# 8 METHODS FOR WORKER PROTECTION

## 8.1 INFORMING WORKERS OF HAZARDS

On November 21, 1983, OSHA promulgated an occupational safety and health standard entitled "Hazard Communication." Under the provisions of this standard (29 CFR 1910.1200), employers in the manufacturing sector (i.e., SIC Codes 20 through 39) must establish a comprehensive hazard communication program that includes, at a minimum, container labeling, material safety data sheets (MSDSs), and a worker training program. The hazard communication program is to be written and made available to workers and their designated representatives.

Chemical manufacturers, importers, and distributors are required to ensure that containers of hazardous chemicals leaving their workplaces are labeled, tagged, or marked to show the identity of the chemical, appropriate hazard warnings, and the name and address of the manufacturer or other responsible party. Employers must ensure that labels on incoming containers of hazardous chemicals are not removed or defaced unless they are immediately replaced with other labels containing the required information.

Each container in the workplace must be prominently labeled, tagged, or marked to show the identity of any hazardous chemical it contains and the hazard warnings appropriate for worker protection. If a work area has a number of stationary containers that have similar contents and hazards, the employer may post hazard signs or placards rather than label each container. Employers may use various types of standard operating procedures, process sheets, batch tickets, or other written materials as substitutes for individual container labels on stationary process equipment. However, these written materials must contain the same information that is required on the labels and must be readily accessible to workers in the work areas. Pipes or piping systems are exempted altogether from the OSHA labeling requirements, although NIOSH recommends that filler ports and outlets be labeled. In addition, NIOSH recommends that a system be set up to ensure that pipes containing hazardous materials are identified to avoid accidental cutting and discharge of their contents.

Employers are not required to label portable containers holding hazardous chemicals that have been transferred from labeled containers and that are intended only for the immediate use of the worker who performs the transfer. According to the OSHA definition of "immediate use," the container must be under the control of the worker performing the transfer and must be used only during the workshift in which the chemicals are transferred.

The OSHA Hazard Communication standard requires chemical manufacturers and importers to develop an MSDS for each hazardous chemical they produce or import. Employers in

the manufacturing sector (which includes paint and allied coating products) are required to obtain or develop an MSDS for each hazardous chemical used in the workplace. The MSDS is required to provide information such as the chemical and common names for the hazardous chemical. For hazardous chemical mixtures, the MSDS must list each hazardous component that constitutes 1% or more of the mixture. NIOSH suggests that any potential occupational carcinogen be listed. Ingredients present in concentrations of less than 1% must also be listed if there is evidence that the PEL may be exceeded or that the ingredients could present a health hazard in those concentrations. Additional information on the MSDS must include the physical and chemical characteristics of the hazardous chemical, known acute and chronic health effects, precautionary measures, and emergency and first aid procedures. The NIOSH publication entitled *A Recommended Standard—An Identification System for Occupationally Hazardous Materials* [NIOSH 1974] can be used as a guide when preparing the MSDS. Required information can be recorded on the MSDS shown in Appendix B or on a similar form.

Employers should establish a training program for all workers exposed to hazardous chemicals. Training should be provided whenever a new job is assigned and whenever a new chemical hazard is introduced into the work area. Workers should be informed about (1) any hazardous chemicals in their work areas, and (2) the availability of information about individual chemicals in the MSDS.

Workers should also be trained in methods for detecting the presence or release of hazardous chemicals (e.g., monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when released, etc.). Training should include information about measures workers can take to protect themselves from exposure to hazardous chemicals (e.g., the use of appropriate work practices, emergency procedures, and personal protective equipment).

## 8.2 WORK PRACTICES

### 8.2.1 Worker Isolation

If feasible, workers should be isolated from direct contact with the work environment by the use of automated equipment operated from a closed control booth or room. The control room should be maintained at a positive pressure so that air flows out of rather than into the room. However, when workers must perform process checks, adjustments, maintenance, or other related operations in work areas where EGME, EGEE, or their acetates are present, personal protective clothing and equipment may be necessary, depending on exposure concentrations and the potential for dermal contact.

