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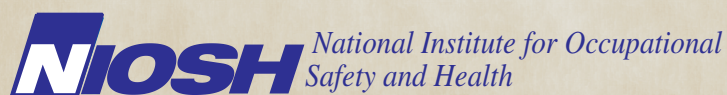
Evaluation of Employee Exposures in a Bus Maintenance Shop

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Centers for Disease Control and Prevention



The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

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ABBREVIATIONS

ACGIH®	American Conference of Governmental Industrial Hygienists
ASPH	Association of Schools of Public Health
CFR	Code of Federal Regulations
HHE	Health hazard evaluation
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
NMAM	NIOSH Manual of Analytical Methods
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PPE	Personal protective equipment
REL	Recommended exposure limit
STEL	Short term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
WEEL	Workplace environmental exposure limit

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION

The National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at Huntington Coach in Huntington Station, New York. The employees submitted the HHE request because of concerns with exposure to asbestos-containing dust and cleaning solvents during vehicle brake repair work, exposure to diesel exhaust, and possible safety hazards including ignition sources near flammable liquids and use of unsafe vehicle jack stands. Employees also reported dermatitis and respiratory irritation. NIOSH investigators conducted an evaluation in March 2007.

What NIOSH Did

- We looked at vehicle maintenance and repair activities.
- We took bulk samples of brake dust and pieces of brake shoes and pads and checked them for asbestos.
- We reviewed information on the brake cleaners and washes.
- We spoke privately with employees about their health concerns and work exposures.

What NIOSH Found

- Bulk samples of brake dust and pieces of brake shoes and pads did not contain asbestos.
- The fittings connecting vehicle exhaust pipes and flexible exhaust hoses were loose, which contributed to poor ventilation in the 5th Avenue maintenance shop.
- Solvent odors were detected outside the flammable liquid storage cabinet.
- Two of the brake cleaners used contained tetrachloroethylene, a potential carcinogen.
- Employees used latex gloves to protect their hands from oils and grease.
- Several employees were concerned about poor ventilation and fire safety, and some indicated that a “no smoking” policy was not enforced in the 4th and 5th Avenue shops.
- One employee had possible work-related skin and throat irritation; one had eye irritation.
- Some employees did not remember having respirator training or fit testing and reported that the company did not issue replacement respirator cartridges; one employee reported that he had to buy his own replacement cartridges.

What Managers Can Do

- Continue to select and use non-asbestos brake shoes and pads.
- Tighten connections between vehicle exhaust pipes and the shop exhaust hoses.
- Connect vehicular exhaust hoses to exterior windows.
- Keep the flammable liquid storage cabinet doors closed and don't overfill the cabinet.

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION (CONTINUED)

- Keep all solvent and paint containers closed during storage.
- Move the 4th Avenue body shop grinding station away from the flammable storage cabinet.
- Do not use brake cleaners that contain tetrachloroethylene.
- Provide thin nitrile rubber gloves for employees as an alternative to latex gloves.
- Educate employees in good skin care practices, such as cleaning with mild soap and water and using moisturizing lotion.
- Review the respiratory protection program to ensure it is consistent with OSHA requirements.
- Enforce a “no smoking policy” in the 4th and 5th Avenue shops.

What Employees Can Do

- Wear nitrile rubber instead of latex gloves when using brake-cleaning solvents or working with oils and grease.
- Use mild soap and water to clean skin.
- Use moisturizing lotion to protect the skin and make the skin easier to clean.
- Do not smoke in the workplace.
- Report to your supervisor health concerns that may be work related.

NIOSH investigators evaluated employee concerns about cleaning solvents, diesel exhaust, and potential asbestos exposure. We found fiberglass and cellulose, but no asbestos, in brake dust and brake shoe and pad samples. Connections between vehicle exhaust pipes and exhaust hoses were loose and not routinely vented to the outdoors, allowing vehicular exhaust to enter the maintenance shop. One employee had skin and throat irritation that was likely work related; one reported eye irritation. Recommendations are given to reduce diesel exhaust and solvent exposure, reduce skin exposure to solvents and fiberglass, enforce a no smoking policy in the maintenance and body shops, follow the OSHA respiratory protection program, and take precautions to lessen skin and respiratory irritation.

