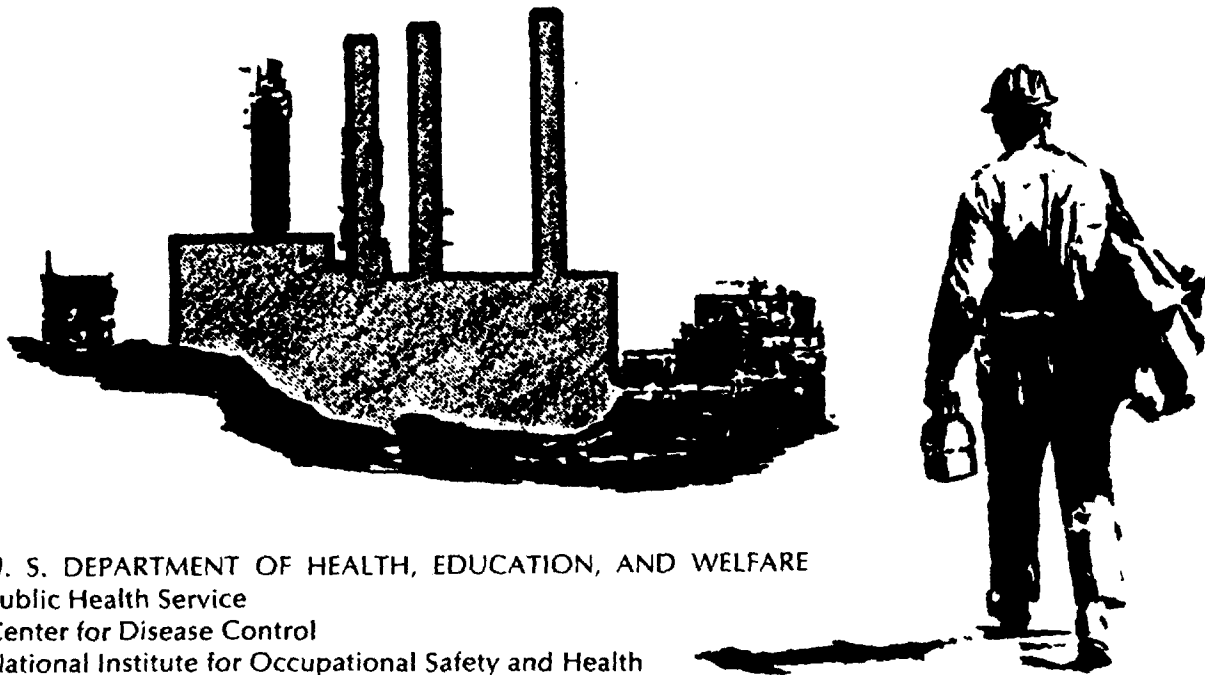


NIOSH

CRITERIA FOR A
RECOMMENDED STANDARD....

OCCUPATIONAL
EXPOSURE TO

GLYCIDYL ETHERS



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

**OCCUPATIONAL EXPOSURE
TO
GLYCIDYL ETHERS**



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
June 1978

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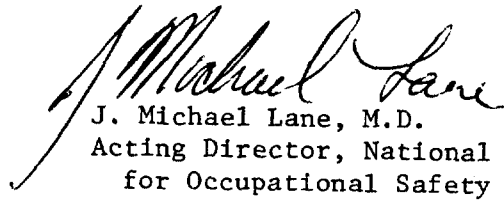
PREFACE

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 glycidyl ethers by NIOSH staff, other Federal agencies or departments, the review consultants, the reviewers selected by the Society for Occupational and Environmental Health, 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, were considered carefully and were 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.


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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 glycidyl ethers. Catherine Woodbury, Ph.D., of this Division served as criteria manager. SRI International developed the basic information for consideration by NIOSH staff and consultants under contract CDC-99-74-31.

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I. RECOMMENDATIONS FOR A GLYCIDYL ETHERS STANDARD

NIOSH recommends that employee exposure to glycidyl ethers in the workplace be controlled by adherence to the following sections. The recommended 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 substantially reduce any risk of mutagenic or tumorigenic effects of glycidyl ethers and prevent other adverse effects of exposure in the workplace. Employers should regard the recommended workplace environmental limit as the upper boundary for exposure and make every effort to keep the exposure as low as is technically feasible. The criteria and standard will be subject to review and revision as necessary.

