Evaluation of Worker Exposures to Noise, Metalworking Fluids, Welding Fumes, and Acids During Metal Conduit Manufacturing

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ABBREVIATIONS

ACGIH®	American Conference of Governmental Industrial Hygienists
AG	Acid gas
AL	Action level
ANSI	American National Standards Institute
CIH	Certified Industrial Hygienist
CO	Carbon monoxide
CSP	Certified Safety Professional
Cr(III)	Trivalent chromium
Cr(VI)	Hexavalent chromium
CT	Charcoal tube
dB	Decibel
dBA	Decibels, A-scale
GA	General area
HCl	Hydrochloric acid
HHE	Health hazard evaluation
HL	Hearing levels
Hz	Hertz
JSA	Job safety analysis
LOTO	Lockout/Tagout
Lpm	Liters per minute
µm	Micrometer
$\mu g/m^3$	Micrograms per cubic meter
mg/m^3	Milligrams per cubic meter
mL	Milliliter
mm	Millimeter
MSDS	Material safety data sheet
MWF	Metalworking fluid
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible exposure limit
PPM	Parts per million
PPE	Personal protective equipment
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
REL	Recommended exposure limit
SAR	Supplied air respirator
SCBA	Self-contained breathing apparatus
SLM	Sound level meter
STEL	Short term exposure limit
STS	Standard threshold shift
TLV®	Threshold limit value
TWA	Time-weighted average

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 Republic Conduit in Louisville, Kentucky. This HHE was requested because of concerns about exposures to acids, unsafe confined space entry procedures, and inadequate personal protective equipment. NIOSH investigators conducted site visits in November 2006 and March 2007.

What NIOSH Did

- We looked at conduit manufacturing.
- We talked to workers about their concerns about workplace hazards.
- We looked at previous air sampling records, injury and illness records, and material safety data sheets.
- We sampled for acid mists, metalworking fluids (MWFs), elements, and hexavalent chromium.
- We measured workers' noise exposures.
- We looked at hearing test records, written confined space entry procedures, and the respiratory protection program.

What NIOSH Found

- Workers were not overexposured to acid mists, elements, or hexavalent chromium.
- Most workers were overexposed to noise.
- Some workers wore their hearing protection incorrectly.
- Three workers had MWF exposures at or above the NIOSH recommended exposure limit.
- The respiratory protection and confined space programs were incomplete.
- Grade D breathing air was not available for supplied air respirators.
- Lockout/tagout rules were not followed.
- Workers said they had upper respiratory symptoms caused by acid and hand injuries caused by contact with conduit.
- Workers were concerned about improper personal protective equipment and poor ventilation.
- Workers mentioned a lack of training and poor hazard communication.

What Republic Conduit Managers Can Do

- Reduce metal to metal contact noise.
- Have workers wear hearing protection.
- Start a hearing loss prevention program.
- Enclose the mills and install local exhaust ventilation.

Highlights of the NIOSH Health Hazard Evaluation (continued)

- Develop an entry checklist for each confined space.
- Provide grade D breathing air for supplied air respirators.
- Follow the Occupational Safety and Health Administration's (OSHA) lockout/tagout rules.
- Use the *OSHA Small Entity Compliance Guide* to write a respiratory program.
- Provide workers personal protective equipment.
- Write an incident response program for emergencies.
- Follow OSHA's Hazard Communications standard.
- Educate and train workers about MWFs.
- Start an employee-management health and safety committee.

What Republic Conduit Employees Can Do

- Follow all lockout/tagout procedures.
- Wear personal protective equipment when working around acids.
- Wear hearing protection in noisy areas.
- Wear both ear plugs and ear muffs when working near the hot dip area or the steam cannon.
- Report any work-related symptoms or safety concerns to your supervisor.
- Talk to your doctor if you think your symptoms are work-related.

Summary

Noise exposure measurements for 94% of the workers evaluated were above the NIOSH REL. Three workers were exposed to MWFs at concentrations equal to or greater than the NIOSH REL. Airborne concentrations of acids were either not detected or were much lower than their OELs. NIOSH recommends that engineering controls be implemented to reduce exposures to noise and MWFs below their NIOSH RELs. Recommendations are also provided for improving the confined space entry and respiratory protection programs.