NIOSH received a confidential employee request for an HHE at the Huntington Coach Corporation bus repair and body shops, Huntington Station, New York, in November 2006. Employees were concerned that exposures to cleaning solvents, paint vapors, diesel exhaust, and asbestos-containing brake dust were causing skin rashes and respiratory irritation. The request also mentioned possible safety hazards including ignition sources near flammable liquids and use of unsafe vehicle jack stands. On March 15, 2007, we conducted an evaluation that included an opening meeting with management and union representatives, a walk-through survey of the facility's 4th Avenue body shop and 5th Avenue maintenance shop, observations of work practices and PPE use, employee exposure and health assessments, an assessment of building ventilation and potential solvent exposure, and confidential employee interviews. We also collected bulk samples of brake pad pieces and dust samples from the brake rotor lathe and the brake drums and wheels of buses being serviced.

We found fiberglass and cellulose in the bulk samples of dust and brake shoes and pads, but no asbestos. In the 5th Avenue maintenance shop, connections between vehicle exhaust pipes and flexible exhaust hoses were loose, and the flexible hoses often did not extend to the outdoors. In the 4th Avenue body shop, a poorly ventilated flammable liquid storage cabinet was overfilled. Two brake cleaners used by the maintenance shop contained tetrachloroethylene, a potential carcinogen. One employee had contact dermatitis that may have been work related.

We recommend tightening connections between exhaust pipes and flexible exhaust hoses and increasing the length of the flexible hoses so they extend outdoors to reduce diesel exhaust exposure within the maintenance shop. We recommend using brake cleaners that do not contain tetrachloroethylene and continuing use of brake shoes and pads that contain no asbestos. The flammable liquid storage cabinet should be ventilated and relocated away from potential ignition sources. Huntington Coach should provide nitrile rubber gloves instead of latex gloves to reduce skin contact with fiberglass, grease, and solvents. We recommend that the company ensure that their written respiratory protection program conforms to OSHA requirements and a no-smoking policy is enforced. Employees should be encouraged to report potentially work-related health problems to their supervisors so that workplace problems can be addressed.

Keywords: NAICS 485410 (School and Employee Bus Transportation), engine grease, solvents, diesel exhaust, asbestos, tetrachloroethylene, skin irritation, respiratory irritation

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Background

Huntington Coach is a family-owned and operated school transportation contractor with facilities on the north shore of Nassau and Suffolk Counties in New York. The 4th Avenue body shop and the 5th Avenue maintenance shop repair and maintain 158 school buses that transport preschool through 12th grade students attending 180 public and private schools. The 3rd Avenue facility, which maintains and repairs school vans and school personnel vehicles, was not included in the HHE. At the time of the evaluation the body shop had 11 full-time employees and three supervisors; the maintenance shop had eight full-time employees and three supervisors. Employees of the three facilities were represented by the United Steel Workers of America, Local 14753.

The majority of the 158 buses maintained by Huntington Coach were manufactured by International IC®; the rest were made by Freightliner®. The smaller vans were manufactured by either General Motors or Ford. In addition to receiving a mandatory full inspection four times per year, a Huntington Coach bus or van also received a daily driver inspection which included a review of the previous daily inspection report. The 5th Avenue maintenance shop management could also decide whether to remove a bus or van from service.

The 4th Avenue body shop had a spray paint area and a separate garage area with two large bays for cleaning engines and brakes, performing brake inspections, and providing Department of Transportation "inspection ready" services. The 4th Avenue body shop did spot repairs and limited body work including removing dents,

INTRODUCTION (CONTINUED)

applying plastic filler, removing rust, sanding filler, and applying new primer and paint. The shop did not repaint entire vehicles. Air spray guns were cleaned in a Safety Kleen® paint spray gun cleaning station; latex gloves were worn when handling the spray guns. General ventilation in the body shop was provided by a wall-mounted axial fan. The body shop lacked local exhaust ventilation.

The 5th Avenue maintenance shop was a 100-foot-long building with eight bays where buses received the heaviest repair work, including engine overhaul and complete brake replacement. The ceiling height was 14 feet, 8 inches; ceiling fans were used to circulate the room air. The building was heated with gas-fired ceiling-mounted units. The building had no mechanical exhaust ventilation system, but the garage doors were opened (weather permitting) to provide passive general ventilation.

