

A Guide to Occupational Exposure to Isocyanates



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This guide is the fourth in a series of industry guides focused on the Health Hazards Special Emphasis Program. It is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.

The information in this guide was updated in 2013.

To obtain additional copies of this guide, or if you have questions about North Carolina occupational safety and health standards or rules, please contact:

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Additional sources of information are listed on the inside back cover of this guide.

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Foreword

Isocyanates, especially diisocyanates, are widely used in the manufacture of flexible and rigid foam, adhesives, fibers and coatings. Today we know that employees who use or work with unreacted isocyanate compounds can experience health effects, including skin and respiratory irritation, following exposure to these substances in the workplace that can result in future allergic reactions. To protect workers from exposure to isocyanates, employers are required to limit employee exposure to these substances.

A Guide to Occupational Exposure to Isocyanates examines the workplace requirements for safely working around substances containing unreacted isocyanates. The potential threat that airborne isocyanates can pose to workers' health is also examined.

In North Carolina, the N.C. Department of Labor enforces the federal Occupational Safety and Health Act through a state plan approved by the U.S. Department of Labor. NCDOL offers many educational programs to the public and produces publications to help inform people about their rights and responsibilities regarding occupational safety and health.

When reading this guide, please remember the mission of the N.C. Department of Labor is greater than just regulatory enforcement. An equally important goal is to help citizens find ways to create safe workplaces. Everyone profits when managers and employees work together for safety. This booklet, like the other educational materials produced by the NCDOL, can help.

Cherie Berry
Commissioner of Labor

Note

This guide is intended to provide a generic overview of the standard-related topic and is not intended to alter or determine compliance responsibilities.

Generally speaking, Part 1910 standards apply to general industry, Part 1926 standards apply to the construction industry, and Part 1915 standards apply to shipyards. However, in instances where there are gaps in coverage, standards may apply across boundaries.

This guide discusses the occupational safety and health standards relevant to employee exposure to isocyanates. Provisions that are not applicable to all industry settings are identified within the text of this guide. **It is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.**

What Are Isocyanates?

Isocyanates are a group of highly reactive, low molecular weight compounds that contain the isocyanate group, $-N=C=O$. They react exothermically (i.e., producing heat) with the hydroxyl ($-OH$) groups in alcohols, to produce compounds containing the carbamate ($-NHCOO-$) group, which is commonly referred to as a *urethane*.

Isocyanates are the raw materials that make up all polyurethane products. Jobs that may involve exposure to isocyanates include painting, foam-blowing, and the manufacture of many polyurethane products, such as chemicals, polyurethane foam, insulation materials, surface coatings, car seats, furniture, foam mattresses, under-carpet padding, packaging materials, shoes, laminated fabrics, polyurethane rubber, and adhesives, and during the thermal degradation of polyurethane products.

Health effects of isocyanate exposure include irritation of skin and mucous membranes, chest tightness, and difficult breathing. Isocyanates include compounds classified as potential human carcinogens and known to cause cancer in animals. The main effects of hazardous exposures are occupational asthma and other lung problems, as well as irritation of the eyes, nose, throat and skin.

Sources of Occupational Exposure to Isocyanates

Exposure to isocyanates can occur in the following industries:

- Automotive: paints, glues, insulation, sealants and fiber bonding, truck bed lining
- Casting: foundry cores
- Building and construction: sealants, glues, insulation material, fillers
- Electricity and electronics: cable insulation, PUR® coated circuit boards
- Mechanical engineering: insulation material
- Paints: lacquers
- Plastics: soft and hard plastics, plastic foam and cellular plastic
- Printing: inks and lacquers
- Timber and furniture: adhesive, lacquers, upholstery stuffing and fabric
- Textile: synthetic textile fibers
- Medical care: PUR casts
- Mining: sealants and insulating materials
- Food industry: packaging materials and lacquers

(List taken from International Consensus Report on Isocyanates, 2001 (Reference 3).)

Additional industry sectors where occupational exposure to isocyanates is known to occur can be found in Appendix A of this document. Some of the more common isocyanate compounds used in industry are listed in Table 1.

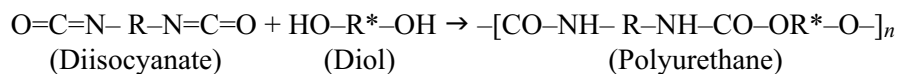
Table 1.
Some Commonly Used Isocyanates

Chemical Name and Formula	CAS No. ¹	Synonyms and Trade Names
Methyl isocyanate C_2H_3NO CH_3NCO	624-83-9	MIC
Methylene bisphenyl isocyanate $C_{15}H_{10}N_2O_2$ $CH_2(C_6H_4NCO)_2$	101-68-8	4,4-Methylene disphenyl diisocyanate; 4,4'-Diphenylmethane diisocyanate; MDI; Methylene bis(4-phenyl isocyanate); Methylene di- <i>p</i> -phenylene ester of isocyanic acid
Hexamethylene diisocyanate $C_8H_{12}N_2O_2$ $OCN(CH_2)_6NCO$	822-06-0	1,6-Diisocyanatohexane; HDI; Hexamethylene-1,6-diisocyanate; 1,6- Hexamethylene diisocyanate; HMDI
Toluene-2,4-diisocyanate $C_9H_6N_2O_2$ $CH_3C_6H_3(NCO)_2$	584-84-9	TDI; 2,4-TDI; 2,4-Toluene diisocyanate

1. Chemical Abstracts Service number provided for information purposes only.

A Brief Lesson in Organic (and Polymer) Chemistry

When a diisocyanate (a compound containing two isocyanate groups) reacts with a polyol (a compound with more than one hydroxyl group), the result is the formation of a type of polymer, which is referred to as a *polyurethane*.



where the urethane group $-[CO-NH-R-NH-CO-OR^*-O-]$ is repeated n times in the polymer, based on the amount of each reactant used.

