Evaluation of Employee Exposures at a Plastic Bag Sealing Plant

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from an employer who was concerned about employee exposures to the smoke created during the thermal cutting and sealing of plastic film into bags. We visited the plant in July 2016.

What We Did

- We collected personal air samples for acetaldehyde, acrolein, formaldehyde, and respirable dust.
- We collected area air samples for volatile organic compounds.
- We measured carbon monoxide in area air samples taken near the operator station at the two bag sealing areas.
- We used ventilation smoke tubes to observe airflow patterns near the bag sealing machines and to evaluate the effectiveness of the recently installed local exhaust ventilation systems.

We were asked to evaluate employees' exposures during the manufacture of plastic bags. Employees were not overexposed to acetaldehyde, formaldehyde, or respirable dust. We recommend improving the local exhaust ventilation at each machine and forming a health and safety committee consisting of employees and managers.

What We Found

- Employees who were heat-sealing plastic bags were not overexposed to acetaldehyde, formaldehyde, or respirable dust. There was a slight visible smoke in the wicketer area.
- Employees did not report any health symptoms that they thought were related to work or exposure to smoke.
- Carbon monoxide levels were higher in the flatbed bagger area than in other areas.
- The local exhaust ventilation for the wicketers and flatbed bagger could be improved. The local exhaust ventilation was recently installed in the wicketer area. Employees reported that the smoke in this area had decreased since this installation.

What the Employer Can Do

- Straighten the flexible duct for the slot hood near the wicketers to increase the efficiency of the local exhaust ventilation system.
- Move the slot hood local exhaust ventilation closer to the wicketer heat-sealer.
- Place the exhaust fan on the terminal point of the local exhaust ventilation.

- Hire a ventilation engineer to evaluate the exhaust hood over the flatbed bagger and any changes that are made to the wicketer exhaust hood.
- Ask employees to report any symptoms they consider to be work related to their supervisor and personal physician.
- Create a health and safety committee with employer and employee representatives from this building.

What Employees Can Do

- Position fans toward the heat-sealing portion of the machinery so that the smoke moves away from you.
- Report any symptoms you believe to be work related to your supervisor and personal physician.
- Participate in the health and safety committee.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
CO	Carbon monoxide
EPA	Environmental Protection Agency
LEV	Local exhaust ventilation
mg/m^3	Micrograms per cubic meter
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
ppm	Parts per million
REL	Recommended exposure limit
STEL	Short-term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
VOCs	Volatile organic compounds

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Introduction and Process Description

The Health Hazard Evaluation Program received a request from a manager at a plastic bag manufacturing plant. Employees who were heat-sealing polyethylene plastic bags were concerned about the smoke that came off of the wicketers and flatbed bagger, two types of bag-making machines. There were no specific health complaints reported. We visited the company in July 2016. After the visit we sent letters to the employer and employee representatives summarizing our activities and initial recommendations. We also sent individual notification letters to employees who participated in personal air sampling and requested their sampling results.

The plant was located in a larger manufacturing and office complex that was built in 1982. Since 1998 it has occupied approximately 10,000 square feet of production space in a building that was separate from the remaining manufacturing/office complex. The plant made and shipped partially sealed polyethylene bags of varying sizes to customers for subsequent filling and final heat-sealing. This plant did not produce the polyethylene film used to manufacture the bags, and did not print labels or fill bags with product. At the time of our visit, the plant operated one 8-hour shift from 7:00 a.m. to 3:00 p.m., 5 days per week. The five employees working in the plastic bag sealing area of the plant were not part of a union and did not participate in the health and safety committee at the company's main manufacturing plant.

