Isocyanate Exposure Control Plan

1. Purpose & Background

The University of British Columbia (UBC) is committed to providing a safe and healthy workplace by protecting UBC members from the potential adverse effects that could result from exposure to isocyanates in accordance with the Occupational Health and Safety Regulations (OHSR).

Isocyanates are reactive, low molecular weight, organic chemicals that contain an -N=C=O functional group, also referred to as an isocyanate group. Isocyanates make up all polyurethane products and are hazardous until they cure. However, even cured polyurethane products can release isocyanates if heated or abraded. This ECP should be reviewed to learn about the dangers associated with isocyanates and the controls that should be implemented to mitigate exposure risks.

Isocyanates are usually expected to be used in the construction, manufacturing, and automotive repair industries. However, isocyanates can also be found in academic settings, such as UBC, where they are used in research labs, theatre productions, art classes, and extracurricular activities. Two commonly used isocyanates are toluene diisocyanate (TDI) and methylene diphenyl diisocyanate (MDI).

All isocyanates can have a negative impact on the lungs of workers when they breathe in the vapours or aerosols of this chemical before curing takes place. In addition, workers may be exposed to this hazard if the skin comes into contact with liquids, resins, or droplets of isocyanate containing products. Please note that workers not directly handling or applying isocyanates but working in close proximity, may also be at risk of exposure if proper controls are not implemented.

2. Scope

This Exposure Control Plan (ECP) is applicable to all UBC faculty, staff, students, and contractors who carry out work, both on campus and off, where there is the potential for isocyanate exposure to occur.

3. Legal and University Requirements

- Occupational Health and Safety Regulation (OHSR) - Section 5.54-5.57
- Occupational Health and Safety Regulation (OHSR) - Exposure Limits
- University Health and Safety Policy - SC1

4. Roles and Responsibilities

The roles and responsibilities described in this Exposure Control Plan (ECP) are in accordance with the OHSR and University Health and Safety Policy - SC1.

4.1 Employer Responsibilities

- Ensure workers are protected from isocyanate hazards in the workplace by considering the hierarchy of controls (e.g. in order of elimination, substitution, engineering, administrative and personal protective equipment (PPE))
- Ensure workers are informed on the hazards of isocyanates and trained on how to minimize exposure to isocyanates
- Ensure resources are made available for isocyanate air monitoring, when required
- Provide workers with the necessary materials, tools and equipment, PPE and other resources required to minimize isocyanate exposure
- Ensure isocyanate exposures at the workplace are investigated and, based on the findings, develop ways to prevent similar incidents from occurring
- Ensure workers who are exposed to isocyanates participate in health monitoring, when required

4.2 Department Manager/Supervisor Responsibilities

- Attend education and training sessions provided by the employer
- Identify and evaluate occupations, tasks or areas where the potential for isocyanate exposure exists
- Ensure employees have the appropriate education and training for working with isocyanates and demonstrate competency for identified tasks
- Provide workers with adequate supervision to ensure that work practices eliminate or minimize isocyanate exposure
- Ensure employees are able to recognize the health signs and symptoms associated with isocyanate exposure
- Ensure the hierarchy of controls is considered and implemented accordingly
- Ensure all tools, equipment, PPE, and materials needed to control against isocyanates are available
- Develop and provide site-specific isocyanate safe work procedures to workers
- Ensure isocyanate exposure incidents are investigated appropriately. Ensure the results of investigations are posted at the workplace

4.3 Employee Responsibilities

- Follow ECP and safe work practices established by the employer
- Attend education sessions provided by the employer
- Understand the hazards of isocyanates and symptoms of exposure
- Understand the importance of evacuating work areas when signs of isocyanate exposure arise
- Adhere to the hierarchy of controls for isocyanates
- Ensure all tools, equipment, PPE and materials needed to control against isocyanates are in good working condition
- Report unsafe isocyanate exposure conditions to their supervisor
- Participate in incident/accident investigations, where required

4.4 Safety & Risk Services Responsibilities

- Develop and maintain an Isocyanate ECP in accordance with OHSR
- Assist in the implementation of this Isocyanate ECP through training and consultation
- Provide education on isocyanate exposure including how to recognize early symptomology
- Assist with isocyanates risk identifications and assessments, as requested
- Ensure air monitoring for isocyanates is conducted, when required
- Conduct respirator fit testing sessions for tight-fitting respirators

5. Routes of Exposure & Health Hazards

The 3 routes of exposure into the body for any hazard are through ingestion, inhalation, and dermal (skin & eye) exposure. Isocyanate exposure takes place mostly through the inhalation and dermal routes. Ingestion of isocyanates is rare but may occur through a lack of personal hygiene and cross-contamination.