R can be an aliphatic group (e.g., $[CH_2]_6$ as in HMDI), cycloaliphatic group (e.g., isophorone diisocyanate) or an aromatic ring group (e.g., C_7H_6 as in 2,4-TDI). **R*** is typically an open chain structure (e.g., CH_2 or $[CH_2]_3$).

This reaction is usually done in the presence of a chemical catalyst, such as a tertiary amine compound, that does not become part of the resulting polymer but aids the reaction in forming a polyurethane at a reasonable rate and yield.

The diisocyanate, in turn, can be synthesized from the corresponding diamino (having two $-NH_2$ groups) compound, $H_2N-R-NH_2$, by reacting it with phosgene, $Cl-C(O)-Cl$, a highly toxic agent.

Because the term “isocyanate” is often used to refer to a *diisocyanate*, the use of the term “isocyanate” in this document will refer to “diisocyanate” unless otherwise specified.

Health Effects of Exposure to Isocyanates

Methyl isocyanate (MIC), listed in Table 1, is a Class 1B flammable liquid (flash point 19°F, boiling point 102–104°F) and is highly toxic. MIC is used as an intermediate in the manufacture of carbamate pesticides, such as carbaryl (Sevin), carbofuran (Furadan, Curater), methomyl and aldicarb (Temik). It is also the chemical responsible for the deaths of more than 3,700 people in Bhopal, India, following a massive release from a chemical plant in December 1984.

Other isocyanates, such as TDI, are powerful irritants to the mucous membranes of the eyes and gastrointestinal and respiratory tracts. Direct skin contact can also cause marked inflammation.

Isocyanates can also sensitize workers, making them subject to severe asthma attacks if they are exposed again. Death from severe asthma in some sensitized subjects has been reported. Workers potentially exposed to isocyanates who experience persistent or recurring eye irritation, nasal congestion, dry or sore throat, cold-like symptoms, cough, shortness of breath, wheezing, or chest tightness should see a physician knowledgeable in work-related health problems.

Case Reports

The following six case reports from NIOSH (see reference 4) highlight examples of occupational asthma, other respiratory disease, and death resulting from exposure to isocyanates.

1. Spray Painting (One Death)

A 37-year-old male, self-employed car painter was admitted to the hospital with asthma symptoms that first developed five years earlier and were thought to be related to his occupation. He had been working in the same environment for more than 20 years.

The car painter was diagnosed with occupational asthma induced by isocyanates and advised to change his job or avoid the use of polyurethane paints. He nevertheless continued to work as a car painter using medications such as bronchodilators and steroids to treat his asthma.

Six years later, he was spraying a car with a two-component polyurethane paint while wearing a mask when he developed severe, prolonged asthma. His symptoms continued at night despite medication. He returned to work, sprayed the polyurethane paint again, and developed severe asthma, which required emergency treatment. However, he died in the ambulance en route to the hospital. The manufacturer reported that the paint contained small amounts of TDI, and a chemical analysis confirmed the presence of TDI mixed with solvents.

2. Highway Spill

Two police officers who were in the immediate vicinity of an overturned tank car developed asthma-like illness following a single exposure to TDI. After briefly directing traffic at the accident scene, both officers received medical care for severe symptoms, including burning eyes, throat irritation, cough, chest tightness, and difficult breathing. Treatment included steroids and a bronchodilator.

Both police officers developed a chronic bronchospastic disorder after their relatively brief exposure to high concentrations of TDI. Though considerable improvement occurred in both cases, symptoms persisted.

3. Spray Painting

Occupational asthma was reported in nine workers in the paint shops of a large assembly plant. Of the nine affected workers (males aged 23 to 59), six had significantly reduced lung function after using paint that contained isocyanates. The duration of exposure to isocyanates for workers in the paint shops ranged from three to five years.

4. Isocyanate Foam Operation (One Death)

A maintenance worker became ill after repairing an MDI foaming system at a plant that manufactured artificial plants with polyurethane foam bases. The worker later suffered recurrent bouts of respiratory illness.

After showing further respiratory symptoms associated with isocyanate exposure, the worker quit his job but continued to experience coughing and progressive loss of lung function. His illness was eventually complicated by productive cough, weakness, sweats, muscle aches and shortness of breath. He eventually died.

Worksite evaluations found detectable air concentrations of MDI and inadequate ventilation systems in the foaming areas. Vapors and aerosols were observed rising into the faces of employees working with the foam. Skin contact with the curing foam was also noted during the survey.

5. Wood Products Manufacturing

Ten workers at an engineered wood products plant developed occupational asthma from exposure to MDI. The workers were employed one to eight months at the plant before their diagnosis of occupational asthma. None of the 10 workers reported pre-existing asthma.

Respiratory symptoms included chest tightness, wheezing and coughing at night. Six workers reported a relationship between symptoms and work: they either reported improved symptoms while away from work or increased symptoms on their first day back at work. Eight workers showed a decline in lung function over the workweek or over their period of employment, or they showed increased lung function after treatment with a bronchodilator.

All 10 workers reported respiratory symptoms when they were in areas where MDI was used. The physician who examined the 10 workers recommended that they be removed from areas where exposure to MDI might exist.