When it was necessary to keep a bus engine running during work in a repair bay, a flexible hose (approximately 4 to 5 inches in diameter) was connected to the vehicle's tailpipe to vent the exhaust gases outside the building. Employees cleaned and repaired brakes using Safety Kleen® Parts Cleaning Solvent, Safety Kleen® Parts Washer Solvent, and Brakleen® (a brake parts cleaner). Several power tools were used in brake work, including air chisels, impact guns, drills, grinders, grease guns, and welding equipment.

According to management, non-asbestos brake shoes and pads made by Carlisle and Raybestos, which may be of either domestic or foreign origin, were purchased for installation as replacement parts. Three manually agitated Safety Kleen® parts washers were used to clean mechanical parts. One portable parts washer unit had a brush and re-circulating system and was used for brake cleaning. Employees used Safety Kleen® waterless hand cleaner to clean their hands.

Employees of Huntington Coach worked four staggered shifts per day, rotating between two shifts that began between 6:30 a.m. and 9:00 a.m. and ended between 2:30 p.m. and 5:30 p.m. Mechanics provided their own tools and most purchased their own latex gloves for protection against used oil and greasy parts. The company required respirators be worn when brake drums were disassembled and wheels were painted. In the paint shop, painters were supplied with half-mask air-purifying respirators with 3M™ 7192 with organic vapor/N95 combined cartridges; sanders were provided half-mask air-purifying respirators with 3M 9211 cartridges with N95 particulate filters. The company had a written respiratory protection program that included fit testing. Thick rubber gauntlet gloves were provided

INTRODUCTION (CONTINUED)

to employees to use when dipping parts into the tanks containing cleaning solvents. Latex gloves were provided to employees and were used when handling greasy parts or when solvent exposure would be light. Ear plugs and safety glasses were also provided by the management.

Huntington Coach contracted with local medical centers to provide care to employees when needed. The company also contracted a local optometrist in the event of an eye injury.

ASSESSMENT

We toured the 4th and 5th Avenue vehicle maintenance and body shops on March 15, 2007, to observe work practices and equipment, interview employees, and evaluate the ventilation systems. We observed the ventilation systems for removing diesel exhaust from maintenance shops but did not collect air samples for diesel exhaust. Bulk samples were collected of brake dust and pieces of brake shoes and pads. The bulk samples were analyzed for asbestos by polarized light microscopy with dispersion staining according to NIOSH Method 9002 [NIOSH 2008]. The reliable limit of quantitation of the method is 1%, although asbestos may be qualitatively detected at concentrations less than 1%. Appendix A discusses occupational exposure limits and health effects for solvents, specifically tetrachloroethylene.

Confidential interviews and medical examination of the skin were conducted among 4th and 5th Avenue maintenance and body shop employees. Interviews focused on medical and occupational history and potentially work-related symptoms. Information on employee hand-cleaning agents and PPE provided by management was also reviewed.

RESULTS

The results of the bulk sampling of brake dust and brake shoes and pads are shown in Table 1. None of the bulk samples contained asbestos. The fibers that were present were identified as either fiberglass or cellulose (one sample contained what appeared to be metal shavings).

At the 5th Avenue maintenance shop we observed that some fittings connecting the bus exhaust pipes to the flexible ventilation hoses were loose, and several of the flexible ventilation hoses were not long enough to extend outdoors.

In the 4th Avenue body shop we opened a flammable liquid storage cabinet that was located in a side room. Solvent vapor odors were

RESULTS (CONTINUED)

Sample Location and Type	Asbestos Content	Non-asbestos Fibers (% and type)	Non-fibrous Materials (type)
Dust from rear right drum of 750 bus	Not detected	<1% cellulose fiber	Binder/filler
Dust from rear left drum of 750 bus	Not detected	<1% cellulose fiber	Binder/filler
Brake shoe from 750 bus	Not detected	20% unidentified fiber	Binder/filler
Rear brake shoe (Carlisle 4707, part no. CF 2000)	Not detected	35% fibrous glass	Binder/filler
Front brake shoe (Meritor, part no. SMA2124702)	Not detected	20% fibrous glass	Binder/filler
Friction material (Carlisle 4707, part no. MB21)	Not detected	25% fibrous glass	Binder/filler
Front brake shoe (Meritor, part no. R202)	Not detected	20% fibrous glass < 1% cellulose	Binder/filler
Dust from brake rotor lathe in the machine shop	Not detected	No fibers detected	Binder/filler
Dust from front passenger-side wheel on van (van ID no. 663)	Not detected	No fibers detected	Binder/filler
Front disk brake pad (Wagner® Thermo Quiet®, part no. MX655)	Not detected	< 1% cellulose fibers	Binder/filler

