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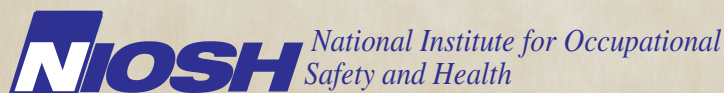


Evaluation of Exposure to Epoxy Resin while Manufacturing Artificial Floral Arrangements

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ABBREVIATIONS

ACGIH®	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
CT	Charcoal tube
GA	General area
HHE	Health hazard evaluation
Lpm	Liters per minute
mg/m ³	Milligrams per cubic meter
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
ND	Not detected
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible exposure limit
ppm	Parts per million
PPE	Personal protective equipment
REL	Recommended exposure limit
STEL	Short term exposure limit
TD	Thermal desorption
TLV®	Threshold limit value
TWA	Time-weighted average
VOC	Volatile organic compound
WEEL	Workplace environmental exposure level

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation at Immortalis Botanicals in Farmville, Virginia. The company submitted the request because of concern about employee exposure to epoxy resins while making floral arrangements.

What NIOSH Did

- We evaluated the worksite in November 2008.
- We took air samples for volatile organic compounds (VOCs) and amines.
- We looked at employees' personal protective equipment use.
- We asked employees about their health concerns.
- We observed employees' work practices.

What NIOSH Found

- Employees were exposed to epoxy resin and isopropyl alcohol (IPA) through skin contact.
- Airborne exposures to selected VOCs, including some amines, were very low.
- The Mixer/Pourer wore a respirator per the company's written procedure. Air sampling results indicate that respiratory protection is not required.
- Employees did not wear eye protection when pouring epoxy resin.
- Employees stood to prepare floral arrangements and knelt to pour the epoxy resin. These postures may lead to joint problems over time.
- Employees did not report health problems related to their work.

What Managers Can Do

- Install a dispensing gun for adding epoxy resin to the vases.
- Install a sink with warm water and an emergency eye wash station in the production area.
- Require the use of eye protection when mixing epoxy resin.
- Provide the Mixer/Pourer with safety glasses, butyl rubber gloves (either shoulder or gauntlet length), and a butyl rubber apron to wear when handling epoxy resin and IPA.
- Provide the Mixer/Pourer with an adjustable wheeled stool to use when pouring epoxy resin into the vases.
- Provide the Arranger a sit-stand stool and antifatigue mat to prevent leg strain.

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION (CONTINUED)

What Employees Can Do

- Avoid getting epoxy resin or IPA on your skin or in your eyes.
- Wear skin and eye protection when mixing and pouring epoxy resin or handling IPA.
- Wash skin as soon as possible with soap and water if epoxy resin gets on it.
- Flush your eyes with water if you get epoxy resin in them.
- Talk to your supervisor about any workplace health concerns you have.

SUMMARY

On August 31, 2007, NIOSH received an HHE request from management at Immortalis Botanicals (Immortalis) in Farmville, Virginia. The company was concerned about employee exposure to epoxy resin used during the manufacture of luxury artificial floral arrangements.

We evaluated the worksite on November 5–7, 2008. We observed work practices, reviewed PPE use, and spoke with employees about work-related health concerns. We used TD tubes (qualitative analysis) and charcoal tubes (quantitative analysis) to collect PBZ air samples for VOCs. We also collected PBZ air samples for amines.

NIOSH measured airborne VOCs and amines from epoxy resins during the manufacture of artificial floral arrangements. We found low concentrations of VOCs and detected no amines. However, the Mixer/Pourer had skin contact with the epoxy resin and isopropyl alcohol. We recommend employees use a dispensing gun for adding epoxy resin to flower vases and wear chemical protective clothing to minimize skin contact.

Based on the TD results, the charcoal tubes were analyzed for toluene, 2-butoxyethanol, cellosolve acetate, xylene, and ethyl benzene. Samples were also analyzed for butyl glycidyl ether, an ingredient in the epoxy resin. Very low concentrations of these VOCs were detected, and all PBZ sample results were below the applicable OELs. Amines were not detected. We observed epoxy resin and isopropyl alcohol on employees' skin, increasing their risk for contact dermatitis and sensitization. We also observed employees working in awkward postures, placing them at risk of developing musculoskeletal disorders.