On August 8, 2006, NIOSH received a confidential employee request for an HHE at Republic Conduit in Louisville, Kentucky. The requestors expressed concerns about workplace exposures to acids, unsafe confined space entry procedures, and inadequate PPE for handling acids. We conducted an initial site visit to Republic Conduit on November 13, 2006, during which we performed a walk-through of the facility and interviewed workers. Based on our observations, workers were potentially exposed to acids, Cr(VI), MWFs, welding fumes, and noise. Of the 13 employees who we selected for medical interviews, two reported acute upper respiratory symptoms and exacerbation of asthma symptoms related to a brief exposure to HCL during a leak. Four reported injuries not associated with acid exposure, which included back pain, skin irritation, lacerations, and crushed fingers. A review of OSHA's Form 300 Log of Work-Related Injuries and Illnesses for 2006 revealed that of 21 entries, 11 listed crushed fingers or lacerations caused by contact with conduit.

We conducted a follow-up site visit to Republic Conduit during March 5–8, 2007, to sample for acid mists, MWFs, elements from welding fumes, and Cr(VI) from chromic acid; conduct noise dosimetry; and review the company's written health and safety programs. All sampling results were below applicable OELs except for noise and MWFs. Of the 35 personal noise exposure measurements taken during this evaluation, 33 exceeded the NIOSH REL of 85 dBA. Because OSHA uses different criteria to measure noise exposure, only six exceeded the OSHA PEL of 90 dBA, though 29 exceeded the OSHA AL of 85 dBA. Three of 21 PBZ sample results equaled or exceeded the NIOSH REL-TWA for MWFs of 0.4 mg/m^3 (thoracic particulate mass).

During the March 2007 site visit, we provided all 168 production workers on three shifts a survey form asking about their workplace exposures, use of PPE, hazard communication, and confined space entry procedures. Sixty-nine workers (41%) completed the voluntary survey. In general, workers were concerned about their workplace exposures, specifically to acids and zinc oxide dust.

Based on PBZ air sampling conducted during this evaluation, we recommend that Republic Conduit enclose the mills and install local exhaust ventilation to reduce airborne MWF concentrations below the NIOSH REL. We recommend mill operators use respiratory protection until airborne concentrations of MWFs are below the NIOSH REL-TWA. After the controls are installed, additional PBZ air sampling should be conducted to determine if the airborne concentration of MWFs has been reduced and if respiratory protection is still needed. Controls should be installed to reduce impact noise generated by metal to metal contact, and hearing protection should be used properly to reduce the risk of hearing loss. We also provide recommendations for protecting workers while performing maintenance on systems with acids, reducing injuries, and revising the written respiratory protection and confined space entry programs. Further recommendations are provided in the recommendations section of this document.

Keywords: NAICS 332813 (Electroplating, plating, polishing, anodizing, and coloring), nitric acid, sulfuric acid, hydrochloric acid, metalworking fluids, MWFs, welding, noise, hearing loss, impact noise, confined spaces, hexavalent chromium, Cr(VI)

Introduction

On August 8, 2006, NIOSH received a confidential employee request for an HHE at Republic Conduit in Louisville, Kentucky. The requestors expressed concerns about workplace exposures to acids, unsafe confined space entry procedures, inadequate PPE for acid exposures, and work-related throat irritation. Two NIOSH industrial hygienists and a nurse epidemiologist conducted an initial site visit to Republic Conduit on November 13, 2006. During the site visit we interviewed workers and conducted a walk-through tour of the facility. We observed that workers were exposed to one or more of the following chemical and physical hazards; acids, MWFs, welding fumes, zinc oxide, Cr(VI), and noise.

Based on our observations during the initial site visit, we conducted a second visit to Republic Conduit during March 5–8, 2007, to sample airborne for acid mists, Cr(VI), MWFs, and metals from welding fumes; conduct noise dosimetry; and review the health and safety programs.

Republic Conduit occupies a 400,000 square foot building that was constructed in 2005 and is part of Tenaris, a global manufacturer and supplier of tubular products. At the time of this evaluation the plant had 168 production employees. All production workers at Republic Conduit wear safety glasses, hearing protection, safety shoes, and hard hats. Some workers wear Kevlar, leather, or nitrile gloves, based on their job requirements.

Process Description

Republic Conduit receives rolls of sheet metal that are slit into strips, with the strip width corresponding to the desired circumference of the conduit. The strips are manually aligned, and the ends welded to ensure a continuous feed of sheet metal strips through the mills. As the sheet metal strips move through the mills on conveyors, the mills form the strips into tubing, weld the seam, and cut the tubing to the desired length. At the time of this evaluation, only two of the five mill lines were in operation. Synthetic MWF (a mixture of 6% neat fluid added to water) is used to cool the tubing during the forming and welding process.

