Evaluation of Cadmium Exposures at an Aircraft Equipment Depot

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HHE Report No. 2015-0019-3273
March 2017

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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 for an evaluation at an aircraft equipment depot. The employer was concerned about employee exposures to cadmium from corroded cadmium-plated parts used in wing aerial refueling pods. We visited the depot in January 2015, June 2015, and March 2016.

What We Did

- We evaluated wing aerial refueling pod decommissioning and maintenance activities.
- We observed work practices and workplace conditions.
- We tested personal air samples and work surfaces for cadmium.

What We Found

- Employees removing corroded cadmium-plated parts were exposed to cadmium above Occupational Safety and Health Administration limits.
- Cadmium exposures were below Occupational Safety and Health Administration limits when work did not involve removing corroded cadmium-plated parts.
- Production and non-production surfaces and employee respirators had cadmium contamination.

We measured employees' exposures to cadmium during wing aerial refueling pod decommissioning and maintenance at an aircraft equipment depot. Cadmium air concentrations exceeded occupational exposure limits when employees removed corroded cadmium-plated parts. Cadmium was found on production and nonproduction surfaces and inside respirators. We recommended using a vacuum equipped with a high efficiency particulate air filter and wet wiping to clean internal pod surfaces, work surfaces, and tools; personal protective equipment; and diligent housekeeping.

What the Employer Can Do

- Ensure employees use a vacuum equipped with a high efficiency particulate air filter to clean the inside of wing aerial refueling pods and production areas.
- Train employees about hazards from cadmium and how to protect themselves.
- Provide personal protective equipment, including respirators, for employees removing corroded cadmium-plated parts.

What Employees Can Do

- Learn about the hazards of cadmium and other materials you work with.
- Properly wear and store personal protective equipment.
- Tell your doctor that you work with cadmium. Give your doctor a copy of this report.

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Abbreviations

µg/m^3	Micrograms per cubic meter
ACGIH®	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
WARP	Wing aerial refueling pod
WEEL™	Workplace environmental exposure level

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Introduction

The Health Hazard Evaluation Program received a request from an employer at an aircraft equipment depot. The employer was concerned about employee exposures to cadmium during inspection, repair, maintenance, and decommissioning of wing aerial refueling pods (WARPs). We visited the depot in January 2015, June 2015, and March 2016 to evaluate employee exposures. We toured the depot, spoke with employees, observed employee work practices and work conditions, and learned about the decommissioning schedule for two WARPs. We sent letters summarizing our preliminary recommendations to employer and employee representatives after each visit. We notified participants of their sampling results, when requested, after each visit.

Background

WARPs contain cadmium-plated components that corrode over time. Components comprise of (1) aircraft general standard parts (small items such as bolts, nuts, rivets, fork joints, taper pins) common to all types of aircraft, and (2) line-replaceable units (modular components designed to be replaced quickly). The level of corrosion can range from light surface corrosion to deep pitting and scaling.

In 2014 the depot received a pair of WARPs from the United Kingdom in shipping containers that were marked with cadmium warning labels. The depot was told by their United Kingdom office that the WARPs had been removed from the shipping crates and left outside, unprotected from the weather, for an unknown period. WARPs are normally stored inside their shipping crates to protect them. Upon inspection, depot employees found that the cadmium-plated components of the WARPs were much more corroded than was previously seen (Figure 1).

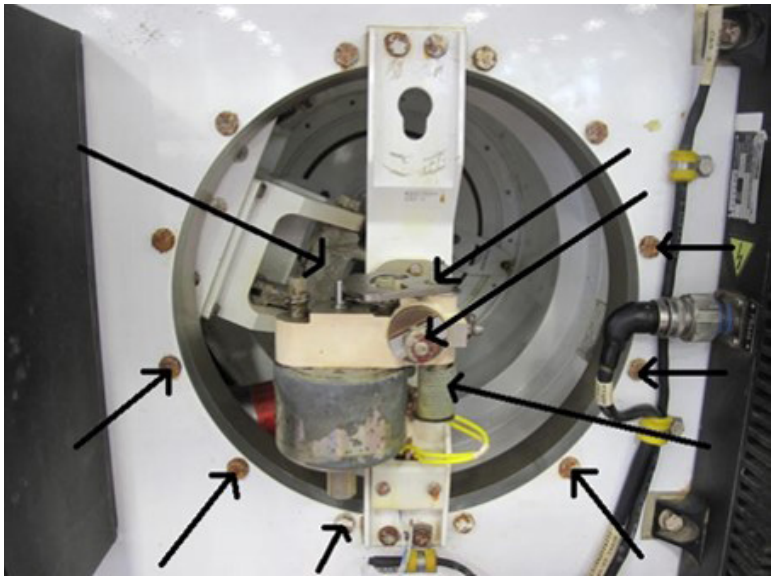

Figure 1. Arrows point to corroded components inside a WARP. Photo by the company.