6. Isocyanate Roofing Foam

Isocyanate exposure has also occurred at nonindustrial worksites such as public schools. Thirteen of approximately 85 staff members from a middle school were reported to have asthma with an estimated 21 additional cases possible. It was determined that large quantities of polyurethane foams and isocyanate coating materials had been applied to the school roof on several occasions. School staff members reported odors during roofing application, suggesting possible exposures to roofing materials that included isocyanates. Air sampling conducted later during a test pouring of the roofing materials at another location indicated the release of isocyanates during roofing and a potential for exposure.

These case reports demonstrate the importance of communicating information regarding the hazards of isocyanate-containing substances to employees and to employers of other employees on multi-employer worksites. They also show the importance of implementing proper engineering controls and work practices, as well as the need for appropriate personal protective equipment—in particular, respirators—when working with processes that involve the use of isocyanates. The remaining sections of this document that follow discuss the provisions of OSH standards, as well as general recommendations, that are applicable to worker exposure to isocyanates.

Exposure Monitoring and Control

Permissible Exposure Limits

There are currently no chemical-specific standards that regulate worker exposure to isocyanates. However, exposure levels for some of the isocyanates have been set and are included in the air contaminant standards for general industry (29 CFR 1910.1000), construction (29 CFR 1926.55) and shipyards (29 CFR 1915.1000) and are identical for these major industry groups.

Unless otherwise specified by a (C) designation, the permissible exposure limit (PEL) for a specific substance listed in Table 2 below is an eight-hour time-weighted average. The (C) designation denotes a ceiling limit that is never to be exceeded at any moment. Where marked with an “X” in the column labeled “Skin,” absorption through the skin also constitutes a major route of exposure for that substance.

Table 2.

Permissible Exposure Limits for Isocyanates

Chemical Name	CAS No. ¹	PEL		
		Parts per million (ppm)	Milligrams per cubic meter (mg/m ³)	Skin
Methyl isocyanate (MIC)	624-83-9	0.02	0.05	X
Methylene bisphenyl isocyanate (MDI)	101-68-8	(C) 0.02	(C) 0.2	--
Hexamethylene diisocyanate ³ (HMDI)	822-06-0	--	--	--
Toluene-2,4-diisocyanate (2,4-TDI)	584-84-9	(C) 0.02	(C) 0.14	--
Toluene-2,6-diisocyanate ² (2,6-TDI)	91-08-7	--	--	--

1. Chemical Abstracts Service number provided for information purposes only.
2. Toluene-2,6-diisocyanate often occurs as an impurity in the synthesis (manufacture) of toluene-2,4-diisocyanate and is a structural isomer of 2,4-TDI.
3. NIOSH REL (Recommended Exposure Level): TWA 0.005 ppm, C 0.020 ppm.

Exposure Assessment

Employers who have a workplace or work operations where workers use or are exposed to compounds containing isocyanates should ensure that employees are not exposed above mandated—or in the absence of such, recommended—exposure level(s). To achieve this, employers should assess all work operations for their potential to generate airborne isocyanate exposure, including spraying operations.

Where respirators are identified as necessary to protect against inhalation of isocyanates, the exposure assessment should be sufficient to permit the employer to select and provide a respirator that meets the requirements of the Respiratory Protection Standard, 29 CFR 1910.134, and provides an appropriate level of protection to the employee. To accomplish this, employers can use personal monitoring results, historical monitoring data, objective data or a combination of these.

Personal Monitoring

When personal monitoring is chosen to establish an exposure assessment, a sufficient number of samples should be collected in the breathing zone of each sampled employee to fully characterize the full shift exposure to the isocyanates present. The most thorough way to do this is by sampling a representative number of employees in each job classification on every shift where employees may be exposed and without regard to any use of respiratory protection.

Additional Monitoring

Employers should conduct additional exposure assessments, (e.g., personal monitoring) when a change occurs in the production process, raw materials, equipment, personnel, work practices or control methods that could result in new or additional exposures to isocyanates or when the employer believes new or additional exposures may have occurred. The following example demonstrates circumstances in which an employer might conduct additional monitoring.

Example: Initial monitoring of the spray application of truck bed liners for a low-pressure application process was done for a two-component spray system containing 30 percent MDI. The company later switched to a two-component system that uses 45 percent MDI. In this example, the monitoring done for the previous application process would underestimate the level of exposure using the new, higher concentration two-component system.

Regulated Areas

Although there are no substance-specific standards regarding occupational exposure to isocyanates, employers are encouraged to establish a regulated area to warn employees about work areas where levels of airborne isocyanates exceed, or may be expected to exceed, the PEL or another relevant exposure limit. Additionally, the Hazard Communication Standard (29 CFR 1910.1200) requires employers to inform their employees about the hazards of any chemical substances that they may use or to which they may be exposed. Employers are further required to convey this information to other employers or contractors whose employees may also be affected.

Demarcation of the area can be done using warning signs, gates, ropes, barricades, lines, textured flooring or any other method that may be appropriate. The standard regarding specifications for accident prevention signs and tags, 29 CFR 1910.145, can be used as guidance for developing appropriate warning signs.

The choice of warning method should effectively caution unauthorized workers not to enter the area. (Authorized personnel are those employees whose job duties require them to be in the area and may include maintenance personnel, managers and quality control engineers.) In addition, designated worker representatives may enter the regulated area to observe exposure monitoring. However, all people who enter the regulated area must use proper protective equipment, including respirators, when necessary or required.

