

NIOSH

CRITERIA FOR A
RECOMMENDED STANDARD.....

OCCUPATIONAL
EXPOSURE TO

DIISOCYANATES

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health



criteria for a recommended standard....

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National Institute for Occupational Safety and Health

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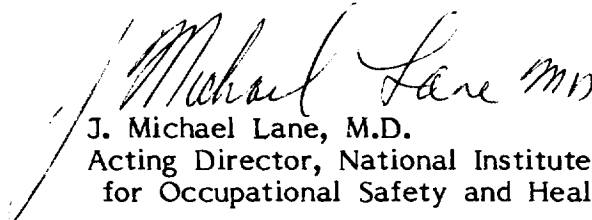
PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and provide for the safety of workers occupationally exposed to an ever-increasing number of potential hazards. The National Institute for Occupational Safety and Health (NIOSH) evaluates all available research data and criteria and recommends standards for occupational exposure. The Secretary of Labor will weigh these recommendations along with other considerations, such as feasibility and means of implementation, in promulgating regulatory standards.

NIOSH will periodically review the recommended standards to ensure continuing protection of workers and will make successive reports as new research and epidemiologic studies are completed and as sampling and analytical methods are developed.

The contributions to this document on diisocyanates by NIOSH staff, other Federal agencies or departments, the review consultants, the reviewers selected by the Society for Occupational and Environmental Health and the American Medical Association, and Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, are gratefully acknowledged.

The views and conclusions expressed in this document, together with the recommendations for a standard, are those of NIOSH. They are not necessarily those of the consultants, the reviewers selected by professional societies, or other Federal agencies. However, all comments, whether or not incorporated, have been sent with the criteria document to the Occupational Safety and Health Administration for consideration in setting the standard. The review consultants and the Federal agencies which received the document for review appear on pages v and vi.



J. Michael Lane, M.D.
Acting Director, National Institute
for Occupational Safety and Health

The Division of Criteria Documentation and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for the development of the criteria and recommended standard for diisocyanates. Stephanie Soucek of this Division served as criteria manager. SRI International developed the basic information for consideration by NIOSH staff and consultants under contract 210-77-0015.

The Division Review of this document was provided by Douglas L. Smith, Ph.D. (Chairman), Keith H. Jacobson, Ph.D., Howard L. McMartin, M.D., Geoffrey Taylor (Division of Respiratory Disease Studies), and Seymour D. Silver, Ph.D. (consultant).

REVIEW CONSULTANTS

N. Franklin Adkinson, Jr., M.D.
Assistant Professor of Medicine
The Johns Hopkins University
School of Medicine
Baltimore, Maryland 21205

Brian T. Butcher, Ph.D.
Assistant Professor of Medicine
Tulane University Medical Center
New Orleans, Louisiana 70112

George Ozga, Ph.D.
Division of Health Standards
Development
Occupational Safety and Health
Administration
Washington, D.C. 20001

Lawrence Samlaska
President, Local 6-665
Oil, Chemical and Atomic Workers
International Union
Cumberland, Wisconsin 54829

Henry J. Surovic
Director
Erie County Health Department
Waterford, Pennsylvania 16441

David H. Wegman, M.D.
Associate Professor of Occupational
Health
Harvard School of Public Health
Boston, Massachusetts 02115

Dietrich A. Weyel, Sc.D.
Manager, Corporate Industrial
Hygiene Department
Mobay Chemical Corporation
Pittsburgh, Pennsylvania 15205

FEDERAL AGENCIES

Department of Defense
Office of Assistant Secretary of Defense
for Energy, Environment, and Safety

Department of the Army
US Army Environmental Hygiene Agency

Department of the Navy
Bureau of Medicine and Surgery
Navy Environmental Health Center

Department of the Air Force
Office of the Surgeon General

Consumer Product Safety Commission
Bureau of Biomedical Science

Environmental Protection Agency
Office of Assistant Administrator for
Research and Development

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I. RECOMMENDATIONS FOR A DIISOCYANATES STANDARD

NIOSH recommends that employee exposure to diisocyanates in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and provide for the safety of employees for up to a 10-hour workshift, 40-hour workweek, over a working lifetime. Compliance with all sections of the recommended standard should prevent adverse effects of diisocyanates on the health of unsensitized workers and provide for their safety. Sufficient technology exists to permit compliance with the recommended standard. Although NIOSH considers the workplace environmental limits to be safe levels based on current information, the employer should regard them as the upper boundaries of exposure and make every effort to keep the exposure as low as possible. The recommended standard will be reviewed and revised as necessary.

