Epoxy Resin Systems

Safe Handling Guide

AIR PRODUCTS

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The Society of the Plastics Industry, Inc.

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Safe Handling Guide

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1. INTRODUCTION

The information contained in this guide is intended to assist supervisors in providing instruction to employees in the safe handling of epoxy resin systems. Safety and health personnel responsible for identifying, evaluating, and controlling hazards associated with epoxy resin systems will also find this information useful. The guide may be used to complement other health and safety information, including material safety data sheets (MSDS), product labels, and product information bulletins. Because this guide is general in scope, workers should refer to MSDS for specific information about the systems with which they are working.

2. CHEMICALS USED/HEALTH EFFECTS

Epoxy resin systems are mixtures made up of varying amounts of several components. The main components of epoxy resin systems are the epoxy resin and the curing agent (also known as hardener). In addition, other components of the epoxy resin system may include solvents, reactive diluents and fillers. In general, epoxy resin systems have hazardous properties, but can be handled safely. The hazards associated with the specific epoxy resin system being handled will depend on the hazardous properties of the components. The following sections describe potential hazards associated with the various components of epoxy resin systems.

EPOXY RESINS

Epoxy resins are a family of synthetic resins including products which range from liquids to solids. The most common resins are produced by reacting epichlorohydrin with bisphenol A or bisphenol F. The three general classes of epoxy resins are liquid, solid and modified liquid.

General Classes

Liquid resins are mild to moderate irritants to the skin, eyes and mucous membranes. The irritant potential is increased by their "sticky" nature which tends to lead to prolonged skin contact. These resins are generally mild to moderate dermal (skin) sensitizers in susceptible individuals.

Solid resins are not readily absorbed through the skin and present a low risk of skin irritation. Direct contact with solutions of these resins can cause mild to moderate irritation of the skin and the eyes, principally because the solvents "de-fat" the skin. When crushed to a fine powder, the materials should be considered an irritant dust; inhalation and skin contact should be avoided. Solid resins are generally low to mild sensitizers.

Modified liquid resins are resins modified by the addition of reactive diluents (see page 4) or solvents (see page 2). Both chemicals and water are used as solvents. When water is used, the resins are referred to as "waterborne resins." These resins should be handled with the same precautions as those in chemical solvents. They are mild to moderate skin irritants. These low molecular weight resins and the reactive diluents are moderate to strong sensitizers. Their sensitizing potential tends to increase with decreasing molecular weight. Epoxy components with significant volatility could cause irritation to skin, eyes and respiratory tract, but inhalation is normally not a hazard except under certain conditions of use, i.e., heating, spraying, or applications with large surface areas. Certain modified resins, such as cycloaliphatic epoxy resins have been shown to cause skin cancer in laboratory animals.

Table 1, page 3, summarizes the hazards associated with epoxy resins.

CURING AGENTS/HARDENERS

The purpose of the epoxy curing agent or hardener is to join or crosslink epoxy resin reactive sites (functional groups) to form a fully reacted or cured polymer. Just as there are many epoxy resins, there are a variety of curing agents that are commonly used that contribute to the characteristics of the final products. Amines are the most widely used curing agents for epoxy resins systems. The amine curing agents fall into several chemical families that include the aliphatic amines, cycloaliphatic amines, and aromatic amines. Anhydrides are another class of curing agents for epoxy resin systems. Some effects of common curing agents are described below.

The aliphatic amines, cycloaliphatic amines and anhydride curing agents may cause irritation or damage to the skin, eyes, and lungs. Certain aliphatic and cycloaliphatic amines are skin sensitizers. Solid anhydride curing agents may cause sensitization in workers exposed to the curing agent dust. The aromatic amines are not strong irritants, but several are skin sensitizers. Certain aromatic amines may absorb through the skin and cause damage to organs such as the liver and interfere with the blood's ability to carry oxygen. Certain aromatic amine curing agents are known to cause cancer in laboratory animals.