Control Measures

When exposures to isocyanates exceed the PEL, employers must use engineering and work practice controls to reduce and maintain exposures to or below the corresponding PEL. When feasible engineering and work practices controls have been used to reduce airborne exposures to isocyanates to the lowest levels achievable but the levels remain above the PEL, employers must supplement them with respirators that are used in compliance with the requirements of the Respiratory Protection Standard, 29 CFR 1910.134, as discussed below.

Engineering controls include substitution (using a less toxic material or process that results in lower exposures), isolation (enclosing the source of exposure), and ventilation (such as local exhaust ventilation near the source of the exposure).

Work practice controls involve making adjustments in the way a task is performed. Workers must know the best practices when performing a task so that they minimize their exposure and maximize the effectiveness of the control. For example, workers spraying foam insulation should be trained to position themselves upstream from the direction of spraying and the source of local exhaust ventilation, where feasible. This example shows how work practice controls can complement engineering controls in providing worker protection.

Respiratory Protection

Employers are required to provide respirators to employees when engineering and work practice controls are not sufficient to maintain employee exposure to isocyanate compounds at or below the PEL. Respirators are specifically required during:

- Work operations where engineering and work practice controls are not feasible (e.g., maintenance and repair activities) to maintain exposures below the PEL;
- Periods necessary to install or implement feasible engineering and work practice controls;
- Operations where all feasible engineering and work practice controls have been implemented but are not sufficient to reduce exposures to or below the PEL; or
- Emergencies (i.e., an occurrence that results, or is likely to result, in uncontrolled release of isocyanates that is not an incidental release that can be controlled by employees in the immediate area or by maintenance personnel).

Where respirator use is required or necessary, the employer must establish a respiratory protection program that meets the requirements of the Respiratory Protection Standard, 29 CFR 1910.134, and provide the employee with a respirator having an appropriate assigned protection factor.

When choosing respirators for protection against isocyanates, employers must consider that there are few air purifying respirator cartridges and canisters available that have end-of-service life indicators (ESLI) and there are none available for isocyanates. Furthermore, many diisocyanates have poor warning properties with odor threshold levels (e.g., 2,4-TDI, 0.17 ppm; MDI, 0.4 ppm) that are several times the PEL. This means that the employee may already be overexposed if they can smell the isocyanate. Because of the poor warning properties of isocyanates, a more protective type of respirator is recommended. These respirators include any self-contained breathing apparatus with a full facepiece operated in a pressure-demand or other positive-pressure mode, and any supplied-air respirator with a full facepiece operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode. However, in situations where their use is not feasible and the use of an air-purifying respirator is permissible, employers must ensure that cartridges and canisters are replaced at intervals recommended by the respirator manufacturer and before the end of their service life.

The N.C. Department of Labor has prepared a publication (*Industry Guide #44: A Guide to Respiratory Protection*) to assist employers in understanding and meeting the requirements of this standard. In addition, a sample respiratory protection program can be accessed by going to http://www.nclabor.com/osha/consult/sample_programs.htm.

Medical Surveillance

Medical surveillance serves several purposes when considering worker exposure to isocyanates. It allows physicians or other healthcare professionals to determine if an individual can be exposed to isocyanates at their workplace without experiencing adverse health effects. It permits appropriate intervention to be taken when isocyanate-related adverse health effects are identified in an individual. Finally, it determines an employee's fitness to use personal protective equipment, in particular, respirators.

A medical surveillance program should be provided for all employees who:

- Are exposed or may be exposed to isocyanates at concentrations at or above the PEL or TLV;
- Experience signs and symptoms of adverse health effects associated with isocyanate exposures; or
- Are exposed in an emergency situation (i.e., any occurrence resulting in an uncontrolled release of isocyanates that is not an incidental release that can be controlled by workers in the immediate area or by maintenance personnel).

What are some signs and symptoms of exposure to diisocyanates? Exposure to diisocyanates can exert health effects as the result of irritation of the eyes and nose, through skin contact and by inhalation. Acute exposure to diisocyanates through inhalation can lead to occupational asthma. Chronic exposure through inhalation of diisocyanates can lead to hypersensitivity. A medical questionnaire suitable for use in evaluating the health impact of isocyanates on workers can be found in Appendix B.

Employers are not currently required to pay for the cost of medical evaluations associated with isocyanate exposure except as required by an applicable standard. These standards include the Respiratory Protection Standard, 29 CFR 1910.134, the Process Safety Management Standard, 29 CFR 1910.119, and the Occupational Exposure to Hazardous Chemicals in Laboratories ("Laboratory") Standard, 29 CFR 1910.1450.

Protective Work Clothing and Employee Training

Because isocyanates can also produce health effects resulting from contact with the eyes or skin, the employer must also provide appropriate protective clothing and equipment whenever contact with isocyanates poses or is likely to pose a hazard to workers. Some examples of protective clothing and equipment that may be necessary include, but are not limited to, gloves, aprons, coveralls, foot coverings and goggles.

The general requirements for personal protective equipment, as found in 29 CFR 1910.132, requires each employer to conduct a job hazard assessment for the purpose of identifying hazards that require the use of personal protective equipment (PPE). The employer must also verify by written certification that the job hazard assessment was done. The job hazard assessment certification must identify the workplace evaluated, the person who conducted the hazard assessment, the date(s) on which it was conducted, and that the document is a certification of hazard assessment. In addition, the employer must train employees in the proper use of PPE and ensure that they use it when exposed or potentially exposed to diisocyanates.