Site and Process Description

The depot is approximately 4,000 square feet, with about one quarter of that space designated for WARP-related work. The depot is serviced by two residential-style heating, ventilation, and air-conditioning systems. There are no dedicated local exhaust ventilation systems. Each of the six employees had a desk or office outside of production areas. Adjacent to the production area was a kitchenette with a sink, refrigerator, coffee pot, and microwave. An adjacent building of approximately 12,000 square feet was used as storage for WARPs and their shipping crates.

Employees used a cart to hold equipment and tools while working on WARPs. When performing these activities, employees were required to wear safety glasses; employees also voluntarily wore nitrile gloves. We were told that no tasks (e.g., inspection, repair, maintenance, decommissioning) involving WARPs required employees to sand, grind, or scrape cadmium-plated components.

When removing corroded cadmium-plated components from WARPs, employees told us that they usually wore their half-mask elastomeric respirators equipped with organic vapor cartridges and N95 prefilters; although respirators were not required by management for this task. Employees told us they primarily used these respirators when handling paint and paint-removal products. They used pre-moistened wipes to clean WARP and work surfaces as well as tools and hands.

Decommissioning involved removing all components from inside and outside the WARP. Two employees spent approximately two hours of their eight-hour shift on this task. They worked separately, on one WARP each, using the same tools and PPE, performing the same tasks (Figures 2 and 3).

Figure 2. Employee decommissioning a WARP from the outside. Photo by NIOSH.

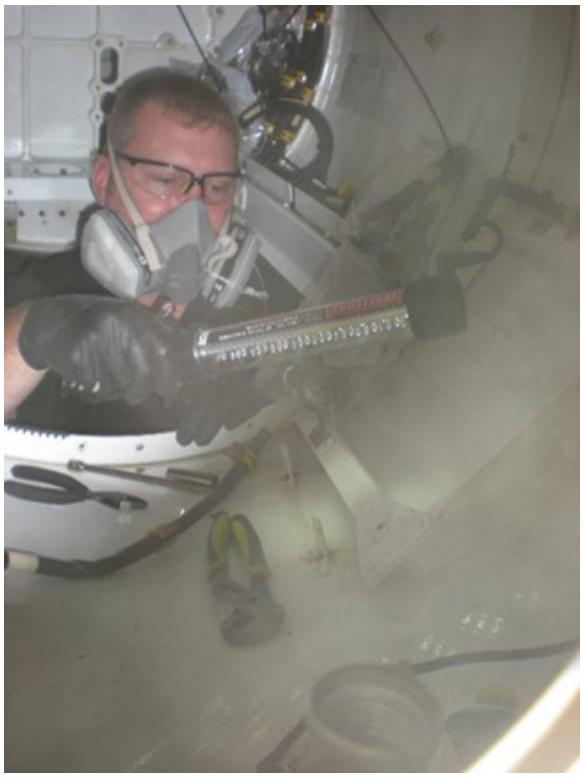

Figure 3. Employee decommissioning a WARP from the inside. Photo by NIOSH.

Methods

The objectives of this evaluation were to (1) evaluate employee exposures to airborne cadmium during the decommissioning of two WARPs, (2) evaluate employee exposures to airborne cadmium during inspection, repair, and maintenance of WARPs, and (3) evaluate other sources of cadmium exposure, including surface contamination in production and nonproduction areas and inside respirators.

Air and Surface Sampling

We sampled for cadmium in airborne particulate using the National Institute for Occupational Safety and Health (NIOSH) Method 7303 [NIOSH 2017] using Solu-CAP™ sample cassettes as the sampling media for all breathing zone air samples. We collected 29 full-shift personal air samples for total particulate during our three visits and compared the results to the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 5 micrograms per cubic meter of air ($\mu g/m^3$) and action limit (AL) of 2.5 $\mu g/m^3$ for cadmium. During our second and third visits, we also collected 17 full-shift personal air samples for respirable particulate. We used BGI GK2.69 stainless steel cyclones on one shoulder with the total particulate sampler on the other. We compared the results to the American Conference of Governmental Industrial Hygienists (ACGIH) limit of 2 $\mu g/m^3$ [ACGIH 2016].