Isocyanates are an inhalation hazard when there is unreacted (unconsumed) isocyanate that remains airborne following the use of isocyanate containing products. Examples of work activities where isocyanates can become airborne include:

- Spraying of paints and foams containing isocyanates
- Heating polyurethane plastics or foams
- Applying varnishes containing isocyanates
- Hand painting or rolling isocyanate coatings

Dermal exposure of isocyanates is often overlooked but is an equally important route of exposure as inhalation. Once isocyanates contact the skin, the chemical can be absorbed into the body and transported through the bloodstream. Examples of activities that can lead to dermal exposure to isocyanates include: direct contact with contaminated surfaces, the deposition of aerosols on the skin, splash on the skin, or immersion of the skin into product. It is important to determine the time required for isocyanate containing products to cure so that gloves, lab coats, and other PPE continue to be used for protection against dermal exposure.

5.1 Health Hazards

The health effects arising from an exposure to a hazard can be categorized as either acute or chronic. Acute health effects are observed shortly after exposure (within 4 hours) while chronic health effects take time to manifest. The following will describe the acute and chronic health effects associated with isocyanates from each route of exposure.

5.1.1 Acute Health Effects

Inhalation

Isocyanates can cause serious short-term respiratory health effects soon after exposure. For example, the vapors of TDI are a category 1 for acute inhalation toxicity. Category 1 is the highest-ranking hazard level in the acutely toxic hazard class. Listed below are some respiratory related symptoms that may be observed after exposure to isocyanates through inhalation:

- Irritation of the respiratory tract, including the nose, mouth, throat, and lungs
- Coughing, wheezing, and/or shortness of breath
- Tight chest and/or chest pains
- Runny nose
- Sore and/or dry throat

In certain circumstances, there may be a delay in the onset of respiratory symptoms to later in the day once work has been completed. For example, the health effects from the inhalation of acutely toxic products (i.e. TDI) can be up to 4 hours post exposure. As a result, employees should continue to monitor themselves closely even after isocyanate work is completed.

A medical assessment may be needed if the above symptoms are observed to further investigate a potential relationship between exposure and symptoms.

Skin & Eye

Acute health effects from isocyanate exposure to the eye include irritation, excessive tear secretion, blurred vision, and cornea damage.

Direct skin exposure with isocyanates can lead to reddening, rashes, blistering, burns, and/or dermatitis. For example, TDI is classified as a category 2 product for skin corrosion/irritation.

5.1.2 Chronic Health Effects

Sensitization

Sensitization develops from repeated exposure to an agent that an individual's immune response may recognize as a threat and build antibodies against. Eventually, with the build-up of enough antibodies, any subsequent exposure to that agent, even at low concentrations, could trigger a severe allergic response. At this point, an individual has become sensitized to this agent and this is a permanent irreversible chronic health effect. Once sensitization has been established, even a small exposure to the agent can trigger an immune response.

There are two types of sensitizations: dermal and respiratory. The symptoms associated with dermal sensitization include itchiness, redness, swelling and hives. These symptoms can last anywhere from a few hours to days. Only once the body's immune system returns to its normal state, the symptoms of dermal sensitization will disappear. Respiratory sensitization is much more serious as it may trigger an extreme asthmatic attack, where individuals will have difficulty breathing and will require immediate medical attention. For this reason, respiratory sensitization is considered life-threatening.

According to WorkSafeBC, approximately 1 in every 20 employees that work with isocyanates can become occupationally sensitized. Both TDI and MDI are able to cause skin and respiratory sensitization. If an employee has a diagnosed sensitivity to isocyanates, they should be removed from situations where there is potential for exposure.

Carcinogenicity

Some isocyanates are also suspected carcinogens for humans and known to cause cancer in experimental animals. A carcinogenic warning will be found with the SDS of TDI products.

6. Risk Identification & Assessment

Risk identification is the process by which hazards are determined. Reviewing past inspection records, job/task demands, working procedures, first aid records and incident investigation reports can help identify occupational exposure risks to isocyanates. Performing a walk-through of spaces where isocyanate activities occur can also help with risk identification. Note that the SDS sheet should be used to identify isocyanates within products as the brand name/trade name alone often won't provide this detail.