Where such hazards are present, the employer must select and provide PPE at no cost that is appropriate to protect employees against the identified hazards. In particular, attention must be made to the potential for exposure to isocyanates through skin contact. To prevent skin contact, the employer must ensure that the protective clothing chosen will prevent contact, either directly or by soaking through to the skin. Where the potential for contact with the hands can occur, the employer must provide gloves of an appropriate type that will not degrade in the presence of the chemical(s) used and will resist permeation of the chemical through the glove material. Many manufacturers of chemical-resistant gloves provide charts that indicate the suitability of glove materials for use with individual chemicals or classes of chemicals.

Housekeeping

The removal of residue following spray application of isocyanates is necessary to ensure that combustible residue is not allowed to accumulate and become a fuel source for fires. The standard on spray finishing using flammable and combustible materials (29 CFR 1910.107) requires that all spraying areas be kept as free as practical from accumulations of combustible residue. If necessary, this must be done on a daily basis. Combustible residue must be immediately removed from the premises and properly disposed after it has been removed. In addition, spray finishing operations that involve the use of dual components, such as application of diisocyanates with polyols or polyesters, must be conducted in approved sprinklered spray booths.

Proper housekeeping is also important in removing a potential source of employee exposure to airborne diisocyanates. Residue from polyurethanes that has been trimmed off immediately following spray application but allowed to remain may not be completely “cured.” As a result, unreacted diisocyanates can “off gas” and present an inhalation hazard as well as be an irritant to the eyes and nose of exposed workers. Maintaining working surfaces as free as practicable from isocyanate-containing residues is also important in preventing employee sensitization to isocyanates through direct contact.

Employee Training and Communication

In addition to training regarding the proper use of personal protective equipment, employers must inform employees about the hazards associated with exposure to isocyanates and understand the necessary measures they can take to protect themselves. Through a comprehensive hazard communication program, as required by the Hazard Communication Standard (29 CFR 1910.1200), employers must provide employees with the information and training regarding labels and safety data sheets (SDS).

In particular, employers must ensure that employees who are exposed to isocyanates are trained in and have access to the following information:

- ✓ The specific nature of the operations in their workplace where exposure may occur;
- ✓ SDSs for chemicals containing isocyanates;
- ✓ Signs and symptoms of isocyanate exposure;
- ✓ Importance of avoiding skin contact when working with isocyanates;
- ✓ Engineering controls implemented to reduce employee exposure to isocyanates;
- ✓ Specific work practices to use to reduce isocyanate exposures;
- ✓ Use of appropriate PPE, including respirators and skin protection;
- ✓ Methods used to detect the presence of isocyanates in the workplace, such as workplace monitoring; and
- ✓ The results of industrial hygiene sampling conducted for isocyanate exposure levels.

4

Recordkeeping

Why do employers need to maintain records regarding occupational exposure to isocyanates? Accurate records can verify employer compliance with applicable isocyanate PELs and can assist in diagnosing and identifying workplace-related illnesses. In addition to records required by specific standards that apply to occupational exposure to isocyanates, such as 29 CFR 1910.134(m), additional types of records may be generated regarding employee exposure to isocyanates. These include records of employee exposure assessments (air monitoring data, historical monitoring data and objective data, and safety data sheets) and medical surveillance records.

Employee Exposure Records

In accordance with the requirements of 29 CFR 1910.1020, *Access to Employee Exposure and Medical Records*, employers are required to maintain records of employee exposure to isocyanates for at least 30 years. Employee exposure assessments used to comply with the Air Contaminants Standard, 29 CFR 1910.1000, or the Respiratory Protection Standard, 29 CFR 1910.134, typically consist of data obtained from representative employee sampling. However, it can also consist of historical monitoring data, objective data or a combination of all three.

Air Monitoring Data

The record of air monitoring should include:

- The date of measurement for each sample taken;
- The operation involving exposure to isocyanates that was monitored;
- Sampling and analytical methods used and evidence of their accuracy;
- The number, duration and results of samples taken;
- The type of protective devices used (e.g., type of respirators worn); and
- The name and job classification of all workers represented by the monitoring and specifying which employees were actually monitored.

Historical Monitoring Data

When an employer relies on historical monitoring data to determine worker exposure to isocyanates, an accurate record of the historical monitoring data must be maintained. Appropriate information might include:

- That data were collected using validated methods;
- That the processes and work practices, characteristics of the isocyanate-containing material, and environmental conditions at the time the data were obtained were essentially the same as those of the job for which current exposure is being determined; and
- Any other relevant data regarding operations, materials, processes or work exposures.

Objective Data Records

Where employers use objective data to demonstrate compliance with the Air Contaminants Standard, they must keep an accurate record for as long as it is relied upon. The record must include:

- The isocyanate-containing material in question;
- The source of the objective data;
- The testing protocol, test results and analysis of the material for release of isocyanates;
- A description of the process, operation or activity and how the data support the determination; and
- Other data relevant to operations, materials, processes or employee exposures.

Employers must make exposure records available when requested by affected employees, former employees, their designated representatives, and the commissioner of labor or designee.

Medical Surveillance Records

As required by 29 CFR 1910.1020, employers must keep all medical surveillance records for the duration of the employee's employment plus 30 years. Employee medical records include:

- The employee's name (and unique identifier, if required);
- The employee's medical examination results, including the medical history, questionnaires, responses, test results and physician's recommendations;
- The written opinions of the physician or licensed healthcare professional (PLHCP);
- Any employee medical complaints related to isocyanate exposure; and
- A copy of the information provided to the examining PLHCP (i.e., a description of the worker's duties as they relate to occupational isocyanate exposure; worker's isocyanate exposure levels; a description of PPE used by the worker; and information from previous employment-related medical examinations).