Glycidyl ethers are characterized by the presence of a three-carbon chain with an epoxide group and an ether linkage. This recommended standard applies to monoglycidyl ethers and diglycidyl ethers that contain an alkyl group, an aromatic group, or a moiety of the structure $-(RO)_n-R'$. It does not include any halogenated compounds or polymerized forms.

Most of the glycidyl ethers are liquids but some are solids. The most common use of these compounds is as reactive diluents in epoxy resins. Toxicologic data concerning these compounds are scarce, but those available show that glycidyl ethers are primary skin and eye irritants and that they are potential skin sensitizing agents. Some data suggest that di(2,3-epoxypropyl) ether should be regarded as a potential occupational

carcinogen and that n-butyl glycidyl ether is a mammalian mutagen. Some glycidyl ethers have also produced cytotoxic effects in animals.

The differences in toxicity among members of the class of glycidyl ethers and the absence of data on some of them prevent the setting of a single environmental limit for all glycidyl ethers. Dermal contact is the major route of exposure to glycidyl ethers; in addition to producing irritation and sensitization, high doses of the compounds may be absorbed through the skin and cause systemic effects. Glycidyl ethers have relatively low vapor pressures, but inhalation is, nevertheless, a possible secondary route of exposure to these compounds. Exposures to airborne glycidyl ethers have caused eye irritation and, at high concentrations, systemic effects and death in animals.

"Occupational exposure" to glycidyl ethers is defined as work in any area where these substances are manufactured, stored, used, or handled.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure to glycidyl ethers shall be controlled so that concentrations do not exceed the following ceiling concentration limits, listed in milligrams per cubic meter of air (mg/cu m) and converted to parts per million (ppm), as determined during a 15-minute sampling period:

Allyl glycidyl ether (AGE)	45 mg/cu m (9.6 ppm)
Isopropyl glycidyl ether (IGE)	240 mg/cu m (50 ppm)
Phenyl glycidyl ether (PGE)	5 mg/cu m (1 ppm)
n-Butyl glycidyl ether (BGE)	30 mg/cu m (4.4 ppm)
Di(2,3-epoxypropyl) ether (DGE)	1 mg/cu m (0.2 ppm)

(b) Sampling and Analysis

Procedures for the collection and analysis of workroom air samples for compliance with the standard shall be as provided in Appendices I, II, and III or by any methods shown to be at least equivalent in precision, sensitivity, and accuracy to the methods specified.

Section 2 - Medical

Medical surveillance shall be made available as outlined below to all workers with occupational exposure to glycidyl ethers.

(a) Preplacement examinations shall include at least:

(1) Comprehensive medical and work histories with special emphasis directed to past exposure to glycidyl ethers or other vinyl derivatives and history of sensitivities, allergies and reproductive events.

(2) Physical examination giving particular attention to the skin, eyes, and mucous membranes.

(3) If indicated in the judgment of the responsible physician, clinical tests, such as total and differential leukocyte counts, urinalysis, pulmonary function tests, and tests of manual dexterity and visual-motor coupling.

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

(b) Periodic examinations shall be made available as directed by the responsible physician. These examinations shall include at least:

(1) Interim medical and work histories.

(2) Physical examination as outlined in (a)(2) and (a)(3) above.

(c) During examinations, applicants or employees found to have medical conditions, such as neurodermatitis, dyshydrosis, or atopy (an inherited predisposition to allergy), that would be directly or indirectly aggravated by exposure to glycidyl ethers shall be counseled on the increased risk of impairment of their health from working with these substances. Workers shall also be notified that BGE was mutagenic in mice and bacteria and DGE caused skin papillomas in mice. Strict adherence to work practices and sanitation are advised.

(d) In the event of an illness known or suspected to be due to glycidyl ethers, a physical examination as described in paragraphs (a)(2) and (a)(3) above shall be made available.

(e) In the event of an emergency involving gross contamination with or inhalation or ingestion of glycidyl ethers, appropriate first-aid treatment shall be given, and a physician shall be contacted.