### 8.2.2 Storage and Handling

Containers of EGME, EGEE or their acetates should be stored in a cool, dry, well ventilated location away from any area containing a fire hazard. Outside or detached storage is preferred. These glycol ethers should be isolated from materials with which they are

incompatible; contact with strong oxidizing agents may cause fires and explosions. Containers of solvents, including those that contain EGME, EGEE, or their acetates, should be tightly covered at all times except when material is transferred. Working amounts of these solvents should be stored in containers that (1) hold no more than 5 gal, (2) have spring-closing lids and spout covers, and (3) are designed to safely relieve internal pressure in case of fire. Because small amounts of residue may remain and present a fire hazard, containers that have held solvents should be thoroughly cleaned with steam and then drained and dried before reuse. Fittings should not be struck with tools or other hard objects that may cause sparks. Special spark-resistant tools of nonferrous materials should be used where flammable gases, highly volatile liquids, or other explosive substances are used or stored [NSC 1980]. In addition, all sources of ignition such as smoking and open heaters should be prohibited except in specified areas. Fire hazards around tank trucks and cars can be reduced by keeping motors turned off during loading or unloading operations.

Specific OSHA requirements for the storage and handling of flammable and combustible liquids are given in 29 CFR 1910.106.

### 8.2.3 Sanitation and Hygiene

The preparation, storage, or consumption of food should not be permitted in areas where there is exposure to EGME, EGEE or their acetates. The employer should make handwashing facilities available and encourage the workers to use them before eating, smoking, using the toilet, or leaving the worksite. Tools and protective clothing and equipment should be cleaned as needed to maintain sanitary conditions. Toxic wastes should be collected and disposed of in a manner that is not hazardous to workers or the environment. Vacuum pickup or wet mopping should be used to clean the work area at the end of each workshift or more frequently if needed to maintain good housekeeping practices. Collected wastes should be placed in sealed containers that are labeled as to their contents. Cleanup and disposal should be conducted in a manner that enables workers to avoid contact with the waste.

Tobacco products should not be smoked, chewed, or carried uncovered in work areas. Workers should be provided with and advised to use facilities for showering and changing clothes at the end of each workshift. Work areas should be kept free of flammable debris. Flammable work materials (rags, solvents, etc.) should be stored in approved safety cans.

### 8.2.4 Spills and Waste Disposal

Procedures for decontamination and waste disposal should be established for materials or equipment contaminated with EGME, EGEE, or their acetates. The following procedures are recommended in the event of a spill of these glycol ethers [NIOSH 1981; DOT 1984; Canadian Center for Occupational Safety and Health 1988]:

- Exclude persons not wearing protective clothing and equipment from areas of spills or leaks until cleanup has been completed.
- Remove all ignition sources.

- Ventilate the area of a spill or leak.
- Absorb small spills on paper towels. Allow the vapors to evaporate in a suitable place such as a fume hood, allowing sufficient time for them to clear the hood ductwork. Burn the paper towels in a suitable location away from combustible materials.
- Absorb large quantities with sand or other noncombustible absorbent material and atomize the contaminated material in a suitable combustion chamber.
- Collect contaminated waste and place in sealed containers for disposal in accordance with existing regulations of the U.S. Environmental Protection Agency and the U.S. Department of Transportation. State and local regulations may supersede Federal regulations if they are more restrictive.

## 8.3 LABELING AND POSTING

In accordance with 29 CFR 1910.1200 (Hazard Communication), workers must be informed of chemical exposure hazards, of their potential adverse health effects, and of methods to protect themselves. Labels and signs also provide an initial warning to other workers who may not normally work near processes involving hazardous chemicals such as EGME, EGEE, or their acetates. Depending on the process, warning signs should state a need to wear eye protection or a respirator, or they may be used to limit entry to an area without protective equipment. For transient nonproduction work, it may be necessary to display warning signs at the worksite to inform other workers of the potential hazards.

All labels and warning signs should be printed in both English and the predominant language of workers who do not read English. Workers who cannot read labels or posted signs should be identified so that they may receive information about hazardous areas and be informed of the instructions printed on labels and signs.