We took 11 surface samples using SKC Inc. Full Disclosure® kits for cadmium. We sampled surfaces inside WARPs, in production and nonproduction areas, and in two employees' respirators. We wore a new pair of nitrile gloves for each sample we collected to avoid cross contamination. We used a 10-centimeter by 10-centimeter template to outline surface wipe sample areas where possible. For small or irregularly shaped surfaces we estimated the sample area or sampled the entire surface (e.g., inside respirators). We stored each surface wipe in a separate, clean plastic vial for shipment to the laboratory for quantitative analysis using NIOSH Method 7303.

Results and Discussion

After making three visits and observing employees perform different tasks with WARPs and elsewhere in the depot, we were able to conclude that WARP maintenance tasks involved different levels of interaction with the WARPs and their corroded cadmium-plated components:

- High - Work that involves being inside the WARP, removing corroded cadmium-plated components and/or hardware.
- Medium - Work that involves being inside the WARP, but little to no interaction with corroded cadmium-plated components and/or hardware.
- Low - Work that does not involve being inside the WARP with little to no interaction with corroded cadmium-plated components and/or hardware.

Personal Air Sampling

Personal air sample results for cadmium in total particulate are shown in Table 1. Employees with a high level of interaction with cadmium-plated components had the highest exposures to airborne cadmium, despite the short duration of these tasks (less than 2 hours of an 8-hour shift). These employees performed medium to low interaction activities for the remainder of the shift. High level of interaction tasks included working inside the WARPs where the small workspace often placed cadmium-plated components close to the employee's breathing zone. In contrast, employees performing tasks with medium to low levels of interaction with cadmium-plated components had little to no exposures to airborne cadmium.

Table 1. Results for cadmium in total particulate breathing zone air samples (N = 29) in µg/m^3

Sample date	Job title	Job activity	Time (min)	Interaction level*	TWA
1/13/2015	Field service engineer 1	Decommissioning WARP	384	High	9.3
	Field service engineer 2	Decommissioning WARP	382	High	1.2
	Field service engineer 3	WARP inspections	380	Medium	(0.042)
6/8/2015	Field service engineer 1	Stock and inventory	456	Medium	(0.032)
	Field service engineer 2	Decommissioning WARP	445	High	4.4
	Field service engineer 4	Stock and inventory	430	Low	ND
	Program manager	Office work	369	Low	ND
	Office administrator	Office work	307	Low	ND
6/9/2015	Field service engineer 1	Stock and inventory	464	Low	ND
	Field service engineer 2	Stock and inventory	419	Medium	(0.053)
	Field service engineer 3	Stock and inventory	361	Low	ND
	Field service engineer 4	Stock and inventory	450	Low	ND
	Program manager	Office work	449	Low	ND
	Office administrator	Office work	332	Low	ND
6/10/2015	Field service engineer 1	Stock and inventory	501	Low	(0.052)
	Field service engineer 2	Shop maintenance	509	Low	(0.054)
	Field service engineer 3	Stock and inventory	504	Low	(0.064)
	Field service engineer 4	Stock and inventory	289	Low	ND
	Program manager	Office work	425	Low	ND
	Office administrator	Office work	404	Low	ND
3/15/2016	Field service engineer 1	Office work	410	Low	ND
	Field service engineer 2	WARP inspections	422	Medium	(0.069)
	Field service engineer 3	WARP inspections	415	Medium	ND
3/16/2016	Field service engineer 1	Office work	412	Low	(0.021)
	Field service engineer 2	WARP inspections	441	Low	ND
	Field service engineer 3	WARP inspections	461	Medium	(0.043)
3/17/2016	Field service engineer 1	Stock and inventory	446	Low	ND
	Field service engineer 2	Stock and inventory	326	Low	ND
	Field service engineer 3	Stock and inventory	453	Low	(0.032)
NIOSH recommended exposure limit					†
OSHA permissible exposure limit					5
ACGIH threshold limit value					10

( ) = Values shown in parentheses are between the minimum detectable and minimum quantifiable concentrations for this sample set. More uncertainty is associated with these concentrations.