We recommend that the Mixer/Pourer use a dispensing gun to add epoxy resin to the vases to minimize spills and prevent employees from placing their forearm on the table while pouring epoxy resin from a beaker. We also recommend that the Mixer/Pourer wear butyl rubber gloves (either shoulder or gauntlet length) and a butyl rubber apron when handling epoxy resins or isopropyl alcohol. We recommend using a wheeled stool to avoid kneeling when pouring epoxy resin into the vases, and providing an antifatigue mat for the Arranger to prevent leg strain. A sink with warm water and soap and an emergency eyewash station should be installed near the mixing area.

Keywords: NAICS 339999 (All Other Miscellaneous Manufacturing), epoxy resin, butyl glycidyl ether, VOCs, amines, contact dermatitis, small business

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NIOSH received a management request for an HHE from Immortalis Botanicals (Immortalis) in Farmville, Virginia, because of concerns about possible health effects in employees who mix and handle epoxy resin. We visited the Immortalis site on November 5–7, 2008. During the site visit we held an opening meeting with management and an employee representative and offered confidential medical interviews to any interested employees. We toured the facility, observed work processes and PPE use, and spoke with employees. We collected GA and PBZ air samples for VOCs and amines that could be present in the epoxy resins. At the end of the site visit we held a meeting to discuss our preliminary findings and recommendations. A summary letter dated December 1, 2008, was sent to Immortalis management and an employee representative.

Background

Immortalis (formerly known as Castaway Glass) manufactures luxury floral arrangements for commercial and residential applications. Six employees plus the owner work in a single-story building that is divided into a 500-square foot production room, in addition to office, shipping, storage, show, and break rooms.

The manufacturing process begins when an employee called the Arranger, following instructions in a production manual, puts together a floral arrangement in a vase. Pieces of imitation sea glass (smooth colored glass) are placed on the bottom of the vase to add color and texture. The imitation sea glass is purchased or made on site by breaking glass bottles and tumbling the pieces with an abrasive powder in a wet, enclosed process. The vase is then placed on a level table. A clear epoxy resin is poured into the vase to permanently hold the arrangement in place and to give the impression that the floral arrangement is set in water. Following written Immortalis procedures, the Mixer/Pourer measures out epoxy resin and a curing agent and blends them with an electric paddle mixer (Figure 1). The Mixer/Pourer then adds the prescribed amount of clear epoxy resin into the vase through plastic funnels (Figure 2). The Mixer/Pourer must avoid getting epoxy resin on the sides of the vase or introducing bubbles. Isopropyl alcohol is used to clean the equipment and spills. To ensure the epoxy resin cures properly, relative humidity is kept between 30% and 40% in the production room by using humidifiers in winter or dehumidifiers in the summer, as needed. Once the epoxy resin is cured, the vase is moved to another room for packaging and shipping to customers.

INTRODUCTION (CONTINUED)

Management reported that in June 2007, an employee working as a Mixer/Pourer developed a rash on her hands and abdominal areas, which had repeatedly been in contact with the uncured epoxy resin.



Figure 1. Employee using a handheld drill to mix epoxy resin in a bucket, while sitting and wearing a filtering facepiece respirator, gown, sleeves, and gloves.



Figure 2. Employee pouring epoxy resin in vases with artificial floral arrangements while kneeling and wearing gloves, apron, and kneepads.

ASSESSMENT

During the first day of the evaluation we toured the facility and observed the work process to see what tasks had the potential for hazardous exposures. We reviewed the MSDSs provided by Immortalis management for the epoxy resin and curing agent. The epoxy resin contained alkylglycidyl ether, and the curing agent contained aliphatic amine, nonylphenol, and phenyl carbonyl as the main ingredients. Based on this information we collected short-term GA air samples for VOCs on TD tubes to qualitatively determine the VOCs and amines that may be present during mixing and pouring of the epoxy resin. We also collected short-term (15 minutes) and full-shift (total time mixing and pouring was approximately 5 hours) PBZ air samples using CTs for quantitative analysis of VOCs based on the results of the TD tube analyses. We sampled for amines [2-(2-aminoethylamino)ethanol, diethanolamine, diethylenetriamine, ethanolamine, ethylenediamine, triethylenetetramine] using 1-naphthylisothiocyanate-treated XAD-2 tubes. Details of the sampling and analytical methods are discussed in Appendix A. Information on the composition and health effects of epoxy resins is provided in Appendix B.