## 8.4 EMERGENCIES

The employer should formulate a set of written procedures covering fire, explosion, asphyxiation, and any other foreseeable emergency that may arise during the use of materials that may contain EGME or EGEE, or their acetates. All potentially affected workers should receive training in evacuation procedures to be used in the event of fire or explosion. All workers who are using materials containing these glycol ethers should be thoroughly trained in proper work practices that reduce the potential for starting fires and causing explosions. Selected workers should be given specific training in first aid, cardiopulmonary resuscitation, and fire control. Procedures should include prearranged plans for transportation of injured workers and provision for emergency medical care. At least two trained persons in every work area should have received extensive emergency training. Necessary emergency

equipment, including appropriate respirators and other personal protective equipment, should be stored in readily accessible locations.

## 8.5 ENGINEERING CONTROLS

Engineering controls should be the principal method for minimizing exposure to airborne EGME, EGEE, or their acetates in the workplace. To achieve and maintain reduced airborne concentrations of these glycol ethers, adequate engineering controls are necessary (e.g., properly constructed and maintained closed-system operations and ventilation). Control technology applicable to spray painting is discussed in a NIOSH document [O'Brien and Hurley 1981].

Airborne concentrations of these glycol ethers can be most effectively controlled at the source of contamination by enclosure of the operation and use of local exhaust ventilation. Enclosures, exhaust hoods, and ductwork should be kept in good repair so that designed airflows are maintained. Measurements of variables such as capture velocity, duct velocity, or static pressure should be made at least semiannually, and preferably monthly, to demonstrate the effectiveness of the mechanical ventilation system. The use of continuous airflow indicators (such as water or oil manometers marked to indicate acceptable airflow) is recommended. The effectiveness of the system should also be made as soon as possible after any change in production, process, or control that may result in any increase in airborne contaminants.

It is essential that any scheme for exhausting air from a work area also provide a positive means of bringing in at least an equal volume of air from the outside, conditioning it, and evenly distributing it throughout the exhausted area. The ventilation system should be designed and operated to prevent the accumulation or recirculation of airborne contaminants in the workplace. Technical criteria to ensure this are discussed in the NIOSH publication, *The Recirculation of Industrial Exhaust Air* [NIOSH 1978].

Principles for design and operation of ventilation systems are presented in *Industrial Ventilation—A Manual of Recommended Practices*, published by the American Conference of Governmental Industrial Hygienists [ACGIH 1988a]; *American National Standard: Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2(1971)*, published by the American National Standards Institute [ANSI 1979]; and *Recommended Industrial Ventilation Guidelines*, published by NIOSH [Hagopian and Bastress 1976].

## 8.6 PERSONAL PROTECTIVE EQUIPMENT (PPE)

### 8.6.1 Protective Clothing and Equipment

Workers should use appropriate personal protective clothing and equipment that must be carefully selected, used, and maintained to be effective in preventing skin contact with EGME, EGEE or their acetates. The PPE ensemble is dictated by the worker's potential

exposure to these glycol ethers and ranges from gloves to encapsulating suits. The following materials have good but varied resistance to the chemicals indicated below [Forsberg and Mandorf 1989]:

| Chemical | PPE material | Breakthrough time (hr) |
|---|---|---|
| EGEE | Butyl rubber, Saranex® | >8 |
| | PE/EVAL laminate | >4 |
| | Neoprene, nitrile | 1-4 |
| EGME | Butyl rubber | >8 |

To evaluate the use of these materials with EGMEA or EGEEA, users should consult the best available performance data and manufacturer's recommendations. Significant differences have been demonstrated in the chemical resistance of generically similar PPE materials (e.g., butyl) produced by different manufacturers [Mickelsen and Hall 1987]. In addition, the chemical resistance of a mixture may be significantly different from that of any of its neat components [Mickelsen et al. 1986]. Users should therefore test the candidate material with the chemicals to be used.

The worker should be trained in the proper use and care of the chemical protective clothing. After this clothing is in routine use, it should be examined along with the workplace to ensure that nothing has occurred to invalidate the effectiveness of these materials. The NIOSH publication *A Guide for Evaluating the Performance of Chemical Protective Clothing* [Roder 1990] may be helpful. Safety showers and eye wash stations should be located close to operations that involve EGME, EGEE, or their acetates.

Splash-proof chemical safety goggles or face shields (20 to 30 cm minimum) should be worn during any operation in which a solvent, caustic, or other toxic substance may be splashed into the eyes.