At the workplace, isocyanate exposure is observed from the inhalation of vapours, mists, aerosols, or dusts. Isocyanate may also be absorbed through the eyes or skin. Once the potential for isocyanate exposure has been identified, an assessment should be performed to evaluate the risk of developing an isocyanate related illness. When conducting a risk assessment, it is important to remember isocyanate exposures will depend on the following factors:

- Volatility of the product – i.e. most volatile isocyanates usually have low molecular weights
- Application process – i.e. isocyanates that require the need to be heated, or generate heat, have a higher risk of vaporization
- Duration and frequency of exposure to isocyanate containing products

As part of the risk assessment, isocyanate levels can be quantified using NIOSH analytical methods and sampling strategies as a reference guide. Impingers or glass fiber filters, with a sampling pump, are common sampling techniques for determining airborne isocyanate levels. However, these techniques are still limited in their degree of accuracy and sensitivity because most isocyanates are very reactive, unstable, and found in various vapor or aerosol particle sizes.

Wipe sampling may also be done to detect isocyanate contamination on surfaces that can lead to dermal exposure. Wipe samples, that change color in real-time, are available as a screening tool to determine the presence and extent of aromatic isocyanate contamination. Areas that screen positive can be further wipe sampled for lab analysis and confirmation.

It is the responsibility of workplace supervisors to identify hazards and conduct risk assessments. The following SRS website offers guidance on creating risk assessments: Risk Assessment & Safe Work Procedure | Safety & Risk Services (ubc.ca). UBC SRS can also be contacted to for consultation in this process and/or to assist with sampling.

7. Regulations

WorkSafeBC has established exposure limits for hazardous chemical substances, such as isocyanates, which if exceeded can result in workers developing adverse health effects. The three primary types of exposure limits that must be adhered to are:

- TWA: the time weighted average (TWA) concentration of a substance in the air that cannot be exceeded over an 8-hour work day and 5-day work week.
- STEL: the short-term exposure limit (STEL) TWA concentration of a substance in the air that cannot be exceeded over a 15-minute period, limited to no more than 4 such periods in an 8-hour work shift with at least one hour between any 2 successive 15-minute excursion periods.
- Ceiling Limit: the concentration that cannot be exceeded at any point in the work period.

It is important to note that the TWA, STEL and Ceiling limits are the maximum exposures that are permitted without any controls present.

The table below summarizes the WorkSafeBC airborne exposure limits for commonly used isocyanates:

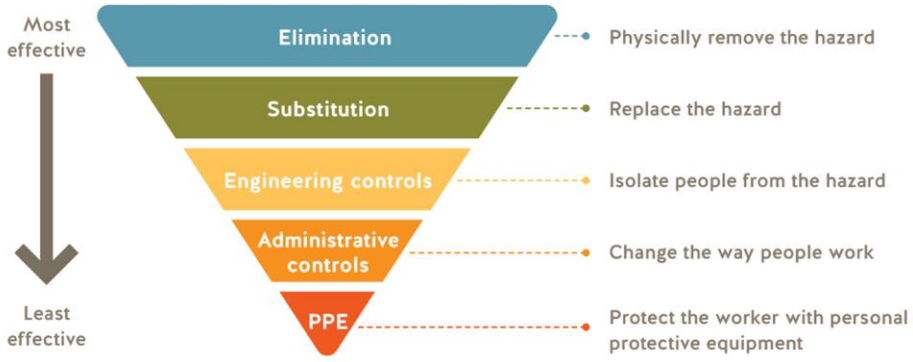
Isocyanate Species	TWA (ppm)	STEL (ppm)	Ceiling (ppm)
Toluene-2,4-Diisocyanate	0.005	-	0.01
Toluene-2,6-Diisocyanate	0.005	-	0.01
Methylene Bisphenyl Isocyanate	0.005	-	0.01
Hexamethylene Diisocyanate	0.005	-	0.01
1,5-Naphthalene Diisocyanate	0.005	-	0.01
Methyl Isocyanate	0.02	0.006	-
Isophorone Diisocyanate	0.005	-	0.01

According to the OHSR, an employer is required to develop, implement and maintain an Isocyanate Exposure Control Plan (ECP) when a worker may be exposed to an ambient concentration of isocyanates in excess of 50% of its exposure limit or when measurement is not possible at 50% of its exposure limit.

Monitoring for airborne levels of isocyanates to ensure TWA, STEL, and Ceiling levels are in compliance can take place using the sampling methodology described earlier. However, it is important to note that Part 5 of the Occupational Health and Safety Regulation characterizes isocyanates as a designated substance due to their sensitizing and carcinogenic properties. All designated substances must have their levels kept As Low As Reasonably Achievable (ALARA), with the aid of appropriate controls, even if exposure limits are met.