Comment:

A small amount of each bulk sample was evaluated for asbestos using polarized light microscopy with dispersion staining. The percentages are results of visual estimations; the reliable limit of quantitation of the method is 1%.

detectable in the room; some employees might find them irritating. We examined the storage cabinet and found it completely full of containers of Class I or II liquids, and at least one solvent container in the cabinet was uncovered. This type of approved flammable liquid cabinet should be able to contain solvent odors if all containers were kept closed, and if the number of containers was reduced to allow more air space inside the cabinet. Approximately 30 feet of 1.5-inch diameter flexible duct connected this flammable storage cabinet to an exterior wall to provide passive ventilation. However, due to the length and the number of bends in the flexible duct, the amount of air movement between the cabinet and the exterior was likely minimal. An infrequently used grinding station was located about 8 feet from the flammable liquid storage cabinet. In our view, this was too close because a wayward spark from grinding could possibly enter the room used to store flammable liquids. We also observed one employee smoking inside one of the bay doors of the 5th Avenue maintenance shop.

Table 2 lists the various brake wash products used by Huntington Coach mechanics, along with their major ingredients. According to the management at Huntington Coach, the vehicle maintenance and body shop facilities changed from purchasing bulk liquid brake parts cleaners to brake parts cleaners in aerosol cans about a year before the NIOSH evaluation. This product switch had been prompted by

RESULTS

(CONTINUED)

Table 2. Brake Wash and Other Shop Products used by Huntington Coach Employees

Product Name	Major Ingredient(s)*
ZEP Brake Parts Cleaner (XT-3699)	Acetone
ZEP Brake Wash	Hexane, isopropyl alcohol
ZEP Brake Flush	Acetone, heptane
Johnsens Brake Parts Cleaner	Tetrachloroethylene
Tekusolve II (aerosol)	d-limonene
ZEP Soy Response (liquid)	Alkyl methyl esters, ethoxylated alcohols
ZEP Soy Power (liquid)	Alkyl methyl esters, naphtha
ZEP Soy Response (aerosol)	Alkyl methyl esters, isobutane
ZEP Soy Cling	Alkyl methyl esters, isobutane
CRC Brakleen/Brake Parts Cleaner (bulk)	Acetone, toluene, methanol
CRC Brakleen/Brake Parts Cleaner (aerosol, nonchlorinated)	Toluene, methanol, acetone
CRC Brakleen/Brake Parts Cleaner (aerosol, chlorinated)	Tetrachloroethylene
ID Flush	Proprietary solvent blend
Safety Kleen 105 (solvent used in parts washer)	Mineral spirits, C ₈ aromatics

* Only ingredients > 5% are listed. The remaining ingredients were typically propellant gases.

employee complaints about the old product's odor, and employees were generally more satisfied with the new aerosol product. Two brake part cleaning products being used by maintenance shop employees contained tetrachloroethylene, a potential human carcinogen.

Sixteen of the 18 employees scheduled to work in 4th and 5th Avenue maintenance and body shops were interviewed; the remaining two employees were unavailable. Eight employees worked at the 4th Avenue body shop, six worked at the 5th Avenue maintenance shop, and two rotated between the two facilities. All interviewed employees were male, their average age was 38 years (ranging from 21 to 54 years), and their average work tenure at Huntington Coach was 4 years (ranging from 2 months to 10 years).

Fourteen of 16 employees reported no health problems related to their work. One employee reported a sore throat and a finger rash he believed to be related to working with brake cleaning solvents. Upon examination, the skin of the affected finger appeared dry with small, superficial fissures. Another employee reported eye irritation while at work. All interviewed employees reported wearing a NIOSH-approved half-mask air-purifying respirator with combination cartridges when spraying paint and/or performing brake work, and wearing latex gloves when working with grease-covered parts. Employees reported using the waterless hand cleaner and/or "the pink soap" with water for hand cleaning.

RESULTS

(CONTINUED)

Four of the 16 employees expressed concerns about inadequate ventilation. For example, employees reported that the exhaust tailpipes of the smaller buses and vans that were serviced at the 4th Avenue body shop did not fit tightly into the flexible ventilation hoses, resulting in potential diesel exhaust leaks into the work area. This is important because, according to employees, some bus engines idle up to 30 minutes while indoors. Also, vapors and dust produced by one employee during automotive repair can drift into the work areas of adjacent employees because of lack of local exhaust ventilation. The primary means of ventilating either the 4th or 5th Avenue facilities was by opening the bay doors, and this was weather dependent.