We spoke with employees about their job tasks, health concerns, and PPE use. We observed work practices (to look for skin contact with epoxy resin) and work postures.

RESULTS

The chemicals most prevalent on the TD tubes during mixing and pouring of the epoxy resin were toluene, 2-butoxyethanol, isopropanol, phenol, butyl acetate, diisobutyl phthalate, cellosolve acetate, xylene, and ethyl benzene. Of these, toluene, 2-butoxyethanol, cellosolve acetate, xylene, and ethyl benzene were analyzed quantitatively from the CT samples. Butyl glycidyl ether, an ingredient in the epoxy resin, was also analyzed. Only two chemicals, toluene (Table 1) and 2-butoxyethanol, were present above trace concentrations; exposure levels, however, were at least two orders of magnitude below their OELs. Concentrations of 2-butoxyethanol ranged from ND (< 0.003 ppm) to 0.031 ppm. The remaining chemicals (butyl glycidyl ether, cellosolve acetate, ethylbenzene, and xylene) were either ND (< 0.003 ppm or lower) or present in trace amounts (between < 0.003 and 0.0089 ppm). The lowest NIOSH REL for any of these VOCs is 0.5 ppm for cellosolve acetate. The OSHA PELs are much higher.

RESULTS

(CONTINUED)

Table 1. Air sampling results for toluene

Sample type	Sample location	Sample time (min)	Concentration (ppm)
PBZ-STEL	Mixing epoxy	16	0.072
PBZ-STEL	Mixing epoxy	16	0.073
PBZ-STEL	Mixing epoxy	19	0.077
PBZ-STEL	Arranging	18	0.070
PBZ	Arranging	295	0.063*
PBZ	Arranging	292	0.064*
PBZ	Mixing epoxy	287	0.069*
PBZ	Mixing epoxy	288	0.065*
NIOSH REL-TWA			100
NIOSH REL-STEL			150
OSHA PEL-TWA			200

*The PBZ concentrations shown are TWAs over the period sampled. These concentrations would be even lower if calculated over an 8-hour work shift and assuming no additional exposure to toluene.

The following amines were ND (below 0.0027 mg/m³, based on a maximum air sample volume of 75 liters): triethylenetetramine, ethylenediamine, ethanolamine, diethanolamine, 2-(2-aminoethylamino)ethanol, and diethylenetriamine.

The employee reported to have had a skin rash was no longer working at Immortalis and could not be located. None of the three employees we met during this evaluation reported health effects from workplace exposures or conditions.

Workplace Observations

While preparing the epoxy resin, the Mixer/Pourer wore safety glasses and nitrile rubber gloves. For the mixing task, the Mixer/Pourer wore a 3M model 8247 R95 filtering facepiece respirator with a carbon layer intended to provide relief from organic vapor nuisance odors that do not exceed OSHA PELs. The use of respiratory protection was specified in Immortalis' procedures manual, in keeping with the MSDS for the epoxy resin. The employee also wore a plastic apron, plastic sleeves, and disposable nitrile rubber gloves.

While pouring the epoxy resin into the vases from a plastic cup, the Mixer/Pourer wore latex rubber gloves, a plastic apron and sleeves, and knee pads. We observed the Mixer/Pourer rolling up

RESULTS

(CONTINUED)

the plastic protective sleeves because they caused her arms to sweat. The Mixer/Pourer used isopropyl alcohol to remove the epoxy resin from her skin and equipment. Although the mixing area had a sink, it was not connected to a water supply. No emergency eyewash was available in spite of the potential for epoxy resin to splash in the employee's eyes or for the employee to touch her eyes with soiled gloves.

The Mixer/Pourer rested an elbow on the table to steady her hand as she poured the epoxy resin to avoid getting it onto the sides of the vases (see Figure 2). However, some epoxy resin dripped onto her hands and elbows and occasionally spilled from the pouring container onto the table and floor. We observed dried spilled epoxy resin on work surfaces and on the floor.

As illustrated in Figure 2, the Mixer/Pourer knelt on the floor to pour epoxy resin in the vases. This position allowed her to be at eye level with the vase and to better control the epoxy resin flow. During the process she stood to fill the pouring cup with epoxy resin. The Arranger stood in front of her worktable on a thin rubber mat over the concrete floor.

