for design*, and its companion entitled *Industrial Ventilation: A Manual of Recommended Practice for Operation and Maintenance*; or
 - (iii) The most recent edition of the American National Standard Institute (ANSI) Standard ANSI Z9.2, *Fundamentals Governing the Design and Operation of Local Ventilation Exhaust Systems*
- Part X, Paragraph 10.18 (3)(a) will ensure that a qualified person carries out each inspection, testing and maintenance of the ventilation system, as specified by the instructions given by the employer.
- Part X, Paragraph 10.19 (1)(a) requires that an employee shall be kept free from exposure to a concentration of an airborne chemical agent in excess of the value for that chemical agent adopted by the ACGIH[®], in the most recent version of its publication entitled *Threshold Limit Values and Biological Exposure Indices*.

The COHSR, Part XIX, *Hazard Prevention Program (HPP)* lays out the outline for the implementation and methods for a successful HPP at the work place which would include hazard assessment, preventive and control measures, and employee training/education⁴.

- Part XIX, Section 19.5 states that the employer shall, in order to address identified and assessed hazards, take preventive measures that consist first of the elimination of hazards, then the reduction of hazards and finally, the provision of personal protective equipment. As part of the preventive measures, the employer is also required to develop and implement a preventive maintenance program, as recommended by a qualified person.

5. Control measures

When concentrations to the HDI monomer exceed the TLV[®], the employer is required to reduce employee exposure to the contaminant below the prescribed limit. Since there is no TLV[®] for HDI polyisocyanates, it is the employer's general duty to provide a safe and healthy workplace (Section 124 of the *Canada Labour Code*) that makes it necessary that exposure to the polymer be reduced to the minimum. The controls should primarily focus on eliminating or substituting the exposure and then focus on control measures indicated below such as ventilation, equipment, personal protective equipment, and administrative controls including training and medical programs.

5.1 Engineering controls

1) *Ventilation:*

According to the COHSR Part X, Subsection 10.17 (1) (above)³, work places must implement ventilation systems that will prevent the exposure concentration from exceeding the exposure limit values in the ACGIH[®] TLVs[®] booklet and regulations.

For instructions on paint booths designed for airless spray paint and air spray paint, the ACGIH[®] *Industrial Ventilation* publication or ANSI Standard ANSI Z9.2, *Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems* must be used^{5,6}. For construction and safety, Part 6 of the *National Building Code*, as referenced in Section 1.2 of the COHSR must also be consulted.

As isocyanates are hazardous, it is important that the ventilation is designed and operated in a manner consistent with the prescribed Standards and exposure levels are kept below exposure limits.

2) *Enclosures:*

To effectively control the isocyanate hazards to as small an area as possible, work places using isocyanates must use enclosures such as spray booths or separate areas for tasks that require using isocyanates, especially if there is a danger of isocyanates vapours and mist. The enclosures should also contain adequate ventilation systems that will remove the harmful mist/vapours away from the employee and reduce exposure. The processes can also be automated to limit presence of employees in the enclosures with isocyanates.

Where spray paint booths are used, attention must be paid to the following:

- Exhausts are vented to the outside, away from places where people would be present and from air intakes for the work area;
- Proper paint arresting filters are in place;
- Air filters are placed in doors, when necessary;
- Baffles and water curtains are installed, when necessary, and are in operation. All of the equipment is approved for use in flammable or explosive atmospheres;
- For electrostatic spray booth, automatic high-voltage disconnects for conveyor failure, fan failure or grounding are installed and are in operation;
- Sufficient make-up air is provided; and
- Exhaust fan interlock with make-up air supply and compressed air to spray gun is installed, when necessary, and is in operation.

5.2 Personal protective equipment (PPE)

Personal protective equipment (PPE) should be used together with other control measures at the work place or as the last resort, as it is the least effective form of control. The PPE for isocyanates should include respiratory protection, clothing, goggles, and gloves.

1) Respiratory protection:

The respiratory protection program implemented in the work place must address selection, fit testing, maintenance and inspection, where each step must be conducted by a qualified person. All employees who are provided with and wear respirators must be trained. Reference should be made to the Canadian Standard Association (CSA) Standard Z.94.4, *Selection, use and care of respirators*⁷. A respirator must be of a type approved for its intended use and listed in the *Certified Equipment List* published by National Institute for Occupational Safety and Health (NIOSH)⁸. There are three types of respirators classified according to the mode of operation:

- Atmosphere-supplying respirators;
- Air-purifying respirators; and
- Combination of atmosphere-supplying and air-purifying respirators.

Atmosphere-supplying respirators provide a breathing air that is independent of atmospheric conditions. For air-purifying respirators, ambient air, prior to being inhaled, is passed through a filter, cartridge, or canister that removes particles and gases. It must be noted that air-purifying respirators for organic vapours can adsorb and remove isocyanates from air. However, due to the isocyanates poor warning properties, the respirator user will not be able to know that the sorbent is approaching saturation or is no longer effective. Therefore, NIOSH has not approved any air-purifying respirators for protection against isocyanates.

Since there is no NIOSH approved air-purifying respirator for isocyanates, it is necessary that painters wear a NIOSH certified supplied-air respirator when spraying paints and primers, and when cleaning spray guns by passing solvent through the gun under pressure (free isocyanates may be released into the work environment).

The breathing air that is provided for the purpose of a respirator must meet the standards set out in the most recent edition of the CSA Standard Z180.1 *Compressed breathing air and system*⁹.