Table 1, page 3, summarizes the hazards associated with epoxy curing agents.

SOLVENTS

Solvents may be present in the epoxy resin system formulations or may be used as a cleaning agent for equipment. Examples of solvents typically used in epoxy resin systems are acetone, methyl ethyl ketone (MEK), toluene, xylene, glycol ethers, and alcohols.

Solvents commonly used in epoxy resin applications present a flammability hazard. These solvents present other special health hazards. Contact with solvents will cause "de-fatting" and

TABLE 1
TYPICAL EXPOSURE EFFECTS ASSOCIATED WITH EPOXY RESIN SYSTEMS

EPOXY RESIN SYSTEMS COMPONENTS*	EXAMPLES/TYPE	DERMAL EXPOSURE	INHALATION EXPOSURE	INGESTION EXPOSURE
Liquid Epoxy Resins	based on the reaction product of epichlorohydrin and bisphenol A or bisphenol F	• mild to moderate irritants • mild to moderate sensitizers	• low volatility, exposure unlikely unless heated, sprayed, or spread over large unventilated surfaces	low toxicity
Solid Epoxy Resins	based on the reaction product of epichlorohydrin and bisphenol A or bisphenol F	• mild to moderate irritants and mild sensitizers • not readily absorbed through skin	• low volatility, exposure unlikely unless crushed or ground	low toxicity
Modified Liquid Epoxy Resins	liquid epoxy resins with added reactive diluents or solvents	• mild to moderate irritants • moderate to strong sensitizers	• low volatility, exposure unlikely unless heated, sprayed, or spread over large unventilated surfaces	low toxicity
Aliphatic and Cycloaliphatic Amine Curing Agents		• irritants, sensitizers, corrosive, absorbed through skin	• respiratory irritants	high toxicity
Aromatic Amine Curing Agents		• sensitizers, long term health effects, absorbed through skin	• respiratory irritants	moderate to high toxicity
Anhydride Curing Agents		• corrosive, severe sensitizers	• dusts may be sensitizers	high toxicity
Reactive Diluents	glycidyl ethers	• moderate to strong sensitizers	• moderate volatility, exposure possible	low toxicity
Solvents	acetone, methyl ethyl ketone (MEK), toluene, xylene, glycol ethers, alcohols	• de-fats and dries skin • some may be absorbed • may carry other components through skin	• high volatility, exposure possible • irritation • central nervous system depression (e.g. dizziness, loss of coordination)	low to high toxicity long term effects
Fillers	fiberglass, silicas, calcium carbonate, powdered metal pigments	• some may be absorbed	• dust inhalation	low toxicity

*** Consult MSDS, label, or company bulletin for details on the specific products you are using.**

drying of the skin which may result in an increased chance of skin irritation. Some solvents are absorbed directly through the skin and absorption may be enhanced if the skin is abraded or irritated. They also have the ability to dissolve other epoxy resin system chemicals and carry them through the skin.

The inhalation of solvent vapors or mists may cause respiratory irritation and depression of the central nervous system. This may result in dizziness and sleepiness, lack of coordination, loss of equilibrium, unconsciousness, and even death, if severe overexposure occurs.

Table 1, page 3, summarizes the hazards associated with solvents.

REACTIVE DILUENTS

Reactive diluents are liquids used to reduce the viscosity or "thin" the epoxy resin. Unlike solvents, reactive diluents become part of the polymer. The reactive epoxy diluents fall into the chemical family known as the glycidyl ethers. The glycidyl ethers vaporize more readily than the epoxy resin material and, therefore, have an increased potential for inhalation exposure. These diluents are also likely to be much stronger sensitizers than the epoxy resins.

Table 1, page 3, summarizes the hazards associated with reactive diluents.

FILLERS

Fillers are added to epoxy resins to enhance the properties of the cured resin system. The properties most commonly enhanced with fillers include: thermal, mechanical, electrical, chemical resistance, and flame resistance. Examples of fillers are fiberglass, silicas, calcium carbonate, powdered metals, and pigments.