Employee medical surveillance records must be available to the subject employee, anyone having specific written consent of that employee, and the commissioner of labor or designee.

Glossary

The following terms are used in this document but are not elsewhere defined:

Aliphatic: One of the major groups of organic compounds characterized by straight- or branched-chain arrangement of carbon atoms.

Aromatic: A major group of unsaturated cyclic hydrocarbons containing one or more rings; these are typified by benzene.

Assigned protection factor (APF): The workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by the Respiratory Protection Standard.

Bronchospastic: Spasmodic contraction of the bronchial muscles resulting in constriction of the air passages of the lung (as in asthma).

Diisocyanates (Monomers): The difunctional isocyanate species from which polyisocyanates and polyurethanes are derived. Common examples of monomeric isocyanates include 1,6-hexamethylene diisocyanate (HDI), 2,4- and 2,6-toluene diisocyanate (TDI) and 4,4'-diphenylmethane diisocyanate (MDI).

End-of-service-life indicator (ESLI): An ESLI is a mechanism for warning the user that a respirator is approaching the end of its ability to provide protection. The warning appears on the cartridge itself. For example, after a period of use, an indicator on a cartridge with sorbent material will signal that protection against organic vapors is approaching saturation or is no longer effective. NIOSH has approved ESLIs for only four cartridges or canisters (mercury vapor, carbon monoxide, ethylene oxide and hydrogen sulfide).

Exposure or occupational exposure: Exposure to airborne contaminants that would occur if the employee were not using a respirator.

Intermediates: Species possessing free isocyanate groups, formed during use of isocyanate product by partial reaction of the isocyanate species with a polyol.

Permissible exposure limit (PEL): An exposure limit that is published and enforced by OSHA as a legal standard. The air contaminants standard has PELs listed for only a few isocyanate and diisocyanate compounds.

Polymer: A macromolecule formed by the chemical union of five or more identical combining units called monomers. The polymer that results from the reaction of a diisocyanate with a diol or polyol is called a polyurethane.

Prepolymers: Chemical species or intermediates that have free isocyanate groups, which are available for further reaction, and are prepared by the reaction of a polyol with excess of di- or polyisocyanates.

Respirator: Any device designed to provide the wearer with respiratory protection against inhalation of a hazardous atmosphere. Respirators used in addition to engineering and work practice controls to protect employees from overexposure to diisocyanates must be NIOSH certified.

Tertiary amine: One of a class of organic compounds of nitrogen in which the three hydrogen atoms of ammonia (NH₃) have been replaced with alkyl (aliphatic) groups.

Time-weighted average (TWA): The average exposure level determined from samples, taken for different time periods, throughout a workday. The TWA is determined by multiplying each sample by the time the sample was taken, adding these results and dividing this sum by the total sampling time. Where the TWA is compared to an eight-hour PEL (or AL), the sum is divided by eight hours or 480 minutes, depending on the units of time used.

Unsaturated: Not having all available valence bonds satisfied; in such compounds the extra bonds usually form double or triple bonds, chiefly with carbon.

Standards Applicable to Isocyanate Exposure in General Industry

29 CFR 1910.107	Spray finishing using flammable and combustible materials
29 CFR 1910.119	Process safety management of highly hazardous chemicals
29 CFR 1910.132–.138	Personal protective equipment
29 CFR 1910.132	General requirements—including job hazard analysis and training
29 CFR 1910.133	Eye and face protection
29 CFR 1910.134	Respiratory protection
29 CFR 1910.138	Hand protection
29 CFR 1910.141	Sanitation
29 CFR 1910.145	Accident prevention signs and tags
29 CFR 1910.151	Medical services and first aid
29 CFR 1910.151(c)	(requirement to have eyewash)
29 CFR 1910.1000	Air contaminants
29 CFR 1910.1020	Access to employee exposure and medical records
29 CFR 1910.1200	Hazard communication
29 CFR 1910.1450	Occupational exposure to hazardous chemicals in laboratories
NCGS 95-129(1)	General Duty Clause of the Occupational Safety and Health Act of North Carolina

Standards Applicable to Isocyanate Exposure in Construction

29 CFR 1926.21	Safety training and education
29 CFR 1926.24	Fire protection and prevention
29 CFR 1926.25	Housekeeping
29 CFR 1926.25(b)	(requirement to remove combustible scrap and debris)
29 CFR 1926.50	Medical services and first aid
29 CFR 1926.50(g)	(requirement to have eyewash)
29 CFR 1926.51	Sanitation
29 CFR 1926.55	Air contaminants
29 CFR 1926.59	Hazard communication
29 CFR 1926.64	Process safety management of highly hazardous chemicals
29 CFR 1926.95-.106	Personal protective equipment (including extremities)
29 CFR 1926.102	Eye and face protection
29 CFR 1926.103	Respiratory protection
29 CFR 1926.200	Accident prevention signs and tags
29 CFR 1910.1020	Access to employee exposure and medical records
NCGS 95-129(1)	General Duty Clause of the Occupational Safety and Health Act of North Carolina

References

1. National Institute for Occupational Safety and Health (NIOSH), 1996. *Preventing Asthma and Death From Diisocyanate Exposure*. DHHS (NIOSH) Publication No. 96-111. Washington, D.C.: Superintendent of Documents.
2. Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention. *Toxicological Profile for Hexamethylene Diisocyanate*. September 1998. <http://www.atsdr.cdc.gov/>.
3. International Consensus Report on Isocyanates, 2001. <http://www.arbeidstilsynet.no/binfil/download2.php?tid=77871>.
4. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *A Summary of Health Hazard Evaluations: Issues Related to Occupational Exposure to Isocyanates 1989 to 2002*. January 2004. <http://www.cdc.gov/niosh/>.
5. National Toxicology Program, National Institutes of Environmental Health Sciences. *Report on Carcinogens*, 11th Edition. 2005. <http://ntp.niehs.nih.gov/go/16183>.
6. E. Brooks. OSHA Compliance Issues: Isocyanate Exposure in an Autobody Repair and Collision Center. *J. Occ. Environ. Hyg.* 3: D24-D27 (2006).