(f) Pertinent medical records shall be maintained for at least 30 years after termination of employment. Records of environmental exposure applicable to an employee shall be included in that employee's medical records. 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

All labels and warning signs shall be printed both in English and in the predominant language of non-English-reading workers. Workers unable to

read the labels and signs provided shall receive information regarding hazardous areas, the hazards of working with glycidyl ethers, practices and procedures for protecting themselves, and the instructions printed on labels and signs.

(a) Containers

Shipping and storage containers of glycidyl ethers shall have a readily visible label that bears the name of the ether and information on the effects of exposure on human health. The information may be arranged as in the following example:

NAME OF ETHER

(synonym)

WARNING!

COMBUSTIBLE (or FLAMMABLE, as appropriate)

MAY CAUSE SKIN SENSITIZATION

OR OTHER ALLERGIC RESPONSE

Keep containers closed when not in use.
Prevent all contact with skin and eyes.
Do not inhale vapors or aerosols.
Use only with adequate ventilation.
Store in a cool area - Compound may react
violently if heated.

First Aid: In case of contact with eyes, immediately flush eyes with plenty of water and consult a physician. In case of skin contact, wash with soap and water.

Many glycidyl ethers are combustible or flammable liquids, and this information, when pertinent, shall be included on the label directly under the word "WARNING." Labels for 2,3-(epoxypropyl) ether (DGE) shall also include the words "CANCER SUSPECT AGENT."

(b) Posting

In all areas where occupational exposure to glycidyl ethers occurs, warning signs that bear the name of the ether and information on its effects on human health shall be prominently displayed. The information on these signs may be arranged as in the following example.

NAME OF ETHER
(synonym)
WARNING!
COMBUSTIBLE (or FLAMMABLE, as appropriate)

MAY CAUSE SKIN SENSITIZATION
OR OTHER ALLERGIC RESPONSE

Many glycidyl ethers are combustible or flammable, and this information, when appropriate, shall be included on the sign directly under the word "WARNING." Signs for areas where DGE is used shall also include the words "CANCER SUSPECT AGENT."

Section 4 - Personal Protective Clothing and Equipment

Engineering controls and work practices shall be used to keep concentrations of airborne glycidyl ethers at or below the recommended

ceiling concentrations and to prevent skin and eye contact with glycidyl ethers. In addition, employers shall provide protective equipment and clothing to employees when necessary.

(a) Protective Clothing

(1) The employer shall provide appropriate clothing, including gloves, aprons, suits, boots, and faceshields (8-inch minimum), made of materials impervious to glycidyl ethers, eg, milled butyl rubber or polyvinyl alcohol, and shall ensure that such clothing is worn by every employee to prevent skin contact. The protective clothing shall also be fire-resistant. Gloves shall be of sufficient length to protect the forearms of the employees.

(2) The employer shall ensure that a change of clothing is immediately available to any employee whose clothes become grossly contaminated with glycidyl ethers.

(3) Leather articles, such as belts or shoes, that become contaminated with glycidyl ethers shall be rendered unfit for use and discarded.

(4) The employer shall provide separate storage facilities for work clothes and for street clothes and shall ensure that employees do not remove protective clothing from the workplace.

(5) The employer shall inform persons involved in laundering or handling the contaminated clothing of the hazardous properties of glycidyl ethers.

(6) Safety showers and eyewash fountains shall be provided in appropriate areas. This equipment shall be checked periodically to ensure that it is in proper working condition.

(b) Eye and Face Protection

Chemical safety goggles (splashproof) or face shields (8-inch minimum) with goggles meeting the requirements listed in 29 CFR 1910.133 and ANSI Z87.1-1968 shall be provided by the employer and shall be worn during any operation in which there is a reasonable possibility of a glycidyl ether being splashed into the eyes.