8. Risk Controls

Once a risk to isocyanates has been identified and assessed, the hierarchy of controls must be implemented to ensure exposure is eliminated or mitigated. The hierarchy of controls is a systematic approach to control for the risks in a workplace from most effective to least effective.



Picture 1 : Hierarchy of Controls Diagram received from Controlling risks - WorkSafeBC

8.1 Elimination / Substitution

Whenever practicable, products that do not contain isocyanates should be used so that the risk of exposure can be eliminated. However, if isocyanates must be used then considerations should be taken for choosing those isocyanates that are less hazardous. For example, MDI is preferred over TDI because MDI will not vaporize as easily after application due to its lower vapour pressure. In addition, SDS sheets should be reviewed to determine the percentage of isocyanate composition in the product being used and only those products with a smaller percentage of isocyanate should be chosen.

8.2 Engineering

Engineering controls are designed to minimize personal exposure to isocyanates through physical modifications to the facility, equipment and/or process. For isocyanates, engineering controls mainly mitigate the risk of exposure by inhalation rather than other exposure routes.

Workplaces where isocyanates are to be used should be equipped with enclosures, such as spray booths, to contain vapours/mists and protect other workers using the space. The enclosures should also be designed with built-in ventilation to exhaust any remaining airborne isocyanates. Other important considerations involved in the safe use of spray booths include:

- Orienting spray booth exhausts to the outside, away from people and building air intakes
- Installing the appropriate filters and maintaining adequate air flow
- Providing sufficient make up air back into the spray booth so that no “dead” zones are present
- Scheduling planned preventative maintenance of the ventilation system

If a spray booth is not available, other types of engineering controls, such fume hoods, can also minimize exposure risks. Listed below are the precautionary measures that will allow for good containment of hazards in fume hoods:

- Fume hood sashes should be lowered to the correct height and be clear and free of cracks
- Cross drafts created from doors, windows, etc. should be minimized as much as possible
- Equipment/chemicals should be worked with at least 6 inches away from the face opening of fume hoods so that there is no obstruction of air moving into the hood.
- Fume hoods should not be overloaded with unnecessary tools, equipment, and materials. The presence of these substances may affect air flow within the fume hood.
- Any equipment placed inside the fume hood should be elevated off the hood surface to allow for air to flow easily around and under the equipment.
- Containers of chemical waste should be properly discarded and not stored inside fume hoods. The fume hood should not be used for the purpose of evaporating chemicals.
- Fume hoods should be audited annually, through UBC SRS, for proper airflow

Localized exhaust ventilation (LEV) systems are another form of engineering control and may be used to protect against isocyanate exposure depending on the type of work being done. LEV’s are designed to capture contaminants close to the source so they don’t enter the breathing zone of workers. Capturing hoods and downdraft tables are examples of LEV’s.

8.3 Administrative

Administrative controls aim to minimize exposure to isocyanates through the use of work methods and work procedures.

All individuals working with products containing isocyanates must be trained on its safe use, handling, and storage. Individuals must also be educated on the hazards and risks associated with isocyanate exposure and should identify and disclose any harmful situations to their supervisor. More details on the expectations surrounding education and training will be described in a section below.

Additional examples of administrative controls include:

- Developing Safe Work Procedures for the specific work to be done with isocyanates. Note: this ECP should be used a guidance document but does not replace the need for site or process specific safe work procedures.
- Practicing good hygiene principles such as regular handwashing and no eating/drinking in workspaces where isocyanate containing products are being used
- Proper storage & labelling of isocyanate containing products and ensuring SDS sheets are available & accessible
- Restricting access to areas where isocyanates are being used for unprotected workers. Unprotected workers should not be allowed within 8 meters of any indoor work zone where polyurethanes are being used or 3 meters of an outdoor work zone.
- Planning & scheduling work to minimize the number of employees inside the spray booth
- Cleaning spills as per spill clean up instructions
- Reporting any isocyanate exposures into UBC CAIRS
- Posting warning signs in the work area
- Ensuring adequate supervision is provided to workers
- Air monitoring for worker exposure to isocyanates, when necessary

8.4 Personal Protective Equipment (PPE):

When working with isocyanates, the use of PPE should be considered, alongside the other more effective controls mentioned above, to help further reduce an individual's exposure. As isocyanates are a known dermal and respiratory sensitizer, proper personal protective equipment will help in achieving the ALARA principles. Examples of personal protective equipment include:

- Face shields with goggles for eye protection if a full-face respirator is not being used
- Chemical resistant gloves (ie. nitrile, butyl)
- Closed toed fitted boots
- Lab coats, aprons or overalls to protect the arms and legs – preferably disposable

A designated location should be setup, separate from eating areas, where personal protective equipment can be removed and stored. Contaminated personal protective equipment should not leave the worksite.