Diisocyanates irritate the respiratory tract and can act as respiratory sensitizers, producing asthma-like symptoms in sensitized individuals with exposure at very low concentrations. Exposure to diisocyanates may also result in chronic impairment of pulmonary function.

NIOSH published criteria for a recommended standard for toluene diisocyanate (TDI) in 1973. The present recommended standard is expanded to include all diisocyanates, but not their polymerized forms. It includes most of the provisions recommended in the TDI document but differs where appropriate to reflect newer information or special provisions for other diisocyanates. Most of the information currently available on effects of exposure to diisocyanates concerns TDI and, to a lesser extent, diphenylmethane diisocyanate (MDI). In addition to TDI and MDI, occupational exposure limits are recommended for other diisocyanates that have had widespread industrial application: hexamethylene diisocyanate (HDI), naphthalene diisocyanate (NDI), isophorone diisocyanate (IPDI), and dicyclohexyl methane diisocyanate (hydrogenated MDI).

"Occupational exposure to diisocyanates" is defined as exposure to airborne diisocyanates at concentrations above one-half the recommended time-weighted average (TWA) occupational exposure limit or above the recommended ceiling limit. Adherence to all provisions of the standard is required if employees are occupationally exposed to airborne diisocyanates. If employees are exposed to airborne diisocyanates at concentrations of one-half the recommended TWA workplace environmental limit or less, the employer shall comply with all sections of the recommended standard except Sections 2(b), 4(c), 8(b), and the monitoring provisions of 8(c).

Section 1 - Environmental (Workplace Air)

(a) Concentrations

Exposure to diisocyanates shall be controlled so that no employee is exposed at concentrations greater than the limits specified below. These limits expressed in $\mu\text{g}/\text{cu m}$ are equivalent to a vapor concentration of 5 ppb as a TWA concentration for up to a 10-hour workshift, 40-hour workweek, and 20 ppb as a ceiling concentration for any 10-minute sampling period. The μg equivalents for selected diisocyanates are as follows:

	<u>TWA</u>	<u>Ceiling</u>
Toluene diisocyanate (TDI)	35 $\mu\text{g}/\text{cu m}$	140 $\mu\text{g}/\text{cu m}$
Diphenylmethane diisocyanate (MDI)	50 $\mu\text{g}/\text{cu m}$	200 $\mu\text{g}/\text{cu m}$
Hexamethylene diisocyanate (HDI)	35 $\mu\text{g}/\text{cu m}$	140 $\mu\text{g}/\text{cu m}$
Napthalene diisocyanate (NDI)	40 $\mu\text{g}/\text{cu m}$	170 $\mu\text{g}/\text{cu m}$
Isophorone diisocyanate (IPDI)	45 $\mu\text{g}/\text{cu m}$	180 $\mu\text{g}/\text{cu m}$
Dicyclohexylmethane 4,4'-diisocyanate (hydrogenated MDI)	55 $\mu\text{g}/\text{cu m}$	210 $\mu\text{g}/\text{cu m}$

If other diisocyanates are used, employers should observe environmental limits equivalent to a ceiling concentration of 20 ppb and a TWA concentration of 5 ppb.

(b) Sampling and Analysis

Environmental samples shall be collected and analyzed by the methods described in Appendix I or by any other method at least equivalent in accuracy, precision, and sensitivity.

Section 2 - Medical

Medical surveillance shall be made available as outlined below to all workers exposed to diisocyanates in the workplace.

(a) Preplacement examinations shall include at least:

(1) Comprehensive medical and work histories, with special emphasis directed to evidence of preexisting respiratory conditions such as asthma. A smoking history should also be compiled.

(2) Physical examination giving particular attention to the respiratory tract.

(3) Specific clinical tests including a 14- x 17-inch posteroanterior chest roentgenogram and baseline measurements of forced vital capacity (FVC) and forced expiratory volume at 1 second (FEV 1).