Additional Resources

Standards

Air Contaminants, 29 CFR 1910.1000 (General Industry)

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9991

Gases, vapors, fumes, dusts, and mists, 29 CFR 1926.55 (Construction)

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10628

Personal Protective Equipment—General Requirements, 29 CFR 1910.132

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777

Respiratory Protection, 29 CFR 1910.134

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716

Respiratory Protection—Appendix A (Fit Test Procedures)

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9780

Hand Protection, 29 CFR 1910.138

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9788

Hazard Communication, 29 CFR 1910.1200

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099

Spray Finishing Using Flammable and Combustible Materials, 29 CFR 1910.107

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9753

Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9760

Sample Programs

Hazard Communication (PDF)

<http://www.nclabor.com/osha/consult/sampleprograms/HAZCOM.pdf>

Hazard Communication (Word)

<http://www.nclabor.com/osha/consult/sampleprograms/HAZCOM.doc>

Respiratory Protection (PDF)

<http://www.nclabor.com/osha/consult/sampleprograms/RespiratoryProtection.pdf>

Respiratory Protection (Word)

<http://www.nclabor.com/osha/consult/sampleprograms/RespiratoryProtection.doc>

Operating Documents

Special Emphasis Program for Exposure to Health Hazards—OPN 135E

<http://www.nclabor.com/osha/compliance/publicopn/opn135e.pdf>

Publications

A Guide to Respiratory Protection

<http://www.nclabor.com/osha/etta/indguide/ig44.pdf>

Other Government Resources

NCDOL Isocyanates Topic Page

http://www.nclabor.com/osha/etta/A_to_Z_Topics/isocyanates.htm

OSHA Isocyanates Topic Page

<http://www.osha.gov/SLTC/isocyanates/index.html>

NIOSH Respiratory Protection Subject Index Page

<http://www.cdc.gov/niosh/topics/respirators/>

NIOSH Isocyanates Subject Index Page

<http://www.cdc.gov/niosh/topics/isocyanates/>

EPA—Spray Polyurethane Foam

http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html

EPA—Automotive Refinishing Partnership

<http://www.epa.gov/dfe/pubs/projects/auto/>

Nongovernmental Resources

International Isocyanate Institute

<http://www.diisocyanates.org/>

Center for the Polyurethanes Industry

http://www.polyurethane.org/s_api/index.asp

Appendix A

Industry Sectors Where Exposure to Isocyanates Is Known to Occur

Industry Sector	SIC	SIC Code Title	NAICS	NAICS Code Title
Electrical Work	1731	Electrical Work	238210	Electrical Contractors
Floor Laying	1752	Carpentry and Floor Work	238330	Flooring Contractors
Coated Fabrics	2296	Misc. Textile Goods	314992	Tire Cord and Tire Fabric Mills
Automotive Trimmings	2396	Misc Fabricated Textile Products	336360*	Motor Vehicle Seating and Interior Trim Manufacturing
Millwork	2431	Millwork, Veneer, Plywood	321911*	Wood Window and Door Manufacturing
Reconstituted Wood Products	2493	Misc. Wood Products	321219	Reconstituted Wood Product Manufacturing
Public Building Furniture	2531	Public Building and Related Furniture	336360*	Motor Vehicle Seating and Interior Trim Manufacturing
Drapery Hardware	2591	Misc. Furniture and Fixtures	337920	Blind and Shade Manufacturing
Commercial Printing	2759	Commercial Printing	323112*	Commercial Flexographic Printing
Paints, Varnishes, Lacquers, Enamels, and Allied Products	2851	Paints, Varnishes, Lacquers, Enamels, and Allied Products	325510	Paint and Coating Manufacturing
Rubber/Plastics Hose	3052	Gaskets, Packing, and Sealing Devices	326220	Rubber and Plastics Hoses and Belting Manufacturing
Molded, Extruded	3061	Fabricated Rubber Products, NEC	326291	Rubber Product Manufacturing for Mechanical Use
Plastics Foam Products	3086	Plastics Foam Products (urethane and other foam products)	326150	Urethane and Other Foam Product Manufacturing
Laminated Plastics	3083	Misc. Plastics Products	326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing
Fabricated Rubber Products, NEC	3069	Fabricated Rubber Products, NEC (except rubberized fabric and rubber resilient floor covering)	326299	All Other Rubber Product Manufacturing
Boat Building and Repairing	3732	Boat Building and Repairing (boat building)	336612	Boat Building
Automotive Trimmings, Apparel Finding, and Related Products	2396	Automotive Trimmings, Apparel Finding, and Related Products (textile motor vehicle trimming)	336360	Motor Vehicle Seating and Interior Trim Manufacturing
Plastic Plumbing	3088	Misc. Plastics Products	337215*	Showcase, Partition, Shelving, and Locker Manufacturing
Gray/Ductile Iron Foundries	3321	Iron and Steel Foundries	331511	Iron Foundries
Copper Foundries	3366	Nonferrous Foundries (Castings)	331525	Copper Foundries (except Die-Casting)