Local exhaust ventilation was not available during the epoxy resin mixing and pouring process. Employees used isopropyl alcohol or an ammonia-containing glass cleaner to clean artificial flowers, vases, and epoxy resin spills.

DISCUSSION

We did not notice chemical odors during the epoxy resin mixing and pouring process even though many of the chemicals in the epoxy resins have odor thresholds that are much lower than their OELs.

Employees did not mention any work-related health effects. The primary route of exposure to epoxy resin for the Mixer/Pourer is skin contact. The Mixer/Pourer wore natural rubber latex gloves when pouring epoxy resin. Natural rubber latex is not a suitable material for protecting against exposure to epoxy resins. In addition, NIOSH recommends the use of nonlatex gloves for activities that are not likely to involve contact with infectious agents because some workers can become sensitized or experience allergic reactions while wearing them [NIOSH 1998].

DISCUSSION

(CONTINUED)

Current employees have not experienced skin problems. However, employees who have contact with epoxy resin may become sensitized and experience an allergic skin reaction. Hence, employees should avoid skin contact with epoxy resins by using protective gloves, aprons, and safety glasses and by preventing spills and contact with spilled epoxy resin.

The Mixer/Pourer wore safety glasses while blending the epoxy resin components but wore no eye protection while mixing the two components in a bucket or pouring the mixture in the vases. No emergency eye wash was available to flush the eyes, should a splash exposure occur. An emergency eye wash could prevent serious eye damage. Employees should wear eye protection during all phases of mixing and pouring epoxy resins.

During this evaluation we advised the Mixer/Pourer not to use isopropyl alcohol as a skin cleanser because it could damage her skin barrier and cause irritation. Having a working sink near the mixing station would eliminate the need for the employee to go to the restroom to wash epoxy resin off her hands and may encourage more frequent skin cleaning.

The awkward posture of the Mixer/Pourer may result in muscular strain of the knees and the lower back. Prolonged standing, as observed for the Arranger, has been associated with sore feet [Messing and Kilbom 2001], chronic venous insufficiency [Criqui et al. 2007], varicose veins [Beebe-Dimmer et al. 2005], and low back pain [Hiebert et al. 2007].

CONCLUSIONS

Employees were potentially exposed through skin contact to uncured epoxy resin because of improper (latex rubber) glove selection. Skin contact with epoxy resin may cause sensitization and contact dermatitis. No emergency eye wash station was available in the production room. Because we did not identify an inhalation hazard during the epoxy resin mixing and pouring process, we do not believe mandatory respiratory protection is necessary. However, voluntary respirator use is an option if employees want protection from the epoxy resin odor. Finally, awkward postures and prolonged standing by some production employees may result in knee and lower back pain and strain, sore feet, stiff legs, and varicose veins.

RECOMMENDATIONS

Based on our findings, we recommend the actions listed below to create a more healthful workplace. We encourage Immortalis to use a labor-management health and safety committee or working group to discuss the recommendations in this report and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at Immortalis. Our recommendations are based on the hierarchy of controls approach (Appendix B: Occupational Exposure Limits and Health Effects). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and/or personal protective equipment may be needed.

Elimination and Substitution

Elimination or substitution of a toxic/hazardous process material is a highly effective means for reducing hazards. Incorporating this strategy into the design or development phase of a project, commonly referred to as “prevention through design,” is most effective because it reduces the need for additional controls in the future.

1. Eliminate the use of epoxy resin in future floral arrangements whenever possible.

Engineering Controls

Engineering controls reduce employees’ exposures by removing the hazard from the process or placing a barrier between the hazard and the employee. Engineering controls are very effective at protecting employees without placing primary responsibility of implementation on the employee.

1. Use an epoxy resin dispensing gun instead of a container to decrease the potential for spills and skin contact with the epoxy.
2. Connect the sink by the mixing station to hot and cold water supply lines and drainage. Install a hands-free faucet and emergency eye wash at the sink, and provide soap and moisturizing skin lotion.

RECOMMENDATIONS (CONTINUED)

3. Provide a wheeled, adjustable height stool for the Mixer/Pourer so this employee does not have to kneel while pouring epoxy resin into the flower vases.
4. Provide antifatigue mats and sit/stand stools for the Arranger and at the packing stations.

Administrative Controls

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to workplace hazards. The effectiveness of administrative changes in work practices for controlling workplace hazards is dependent on management commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production.