Wicketers

The wicketers unwound and drew in rolls of polyethylene film and folded them. Depending on the customer's order, zippers or tear perforations were attached to some films prior to sealing. The wicketer added two holes at the top of the film and then heat-sealed and thermally cut the film. This formed two sides and one end of the bag and left the other end of the bag unsealed. The bags were stacked on wire wickets (Figures 1 and 2) and then manually removed by the wicketer operator and packaged into cardboard boxes for shipment. During the site visit, two of the three wicketers were operating, and one wicketer operator was working nearby folding and packaging bags. Employees stated that typically all three wicketers were in operation.

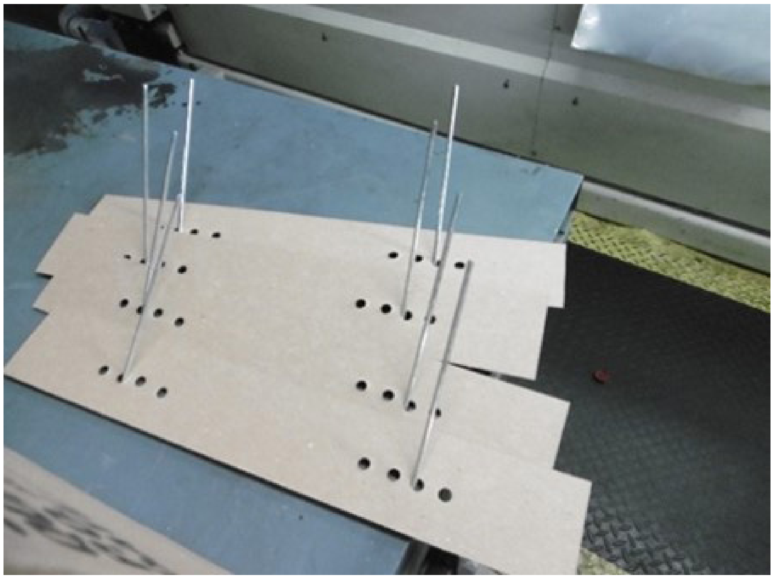

Figure 1. Stack of wire wickets. Photo by NIOSH.

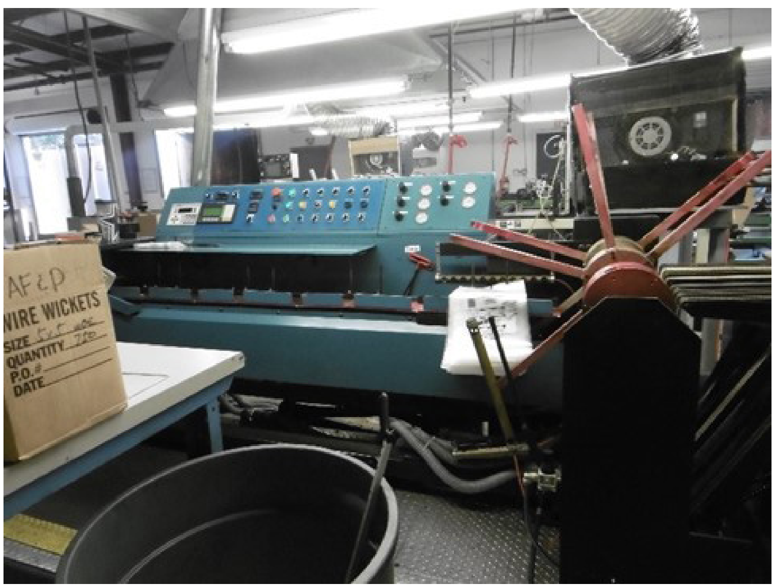

Figure 2. Wicketer stacking finished bags onto wire wickets. Photo by NIOSH.

Flatbed Bagger

The flatbed bagger produced various sizes of bags by unwinding and drawing rolls of polyethylene film, folding the film, and heat-sealing and thermally cutting the edges to form bags. No wickets were used at the flatbed bagger, and the operator was responsible for placing finished bags into boxes for shipment. Only two of the three flatbed baggers were operational, and only one was running during our site visit.