Fillers added to epoxy resin formulations present a potential inhalation and dermal contact hazard. They can cause mechanical damage to the skin which may aggravate the irritant effects of the epoxy resin system. Since fillers are generally handled in the liquid matrix of the epoxy resin system, their potential to present an inhalation hazard is low. However, inhalation exposure to fillers can occur when they are handled in the dry state or when machining or grinding cured epoxy products. Inhalation exposure to fillers such as crystalline silica or fiberglass may result in delayed lung injury.

Table 1, page 3, summarizes the hazards associated with fillers.

THE EPOXY RESIN SYSTEM

The individual components of the epoxy resin system are blended together for final application. The hazards of the system may change as the individual components are blended together.

3. POTENTIAL EXPOSURES

This section summarizes potential exposures associated with several epoxy resin systems production processes and tasks. Section 4 addresses what to do to minimize human exposure.

PRODUCTION PROCESSES AND TASKS

Potential exposures vary with the process or task. Closed systems with engineering controls are often used to prevent workers from exposure to epoxy resin systems, however, occasionally open areas with limited controls are used and the potential for exposure increases. Dermal exposure is the most likely route of exposure, but if certain curing agents or solvents are being used, inhalation exposure may also be a problem. Potential exposures for several production processes and tasks are listed in Table 2, page 6.

There are many other processes and tasks. Any involving hand contact may result in dermal exposure. Any involving a solvent or curing agent may result in dermal and/or inhalation exposure

4. WORK PLACE CONTROLS

Protection of epoxy resin system workers from the two major health hazards they face, skin contact and inhalation of vapors, consists chiefly of three major work place controls:

- adequate ventilation
- proper personal protective equipment and clothing
- good housekeeping

The following four sections describe methods for achieving good work place controls for epoxy resin systems.

ENGINEERING CONTROLS

Engineering controls are the most effective of the work place controls and should be implemented first. Engineering controls include process or equipment modifications that reduce the amount of potentially hazardous material to which an employee may be exposed. Isolation and ventilation are the primary controls utilized when working with epoxy resin systems.

Isolation, or enclosure of a process or work operation to reduce the number of employees exposed, is a standard industrial hygiene control measure. Due to the potential for irritation and sensitization to epoxy resin systems, the use of epoxy resins system chemicals should be isolated, if possible to designated areas, preferably separate from the remainder of the plant. Examples of isolation are spray booths, enclosed curing and mixing rooms, and glove bag systems.

TABLE 2
EXPOSURE POTENTIAL OF PRODUCTION PROCESSES AND TASKS

PROCESSES	EXPOSURE POTENTIAL			COMMENTS
	DERMAL	INHALATION	INGESTION	
Filament Winding/Pultrusion	high	medium	low	
Resin Transfer Molding	high	medium	low	
Pre-preg and Laminate Production	high	high	low	
Flooring, Grouting and Hand Applications	high	high	low	Large surface areas and high temperatures may increase possibility for inhalation exposure.
Coating	high	high	low	Spraying the coatings causes generation of aerosols which increase the potential for inhalation exposure.
TASKS	**EXPOSURE POTENTIAL**			**COMMENTS**
	DERMAL	INHALATION	INGESTION	
Unloading/Mixing/Pouring - hose connect/disconnect - drum pump cleaning/handling - dumping/pouring	high	medium	low	
Cutting/Machining/Finishing	high	high	low	These tasks generate dust which increase the potential for inhalation exposure.
Clean Up	high	high	low	Potential for hazardous effects increases due to solvent use.
Maintenance	high	medium	low	
Spraying	high	high	low	Spraying the coatings causes generation of aerosols which increase the potential for inhalation exposure.
Brushing	high	medium	low	
Hand Layup	high	medium	low	