ND = Not detected (below 0.03 µg/m^3)

TWA = Time-weighted average

*Interaction levels were developed on the basis of observations by NIOSH investigators of employees performing WARP-related maintenance.

†NIOSH considers cadmium to be a potential occupational carcinogen. NIOSH is developing, whenever possible, a quantitative recommended exposure limit for occupational carcinogens, but no quantitative recommended exposure limit for cadmium has yet been established by NIOSH.

Personal air sample results for cadmium in respirable particulate are shown in Table 2. The one employee (field service engineer 2) who performed tasks with a high level of WARP interaction while wearing total and respirable particulate samplers had a total particulate sample concentration of 4.4 µg/m^3 and respirable particulate concentration of 0.27 µg/m^3. The assisting employee (field service engineer 1) working on the outside of the WARP had a cadmium concentration in the total particulate sample of 0.032 µg/m^3; no cadmium was detected in their respirable particulate sample.

Table 2. Results for cadmium in respirable particulate breathing zone air samples (N = 17) in µg/m^3

Sample date	Job title	Job activity	Time (min)	Interaction level*	TWA
6/8/2015	Field service engineer 1	Stock and inventory	456	Low	ND
	Field service engineer 2	Decommissioning WARP	446	High	0.27
6/9/2015	Field service engineer 1	Stock and inventory	463	Low	ND
	Field service engineer 2	Stock and inventory	504	Medium	(0.035)
	Field service engineer 3	Stock and inventory	418	Low	ND
6/10/2015	Field service engineer 1	Stock and inventory	501	Low	(0.010)
	Field service engineer 2	Shop maintenance	510	Low	ND
	Field service engineer 3	Stock and inventory	504	Low	0.10
3/15/2016	Field service engineer 1	Office work	409	Low	ND
	Field service engineer 2	WARP inspections	421	Medium	(0.022)
	Field service engineer 3	WARP inspections	415	Medium	ND
3/16/2016	Field service engineer 1	Office work	412	Low	ND
	Field service engineer 2	WARP inspections	442	Low	(0.010)
	Field service engineer 3	WARP inspections	461	Medium	ND
3/17/2016	Field service engineer 1	Stock and inventory	418	Low	ND
	Field service engineer 2	Stock and inventory	330	Low	ND
	Field service engineer 3	Stock and inventory	450	Low	(0.010)
NIOSH recommended exposure limit					†
OSHA permissible exposure limit					‡
ACGIH threshold limit value					2

( ) = Values shown in parentheses are between the minimum detectable and minimum quantifiable concentrations for this sample set. More uncertainty is associated with these concentrations.

ND = Not detected (below 0.03 µg/m^3)

*Interaction levels were developed on the basis of observations by NIOSH investigators of employees performing WARP-related maintenance.

†NIOSH considers cadmium to be a potential occupational carcinogen. NIOSH is developing, whenever possible, a quantitative recommended exposure limit for occupational carcinogens, but no quantitative recommended exposure limit for cadmium has yet been established by NIOSH.

‡OSHA does not have a PEL for respirable cadmium.

Surface Wipe Sampling

Surface wipe sample results for cadmium are shown in Table 3. Cadmium was detected on all 11 wipe samples. All but one of the highest surface levels were from production areas. The second highest surface sample was obtained in the kitchenette area in front of the microwave, suggesting that employees may have a risk of cadmium exposure by skin absorption and ingestion. Employee's hands, clothing, and tools contacted cadmium-contaminated interior surfaces in WARPs during decommissioning, inspections, and maintenance, creating potential dermal exposures. We also found cadmium inside respirators that were improperly stored on work benches in the production area.

Table 3. Cadmium in surface wipe samples, shown in µg/100 cm^2, unless otherwise noted

Sample area	Concentration (µg/100 cm^2)
In the production area	
Inside WARP unit FR XX50, lower lip	4,200
Cart	120
Inside WARP unit FR XX50, lower front belly	86
Inside WARP unit FR XX24, lower front belly	54
Cart, laptop keyboard	43
Inside field service engineer 2 respirator	3.6*
Inside field service engineer 1 respirator	2.4*
Inside WARP unit FR XX24, lower lip	0.27
Outside of the production area	
Kitchenette area, in front of microwave	1,200
Kitchenette area, on microwave keypad	2.1
Kitchenette area, next to coffee machine	0.080

*Surface area was irregular and less than 100 cm^2.