Methods

The objectives of this evaluation were to determine if employees in the bag sealing areas were overexposed to chemicals and decomposition products from plastic bag manufacturing including respirable dust, aldehydes, volatile organic compounds (VOCs), and carbon monoxide (CO).

Air Sampling

We collected full-shift personal air samples over 2 days for respirable dust on four employees following National Institute for Occupational Safety and Health (NIOSH) Method 0600 [NIOSH 2017].

We collected short-term, 15-minute personal air samples for aldehydes, including formaldehyde, acrolein, and acetaldehyde, on four employees using a modified Environmental Protection Agency (EPA) Method TO-11A [EPA 1999a]. This method was modified to include acrolein and acetaldehyde. We were unable to collect full-shift time-weighted average (TWA) personal air samples for acetaldehyde and formaldehyde because of a shipping error that resulted in not having sufficient monitoring equipment available during the evaluation.

We used thermal desorption tubes to collect area air samples for VOCs according to EPA Method TO-17 [EPA 1999b]. These screening samples were collected by the heat-sealer at one wicketer, between two wicketers, and at the heat-sealer at the flatbed bagger. The thermal desorption tube results were used to qualitatively identify VOCs produced during heat-sealing. We also took charcoal tube air samples side-by-side with the thermal tube air samples so that we could quantitate VOCs of interest as appropriate.

We used TSI Q-Trak indoor air quality monitors to collect area air samples for CO between the operator stations for the two wicketers and near the operator station for the flatbed bagger. We measured CO because it may be a decomposition product from heating polyethylene.

Ventilation Assessment

We used ventilation smoke tubes to observe airflow near the heat-sealing knife and the operator's station of each of the bag sealing machines.

Results and Discussion

Appendix A contains more information on occupational exposure limit (OELs) and health effects for some of the substances we evaluated.

Respirable Dust

The results of personal air sampling for respirable dust are shown in Table 1. These results were compared to the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for particles not otherwise regulated. NIOSH has no recommended exposure limit (REL) for respirable dust. The results were well below the most protective OEL of 5 milligrams per cubic meter (mg/m^3).

Table 1. Personal full-shift air sample results for respirable dust

Day	Job title	Sample time (minutes)	Respirable dust (mg/m^3)
1	Flatbed bagger operator	315*	0.25
	Wicketer operator 1	471	0.17
	Wicketer operator 2	458	0.18
	Wicketer operator 3	457	0.39
2	Flatbed bagger operator	475	0.27
	Wicketer operator 1	478	0.28
	Wicketer operator 2	474	0.23
	Wicketer operator 3	476	0.49
NIOSH REL			None
OSHA PEL			5

*Employee left workplace before the end of shift

Aldehydes

Results of 15-minute short-term personal air samples for acetaldehyde and formaldehyde are shown in Table 2. All results were below applicable ceiling and short-term exposure limits (STELs). Ceiling limits are concentrations that should never be exceeded at any time during a work shift.

Day	Job title	Time taken	Acetaldehyde	Formaldehyde
1	Flatbed bagger operator	10:23 a.m.	0.026*	0.068
	Wicketer operator 1	10:55 a.m.	0.012	0.028
	Wicketer operator 2	11:20 a.m.	0.0064	0.016
	Wicketer operator 3	11:46 a.m.	0.0028	0.0046*
2	Flatbed bagger operator	8:49 a.m.	0.012	0.024
	Flatbed bagger operator	12:58 p.m.	0.0088	0.025
	Wicketer operator 1	9:11 a.m.	0.011	0.024
	Wicketer operator 2	10:14 a.m.	0.010	0.015
	Wicketer operator 3	9:33 a.m.	0.016*	0.030
	Wicketer operator 1	1:27 p.m.	0.0096	0.023
	Wicketer operator 2	1:28 p.m.	NR†	0.019
	Wicketer operator 3	1:35 p.m.	0.012	0.026
NIOSH REL			None	0.1‡
ACGIH TLV			25‡	0.3§
OSHA PEL			None	2§

Table 2. Short-term (15 minute) personal air sampling results, in parts per million (ppm)

ACGIH = American Conference of Governmental Industrial Hygienists

NR = Not reported

TLV = Threshold limit value

*Sample breakthrough for these results was 10%–20%, so the actual concentration may have been higher.