1. Educate employees about the importance of avoiding skin contact with epoxy resins and isopropyl alcohol. Instruct employees to wash epoxy resin off their skin with soap and water as soon as possible. Review skin protection techniques, spill clean-up procedures, and use of the emergency eye wash station as necessary (when installed).
2. Re-evaluate employees' exposures if another type of epoxy resin with different ingredients is used.
3. Update company records to include the MSDSs for the clear epoxy components, the ammonia-containing glass cleaner, and isopropyl alcohol.

Personal Protective Equipment

PPE is the least effective means for controlling employee exposures. Proper use of PPE requires a comprehensive program and calls for a high level of employee involvement and commitment to be effective. The use of PPE requires the choice of the appropriate equipment to reduce the hazard and the development of supporting programs such as training, change-out schedules, and medical assessment if needed. PPE should not be relied upon as the sole method for limiting employee exposures. Rather, PPE should be used until engineering and administrative controls can be demonstrated to be effective in limiting exposures to acceptable levels.

RECOMMENDATIONS

(CONTINUED)

1. Based on our air sampling results, respiratory protection is not required. If employees are required to wear respiratory protection, OSHA requires that the employer comply with all elements of the standard by establishing a respiratory protection program with worksite-specific procedures that include written guidelines for the use and care of respirators, medical monitoring, fit testing, and training. If employees wear filtering facepiece respirators voluntarily, then the only requirement is providing them a copy of Appendix D of 29 CFR 1910.134 "Information for Employees Using Respirators When Not Required Under the Standard" [29 CFR 1910.134].
2. Provide the Mixer/Pourer safety glasses to wear when mixing and pouring epoxy resin. Provide the Mixer/Pourer with butyl rubber gloves (either shoulder or gauntlet length) and a butyl rubber apron to wear when handling epoxy resin [Forsberg and Mansdorf 2007].
3. Encourage employees to wear cushioned footwear that provides arch and heel support.

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Thermal Desorption Tubes

We collected six GA air samples on TD tubes and submitted them for qualitative analysis of VOCs. A TD tube was inserted in the end of Tygon® tubing connected to a calibrated low-flow personal sampling pump set to a nominal flow rate of 0.20 Lpm and allowed to run for approximately 2 hours. The samples were analyzed with a Perkin Elmer ATD 400 automatic TD system using a gas chromatograph with a mass selective detector. The typical desorption procedure is suited for most common organic solvents with a molecular weight below 300 and boiling points around 200°C or less. Samples were analyzed according to NIOSH Method 2549 [NIOSH 2009]. Certain chemicals identified on the TD tubes were selected for further analysis on the CT samples because of their greater relative abundance compared to other compounds, or because of their known irritating or toxic properties.

Charcoal Tubes

We collected eight PBZ and one GA air sample on CTs for analysis for toluene, 2-butoxyethanol, cellosolve acetate, xylene, ethyl benzene, and butyl glycidyl ether. We inserted the CT in the end of Tygon® tubing connected to a low-flow personal sampling pump set to a nominal flow rate of 0.20 Lpm. We placed the pump on the employee and the CT in the employee's PBZ for the duration of the mixing and pouring tasks (approximately 5 hours). The CTs were analyzed for the selected chemicals using NIOSH Method 1501 [NIOSH 2009], with the following modification. The desorbing solvent was changed from carbon disulfide to a mixture of carbon disulfide and 5% n-propyl alcohol. Toluene was detected on the media blank, and the samples were blank corrected.

Amines

We collected two GA and two PBZ and air samples on naphthylisothiocyanate-treated XAD-2 tubes and submitted them for analysis for triethylenetetramine, ethylenediamine, ethanolamine, diethanolamine, 2-(2-aminoethylamino)ethanol, and diethylenetriamine. The XAD tube was inserted on the end of Tygon® tubing attached to a low-flow personal sampling pump set to a nominal flow rate of 0.20 Lpm. The samples were desorbed and analyzed according to NIOSH Method 2540 [NIOSH 2009] modified for reverse-phase high performance liquid chromatography. No amines were detected on the media blanks.