(c) Respiratory Protection

Engineering controls shall be used when needed to keep concentrations of airborne glycidyl ethers at or below the ceiling concentrations specified in Section 1(a). When a local exhaust ventilation system is used, it shall be of sparkproof design and maintained to prevent the accumulation or recirculation of glycidyl ether vapors in the workplace and to remove them effectively from the breathing zone of employees. Exhaust ventilation systems discharging into outside air must conform with applicable local, state, and Federal air pollution regulations and must not constitute a hazard to employees or to the general population. Ventilation systems shall be given regular preventive maintenance and cleaning to ensure effectiveness. This shall be verified by measurements that demonstrate system efficiency, eg, air velocity, static pressure, or air volume, taken at least every 3 months, or more frequently if required for the safe and efficient operation of a particular system. Measurements of system efficiency shall also be made as soon as possible after any change in production, process, or control that might result in an increase in the concentration of airborne glycidyl ether.

(1) Compliance with the recommended workplace environmental limit may be achieved by the use of respirators only under the following conditions:

(A) During the installation, testing, maintenance, or repair of the required engineering controls.

(B) For operations such as nonroutine maintenance and repair activities causing brief exposures at concentrations in excess of the workplace environmental limit.

(C) During emergencies.

(2) When a respirator is permitted by paragraph (c)(1) of this section, it shall be selected and used in accordance with the following requirements:

(A) The employer shall establish and enforce a respiratory protective program. The requirements for an adequate program can be found in 29 CFR 1910.134.

(B) The employer shall provide respirators in accordance with Tables I-1, I-2, I-3, and I-4 and shall ensure that employees use the respirators properly when the concentrations of airborne glycidyl ethers exceed the ceiling concentrations recommended in Section 1(a). The respirators shall be those approved by NIOSH or the Mine Safety and Health Administration (MSHA). The employer shall ensure that respirators are properly cleaned, maintained, and stored when not in use.

(C) Protective equipment suitable for emergency entry shall be located at clearly identified areas outside the work area.

TABLE I-1

RESPIRATOR* SELECTION GUIDE FOR ALLYL GLYCIDYL
ETHER AND ISOPROPYL GLYCIDYL ETHER

Concentration (mg/cu m)		Respirator Type Approved under Provisions of 30 CFR 11	
	AGE	IGE	
Less than or equal to	470	4,700	(1) Chemical cartridge respirator with full facemask and organic vapor cartridge (2) Gas mask with full facepiece and chin-type organic vapor canister (3) Gas mask with full facepiece and front- or back-mounted organic vapor canister (4) Supplied-air respirator with full facepiece operated in the pressure-demand mode (5) Supplied-air respirator with full facepiece, hood, helmet, or suit, operated in the pressure-demand or continuous-flow mode (6) Powered air-purifying respirator with organic vapor canister and full facepiece, hood, or helmet (7) Self-contained breathing apparatus with full facepiece, operated in the pressure-demand mode
Greater than or Emergency (entry into area of unknown concentration for emergency purposes such as firefighting)	470	4,700	(1) Self-contained breathing apparatus with full facepiece, operated in the pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece, operated in the pressure-demand mode and equipped with an auxiliary self-contained air supply

*Full-body protective clothing shall also be worn whenever a respirator is required.

TABLE I-2

RESPIRATOR* SELECTION GUIDE FOR PHENYL GLYCIDYL ETHER

Concentration (mg/cu m)	Respirator Type Approved under Provisions of 30 CFR 11
Less than or equal to 250	<ul style="list-style-type: none"> (1) Chemical cartridge respirator with full facemask and organic vapor cartridge (2) Gas mask with full facepiece and chin-type organic vapor canister (3) Gas mask with full facepiece and front- or back-mounted organic vapor canister (4) Supplied-air respirator with full facepiece operated in demand mode (5) Self-contained breathing apparatus with full facepiece operated in demand mode
Greater than 250 or Emergency	<ul style="list-style-type: none"> (1) Supplied-air respirator with full facepiece operated in pressure-demand mode (2) Supplied-air respirator with full facepiece, hood, helmet, or suit operated in pressure-demand or continuous-flow mode (3) Powered air-purifying respirator with organic vapor canister and full facepiece, hood, or helmet

*Full-body protective clothing shall also be worn whenever a respirator is required.