(4) A judgment of the worker's ability to use negative and positive pressure respirators.

(b) Periodic examinations shall be made available at least annually, as determined by the responsible physician, and shall include:

(1) Interim medical and work histories.

(2) Physical examination giving particular attention to the respiratory tract and including measurements of FVC and FEV 1.

(c) During examinations, applicants or employees found to have medical conditions that could be directly or indirectly aggravated by exposure to diisocyanates, eg, respiratory allergy, chronic upper or lower respiratory irritation, chronic obstructive pulmonary disease, or evidence of sensitization to diisocyanates, shall be counseled on their increased risk from working with these substances. Chronic bronchitis, emphysema, disabling pneumoconiosis, or cardiopulmonary disease with significantly impaired ventilatory capacity similarly suggest an increased risk from exposure to diisocyanates. If a history of allergy other than respiratory allergy is elicited, applicants should be counseled that they may be at increased risk of adverse health effects from exposure to diisocyanates. Employees shall also be advised that exposure to diisocyanates may result in delayed effects, such as coughing or difficulty in breathing during the night.

(d) Pertinent medical records shall be maintained. Records of environmental exposures applicable to an employee shall be included in the employee's medical records. Such records shall be kept for at least 30 years after the last occupational exposure to diisocyanates. These records shall be made available to the designated medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employer, and of the employee or former employee.

Section 3 - Labeling and Posting

(a) Warning signs shall be printed both in English and in the predominant language of non-English-reading workers. Workers unable to read labels and posted signs shall be instructed concerning hazardous areas and shall be orally informed of the instructions printed on labels and signs.

(b) Containers of diisocyanates shall carry a label that bears the chemical name of the compound contained therein and information on the compound's effects on human health and emergency measures. The name and pertinent information may be arranged as in the example below:

COMPOUND NAME
(Synonym or trade name)

HARMFUL IF INHALED

CAUSES BURNS

MAY CAUSE COUGH AND DIFFICULTY IN BREATHING
DURING OR AFTER WORKSHIFT

Use with adequate ventilation.
Avoid breathing vapor, mist, or dust.
Do not get in eyes, on skin, or on clothing.
Wash thoroughly with water and alcohol after handling.

First Aid: In case of eye contact, flush eyes with copious amounts of water. If victim is overcome, remove to fresh air. If breathing stops, give artificial respiration. Call a physician immediately.

Firefighting: Use dry chemical powder, carbon dioxide, or foam extinguisher. Do not use water unless large quantities are available.

(c) In areas where diisocyanates are used, signs bearing information on the effects of the specific compound on human health and emergency measures shall be posted in readily visible locations. This information may be arranged as the example below:

COMPOUND NAME
(Synonym or trade name)

HARMFUL IF INHALED

CAUSES BURNS

MAY CAUSE COUGH OR DIFFICULTY IN BREATHING
DURING OR AFTER WORKSHIFT

First Aid: In case of eye contact, flush eyes with copious amounts of water. If victim is overcome, remove to fresh air. If breathing stops, give artificial respiration. Call a physician immediately.

Firefighting: Use dry chemical powder, carbon dioxide, or foam extinguisher. Do not use water unless large quantities are available.

(d) If respirators are required, the following statement shall be added in large letters to the sign required in Section 3(c):

RESPIRATORY PROTECTION REQUIRED IN THIS AREA

(e) In any area where there is a likelihood of emergency situations arising, signs required by Section 3(c) shall be supplemented with signs giving emergency and first-aid instructions and procedures, the location of first-aid supplies and emergency equipment, and the locations of emergency showers and eyewash fountains.

Section 4 - Personal Protective Equipment and Clothing

The employer shall use engineering controls where needed to keep the concentration of airborne diisocyanates at or below the limits specified in Section (1)(a). The employer shall also provide employees with protective clothing and equipment of materials resistant to penetration by diisocyanates, such as rubber or polyvinyl chloride, when necessary to prevent skin and eye contact with diisocyanates. Protective equipment suitable for emergency use shall be located at clearly identified stations outside the work area.

(a) Eye Protection

The employer shall provide face shields (20-cm minimum) with goggles and shall ensure that employees wear the protective equipment during any operation in which

splashes of liquid diisocyanates are likely to occur. Protective devices for the eyes and face shall be selected, used, and maintained in accordance with 29 CFR 1910.133.