Huntington Coach employees reported that NIOSH-approved half-mask air-purifying respirators were required and provided by management for certain tasks, such as solvent use and brake work. Some employees did not remember having respirator training or fit testing and that occasionally the company did not issue replacement cartridges. Employees also reported that management provided gloves, but one reported that the gloves tore easily and another reported that he had to buy his own gloves.

Employees expressed concerns about exposure to flammable liquids and fire safety. They reported that uncontrolled hot slag and sparks from grinding along with cigarette smoking had previously caused fires. Two employees reported that a “no smoking” policy was not being enforced in the work area. Two other employees reported that previously only one jack stand was in proper working condition and that one of the hydraulic jacks leaked. We later looked at the jack stands in use and did not see any that were broken or not functional.

DISCUSSION

Employees were concerned about skin and upper respiratory irritation, which some employees attributed to the use of brake cleaning chemicals. Employees expressed concerns about poor ventilation, fire safety, jack stand safety, and inadequate PPE. Employees were also worried about the possibility of working with asbestos-containing brake shoes and pads. Our sampling results of brake shoes, pads, and dust found fiberglass and cellulose, but not asbestos. This is consistent with a statement from management representatives that it was company policy to purchase only nonasbestos brake shoes and pads.

Most interviewed employees had no health or safety concerns about their workplace, and indicated that the facilities were well managed. However, our observations during the site visit indicated that some of the hazards noted by a minority of employees were valid. For example,

DISCUSSION (CONTINUED)

in the 5th Avenue maintenance shop the flexible exhaust ventilation hoses were not tightly connected to the vehicle's exhaust pipe and several of the flexible exhaust ventilation hoses did not extend to the outdoors, a condition that may allow diesel exhaust to enter the maintenance shop. The flammable liquid storage cabinet in the 4th Avenue body shop was poorly ventilated and adjacent to a grinding table. Additionally, according to employees, the "no smoking" policy was not consistently enforced in the maintenance and body work shops, which increased the risk of fire due to the presence of flammable or combustible liquids.

Skin irritation is a common symptom when employees work with chemicals, particularly organic solvents. Repeated solvent exposure to the skin is known to dry the skin, breaking down the skin's natural protective barrier and increasing the risk of irritant contact dermatitis. Good skin care practices are important preventive measures to prevent contact dermatitis. These include keeping the hands clean by washing with mild, nonirritating soap and water, keeping the skin moisturized by applying moisturizing lotions (many nongreasy varieties are available), and protecting the hands from harsh chemicals and grease by using protective gloves where possible. Appendix B provides a discussion about contact dermatitis, its relationship to work, and ways to prevent contact dermatitis. The latex gloves currently used by Huntington Coach employees offer very high manual dexterity, which can be critically important in vehicle maintenance work. However, their use should be discouraged because they provide poor protection from many of the chemicals used in the various brake and parts cleaners, and it is possible that some employees could have an allergic reaction to the latex. A suitable alternative to latex gloves would be thin nitrile rubber gloves.

CONCLUSIONS

While we did not find asbestos in the dust and bulk samples of brake shoes and pads, we did identify ventilation problems in the 5th Avenue maintenance shop that could allow diesel exhaust to enter the work areas during vehicular repair. We observed a poorly ventilated flammable liquid storage cabinet in the 4th Avenue body shop that was near a grinding station, a potential ignition source. We also noted that two brake part cleaning products being used by 5th Avenue maintenance shop employees (Johnsens Brake Parts Cleaner and CRC Brakleen/Brake Chlorinated Aerosol Parts Cleaner) contained tetrachloroethylene, a potential human carcinogen. Some Huntington Coach employees we interviewed reported jack stands which were malfunctioning or leaking hydraulic fluid. However, the jack stands we observed in use were functional.

CONCLUSIONS (CONTINUED)

The written respiratory protection program may not have been consistently applied, based on the comments made by some interviewed employees. Employees expressed concerns that a “no smoking” policy was not being enforced in the work areas. Finally, while interviewed employees reported using the waterless hand cleaner and soap, they used latex gloves that do not offer adequate protection from the chemicals used in their repair work, and may cause an allergic reaction in some people.