In addition to the possible need for wearing protective outer apparel (e.g., aprons, encapsulating suits), workers should wear work uniforms, coveralls, or similar full-body coverings that are laundered each day. Employers should provide lockers or other closed areas to store work and street clothing separately. Employers should collect work clothing at the end of each workshift and provide for its laundering. Laundry personnel should be informed about the potential hazards of handling contaminated clothing and instructed about measures to minimize their health risk.

Employers should ensure that protective clothing is inspected and maintained to preserve its effectiveness. Clothing should be kept reasonably free of oil or grease.

Workers and persons responsible for worker health and safety should be informed that protective clothing may interfere with the body's heat dissipation, especially during hot weather or in hot industries or work situations (e.g., confined spaces). Additional monitoring

is required to prevent heat-related illness when protective clothing is worn under these conditions.

### 8.6.2 Respiratory Protection

Engineering controls should be the primary method used to control exposure to airborne contaminants. Respiratory protection should be used by workers only in the following circumstances:

- During the development, installation, or testing of required engineering controls
- When engineering controls are not feasible to control exposure to airborne contaminants during short-duration operations such as maintenance and repair
- During emergencies

Respiratory protection is the least preferred method of controlling worker exposures and should not be used routinely to prevent or minimize exposures. When respirators are used, employers should institute a complete respiratory protection program that includes worker training at regular intervals in the use and limitations of respirators, routine air monitoring, and maintenance, inspection, cleaning, and evaluation of the respirator. Any respiratory protection program must, at a minimum, meet the requirements of 29 CFR 1910.134. Respirators should be used in accordance with the manufacturer's instructions. Each respirator user should be fit-tested and, if possible, receive a quantitative, on-the-job evaluation of his or her respiratory protection factor to confirm the protection factor assumed for that class of respirator. For additional information on the use of respiratory protection, refer to the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a] and *NIOSH Respirator Decision Logic* [NIOSH 1987b].

Selection of the appropriate respirator depends on the types of glycol ethers and their concentrations in the worker's breathing zone. Before a respirator can be selected, an assessment of the work environment is necessary to determine the concentrations of EGME, EGEE, EGMEA, EGEEA and other contaminants that may be present. Respirator types should be selected in accordance with the most recent edition of the *NIOSH Respirator Decision Logic* [NIOSH 1987b].

The actual respirator selection should be made by a qualified individual, taking into account specific use conditions, including the interaction of contaminants with the filter medium, space restrictions caused by the work location, and the use of any required face and eye protective devices. Respirator selection tables are presented in Chapter 1.

## 8.7 CHEMICAL SUBSTITUTION

The substitution of less hazardous materials can be an important measure for reducing worker exposure to hazardous materials.

## 8.8 EXPOSURE MONITORING

An occupational health program designed to protect workers from adverse effects caused by exposure to EGME, EGEE, or their acetates should include the means for thoroughly identifying all potential hazards. Routine environmental sampling as an indicator of worker exposure is an important part of this program, as it provides a means of assessing the effectiveness of work practices, engineering controls, personal protective clothing and equipment, etc.

Prior knowledge of the presence of certain types of interfering compounds in the sampled environment will greatly help the analyst in the selection of the appropriate analytical conditions for sample analysis. This list of compounds can be compiled from the material safety data sheets for the compounds that are used in or around the process where the sampling will take place.

Initial and routine worker exposure surveys should be made by competent industrial hygiene and engineering personnel. These surveys are necessary to characterize worker exposures and to ensure that controls already in place are operational and effective. Each worker's exposure should be estimated, whether or not it is measured by a personal sampler. Therefore, the sampling strategy should allow reasonable estimates of each worker's exposure. The NIOSH publication *Occupational Exposure Sampling Strategy Manual* may be helpful in developing efficient programs to monitor worker exposure [Leidel et al. 1977].

In work areas where airborne exposures to EGME, EGEE or their acetates may occur, an initial survey should be done to determine the extent of worker exposure. In general, TWA exposures should be determined by collecting samples over a full shift. Measurements to determine worker exposure should be taken so that the average 8-hr exposure is based on a single 8-hr sample or on two 4-hr samples. Several short-term interval samples (up to 30 min) may also be used to determine the average exposure concentration.