TABLE I-3

RESPIRATOR* SELECTION GUIDE FOR n-BUTYL GLYCIDYL ETHER

Concentration (mg/cu m)	Respirator Type Approved under Provisions of 30 CFR 11
Less than or equal to 5,000	Supplied-air respirator with full facepiece, hood, helmet, or suit, operated in pressure-demand or continuous-flow mode
Greater than 5,000 or Emergency	(1) Self-contained breathing appara- tus with full facepiece operated in pressure-demand mode (2) Combination Type C supplied-air respirator with full facepiece oper- ated in pressure-demand mode and equipped with auxiliary self- contained air supply

*Full-body protective clothing shall also be worn whenever a respirator is required.

TABLE I-4

RESPIRATOR* SELECTION GUIDE FOR DI(2,3-EPOXYPROPYL)ETHER

Concentration (mg/cu m)	Respirator Type Approved under Provisions of 30 CFR 11
Greater than 1.0 or Emergency	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand or other positive pressure mode and auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode

*Full-body protective clothing shall also be worn whenever a respirator is required.

Section 5 - Informing Employees of Hazards

(a) Employees working in an area that may involve occupational exposure to glycidyl ethers shall be informed of the hazards of such employment, the appropriate emergency procedures to use, and the proper procedures for safe handling and use of glycidyl ethers.

(b) The employer shall institute a continuing education program, conducted by persons qualified by experience or training, to ensure that employees have current knowledge of job hazards, proper maintenance and cleanup methods, and proper respirator use. The instructional program shall also include a description of the general nature of the medical surveillance procedures and of the advantages to the employee of undergoing the examinations recommended. Educational programs for employees engaged in maintenance and repair shall include instruction on those work situations in which they will be occupationally exposed to glycidyl ethers.

(c) Instructional material in written or published form shall be kept on file at each establishment or department where employees are occupationally exposed to glycidyl ethers. Each employee shall be informed of the availability of the required information, which shall include, as a minimum, that prescribed in Appendix IV.

(d) Required information shall be recorded on the "Material Safety Data Sheet" shown in Appendix IV or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor, and shall be kept on file, readily accessible to employees.

Section 6 - Work Practices

(a) Storage and Handling

(1) The handling and storage of liquid glycidyl ethers shall comply with the provisions of 29 CFR 1910.106 for flammable or combustible liquids.

(2) Fire extinguishers approved for use in fighting fires

supported by Class II and Class III combustible or Class I-C flammable liquids, eg, dry chemical extinguishers, shall be available in areas where glycidyl ethers are loaded, unloaded, or stored. Fire extinguishers shall be inspected annually by qualified personnel and recharged or replaced if necessary.

(3) In case of a leak, loading or unloading operations, as appropriate, should continue as rapidly as possible to drain the tank or permit necessary repairs if it is safe to make them. If the leak is severe, causing unsafe conditions, loading or unloading operations should cease and emergency procedures should be instituted.

(4) Whenever flammable or combustible liquids are transferred from one container to another, both containers must be effectively bonded and grounded to prevent the buildup and discharge of static electricity.

(b) Cleanup and Waste Disposal

Spills of large amounts of glycidyl ethers shall be washed with water into an appropriate drainage system as soon as possible where the ethers can be safely stored until they are either recovered or discarded. Discarding of waste shall conform to applicable Environmental Protection Agency (EPA) standards and must not constitute a hazard to employees or to the population at large. When it is not possible to wash a spill with water, the area should be cordoned off until cleanup operations have been completed. If a vacuum truck is used to remove the glycidyl ether, there should be no sources of ignition in the vicinity of the spill and sufficient flashback prevention devices shall be provided.

(c) Entry into Confined Spaces

(1) Entry into confined spaces, such as tanks, pits, and process vessels, that have contained glycidyl ethers shall be controlled by a permit system. Permits shall be signed by an authorized representative of the employer to certify that preparation of the confined space, precautionary measures, and personal protective equipment are adequate and that the prescribed procedure will be followed.

(2) All lines shall be disconnected or blocked while process vessels are being cleaned. All valves or pumps leading to and from the vessel shall be locked in the off position and tagged with a sign stating that work is in progress or other similar message.

(3) A confined space that has contained glycidyl ethers shall be washed with water or some other appropriate agent and purged with air or with nitrogen followed by air before any employee enters it. Provision shall be made for adequate ventilation of the confined space to provide sufficient oxygen for employees working inside.