†This result was not reported because sample breakthrough was greater than 60%.

‡15-minute ceiling limit that should never be exceeded

§15-minute short-term OEL

These short-term sample results for acetaldehyde and formaldehyde cannot be directly compared to 8-hour TWA OELs. If employee exposures remained at these levels throughout the shift, employees' full-shift exposures would have been below the OSHA PEL of 0.75 ppm and the ACGIH TLV of 0.1 ppm for formaldehyde, and well below the OSHA PEL of 200 ppm for acetaldehyde, but would have been above the NIOSH REL of 0.016 ppm for formaldehyde.

Sampling results for acrolein are not provided because of poor laboratory analytical recoveries of less than 50% using EPA Method TO-11A. Additionally, some of the sample results denoted in Table 2 with an asterisk had breakthrough above 10%. This means that these sample results may be lower than what the employee was actually exposed to during the 15-minute sampling time. The reasons for the poor analytical recoveries for acrolein and the breakthrough for acetaldehyde are uncertain.

Volatile Organic Compounds

Area air samples collected near the bag sealing machines and analyzed for VOCs found detectable but low concentrations of benzene (below 0.001 ppm), toluene (below 0.002 ppm), acetone (below 0.031 ppm), propane (below 0.038 ppm), and isopropyl alcohol (below 0.018

ppm). The method is semi-quantitative so these concentrations are estimates. Because the VOC concentrations were so low, we did not feel it was necessary to quantitatively analyze the charcoal tube samples that we collected side-by-side with the thermal desorption tube samples.

Carbon Monoxide

We measured CO concentrations up to 13 ppm on day 1 and 19 ppm on day 2 near the operator stations for the two wicketers that were running, and up to 39 ppm on day 1 and 47 ppm on day 2 at the operator station near the flatbed bagger. Carbon monoxide peaks occurred around 10:00 a.m., 11:15 a.m., 12:00 p.m., and 1:00 p.m. on day 1 at both the wicketer and flatbed bagger (Figure 3), and at approximately 7:45 a.m. to 8:15 a.m., 1:00 p.m., and at 2:45 p.m. on day 2 (Figure 4). We did not observe any differences in production processes or work practices at those times on either day, and according to the operators there were no purging cycles. Carbon monoxide concentrations were higher at the flatbed bagger than at the wicketer. This could mean that the flatbed bagger was generating more CO, or that the local exhaust ventilation (LEV) at the flatbed bagger was less effective in capturing plastic bag sealing emissions compared to the exhaust ventilation at the wicketer.