Ventilation is the standard method of controlling employee exposure to airborne vapors of epoxy resins and solvents. Ventilation involves controlling air flows to reduce exposures. Local exhaust ventilation systems capture the contaminant at the source and either filter or remove it from the work area. The ventilation system needs to be designed such that vapors, aerosols and dusts are pulled away from, and not into, the breathing zone of the workers. A constant supply of fresh non-contaminated air should be available to the workers at all times. Examples of local exhaust ventilation systems are draw down exhaust tables, slot hoods, dust extraction systems, and portable vapor/dust collectors. Good general ventilation which effectively minimizes the accumulation of vapors is essential in all work areas. Care has to be taken to ensure that ventilation systems are utilized and maintained as designed. Some basic rules for good ventilation controls are:

- Check that the ventilation system is on and operating before starting any work involving epoxy resin systems.
- For the ventilation system to operate properly, inspections and maintenance need to be done on a periodic basis, such as checking the flow rate, and checking the condition of the duct work, motors, filters, and belts.

Additional information on ventilation design is outlined in INDUSTRIAL VENTILATION, Manual of Intended Practice (see section 7, Additional Information, page 12).

PERSONAL PROTECTIVE EQUIPMENT

Eye Protection

Eye protection can be provided by safety glasses with side shields, chemical goggles, full face respirators, and face shields with glasses or goggles. The type of eye protection required is dependent on the hazard assessment for the specific applications. When there is danger of vapor, aerosol or dust exposure, such as when mixing, spraying, or pumping material under pressure, the eyes must be protected by chemical goggles at a minimum. Goggles may also need to be worn when grinding or trimming solid-cured epoxy product.

Gloves

Selecting appropriate chemical-resistant gloves for use with epoxy resin systems involves matching the characteristics of the glove with the requirements of the production tasks being performed. The requirements of the production task may be classified as physical and chemical.

Production task requirements will need to be determined for the specific work situation. Glove resistance characteristics can also be classified as physical and chemical. Physical characteristics of production tasks and glove resistance are dexterity, wet grip and cut, tear, puncture, and abrasion resistance. Chemical characteristics of production tasks are type of epoxy resin sys-

TABLE 3
GLOVES: CHEMICAL RESISTANCE GENERALIZATIONS

Generic Glove Material / Epoxy Resins Systems/ Components	Epoxy Resins, Liquid or Solid	Modified Epoxy Resins	Hardeners/ Curing Agents	Solvents
Ethyl Vinyl Alcohol (EVAL) laminate	Excellent	Excellent	Excellent	Excellent
Butyl Rubber	Excellent	Excellent	Excellent	Good
Nitrile (NBR)	Excellent	Good	Fair	Fair
Neoprene	Excellent	Good	Fair	Fair
Vinyl (PVC)	Excellent	Poor	Poor	Poor

Excellent – breakthrough * time > 480 minutes
Good – breakthrough time > 20 minutes
Fair – breakthrough time < 20 minutes
Poor – glove material degradation occurred during testing
* As defined by American Society for Testing and Materials (ASTM) F-739-96

tem, solvents used and degree of contact. Chemical characteristics of glove resistance are permeation and degradation.

Information on glove characteristics can generally be obtained from the manufacturers of the specific gloves being considered. While it is most useful to have chemical resistance information with the specific glove models and process chemicals being used, the following generalizations can be made for generic chemical-resistant glove materials:

Replacement time should be considered when selecting the most appropriate glove. It may be more effective to select a glove with lower chemical resistance but which is replaced frequently than to select a more resistant glove which is reused many times. Regardless of the replacement time chosen for your glove use program, gloves should be replaced whenever signs of degradation are noticed. Typical signs of degradation include swelling, softening, cracking or discoloration of the glove material.