(b) Skin Protection

(1) The employer shall provide appropriate protective clothing and equipment that are resistant to penetration by diisocyanates, including gloves, aprons, suits, and boots, and shall ensure that employees wear these when needed to prevent skin contact with liquid diisocyanates. Workers within 10 feet of spraying operations, or at greater distance when there is a greater drift of spray, shall be protected with impervious clothing, gloves, and footwear in addition to required respiratory protection. Rubber shoes or rubbers over leather shoes shall be worn whenever there is a possibility that liquid diisocyanates may be present on floors.

(2) Protective clothing and equipment shall be cleaned inside and out after each use. Rubbers shall be decontaminated and ventilated if they have become contaminated with diisocyanates. Contaminated leather articles shall be decontaminated or discarded.

(c) Respiratory Protection

Engineering controls shall be used when needed to keep concentrations of airborne diisocyanates at or below the recommended environmental limits. Compliance with the permissible exposure limit by the use of respirators is permitted only during development, installation, and testing of engineering controls, during performance of nonroutine maintenance or repair, when working in confined spaces, during spraying operations in the field, or during emergencies. When use of a respirator is permitted, it shall be selected and used in accordance with the following requirements:

(1) To determine the type of respirator to be used, the employer shall measure the concentrations of airborne diisocyanates in the workplace initially and thereafter whenever control, process, operation, worksite, or climatic changes occur that are likely to increase the concentration of airborne diisocyanates.

(2) The employer shall provide respirators in accordance with Table I-1 and shall ensure that the employees use them properly when respirators are required. The respiratory protective devices provided in conformance with Table I-1 shall be those approved by NIOSH and the Mine Safety and Health Administration as specified in 30 CFR 11.

TABLE I-1

RESPIRATOR SELECTION GUIDE FOR DIISOCYANATES

Concentration	Respirator Type Approved under Provisions of 30 CFR 11*
Less than or equal to 1,000 ppb	Type C supplied-air respirator with full facepiece operated in pressure-demand or other positive pressure mode or with full facepiece, helmet, or hood operated in continuous-flow mode
Greater than 1,000 ppb	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination respirator including Type C supplied-air respirator with full facepiece operated in pressure-demand or other positive pressure mode with auxilliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode
Firefighting and Emergency	Self-contained breathing apparatus with full facepiece, operated in pressure-demand or other positive pressure mode

*Use of supplied-air suits may be necessary to prevent skin contact during exposure at high concentrations of airborne diisocyanates.

(3) Respirators specified for use at higher concentrations of airborne diisocyanates may be used in atmospheres with lower concentrations.

(4) The employer shall ensure that employees are properly instructed and drilled at least annually in the use of respirators assigned to them and on how to test for leakage, proper fit, and proper operation.

(5) The employer shall establish and conduct a program of cleaning, sanitizing, inspecting, maintaining, repairing, and storing respirators to ensure that employees are provided with clean respirators that are in good operating condition.

(6) Respirators shall be easily accessible, and employees shall be informed of their location.

(7) The employer shall ensure that no employee is exposed to diisocyanates above the recommended limits because of improper respirator selection, fit, use, or maintenance.

(8) A respiratory protection program meeting the requirements of 29 CFR 1910.134 that incorporates the American National Standard Practices for Respiratory Protection, Z88.2-1969, shall be established and enforced by the employer.

Section 5 - Informing Employees of Hazards from Diisocyanates

(a) All current and prospective employees working where occupational exposure to diisocyanates may occur shall be informed orally and in writing of the hazards, relevant signs and symptoms of exposure, appropriate emergency procedures, and proper conditions and precautions concerning safe use and handling of diisocyanates. The instructional program shall include a description of the general nature of the environmental and medical surveillance procedures and of the advantages to the employee of participating in these surveillance procedures. Employees exposed to diisocyanates should be warned that symptoms of exposure to diisocyanates, such as nocturnal dyspnea, may occur several hours after the end of the workshift. They should also be advised that improper home use of polyurethane products containing unpolymerized diisocyanates, such as foam kits and varnishes, may increase their risk of work-related health problems. Employees shall be instructed on their responsibilities for following work practices and sanitation procedures to help protect the health and provide for the safety of themselves and of fellow employees.