Wipe samples can provide information regarding (1) the effectiveness of housekeeping practices, (2) the potential for exposure to contaminants by skin absorption or ingestion (e.g., surface contamination on a table that is also used for food consumption), and (3) the potential for contamination of worker clothing and subsequent transport of the contaminant outside production areas or the worksite. Although it is not surprising that contaminant levels were higher on surfaces in production areas compared to non-production areas, good work practices and regular housekeeping can help to minimize levels regardless of the location. There are no occupational limits for cadmium in surface dust, though the OSHA cadmium standard does call for surfaces to be as free as practicable of accumulations of cadmium [29 CFR 1910.1027(k)(1)].

Other Observations

During our June 2015 visit, we observed employees using pre-moistened wipes (GOJO® Scrubbing Wipes, employer provided) to clean their hands, equipment, and work surfaces. These wipes contained two skin sensitizers: limonene and DMDM hydantoin. In a previous health hazard evaluation, NIOSH investigators found wipes that contain these and other potential skin sensitizers [NIOSH 2011].

When painting, cleaning, and using solvents, employees were required to wear a half-mask respirator equipped with a combination organic vapor cartridge and N95 particulate prefilters. No painting or cleaning activities were performed during our visits. Although not required, employees usually wore this same respirator ensemble when performing high interaction tasks involving cadmium-plated components. During our visits, we observed employees also wearing these half-mask respirators for some medium and low interaction tasks. When properly worn (as part of a comprehensive respiratory protection program), these respirators should reduce cadmium exposures to well below the OSHA PEL. The employer had a comprehensive respiratory protection program that included medical clearance, fit testing, and training but needed improvements on respirator maintenance, cleaning, and storage.

We did not observe employees moving the cart out of the WARP maintenance area to nonproduction areas of the depot. However, we did see employees carrying hand and battery-powered tools throughout the depot, though not into the kitchenette area. The employees themselves (by way of their hands, clothing, and footwear) may inadvertently be spreading cadmium contamination throughout the depot, indicating the need to reassess housekeeping practices and procedures.

Based on preliminary recommendations made after our first visit, the employer purchased (1) a vacuum equipped with a high-efficiency particulate air filter, (2) sticky mats, and (3) dedicated respirators fitted with P100 filters for employees to use when working with corroded cadmium-plated components. After our first visit, we also recommended employees used the vacuum to vacuum themselves and tools off when leaving the WARP work area.

Conclusions

Employees with a high level of interaction with cadmium-plated components had personal exposures to airborne cadmium that exceeded OSHA limits, despite the short duration of these tasks. Employees performing tasks involving medium to low levels of interaction with cadmium-plated components had personal exposures to airborne cadmium below OSHA limits or were not detectable. On the basis of personal air sampling results, most of the airborne cadmium particulate was not in the respirable size range. We detected cadmium on all surface wipe samples we collected, including surfaces in the kitchenette area, suggesting a potential dermal and ingestion risk to cadmium.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the aircraft equipment maintenance depot to use its existing health and safety committee 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 for the specific situation at the aircraft equipment maintenance depot.

Our recommendations are based on an approach known as the hierarchy of controls (Appendix A). 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. Use a vacuum with a high efficiency particulate filter followed by wet wiping to clean particulate and corrosion inside WARPs, work surfaces, and tools before maintenance to minimize exposures and prevent transporting cadmium into nonproduction areas.
2. Use a vacuum with a high efficiency particulate filter followed by wet wiping to clean tools and clothing before leaving the work area when working with cadmium-plated components.
3. Use sticky mats under access panels on WARPs to catch and prevent transporting cadmium-containing dust into nonproduction areas.

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. Review the OSHA cadmium standard [29 CFR 1910.1027]. This standard has requirements for preplacement examinations and medical surveillance for employees depending on the frequency and severity of their cadmium exposures. The standard also outlines airborne exposure monitoring (to include the reporting of results to employees) and training requirements. Employers are required to perform airborne exposure monitoring and medical surveillance when employees are exposed to airborne cadmium concentrations at or above the AL 30 or more days per year.
2. Perform additional personal air sampling once engineering controls are implemented to determine if respiratory protection is still needed.