Full-face air supplying respirators, that are NIOSH approved, should be used for protection against isocyanates that are being sprayed as high airborne concentrations of isocyanates can result from this task. Any respirator used in the workplace must meet the selection, fit testing, maintenance, and inspection

criteria addressed in section 8.37 of the OHSR. The breathing air that is provided for air supplying respirators needs to meet the requirements outlined in CSA Standard Z180.1 "Compressed breathing air and system". A NIOSH approved respirator with organic vapor, acid gas, and particulate cartridge filter combination should be used for all other non-spraying polyurethane tasks such as applying isocyanates using a roller or brush. Cartridge/filters should be replaced after every shift. All respirators should be properly wiped down and cleaned after use.

Please note that before any tight-fitting respirators are used, individuals must successfully pass a fit test to ensure the respirator forms a tight seal around the face so that contaminants cannot enter the breathing zone. More information on respirator fit testing and the registration process can be found at: SRS Respiratory Safety.

9. Education and Training

Prior to performing activities where isocyanate exposures might occur, workers must receive suitable education and training to a level of demonstrated competency. Education and training should include:

- Identification of tasks and areas where isocyanate exposure may take place
- Hazards and risks associated with exposure to isocyanates
- Signs and symptoms of isocyanate exposure
- Isocyanate exposure mitigation controls
- Proper use of safety equipment and control systems (e.g. spray booths / respirators)
- Proper use, care, and maintenance of respirators and other PPE
- Effects of cross contamination (e.g. using contaminated gloves to touch personal items such as phones, pens, notebooks etc.)
- Complete a respirator fit test prior to the first use of the tight-fitting respirator and at a minimum on an annual basis thereafter
- How to seek first aid and report isocyanate exposure

Records of attendance, training dates, and training material provided to workers must be documented and retained.

10. Hygiene Facilities

Refer to the product SDS sheet to determine specifics for emergency procedures. Ensure an eye wash station and shower are available should isocyanates come into contact with the eyes or skin. Both the eye wash station and shower must be inspected and maintained in accordance with WorkSafeBC regulations. Work or lab clothes should always be kept separate from street clothing and should not be taken home. Clothing that is heavily contaminated with isocyanates needs to be immediately removed and disposed of. Otherwise, clothing should be laundered before re-use. Finally, proper hand washing should take place prior to taking breaks, eating, or leaving the workplace.

11. Health Monitoring

Health monitoring, also referred to as medical surveillance, is a type of administrative control that may be required if workers are exposed to isocyanates. Health monitoring is done to determine the intake of a chemical into the body by measuring the chemical, or a breakdown product of the chemical, in a biological sample. Alternatively, medical surveillance may consist of a visual examination of the body.

The implementation of medical surveillance will be dependent on how isocyanates are being used in the workplace and if control measures are already in place. Health monitoring can establish a baseline from which to assess changes that may develop in an individual at a future date. Should changes that are consistent with the health effects of isocyanate exposure be detected, steps of further intervention can be investigated. Contact UBC Occupational & Preventative Health (OPH) for further information on health monitoring.

If needed, health monitoring for isocyanates may involve one of more of the below assessments by a qualified medical practitioner:

- A physical examination of the skin
- Respiratory function testing
- Urinary metabolite testing
- Blood work

Depending on the type of monitoring done, and the species of isocyanate being used, the results from the assessment could be compared to limits established for biological exposure by the American Conference of Governmental Industrial Hygienists.

First aid may be required if workers are exposed to isocyanates. Workplace exposure to isocyanates must be immediately reported to the supervisor, inputted into UBC Centralized Accident/Incident Reporting System (CAIRS), and followed up with the appropriate incident/accident investigation. If necessary, the physician at UBC OPH may also be notified for further health assessments.

12. Documentation and Record Keeping

Documentation associated with isocyanates should be maintained by the respective department. This documentation includes, but is not limited to:

- Isocyanate ECP and safe work procedures
- Isocyanate education and training records
- First aid records pertaining to isocyanate exposures
- Incident/accident investigation reports pertaining to isocyanate exposures
- WorkSafe BC inspection reports, if applicable
- Respirator fit test records
- Toolbox talk records
- Safety meeting minutes

13. Program Review

The Isocyanate ECP will be reviewed and updated as needed by Safety & Risk Services and UBC stakeholders to include any necessary changes.

14. References

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