(b) The employer shall institute a continuing education program, conducted at least annually by persons qualified by experience or training, to ensure that all employees have current knowledge of job hazards, proper maintenance and cleanup methods, and proper respirator use. As a minimum, instruction shall include the information prescribed in paragraph 5(c) below. This information shall be readily

available to all employees involved in the manufacture, use, transport, or storage of diisocyanates and shall be posted in prominent positions within the workplace.

(c) Required information shall be recorded on the "Material Safety Data Sheet" shown in Appendix II or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Control of Airborne Diisocyanates

(1) Engineering controls, such as process enclosure or local exhaust ventilation, shall be used when needed to keep exposure to diisocyanates at or below the recommended environmental limit. Ventilation systems, if used, shall be designed to prevent accumulation or recirculation of diisocyanates in the workplace environment and to effectively remove diisocyanates from the breathing zone of employees.

(2) Exhaust ventilation systems discharging to outside air must conform to applicable local, state, and Federal air pollution regulations.

(3) Ventilation systems shall be regularly maintained and cleaned to ensure effectiveness, which shall be verified by semiannual airflow measurements. A log showing design airflow and the results of semiannual inspections shall be kept.

(4) Before maintenance work is undertaken, sources of diisocyanates shall be shut off and isolated. The need for and use of respiratory protective equipment shall be determined as outlined in Section 4.

(b) Confined Spaces

In confined areas where work is performed routinely, such as spray booths, exposure to diisocyanates shall be kept at or below the recommended limits by the use of engineering controls as described in Section 6(a). When nonroutine operations such as cleaning and maintenance must be performed in confined spaces not equipped with such engineering controls, the following requirements shall apply.

(1) Entry into confined spaces, eg, tanks, pits, or process vessels, that may contain diisocyanates shall be controlled by a permit system. Permits shall be signed by an authorized representative of the employer, certifying that preparation of the confined space, precautionary measures, and personal protective equipment are adequate and that prescribed procedures will be followed. Each work permit shall also be signed by the employee entering the confined space.

(2) Confined spaces that have contained diisocyanates shall be isolated by shutting off and sealing sources of diisocyanates.

(3) The confined space shall be cleaned with a solvent, flushed, washed with water, purged with air, and thoroughly ventilated. It shall then be inspected and tested for oxygen deficiency, diisocyanates, and the presence of combustible gases and other suspected contaminants before being entered and reinspected periodically at 1-hour intervals while occupied.

(4) Each employee entering the confined space shall be equipped with a self-contained breathing apparatus as specified in Section 4, a harness, and a lifeline. At least one other employee equipped for entry with the same type of protective equipment shall be stationed outside to monitor the operation. At least one additional person shall be available to assist in an emergency. All persons involved in the operation should be equipped with some mode of continuous communication. Mechanical ventilation shall be provided continuously when workers are inside the vessel.

(c) Storage and Handling

(1) Diisocyanates should be stored in closed containers and should be protected from heat and direct sunlight. They should not be stored near bases, primary or secondary amines, acids, or alcohols, since these chemicals may react violently with diisocyanates.

(2) Diisocyanate containers should be kept closed to prevent water from entering the containers, since water and diisocyanates react to produce a water-insoluble urea and carbon dioxide, which can generate enough pressure to rupture the containers. All containers of diisocyanates should be periodically inspected for signs of increased pressure within the containers and to ensure that the integrity of containers and seals are maintained. Leaking containers should be removed to the outdoors or to an isolated, well-ventilated area before the contents are transferred to other suitable containers, and leaks of diisocyanates should be cleaned up immediately.

(d) Control of Spills and Leaks

(1) Adequate facilities for handling spills of diisocyanates shall be provided and shall include suitable floor drainage and readily accessible hoses, mops, buckets, absorbent or decontaminating materials, and protective equipment and clothing.

(2) All spills or leaks of diisocyanates shall be given prompt attention by trained personnel, and all unessential personnel shall be evacuated from the area during cleanup.