When the potential for exposure to these glycol ethers is periodic, short-term samples may be needed to replace or supplement full-shift sampling. Personal sampling (i.e., samples collected in the worker's breathing zone) is preferred over area sampling. If personal sampling is not feasible, area sampling can be substituted only if the results can be used to approximate worker exposure. Sampling should be used to identify the sources of emissions so that effective engineering controls or work practices can be instituted.

If a worker is found to be exposed to EGME, EGEE, or their acetates at concentrations below the REL but at or above one-half the REL, the exposure of that worker should be monitored at least once every 6 months or as otherwise indicated by a professional industrial hygienist.

When the work environment contains concentrations exceeding the respective RELs for these glycol ethers, workers must wear respirators for protection until adequate engineering controls or work practices are instituted; exposure monitoring is recommended at 1-wk intervals. Such monitoring should continue until consecutive determinations at least 1 wk apart indicate that the workers' exposure no longer exceeds the REL.

When workers' exposures are greater than one-half the REL but less than the REL, sampling should be conducted after 6 months; if the concentrations of these glycol ethers are lower than one-half the REL after two consecutive biannual surveys, sampling can then be conducted annually. Exposure monitoring should be conducted whenever changes in production, process, controls, work practices, or weather conditions may result in a change in exposure conditions.

## 8.9 MEDICAL MONITORING

### 8.9.1 General Requirements

Workers exposed to EGME, EGEE, or their acetates are at risk of suffering adverse health effects. Medical monitoring as described below should be made available to all workers. The employer should provide the following information to the physician responsible for the medical monitoring program:

- Any requirements of the applicable OSHA standard or NIOSH recommended standard
- Identification of and extent of exposure to physical and chemical agents that may be encountered by the worker
- Any available workplace sampling results that characterize exposures for job categories previously and currently held by the worker
- A description of any protective devices or equipment the worker may be required to use
- The frequency and nature of any reported illness or injury of a worker
- The results of any monitoring of urinary MAA or EAA for any worker exposed to unknown concentrations of EGME or EGMEA during a spill or emergency (see Appendix G).

### 8.9.2. Medical Examinations

The objectives of a medical monitoring program are to augment the primary preventive measures, which include industrial hygiene monitoring of the workplace, the implementation of engineering controls, and the use of proper work practices and personal protective equipment. Medical monitoring data may also be used for epidemiologic analysis within large plants and on an industrywide basis; they should be compared with exposure data from industrial hygiene monitoring.

Medical examinations are conducted before job placement and periodically thereafter. The preplacement medical examination allows the physician to assess the applicant's functional

capacity and inform him or her of how it relates to the physical demands and risks of the job. Furthermore, such an examination provides baseline medical data that can be compared with subsequent health changes. The preplacement examination should also provide information about prior occupational exposures. Periodic medical examinations after job placement are intended to detect work-related changes in health at an early stage.

The following factors should be considered during the preplacement medical examination and any periodic medical examinations of the worker: (a) exposure to chemical and physical agents that may produce interdependent or interactive adverse effects on the worker's health (including exacerbation of pre-existing health problems and nonoccupational risk factors such as tobacco use), and (b) potentially hazardous characteristics of the worksite (e.g., confined spaces, heat, and proximity to hazards such as explosive atmospheres and toxic chemicals). The type of information that should be gathered is discussed in the following subsections.

#### *8.9.2.1 Preplacement medical examination*

##### 8.9.2.1.1 Medical history

The medical history should contain information about occupational history, including the number of years worked in each job. Special attention should be given to any history of occupational exposure to hazardous chemical and physical agents [Guidotti et al. 1983].

##### 8.9.2.1.2 Clinical examination

The preplacement clinical examination should determine the fitness of the worker to perform the intended job assignment. Appropriate pulmonary and musculoskeletal evaluation should be done for workers whose jobs may require extremes of physical exertion or stamina (e.g., heavy lifting), especially those who must wear personal respiratory protection. Because the standard 12-lead electrocardiogram is of little practical value in monitoring for asymptomatic cardiovascular disease, it is not recommended. More valuable diagnostic information is provided by physician interviews of workers that elicit reports of the occurrence and work-relatedness of angina, breathlessness, and other symptoms of chest illnesses. Special attention should also be given to workers who require the use of eyeglasses. These workers must be able to wear simultaneously any equipment needed for respiratory protection, eye protection, and visual acuity, and they must be able to maintain their concurrent use during work activities.