RECOMMENDATIONS

We encourage you to review the standards and publications mentioned in our recommendations and to conduct a self assessment to ensure that employees are adequately protected from safety and health hazards. Based on our findings and observations during this evaluation, we offer the following recommendations to improve employee safety and health:

1. Securely connect the flexible vent hoses to exhaust pipes when vehicles are being serviced to reduce diesel exhaust leakage into the 5th Avenue maintenance shop. Equally important, these flexible vent hoses should be exhausted to the outdoors. This may be accomplished by installing fittings in the existing exterior windows at the 5th Avenue maintenance shop and connecting these to the flexible vent hoses.
2. Substitute brake cleaners containing tetrachloroethylene (also known as perchloroethylene, or “perc,” a potential occupational carcinogen) with cleaning products containing less toxic solvents such as hexane, methanol, isopropyl alcohol, acetone, or heptane.
3. Relocate the grinding station in the 4th Avenue body shop further away from the flammable storage cabinet.
4. Do not overfill the flammable liquid storage cabinet and insure that all solvent containers in the cabinet are covered and the cabinet doors are kept closed except when in use.
5. Provide mechanical exhaust ventilation to the flammable liquid storage and mixing room in the 4th Avenue body shop. The fan, wiring, and ductwork would need to meet fire code requirements for a Class I liquid storage area.
6. Enforce a “no smoking” policy in the 5th Avenue maintenance shop and 4th Avenue body shop. Further information regarding workplace smoking policies and smoking cessation programs can be found in *No Smoking: A Decision Maker’s Guide to Reducing Smoking at the Worksite* [American Cancer Society et al. 1985].

RECOMMENDATIONS (CONTINUED)

7. Ensure that the respiratory protection program is consistent with OSHA requirements and is fully implemented.
8. Provide nitrile rubber gloves for employees in a variety of sizes. Nitrile gloves will provide better protection than latex gloves from the chemicals used during vehicle work.
9. Use mild soap and water for hand washing, and encourage employees to use nonallergenic moisturizing lotions to maintain a healthy skin barrier. Using hand lotion before work helps to prevent grease from absorbing into the skin and makes skin easier to clean.
10. Encourage employees to report work-related skin and respiratory irritation to their supervisors.
11. Provide training to employees in the potential hazards of solvent exposure and work practices that prevent skin exposure (see Contact Dermatitis discussion in Appendix B). Information on moisturizers, soaps, and skin cleaners should be included because some components (e.g., lanolin and fragrances) are known allergens and may cause allergic contact dermatitis in sensitive individuals.

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APPENDIX A: OCCUPATIONAL EXPOSURE LIMITS AND 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 to which 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 pre-existing 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 U.S., 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 U.S. 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 2007]. WEELs have been established for some chemicals “when no other legal or authoritative limits exist” [AIHA 2007].

Outside the U.S., 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 A: OCCUPATIONAL EXPOSURE LIMITS AND HEALTH EFFECTS (CONTINUED)

from European Union member states, Canada (Québec), Japan, Switzerland, and the U.S. [http://www.hvbg.de/e/bia/gestis/limit_values/index.html]. 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 [<http://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.

Solvents

The term solvent applies to any substance that dissolves another substance, yielding a solution. Solvents can be water based (aqueous) or hydrocarbon based (organic). Several of the CRC Brakleen and ZEP cleaning and degreasing products used at Huntington Coach contained common organic solvents such as acetone, toluene, hexane, and methanol. However, two cleaning products that we observed in use at Huntington Coach during this evaluation, CRC Brakleen Brake Parts Cleaner and Johnsens Brake Parts Cleaner, contained tetrachloroethylene, a more toxic organic solvent that is discussed below.

Inhalation and dermal exposure are both important routes of exposure to organic solvents in the workplace. Absorption through the skin depends upon the degree of both lipid and water solubility of the solvent [Rosenberg et al. 1997]. Almost all organic solvents cause irritation of the skin because they remove fat from the skin. Inhalation of vapors may cause minimal to mild irritation of the respiratory system. This irritation is usually restricted to the upper airways, mucous membranes and eyes, and it generally resolves quickly without long-term effects [Rosenberg et al. 1997].