(3) Waste material contaminated with diisocyanates shall be disposed of in a manner not hazardous to employees. Disposal methods must conform to applicable local, state, and Federal regulations and shall not constitute a hazard to the surrounding population or environment. Spills of diisocyanates shall not be allowed to enter public sewers or drains in amounts that could cause explosion or fire hazards.

(e) Emergency Procedures

Emergency plans and procedures shall be developed for all work areas where there is a potential for exposure to diisocyanates. The measures shall include those specified below and any others considered appropriate for a specific operation or process. Employees shall be trained to implement the plans and procedures effectively.

(1) Prearranged plans shall be instituted for obtaining emergency medical care and for the transportation of injured workers. A sufficient number of employees shall be trained in first aid so that assistance is available immediately when necessary.

(2) Employees who have significant skin contact with diisocyanates should wash with water or shower to remove the compound from the skin and should then wash the affected areas with alcohol. Contaminated clothing shall be removed and discarded or cleaned before reuse.

(3) In the event of a fire involving diisocyanates, all unessential personnel shall be evacuated from the area. The types of extinguishing media that should be used in fighting diisocyanate-supported fires are dry chemical powder, carbon dioxide, or foam. Water should be used only if large quantities are available. Firefighters should be cautioned of the possibility of exposure to other hazardous chemicals, such as hydrogen cyanide, phosgene, and carbon monoxide.

(4) After the fire has been extinguished, the area shall be inspected by properly protected personnel and shall be decontaminated to remove any suspected diisocyanate residues before unprotected workers are permitted to enter the area.

(f) Laundering

(1) Before being laundered, contaminated clothes shall be placed in a decontaminating solution of water containing 10% ammonia in a container that is impervious to diisocyanates.

(2) Personnel who clean contaminated clothing shall be informed of the hazards involved and shall be provided with guidelines on how to handle diisocyanates safely.

(3) If an outside laundry facility is used, the launderers shall be advised of the hazards and proper procedures involved in handling contaminated work clothing. Contaminated clothing shall be transported to the outside laundry facility in sealed containers.

(g) Laboratory Activities

When diisocyanates are used in laboratory activities, the following provisions, in addition to other sections, shall be followed.

(1) Mechanical pipetting aids shall be used for all pipetting procedures.

(2) Experiments, procedures, and equipment that could produce aerosols or vapors of diisocyanates shall be confined to laboratory-type hoods, glove boxes, or other similar control apparatus. Exposure chambers and associated generation apparatus shall be separately ventilated.

(3) Surfaces on which diisocyanates are handled shall be impervious to absorption or penetration by these compounds.

(4) Laboratory vacuum systems, hoods, and exposure chambers shall be exhaust-ventilated in a manner consistent with Federal and local air pollution regulations.

(5) Airflow in the laboratory shall be established in a pattern flowing from the least to the most contaminated area. Contaminated exhaust air shall not be recirculated or discharged to other work areas.

Section 7 - Sanitation

(a) Preparing, storing, dispensing (including vending machines), and consuming food and smoking shall be prohibited in work areas where occupational exposure to diisocyanates may occur.

(b) Employees who handle diisocyanates or equipment contaminated with diisocyanates shall be advised to wash their hands thoroughly with soap or mild detergent and water before using toilet facilities, eating, or smoking.

(c) Plant facilities shall be maintained in a sanitary manner in accordance with sanitation requirements listed in 29 CFR 1910.141.

(d) The employer shall provide appropriate changing and shower rooms as required in 29 CFR 1910.141(d,e).

Section 8 - Monitoring and Recordkeeping

(a) Industrial Hygiene Surveys

Employers shall conduct an industrial hygiene survey at locations where diisocyanates are present in the workplace air to determine whether there is occupational exposure to airborne diisocyanates. Records of these surveys, including the basis for concluding that concentrations of airborne diisocyanates are at or below one-half the recommended limits, shall be maintained. Surveys shall be repeated at least annually and as soon as practicable after any change likely to result in increased concentrations of airborne diisocyanates.

(b) Personal Monitoring

If it has been determined that there is occupational exposure to diisocyanates, the employer shall fulfill the following requirements:

(1) A program of personal monitoring shall be instituted to identify and measure, or permit calculation of, the exposure of each employee occupationally exposed to diisocyanates. Personal monitoring may be supplemented by source and area monitoring.