Chemical-Resistant Clothing

Chemical-resistant clothing may also be considered to prevent skin contact. The same material and use characteristics described for gloves also apply to chemical resistant clothing. A wide assortment of disposable aprons, coveralls, lab coats, and sleeves is available. Contaminated clothing and other contaminated personal protective equipment (PPE) should be removed and discarded in a manner that will not cause additional exposure.

Respirators

Respirators come in different types, air-supplied or air-purifying. Air-supplied respirators provide the user with an external source of clean breathing air while air-purifying respirators make use of adsorbents and filters to remove chemical vapors and particulates from the workplace air.

Respirators may be required where:

- airborne solvent (vapor and aerosol) levels are high
- dust levels are high (resin mixing, finishing, repair)
- irritating odors are present
- respiratory sensitizers are involved.

Selection of appropriate respiratory protective equipment requires consideration of workplace conditions.

WORK PRACTICES AND PERSONAL HYGIENE

It is essential that the employee use good work practices. Safety instructions and operating procedures for specific tasks must be written, communicated and enforced. Some fundamental and easily implemented work practices that can be used to minimize exposures when working with epoxy resin systems include:

- following the proper procedures for production and control equipment
- using proper maintenance, and cleaning of personal protective equipment
- maintaining a personal hygiene program, which includes provisions for clean up and adequate clothing storage
- laundering or disposing of contaminated clothing
- disposing of contaminated leather articles, such as belts and shoes
- maintaining good housekeeping
- inspecting and maintaining production and control equipment
- providing good supervision
- providing separate eating, drinking and smoking facilities.

TRAINING

The safe use and handling of epoxy resin systems require that all employees who work with these systems must be trained in safe handling procedures. The training program should address at a minimum the following items:

- Labels, Material Safety Data Sheets, and Product Information Bulletins
- Health and Safety Hazards
- Emergency Procedures
- First Aid
- Work Place Controls
- Personal Protective Equipment
- Safe Handling Procedures.

5. FIRST AID

SKIN

If the skin or clothing becomes contaminated with epoxy resin systems remove contaminated clothing and wash the exposed area with soap and water for at least 15 minutes. Seek medical attention immediately if irritation develops.

EYES

If the eyes become contaminated they should be washed out with copious quantities of clean water and medical advice should be sought.

INHALATION

If respiratory distress is experienced, immediately remove the individual from the contaminated area to fresh air. If the person is not breathing, artificial respiration should be provided. Seek immediate medical attention. If breathing is difficult, transport the individual to a medical care facility for treatment and, if available, give supplemental oxygen.

INGESTION

If the material is accidentally ingested, seek immediate medical attention. If the victim is conscious, give water. Do not induce vomiting unless directed to do so by a physician.

6. GLOSSARY

Corrosive — A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

De-fatting — Action in which solvents permeate the skin and cause the natural body oils and fat layer in the skin surface to be removed causing dry skin leading to increased skin cracking and drying allowing for increased potential for skin reactions.

Exposure — Having bodily contact with a material, including inhalation, oral, and dermal (skin) contact.

Exposure Limit/Guideline — An air concentration of a material to which nearly all persons can be exposed day after day without adverse effects. Exposure limits/guidelines are most commonly used as a point of reference in assessing work place exposures.

Hazard — The potential of the material to cause harm.

Irritant — A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of the contact.

Route of Exposure — The path by which a material enters the body, most commonly the mouth (ingestion), skin (dermal absorption) or respiratory tract (inhalation).

Sensitizer — A substance that may cause an allergic reaction in some individuals after repeated exposure. Epoxy resin system components may be skin sensitizers, pulmonary sensitizers or both.

Toxicity — The sum of adverse effects resulting from exposure to a material, generally by the mouth (ingestion), skin (dermal absorption) or respiratory tract (inhalation).

7. ADDITIONAL INFORMATION

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For Emergencies:

CHEMTREC
1-800-424-9300

National Response Center
1-800-424-8802

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1801 K Street, NW, Suite 600K • Washington, DC 20006-1301 • Publication No. AE-155

September, 1997