Almost all volatile, fat-soluble organic solvents can acutely cause nonspecific central nervous system depression. The symptoms of significant acute solvent exposure are similar to those from drinking too many alcoholic beverages, including headache, nausea and vomiting, dizziness, slurred speech, impaired

APPENDIX A: OCCUPATIONAL EXPOSURE LIMITS AND HEALTH EFFECTS (CONTINUED)

balance, disorientation, and confusion. These symptoms go away quickly upon cessation of exposure. Rarely, death from respiratory depression can occur at very high exposure levels.

Tetrachloroethylene

Tetrachloroethylene, also called perchloroethylene or “perc,” is a nonflammable solvent that is used as a commercial dry cleaning agent and for metal cleaning and degreasing [ACGIH 1986]. Inhalation exposure to tetrachloroethylene can cause central nervous system depression, producing symptoms of vertigo, dizziness, narcosis, incoordination, headache, and unconsciousness if exposures are sufficient. Direct contact with the liquid may impair the mucous membranes, eyes, and skin [ACGIH 1986; NIOSH 1976]. Chronic exposure to tetrachloroethylene has been reported to cause liver damage, peripheral neuropathy, and it has produced liver carcinomas in experimental animals [Hathaway et al. 1996].

NIOSH considers tetrachloroethylene an occupational carcinogen and recommends that exposure be reduced to the lowest feasible level [NIOSH 1992]. The 8-hour TWA OSHA PEL is 25 ppm. The ACGIH recommends a TLV of 25 ppm, TWA over an 8-hour work day, and a 15-minute STEL of 100 ppm. The ACGIH lists tetrachloroethylene as a confirmed animal carcinogen with unknown relevance to humans [ACGIH 2001].

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APPENDIX B: CONTACT DERMATITIS

Contact dermatitis makes up 90%–95% of all occupational skin diseases [Fregert 1975; Keil 1983; Mathias 1988]. Contact dermatitis (both irritant and allergic) is an inflammatory skin condition caused by skin contact with a substance or substances. About 80% of contact dermatitis cases are due to irritant reactions, while about 20% are due to allergic reactions. The most frequent causes of irritant contact dermatitis include soaps/detergents, glass fibers (fiberglass) and particulate dusts, food products, cleaning agents, solvents, plastics and resins, petroleum products and lubricants, metals, and machine oils and coolants [Mathias 1988; Mathias 1990]. Only certain chemicals are allergens, and only a small proportion of people are susceptible to them. Causes of allergic contact dermatitis include metallic salts, organic dyes, plants, plastic resins, rubber additives, and germicides/biocides [Mathias 1990]. In most instances, allergic contact dermatitis can be confirmed by skin patch tests using specific standardized allergens or diluted concentrations of workplace materials [Reitchel 1995].

In dermatitis, the skin initially turns red and can develop small, oozing blisters (vesicles), and bumps (papules). After several days, crusts and scales form. Stinging, burning, and itching may accompany the rash. With no further contact the rash usually disappears in 1–3 weeks. With chronic exposure, deep cracking (fissures), skin thickening, scaling, and discoloration can occur. Exposed skin that has the greatest contact with irritants or allergens, such as hands and forearms, are most commonly affected. If the chemical gets on clothing, it can produce rashes at areas of greatest contact, such as thighs, upper back, armpits, and feet. Dusts can produce rashes at areas where the dust accumulates and is held in contact with the skin, such as under the collar and belt line, at the tops of socks or shoes, and in flexural areas (e.g., front of the elbow, back of the knee).

Because people with contact dermatitis can develop long-term skin problems, prevention is key. Employers should provide their employees with proper hygiene facilities for washing hands and arms, good skin cleaning products that do not contain highly irritating or sensitizing chemicals, gloves that match the job's chemical exposure, and training on safe skin care practices [Marks et al. 2002].

APPENDIX B: CONTACT DERMATITIS (CONTINUED)

Employees should adhere to good skin care practices. These include minimizing skin contact with solvents, oil, and grease by wearing suitable gloves during repair work and parts cleaning; only wearing gloves when necessary; not using gloves that are visibly damaged; washing skin contaminants off as soon as possible; and always cleaning hands before eating, smoking, or leaving the shop. When cleaning the skin, use the mildest and least abrasive soap or detergent that will clean the skin; wash no more frequently than necessary; don't use workplace solvents for hand cleaning; use a hand moisturizer or skin protection cream on hands before work; and, if hands are dry or irritated, use a hand moisturizer immediately after washing [Marks et al. 2002].

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