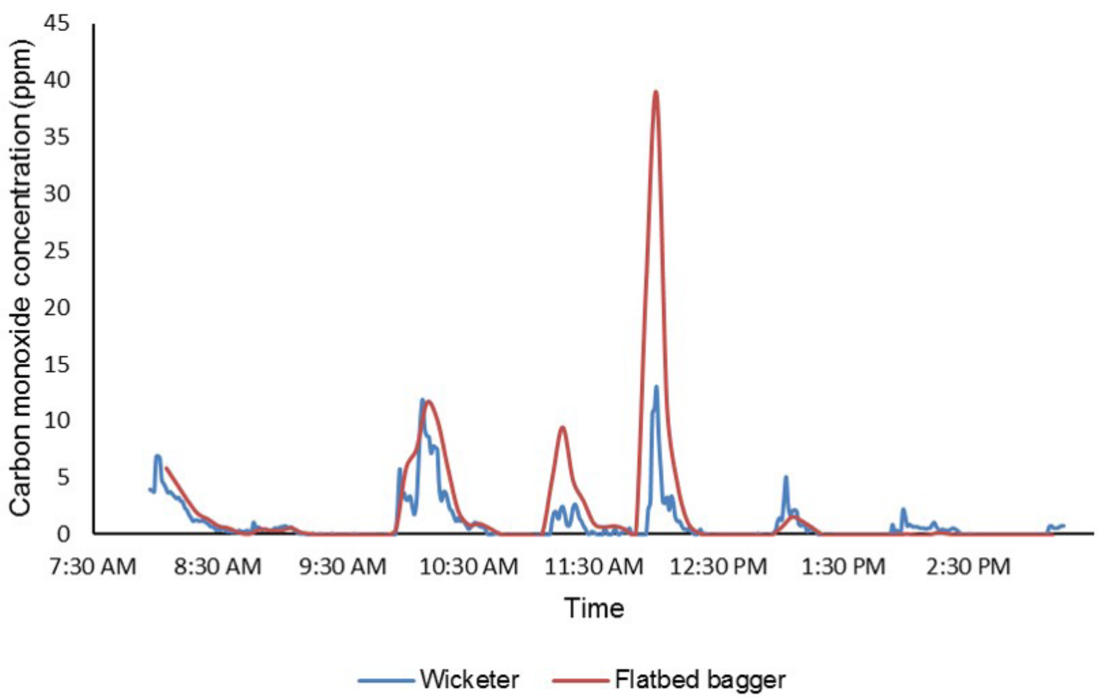

Figure 3. Carbon monoxide concentrations on day 1 of the NIOSH evaluation.

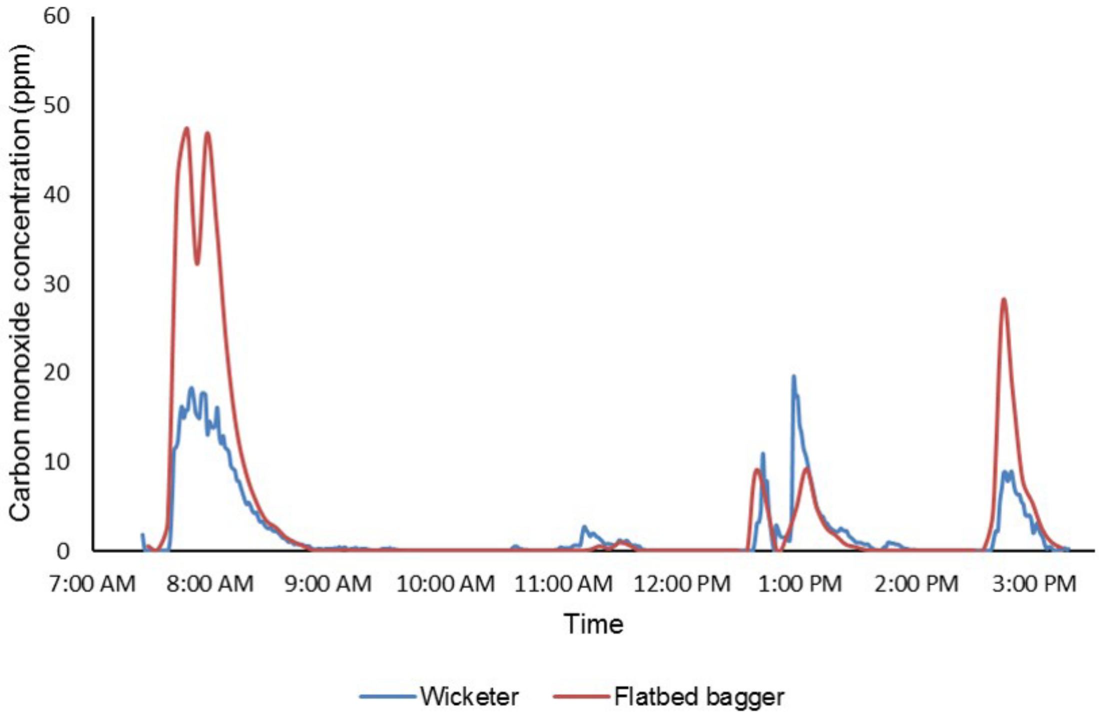

Figure 4. Carbon monoxide concentrations on day 2 of the NIOSH evaluation.