3. Use hand wipes that do not contain potential skin sensitizers.

Personal Protective Equipment

Personal protective equipment is the least effective means for controlling hazardous exposures. Proper use of personal protective equipment requires a comprehensive program and a high level of employee involvement and commitment. The right personal protective equipment must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. Personal protective equipment should not be the sole method for controlling hazardous exposures. Rather, personal protective equipment should be used until effective engineering and administrative controls are in place.

1. Select personal protective equipment, including respirators, on the level of interaction with cadmium-plated components. Modify written programs and employee training to reflect this selection guidance.
2. Ensure employees are part of an effective comprehensive respiratory protection program (per OSHA respiratory protection standard 1910.134) and wear respirators equipped with P100 filters (as a minimum) when performing activities that involve a high level of interaction with cadmium-plated components. Do this until exposure monitoring confirms the effectiveness of engineering controls and work practices per the OSHA cadmium standard 1910.1027(d).
3. Clean respirators with respirator cleaning wipes before storage. Refer to the respirator manufacturer's instructions for additional guidance on proper cleaning.
4. Store respirators in cabinets or shelves that are kept clean, used only for respirator storage, and located outside the work area. Inspect respirators before and after use to make sure no one wears a respirator that is misshapen or damaged.
5. Use nitrile gloves when handling wet wipes that contain potential skin sensitizers.

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 concentrations 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 concentrations. 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 short term exposure limits or ceiling values. Unless otherwise noted, the short-term exposure limit 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 recommended exposure limits 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 recommended exposure limits 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 threshold limit values (TLVs), which are recommended by ACGIH, a professional organization, and the workplace environmental exposure levels (WEELs), which are 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. 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 2016]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2016].

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., 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. 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.

Cadmium

Cadmium is a metal used in batteries, pigments, plastic stabilizers, metal coatings, and television phosphors [ACGIH 2001]. Employees may inhale cadmium particulate when sanding, grinding, or scraping cadmium-metal alloys or cadmium-containing paints [ACGIH 2001]. In addition to inhalation, cadmium may be absorbed via ingestion. Non-occupational sources of cadmium exposure include cigarette smoke and dietary intake [ACGIH 2001]. Early symptoms of cadmium exposure may include mild irritation of the upper respiratory tract, a sensation of constriction of the throat, a metallic taste and/or cough. Short-term exposure effects of cadmium inhalation include cough, chest pain, sweating, chills, shortness of breath, and weakness [Thun et al. 1991]. Short-term exposure effects of ingestion may

include nausea, vomiting, diarrhea, and abdominal cramps [Thun et al. 1991]. Long-term exposure effects may include loss of the sense of smell, ulceration of the nose, emphysema, kidney damage, mild anemia, and an increased risk of cancer of the lung, and possibly of the prostate [ATSDR 1999].

The OSHA PEL for cadmium is 5 $\mu g/m^3$ as an 8-hour TWA. The OSHA cadmium standard also has requirements for preplacement examinations and medical surveillance for employees depending on the frequency and severity of their cadmium exposures [29 CFR 1910.1027]. The ACGIH TLV for cadmium is 10 $\mu g/m^3$ for an 8-hour TWA [ACGIH 2016]. NIOSH considers cadmium to be an occupational carcinogen, but has not set a quantitative recommended exposure limit. NIOSH is revising its cadmium limit and, in the meantime, urges employers to assess the conditions under which their workers may be exposed to cadmium and take all reasonable precautions to reduce these exposures to the fullest extent feasible.

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Keywords: North American Industry Classification System 336413 (Other Aircraft Parts and Auxiliary Equipment Manufacturing); Florida; Aircraft; Cadmium; Cadmium plating; Cadmium-plated; Corrosion; Corroded; Decommissioning; In-flight Refueling Pod; Military; Pod; Wing Aerial Refueling Pod; WARP

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Acknowledgments

Analytical Support: Bureau Veritas North America
Desktop Publisher: Shawna Watts
Editor: Ellen Galloway
Industrial Hygiene Field Assistance: Scott Brueck, Josh Harney
Logistics: Donnie Booher, Kevin Moore

Availability of Report

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Recommended citation for this report:

NIOSH [2017]. Evaluation of cadmium exposures at an aircraft equipment depot. By Feldmann, K. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Health Hazard Evaluation Report 2015-0019-3273, http://www.cdc.gov/niosh/hhe/reports/pdfs/2015-0019-3273.pdf.

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