(2) In all personal monitoring, samples representative of the exposure in the breathing zone of the employee shall be collected.

(3) For each determination of the diisocyanate concentration, a sufficient number of samples shall be taken to characterize employee exposure. Variations in the employee's work schedule, location, or duties and changes in production schedules shall be considered in deciding when samples are to be collected.

(4) Samples from each operation in each work area and each shift shall be taken at least once every 6 months or as otherwise indicated by a professional industrial hygienist. If monitoring shows that an employee is exposed to diisocyanates at concentrations above the environmental limits recommended in Section 1(a), additional monitoring shall be promptly initiated. If this confirms that exposure is excessive, control measures shall be initiated as soon as possible to reduce the concentration of diisocyanates in the employee's environment to less than or equal to the limits recommended in Section 1(a). The affected employee shall be notified of the excessive exposure and of the control measures being implemented. Monitoring of the employee's exposure shall be conducted at least every 30 days and shall continue until two consecutive determinations, at least 1 week apart, indicate that the employee's exposure no longer exceeds the recommended environmental limits. At that point, semiannual monitoring may be resumed.

(c) Recordkeeping

Environmental monitoring records and other pertinent records shall be kept for at least 30 years after the last occupational exposure to diisocyanates. The records shall include the dates and times of measurement, duties and job locations within the worksite, sampling and analytical methods used, the number, duration, and results of samples taken, concentrations of diisocyanates in air estimated from these samples, the type of personal protection in use at the time of sampling, and identification of the exposed employee. Employees shall be able to obtain information on their own environmental exposures. Environmental monitoring records shall be made available to designated representatives of the Secretary of Labor, the Secretary of Health, Education, and Welfare, and the employee or former employee.

Pertinent medical records shall be retained by the employer for 30 years after the last occupational exposure to diisocyanates. Records of environmental exposures applicable to an employee should be included in records. These medical records shall be made available to the designated representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon that were prepared to meet the need for preventing impairment of health arising from occupational exposure to diisocyanates. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "develop criteria dealing with toxic materials and harmful physical agents and substances which will describe...exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

After reviewing data and consulting with others, NIOSH formalized a system for the development of criteria on which standards can be established to protect the health and to provide for the safety of employees exposed to hazardous chemical and physical agents. Criteria for a recommended standard should enable management and labor to develop better engineering controls resulting in more healthful work environments, and simply complying with the recommended standard should not be regarded as the final goal.

These criteria for a recommended standard for diisocyanates are part of a continuing series of documents published by NIOSH. The recommended standard applies to workplace exposure to diisocyanates arising from the processing, manufacture, and use of these compounds as applicable under the Occupational Safety and Health Act of 1970. The standard is not designed for the population-at-large, and any extrapolation beyond the occupational environment is not warranted. It is intended to: (1) protect against irritation of the skin, eyes, and respiratory tract by diisocyanates, reduce the likelihood of sensitization to these compounds, and minimize long-term effects on pulmonary function, (2) be measurable by techniques that are valid, reproducible, and available to industry and government agencies, and (3) be attainable with existing technology.

Criteria for a recommended standard for toluene diisocyanate (TDI) were published by NIOSH in 1973. The present document is intended to extend the coverage of the recommended standard to other diisocyanates and to take into account more recent data.

Occupational exposure to some of the diisocyanates has produced respiratory illness in workers. In addition to irritating the upper and lower respiratory tract, diisocyanates can cause sensitization, and sensitized individuals may develop asthma upon exposure to diisocyanates in very small amounts. Chronic impairment of pulmonary function has been reported in some workers exposed to diisocyanates. Diisocyanates are also irritating to the skin and eyes.

Further research is needed in a number of areas relevant to controlling occupational exposure to diisocyanates. The possibilities of carcinogenic, mutagenic, teratogenic, and reproductive effects from diisocyanates have not been adequately investigated. Studies in which effects on individuals are correlated with their actual exposures are also needed. Screening tests should be developed to permit early recognition of adverse respiratory effects resulting from sensitization to the diisocyanates. Animal experiments should be performed to determine how concentration and length of exposure affect the development of sensitization. Improved engineering controls should be developed to protect workers in certain diisocyanate applications, such as spraying.