Ventilation

The company had installed LEV at the wicketer machines in 2016 that consisted of a slot hood mounted next to the wicketer heat-sealer (Figure 5). Flexible duct connected the slot hood to a fan that exhausted the air through the ceiling to the outdoors. Company managers had visited plants with similar processes and modeled this LEV control after what they had seen. Employees stated that plant air looked less hazy after the LEV installation.

We used smoke tubes to visualize the airflow near the slot hood at the two running wicketers and one flatbed bagger. The smoke from the smoke tubes appeared to be captured effectively near the heat-sealer, and less effectively moving closer to the operator station. The company placed pedestal fans near each wicketer operator station to blow air toward the wicketer heat-sealer to direct odors and smoke away from the operator station. Although using these pedestal fans to blow smoke away from the operator's breathing zone may reduce employee exposures to the bag sealing emissions, they may interfere with LEV effectiveness.

Each wicketer had a slot hood LEV system. On each of these LEV systems, we saw that the flexible duct was loosely attached to the slot hood LEV and that it sagged and was twisted at a 90° angle relative to the slot hood (Figure 5). The loose connection, excess duct, and sharp bends decrease the overall efficiency of the LEV systems. To improve the LEV efficiency the flexible duct should be tightly attached to the slot hood, with no sharp angles or sagging. Figure 5 also shows that the exhaust fan was located in the slot hood, meaning that flexible duct was pressurized between the slot hood until it exhausts to the outdoors. The disadvantage of this design is that any leaks in the exhaust duct could blow contaminated air back into the occupied space. Placing the exhaust fan near the terminal point of the exhaust system (the roof) would be preferable.

Figure 5. Slot hood local exhaust ventilation on the wicketer. Photo by NIOSH.

On the basis of the airflow patterns revealed by the ventilation smoke tubes, the exhaust hood above the running flatbed bagger appeared less effective at capturing the smoke from the heat-sealer than the LEV controls at the wicketers. This could account for the higher CO levels that were measured at the flatbed bagger. The company had not modified the exhaust hood on the two operational flatbed baggers.

Other

We reviewed the OSHA Form 300 Logs of Work-related Injuries and Illnesses for 2012 to 2016. During this time period, there was one mechanical injury recorded.

Conclusions

Full-shift personal exposures to respirable dust were low for employees in the bag sealing plant. Short-term samples for acetaldehyde and formaldehyde were below OELs. Concentrations of CO were higher in the flatbed bagging area than in the wicketer area, and CO peaks occurred during the workday at a location between the wicketer operator stations and the flatbed bagging machine operator stations. The reasons for these periodic peaks was not obvious to us as there did not appear to be a change in operations or work practices at these times. There was visible smoke in the wicketer area, but employees mentioned that smoke (haze) had lessened in the plant following installation of LEV at the wicketers. The LEV on the wicketers could be improved by moving the slot hood closer to the bag sealer, tightening loose connections between the hood and the exhaust duct, and eliminating the sagging and sharp turns in the flexible duct. These changes could also further reduce the amount of smoke in the plant. The exhaust hood above the flatbed bagger did not appear to be as effective as the LEV at the wicketer in removing the visible smoke produced during bag sealing.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the plastic bag manufacturer to use an employer-employee health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations.