Industry Sector	SIC	SIC Code Title	NAICS	NAICS Code Title
Coating/Engraving	3479	Coating, Engraving, and Allied Services	332812*	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers
Industrial Valves	3491	Misc. Fabricated Metal Products	332911	Industrial Valve Manufacturing
Internal Combustion Engines	3519	Engines and Turbines	333618	Other Engine Equipment Manufacturing
	3519	Engines and Turbines	336399	All Other Motor Vehicle Parts Manufacturing
Air-Conditioning	3585	Refrigeration and Service Industry Machinery	333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing
Household Cooking	3632	Household Appliances	335222	Household Refrigerator and Home Freezer Manufacturing
Electronic Coils	3677	Electronic Components and Accessories	334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
Motor Vehicle Parts	3714	Motor Vehicle and Motor Vehicle Equipment	336322*	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing
Aircraft	3721	Aircraft and Parts	336411	Aircraft Manufacturing
Orthopedic	3842	Surgical, Medical, and Dental Instruments and Supplies	339999*	All Other Miscellaneous Manufacturing
Jewelry	3911	Jewelry, Silverware, and Plated Ware	339911	Jewelry (except Costume) Manufacturing
Mfg Industries, NEC	3999	Misc. Manufacturing Industries	326199*	All Other Plastics Product Manufacturing
Water Transportation	4449	Water Transportation of Freight, NEC	483211	Inland Water Freight Transportation
Transportation Services	4789	Misc. Services Incidental to Transportation	488999*	All Other Support Activities for Transportation
Electric Services	4911	Electric Services	221119*	Other Electric Power Generation
Gas and Other Services Combined	4932	Combination Electric and Gas, and Other Utility Services	221210	Natural Gas Distribution
Automotive Repair	7532	Automotive Repair Shops	811121	Automotive Body, Paint, and Interior Repair and Maintenance

*Multiple NAICS codes correspond to SIC code.

10. Please ask the worker the following questions regarding symptoms.

Symptom	Yes	No	If yes, approximately what date did you first notice symptoms?	Do your symptoms occur at work?	Do your symptoms improve when you are away from work such as while on vacation or on the weekends? <i>(Describe):</i>	Do you think your symptoms are brought on by any particular work activity, chemical exposure, or work area? <i>(Describe):</i>
Cough						
Wheezing						
Watery or itchy eyes						
Nose stuffiness or itching						
Skin rash or itching						
Shortness of breath						
Chest tightness						
Fever or chills						

(If worker answers **NO**, go to the next symptom. If the answer is **YES**, ask the questions across the row):

If the worker has been diagnosed with any work-related condition or has symptoms that may be associated with isocyanate exposure, consider obtaining a medical access order (MAO) or asking the worker to sign a medical release to obtain the medical records.

Other Comments:

OSH Publications

We provide a variety of OSH publications. These include general industry and construction regulations, industry guides that cover different OSH topics, quick cards, fact sheets and brochures that cover a wide variety of serious safety and health workplace hazards. Workplace labor law posters are available free of charge. To obtain publications, call toll free at 1-800-NC-LABOR (1-800-625-2267) or direct at 919-807-2875. You may view the list of publications and also download many of them at **www.nclabor.com/pubs.htm**.

Occupational Safety and Health (OSH) Sources of Information

You may call 1-800-NC-LABOR (1-800-625-2267) to reach any division of the N.C. Department of Labor; or visit the NCDOL home page on the World Wide Web: <http://www.nclabor.com>.

Occupational Safety and Health Division

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Local Telephone: 919-807-2900 Fax: 919-807-2856

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 3rd Floor)

For information concerning education, training, interpretations of occupational safety and health standards, and OSH recognition programs contact:

Education, Training and Technical Assistance Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2875 Fax: 919-807-2876

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 4th Floor)

For information concerning occupational safety and health consultative services contact:

Consultative Services Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2899 Fax: 919-807-2902

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 3rd Floor)

For information concerning migrant housing inspections and other related activities contact:

Agricultural Safety and Health Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2923 Fax: 919-807-2924

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 2nd Floor)

For information concerning occupational safety and health compliance contact:

Safety and Health Compliance District Offices

Raleigh District Office (3801 Lake Boone Trail, Suite 300, Raleigh, NC 27607)
Telephone: 919-779-8570 Fax: 919-420-7966

Asheville District Office (204 Charlotte Highway, Suite B, Asheville, NC 28803-8681)
Telephone: 828-299-8232 Fax: 828-299-8266

Charlotte District Office (901 Blairhill Road, Suite 200, Charlotte, NC 28217-1578)
Telephone: 704-665-4341 Fax: 704-665-4342

Winston-Salem District Office (4964 University Parkway, Suite 202, Winston-Salem, NC 27106-2800)
Telephone: 336-776-4420 Fax: 336-767-3989

Wilmington District Office (1200 N. 23rd St., Suite 205, Wilmington, NC 28405-1824)
Telephone: 910-251-2678 Fax: 910-251-2654

To make an OSH Complaint, **OSH Complaint Desk:** 919-807-2796

For statistical information concerning program activities contact:

Planning, Statistics and Information Management Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2950 Fax: 919-807-2951

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 2nd Floor)

For information about books, periodicals, vertical files, videos, films, audio/slide sets and computer databases contact:

N.C. Department of Labor Library

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2850 Fax: 919-807-2849

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 5th Floor)

N.C. Department of Labor (Other than OSH)

1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-733-7166 Fax: 919-733-6197