(4) A calibrated combustible gas meter shall be used to check for explosion hazard. The test shall be performed by a person trained in the use of the combustible gas meter. When it is possible that airborne glycidyl ether vapors could increase in concentration within the confined space, this test shall be repeated every 30 minutes.

(5) The vessel shall then be checked for concentrations of airborne glycidyl ethers, possible oxygen deficiency, and concentrations of other likely contaminants. A positive pressure respirator shall be used during this checking procedure.

(6) The interiors of tanks or vessels shall be illuminated by reflected light or explosion-proof light sources during cleaning or repairs. Only nonferrous (sparkproof) tools are permitted to be used in these operations.

(7) No employee shall enter any tank or vessel that does not have an entrance large enough to admit an employee equipped with safety harness, lifeline, and appropriate respiratory equipment. The employee shall be able to leave the tank or vessel by the same opening.

(8) Employees entering contaminated tanks or vessels shall wear full-body protective clothing until inspection and testing assure safety for personnel in the tank.

(9) When an employee is working in a confined space, another employee shall be stationed at the entrance to keep the first employee under constant observation, and one or more additional employees shall be readily available in case of an emergency. A positive pressure respirator with safety harness and lifeline shall be located outside the tank or vessel for emergency use.

(d) General Work Practices

(1) Smoking, matches, open flames, and spark-producing devices shall be prohibited in areas where glycidyl ethers are handled. Tools used in these areas shall be sparkproof.

(2) Employers shall ensure that workers do not carry smoking materials into areas where glycidyl ethers are handled. If smoking areas are provided, they should be located at a safe distance from glycidyl ether work and storage areas.

(e) Emergency Procedures

The employer shall formulate emergency evacuation, medical, and firefighting procedures and shall ensure that they are posted in all work areas where emergencies involving glycidyl ethers might occur and that employees are instructed in these procedures.

(1) Procedures shall include prearranged plans for obtaining first-aid and emergency medical care and for transportation of injured workers.

(2) Firefighting procedures shall be established and implemented. The glycidyl ether sources shall be clearly marked, and workers and emergency personnel shall be instructed in proper shutoff procedures. The instructions shall include procedures for emergencies involving the release of vapors of glycidyl ethers. In case of fire, glycidyl ether sources shall be shut off or removed. Containers shall be removed or cooled with water. Chemical foam, water, carbon dioxide, or dry chemicals shall be used for fighting glycidyl ether fires, and proper respiratory protection and protective clothing shall be worn by employees engaged in firefighting.

(3) Approved eye, skin, and respiratory protection, as specified in Section 4, shall be used by personnel engaged in emergency operations.

(4) Nonessential employees shall be evacuated from exposure areas during emergencies. During an emergency, perimeters of hazardous areas shall be roped off, posted, and secured.

(5) Personnel who may be required to shut off sources of glycidyl ethers, clean up spills, and repair leaks shall be properly trained in the appropriate procedures.

Section 7 - Sanitation

(a) Food or beverage preparation, storage, dispensing (including vending machines), and consumption shall be prohibited in work areas where glycidyl ethers are present.

(b) Adequate facilities with soap and water for handwashing shall be made available to employees who work with glycidyl ethers.

(c) Employees shall be cautioned not to touch or rub their eyes with hands that may be contaminated with glycidyl ethers.

(d) The employer should recommend that all employees wash their hands before using toilet facilities or eating.

Section 8 - Monitoring and Recordkeeping Requirements

Each employer with a place of employment where glycidyl ethers are present shall conduct an industrial hygiene survey to determine whether exposure to glycidyl ethers may occur. Surveys shall be repeated at least semiannually and within 30 days after any process change likely to result in increased concentrations of airborne glycidyl ethers. Records of these surveys, including the basis for concluding that concentrations of airborne glycidyl ethers are at or below the ceiling concentration limits specified in Section 1(a), shall be maintained.