Our recommendations are based on an approach known as the hierarchy of controls. 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 personal protective equipment may be needed.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Hire a ventilation engineer to:
    - minimize sharp angles in the flexible exhaust on the wicketers,
    - relocate the LEV exhaust fan on the wicketers to the terminal point of the duct system (on the roof),
    - move the LEV hood closer to the heat-sealer on the wicketers, and
    - evaluate the location of the LEV hoods for the wicketers.

    A ventilation engineer should re-evaluate the effectiveness of the LEV at the wicketers and flatbed baggers after these changes are made.

2. Evaluate the source of the periodic CO peaks at the bagging machines.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Form a health and safety committee that includes unionized and non-unionized employees and managers.
2. Ask employees to report any symptoms they consider to be work related to their supervisor and personal physician.

Appendix A: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for 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 if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

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. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit 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; 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. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH RELs are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010]. NIOSH also recommends 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.
- Other OELs commonly used and cited in the United States include the TLVs, which are recommended by ACGIH, a professional organization. The TLVs are developed by committee members of this association from a review of the published, peer-reviewed literature. These OELs are not consensus standards. 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 2017].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/GESTIS/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

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))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., LEV, 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. Control banding focuses on how broad categories of risk should be managed. Information on control banding is available at 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 existing OELs.

Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin absorption. Formaldehyde is a common byproduct of combustion and other natural processes and small amounts can off-gas from products. The most commonly reported health complaints associated with exposure to low concentrations of formaldehyde include irritation of the eyes, nose, and throat; nasal congestion; headaches; skin rash; and asthma [ACGIH 2007].

Under the OSHA general industry standard for airborne exposure to formaldehyde, the PEL is 0.75 ppm for an 8-hour TWA, the action level is 0.5 ppm for an 8-hour TWA, and the STEL is 2 ppm for a 15-minute TWA. The standard requires medical surveillance for employees exposed to formaldehyde at or above the action level or STEL. Formaldehyde is an OSHA-regulated carcinogen [29 CFR 1910.1048]. The NIOSH REL for formaldehyde is 0.016 ppm for up to an 8-hour TWA. NIOSH also has a 15-minute ceiling limit of 0.1 ppm [NIOSH 2010]. NIOSH recommends treating formaldehyde as a potential carcinogen, and recommends that employers and employees minimize formaldehyde exposures to the lowest extent feasible. The ACGIH TLV is 0.1 ppm for an 8-hour TWA for formaldehyde. ACGIH has a STEL of 0.3 ppm [ACGIH 2017]. ACGIH lists formaldehyde as a dermal and respiratory sensitizer, and this short-term limit is meant to minimize eye and respiratory tract irritation. ACGIH has also designated formaldehyde as a suspect human carcinogen [ACGIH 2017].

Carbon Monoxide

Carbon monoxide is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials such as gasoline or propane fuel. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, or nausea. Symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. If the exposure level is high, loss of consciousness may occur without any other symptoms. Coma or death may occur if high exposures continue. The display of symptoms varies widely from individual to individual and my occur sooner in susceptible individuals such as young or aged people, people with pre-existing lung or heart disease, or those living at high altitudes.

Exposure to CO limits the ability of the blood to carry oxygen to the tissues by occupying the oxygen binding sites on hemoglobin to form carboxyhemoglobin. Once absorbed in the bloodstream, the half-life (the time it takes for half of the substance to be removed by the body) of CO from the blood varies widely by individual and circumstance (e.g., removal from exposure, initial carboxyhemoglobin concentration, partial pressure of oxygen after exposure). Under normal recovery conditions breathing ambient air, the expected half-life is approximately 6 hours [NIOSH 2004].

The OSHA PEL for CO is 50 ppm for an 8-hour TWA exposure. The NIOSH REL for CO is 35 ppm for an 8-hour TWA exposure, with a ceiling of 200 ppm that should not be exceeded [NIOSH 1992]. The NIOSH REL is designed to protect employees from health effects associated with carboxyhemoglobin levels in excess of 5% [NIOSH 1972].

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