The worker's duties may be performed near unrelated operations that generate potentially harmful exposures (e.g., asbestos or cleaning or degreasing solvents). The physician must be aware of these potential exposures to evaluate possible hazards to the individual worker.

#### *8.9.2.2 Periodic medical examination*

A periodic medical examination should be conducted annually or more frequently, depending on age, health status at the time of a prior examination, and reported signs or symptoms

associated with exposure to EGME, EGEE, or their acetates. The physician should note any trends in health changes revealed by epidemiologic analyses of examination results. The occurrence of an occupationally related disease or other work-related adverse health effects should prompt an immediate evaluation of industrial hygiene control measures and an assessment of the workplace to determine the presence of a previously unrecognized hazard.

The physician's interview with the worker is an essential part of a periodic medical examination. The interview gives the physician the opportunity to learn of (1) changes in the work setting (e.g., confined spaces), and (2) potentially hazardous workplace exposures that are in the vicinity of the worker but are not related to the worker's job activities.

During the periodic medical examination, the physician should re-examine organ systems at risk to note changes from the previous examination.

## 8.10 BIOLOGICAL MONITORING

Urinary concentrations of the metabolites of EGME, EGEE, and their acetates may be useful biological indicators of worker exposure to these glycol ethers. Biological monitoring accounts not only for environmental concentrations and actual respiratory uptake, but also for absorption through the skin. Information about biological monitoring appears in Section 5.4 of this document and guidelines for biological monitoring are given in Appendix G.

Biological monitoring is suggested when the potential exists for (1) airborne exposure to EGME, EGEE, or their acetates at or above their respective RELs, or (2) skin contact as a result of accidental exposure or breakdown of chemical protective clothing (see Section 8.6.1). Monitoring of urinary MAA or EAA (see Appendix G) should be made available to any worker exposed to unknown concentrations of EGME, EGEE, or their acetates during a spill or other emergency. In the absence of skin exposure, a urinary MAA concentration of 0.8 mg/g creatinine or an EAA concentration of 5 mg/g creatinine approximates the concentration that would result from exposure to the REL for EGME (0.1 ppm) or EGEE (0.5 ppm) during an 8-hr workshift. If a worker's urinary MAA or EAA suggests exposure to EGME, EGEE, or their acetates above their respective RELs, an effort should be made to ascertain the cause (e.g., failure of engineering controls, poor work practices, or nonoccupational exposures).

## 8.11 RECORDKEEPING

Medical records as well as exposure and biological monitoring results must be maintained for workers as specified in Section 1.9 of this document. Such records must be kept for at least 30 years after termination of employment. Copies of environmental exposure records for each worker must be included with the medical records. These records must be made available to the past or present workers or to anyone having the specific written consent of a worker, as specified in Section 1.9.4 of this document.

# 9 RESEARCH NEEDS

The following research is needed to further reduce the risk of adverse developmental and reproductive effects from occupational exposure to EGME, EGEE, or their acetates:

- Investigations should be conducted in the workplace to relate glycol ether exposure to concentrations of metabolites in urine and toxic effects such as reduction in testis size, semen quality, etc.

- Additional studies are needed to define more accurately the human reproductive hazards posed by EGME, EGEE, and their acetates.

- Evaluations of exposed populations are needed to correlate dermal absorption of EGME, EGEE, and their acetates with concentrations of metabolites in urine.

- Additional data should be collected to quantify airborne and dermal exposures to EGME, EGEE, and their acetates under actual conditions of use in the workplace.

- Other glycol ethers should be evaluated to identify any that have effects similar to those of EGME, EGEE, and their acetates (see Appendix E for a list of glycol ethers).

- Physiologically based pharmacokinetic models for EGME, EGEE, and their acetates need to be developed and validated in both human beings and the animal species in which NOAELs were determined.

- Methods are needed for quantitative monitoring of dermal exposure.

- Epidemiologic studies are needed to determine the effects of occupational exposure to EGME, EGEE, and their acetates.

- The method of Groeseneken et al. [1989b] should be validated.