Note:

Some manufacturers state that for some small applications such as the dispensing of liquid polyurethane into a container, the curing process, or touch painting, a half-face or a full-face double cartridge respirator for organic vapours would be sufficient to provide very limited protection against isocyanates as long as the respirator is worn for a short period of time, *e.g.*, 15 minutes. Since there is no NIOSH approved air purifying respirator for isocyanates, it is necessary to contact the manufacturer for additional information on the use of such a respirator. In addition, a qualified person must establish a canister/cartridge change-out schedule based on the canister, cartridge type, the concentration of the isocyanate, humidity levels in the ambient atmosphere, and the user's respiratory rate unless the respirator is equipped with an end-of-service-life indicator.

2) Clothing:

Since isocyanates can affect the skin and eyes, employees who handle isocyanate containing materials must wear protective clothing. The type of protective clothing can depend on the time spent in the environment with isocyanates and the type of isocyanates used. The type to be used by a employee should be determined by a qualified person, after the hazard assessment has been conducted. The following protective clothing can be used:

- Appropriate solvent-resistant gloves, *e.g.*, nitrile, polyurethane, butyl, laminated PE/EVAL and fluorized rubber;
- Closed and properly fitted boots to protect their feet;
- Coveralls to protect their arms and legs; and
- Full face shields with goggles, unless they wear full-face piece respirators, to protect their eyes from irritation or splashes.

5.3 Administrative controls

1) Medical Surveillance

The ACGIH[®] TLVs[®] and BEIs[®] booklet includes isocyanates in the BEIs[®] list which gives level of contaminant in the biological specimens such as urine, blood etc². The qualified person should recommend that medical examination be provided to all employees exposed to isocyanates in the work place. The need for medical examination will depend on how isocyanate containing products are being used and on whether appropriate control measures including respiratory protection are in place.

A baseline health assessment should include the isocyanate exposure history, as well as, any chronic health issues and other activities such as drug use and smoking history. It is also recommended that a pulmonary function test be done on a regular basis, based on health care

professional advice. Forced vital capacity (FVC) and forced expiratory volume (FEV) should be measured and the measurements be repeated during, or at the end of the same work shift, between 4 and 10 hours after the employee resumes exposure to isocyanates. Attention should also be paid to each employee's ability to use respiratory protection.

Employees should also undergo regular biological monitoring so that the level of specific isocyanate levels in their body can be monitored and controlled.

2) Training

All employees who use isocyanate containing products must receive training with respect to the product use, clean up, personal hygiene, handling, hazards, first aid and storage. Particular attention should be paid to ensuring that employees understand the nature of the hazards associated with exposure to isocyanates and the safe ways of doing things. It is also necessary that employees understand the importance of wearing protective clothing and respiratory protection equipment, as well as, the need for good personal hygiene. They must also be aware of emergency strategies and be encouraged to update employer records if there is any change in their health.

Isocyanate containers must be properly labelled and the safety data sheet (SDS) for each product must be available. Employers must keep SDSs readily available for examination by employees. A computerized version of the SDS is acceptable.

5.4 Other preventive strategies

1) Spills and decontamination

The hazard training program for employees must include procedures to follow in an emergency. Along with the hazards from exposure, isocyanates and solvents are flammable therefore smoking must also be prohibited at the work place and "No smoking" signs must be posted. This is also a requirement of the *Non-Smoker's Health Act*.

The following items must be part of procedures explained in the training program:

- Wearing respiratory protection and protective clothing during cleaning and decontamination;
- Treating any spillage with absorbent material, such as sand or sawdust and with an isocyanate neutralizer (liquid decontaminants containing water, ammonia and detergent are commercially available);
- Collecting the residues in a container and if necessary, adding more neutralizers to ensure that the spillage has no free/unreacted isocyanates;
- Discarding the residues (usually after one day);
- Washing down with the isocyanate neutralizer and marking off with a rope the contaminated surface; and
- Cleaning and decontaminating safety equipment.

In case of spills and/or contamination risk or event, the employee exposure profile can change. Therefore, a qualified person must be notified who will then reassess the exposure and set out the appropriate procedures for clean-up.

If there is no qualified person or personnel to take immediate action to clean and decontaminate the spillage, it is necessary that the area be evacuated and the qualified emergency response team be notified. Usually, emergency response teams are on duty 24 hours a day.

Procedures for waste disposal and transport should also be established and the employees should be aware of such procedures.

2) *Storage*

All employees who handle containers and isocyanates must be trained in safe procedures for handling chemical containers and the proper storage requirements. Appropriate firefighting and emergency equipment must be available. In order to meet the pertinent provisions of the COHSR (Sections 10.8 to 10.12) it is necessary that the following storage requirements for isocyanates and isocyanate-containing chemicals be met:

- Separate storage for isocyanates in a cool, lockable, enclosed area with adequate ventilation;
- Storage is separate from incompatible substances, e.g., storing isocyanates away from acids, alkalis or amines, and avoids risks of mixing and cross contamination;
- All containers and packaging are properly labelled and SDSs are easily available to employees;
- Access to chemical storage areas is limited to authorized people only;
- Flammable, explosive or toxic substances are stored away from possible sources of electric spark, heat or flame; and
- All containers are checked against leakage or seepage and lids and caps are kept tightly sealed.

6. Additional resources

1. Isocyanates in industry: <https://www.worksafebc.com/en/resources/health-safety/hazard-alerts/isocyanates-in-industry?lang=en>
2. Work place health and safety bulletin- Isocyanates:
<https://open.alberta.ca/publications/ch005-chemical-hazards>
3. Safe use of isocyanates: <http://www.irsst.qc.ca/media/documents/PubIRSST/RG-773.pdf>
4. Isocyanates Information Sheet (UK):
http://www.hsa.ie/eng/Publications_and_Forms/Publications/Chemical_and_Hazardous_Substances/Isocyanates%20Information%20Sheet.pdf
5. Handling Isocyanates (Australia):
<https://www.safeworkaustralia.gov.au/system/files/documents/1702/guide-to-handling-isocyanates.pdf>

7. References

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