(a) Personal Monitoring

(1) If it is determined that exposure to airborne glycidyl ethers has occurred, a program of personal monitoring shall be instituted to identify and measure, or permit calculation of, the exposure of all employees who are occupationally exposed to glycidyl ethers. Monitoring of employee exposure to airborne glycidyl ethers shall be conducted at least semiannually. If monitoring reveals that an employee is exposed to glycidyl ethers at concentrations in excess of the recommended ceiling concentration limits specified in Section 1(a), control measures shall be initiated, the employee shall be notified of the exposure and of the control measures being implemented to correct the situation, and the exposure of that employee shall be monitored at least once every 30 days. Such monitoring shall continue until two consecutive evaluations, at least 30 days apart, indicate that the employee's exposure no longer exceeds the recommended ceiling concentration limits. Semiannual monitoring may then be resumed.

(2) In all personal monitoring, samples of air representative of the breathing zones of the employees shall be collected.

(3) For each determination, a sufficient number of samples shall be taken to characterize the employee's exposure during each workshift. Variations in work or production schedules and in employee location and job function shall be considered in choosing sampling times, locations, and frequency.

(b) Recordkeeping

Records of environmental monitoring and exposure information shall be kept by the employer for at least 30 years after the employee's last

occupational exposure to glycidyl ethers. These records shall include the dates of measurements, job function and location of the employees at the worksite, sampling and analytical methods used, number, duration, and results of the samples taken, ceiling concentrations estimated from these samples, type of personal protective equipment in use at the time of sampling, and identification of exposed employees. Employees shall have access to 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, the employer, and the employee or former employee.

II. INTRODUCTION

This report presents the criteria and the recommended standard which were prepared to meet the need for preventing occupational disease and injury arising from exposure to glycidyl ethers in the workplace. 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 upon which standards can be established to protect the health and 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 the final goal.

These criteria for a recommended standard for glycidyl ethers are part of a continuing series of criteria developed by NIOSH. The recommended standard applies to the handling, processing, manufacture, use, and storage of the glycidyl ethers. The standard was not designed for the population-at-large, and any extrapolation beyond workplace exposures is not warranted. The standard is intended to (1) protect against the

development of local irritation of the skin and eyes, (2) protect against skin sensitization and the development of systemic toxicity, (3) be measurable by techniques that are valid, reproducible, and available to industry and government agencies, and (4) be attainable with existing technology.

The primary effects of glycidyl ethers on workers reported to date are irritation and skin sensitization. There is also some evidence that cross-sensitization occurs between the glycidyl ethers and their polymerized forms (unmodified epoxy resins). Glycidyl ethers have caused cytotoxic effects and have been mutagenic in bacteria, and n-butyl glycidyl ether was mutagenic to mice in the dominant lethal test. Another glycidyl ether, di(2,3-epoxypropyl) ether, has induced skin papillomas in mice, and triethylene glycol diglycidyl ether induced lung adenomas in rats given high doses by intraperitoneal injection.

The chief use of glycidyl ethers is as reactive diluents in epoxy resin systems. However, because information on the composition of certain epoxy resins is proprietary, it is often difficult to obtain information about the glycidyl ether or ethers that are present in a particular epoxy resin. Furthermore, exposure to the epoxide moiety in both glycidyl ethers and epoxy resins can occur until the resin is completely cured. Thus, workers must be considered to be at risk of exposure to glycidyl ethers from the time the ethers are synthesized until the curing process of the epoxy resin is completed. In addition, since irritation, skin sensitization, and cross-sensitization can occur, it is necessary to take steps to ensure that workers have minimal contact with glycidyl ethers or their vapors.

There is a great need for further research on the metabolism and toxicity of individual glycidyl ethers. Lack of data makes it impossible to determine truly safe exposure concentrations for a number of the ethers used in industry today. Studies of eye and skin irritation and of the effects of inhalation of glycidyl ether vapors by both humans and experimental animals are needed. Epidemiologic studies are necessary to assess the possible effects of long-term exposure of populations of workers on their health and longevity. There is an urgent need for studies on the carcinogenic potential of the glycidyl ethers, especially since some glycidyl ethers are cytotoxic, mutagenic, or tumorigenic.

There are no validated methods for the sampling and analysis of any of the diglycidyl ethers. It is important that such methods be devised and tested, since di(2,3-epoxypropyl) ether is potentially carcinogenic. The validated methods that do exist for some of the glycidyl ethers have not been validated at the limits recommended in this standard. They may be adequate, with certain adjustments, for lower limits and for all glycidyl ethers, but this needs to be demonstrated.