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APPENDIX B: OCCUPATIONAL EXPOSURE LIMITS & HEALTH EFFECTS

In evaluating the hazards posed by workplace exposures, NIOSH investigators use both mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents as a guide for making recommendations. OELs have been developed by Federal agencies and safety and health organizations to prevent the occurrence of adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. However, not all employees will be protected from adverse health effects even if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the employee to produce health effects even if the occupational exposures are controlled at the level set by the exposure limit. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, which contributes to the individual's overall exposure.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended STEL or ceiling values where health effects are caused by exposures over a short period. Unless otherwise noted, the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday, and the ceiling limit is an exposure that should not be exceeded at any time.

In the United States, OELs have been established by Federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits, while others are recommendations. The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits enforceable in workplaces covered under the Occupational Safety and Health Act. NIOSH RELs are recommendations based on a critical review of the scientific and technical information available on a given hazard and the adequacy of methods to identify and control the hazard. NIOSH RELs can be found in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2005]. NIOSH also recommends different types of risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects from these hazards. Other OELs that are commonly used and cited in the United States include the TLVs recommended by ACGIH, a professional organization, and the WEELs recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. They are not consensus standards. ACGIH TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline “to assist in the control of health hazards” [ACGIH 2009]. WEELs have been established for some chemicals “when no other legal or authoritative limits exist” [AIHA 2009].

Outside the United States, OELs have been established by various agencies and organizations and include both legal and recommended limits. Since 2006, the Berufsgenossenschaftliches Institut für Arbeitsschutz (German Institute for Occupational Safety and Health) has maintained a database of international OELs

APPENDIX B: OCCUPATIONAL EXPOSURE LIMITS & HEALTH EFFECTS (CONTINUED)

from European Union member states, Canada (Québec), Japan, Switzerland, and the United States available at www.dguv.de/bgia/en/gestis/limit_values/index.jsp. The database contains international limits for over 1250 hazardous substances and is updated annually.

Employers should understand that not all hazardous chemicals have specific OSHA PELs, and for some agents the legally enforceable and recommended limits may not reflect current health-based information. However, an employer is still required by OSHA to protect its employees from hazards even in the absence of a specific OSHA PEL. OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91-596, sec. 5(a)(1))]. Thus, NIOSH investigators encourage employers to make use of other OELs when making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminate or minimize identified workplace hazards. This includes, in order of preference, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health that focuses resources on exposure controls by describing how a risk needs to be managed. Information on control banding is available at www.cdc.gov/niosh/topics/ctrlbanding/. This approach can be applied in situations where OELs have not been established or can be used to supplement the OELs, when available.

Epoxy resins

Epoxy resins consist of two basic components: an uncured resin and the curing agent, also referred to as the hardener. The two components are liquids that harden when cured. Additional ingredients can be used in different applications to add color and/or texture. The curing agents account for much of the hazards associated with epoxy resins. They include aliphatic amines, aromatic amines, cycloaliphatic amines, acid anhydrides, polyamides, and catalytic curing agents. The aliphatic amines include triethylenetetramine and diethylenetriamine. These amines are highly alkaline with a pH in the 13–14 range. The epoxy resin may also include diluents/solvents, fillers, and pigments [Hathaway and Proctor 2004]. Butyl glycidyl ether is a common diluent in the epoxy resins. Glycidyl ethers have low vapor pressures, so inhalation is less important than skin contact. Solvents used as nonreactive diluents may cause upper respiratory tract, eye, and skin irritation. Solvents include cellosolve, acetone, methyl ethyl ketone, methylene chloride, toluene, 1,1,1-trichloroethane, and xylene. Skin contact with uncured epoxy resins should be avoided because they can cause dermatitis and sensitization [Bray 1999; Amado and Taylor 2008]. Use of skin protection is important. Inhalation of uncured epoxy resin fumes can lead to respiratory sensitization and occupational asthma [Bray 1999]. Once cured (hardened), the epoxy resins are not a health hazard unless they are cut, sanded, or burned [CDPH 1989]. There are no OELs for epoxy resins but some of the ingredients such as solvents and glycidyl ethers do have OELs. NIOSH has an REL-

APPENDIX B: OCCUPATIONAL EXPOSURE LIMITS & HEALTH EFFECTS (CONTINUED)

Ceiling for n-butyl glycidyl ether of 5.6 ppm, and OSHA has an 8-hour PEL-TWA of 50 ppm. NIOSH has an REL-TWA of 1 ppm for diethylenetriamine [NIOSH 2005].

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