Smaller diameter conduit is galvanized by pickling in an acid bath (nitric, sulfuric), then electroplated with zinc. The galvanized pipes are dipped in a chrome bath and dried in an oven. A chrome coating is then sprayed inside the ends. The interconnected galvanizing and electroplating tanks are enclosed by vinyl strip curtains and fans over the pickling and coating tanks capture and exhaust the acid mist through a scrubber.

Larger diameter conduit is cleaned by dipping in an enclosed, ventilated HCl tank, and then coated by dipping in molten zinc. After coating, excess zinc is blown out from the interior of the conduit using high pressure steam, then the conduit is sprayed with diluted chromic acid. The conduit ends are threaded and recoated with zinc (remetalized), then heat treated. Workers in the threading area used aerosol spray cans to apply a zinc coating on parts of the tubing that were not adequately treated during remetalization.

At the time of this evaluation two or three workers were at the hot dip tank. These workers manually add 60 pound bars of zinc to the kettle and stir the molten zinc, requiring them to be close to the kettle. Zinc fumes captured by a canopy hood at the hot dip tank pass through a bag house filter.

ASSESSMENT

After the walk-through tour of the plant, we developed a sampling strategy based on potential worker exposures and addressing the requestors' concerns (see Table 1). Based on our discussions with Republic Conduit management personnel and employees we determined that exposures would probably be greater on day shift and that there was no difference in the production processes conducted during day and night shifts, hence we collected PBZ air samples on day shift employees only. We also collected two GA samples for HCl in the hot dip enclosure, two samples for elements near mills, and one in the threading area. We sampled employees according to their workplace exposures so that those working near the mills were sampled for MWFs and elements from welding fumes, personnel working around acids were sampled for inorganic acids which included HCl, sulfuric, and nitric acid. Personnel working near chromic acid tanks were sampled for Cr(VI). Most employees on who PBZ air sampling was conducted were also sampled for noise. Sampling results for MWFs, acids, Cr(VI), elements from welding fumes, noise are provided in tables A1-A6 in Appendix A. In addition to the results, the tables provide the sampled worker's department and job title as well as the sample time. Details on the methods used for air sampling and noise measurements are explained in Appendix B. The OELs and health

Table 1: Summary of Employees Workplace Exposures	
Department	Exposures
Maintenance	Acid Mists (HCL, Sulfuric, Nitric), MWFs, Cr(VI), Noise
Hot Dip	Acid Mists, Cr(VI), Zinc Oxide, Noise
Welding/Mills	MWFs, Welding Fumes, Noise
Threading	Zinc Oxide, Noise
Lab Tech	Acid Mists, Noise

effects are discussed in Appendix C. All samples were collected during a full shift (generally 8-10 hours) with the exception of two STEL area samples for HCL collected in the hot dip enclosure. We also used ventilation smoke tubes to observe air flow patterns around enclosures for hazardous operations.

During our initial site visit, Republic Conduit representatives provided us with a roster of employees working at the facility. We chose every fifth employee from the roster for interviews about health symptoms. Employees were chosen from the hot dip, galvanizing, maintenance, and welding areas from first and second shift. We reviewed OSHA's Form 300 Log of Work-Related Injuries and Illnesses for 2006 and the written guidelines for the confined space entry and respiratory protection programs.

We provided a survey form to all 168 production workers on three shifts asking about their workplace exposures, use of PPE, hazard communication, and confined space entry procedures. Participation was voluntary and 69 (41%) of the 168 production workers completed the survey.

Results & Discussion

Air Sampling

The PBZ air sampling results for MWFs by job classification are presented in Table A1 (Appendix A). Only one mill was in operation in the morning during the 2 days we conducted air sampling and noise dosimetry. Generally, two mills are in operation at the same time during the entire day, which may result in a higher release of welding fumes and MWF mist. We collected a total of 16 PBZ air samples for MWFs. One MWF sample collected on a mill operator exceeded the NIOSH REL-TWA of 0.40 mg/m^3. The remaining 13 samples measured exposures below the REL. Another mill operator and end finisher had exposures that equaled the REL. In addition to the MWFs the total thoracic particulate mass includes other particles such as elements from welding fumes and ambient dust. The extracted MWF represents the airborne concentration of MWF, however the NIOSH REL applies to the total thoracic particulate mass.

Air sampling results for acid mists are presented in Table A2. We collected a total of 21 PBZ air samples for acid mists and 2 GA samples. Sampling results for acid mists did not exceed applicable OELs. Nitric acid has the lowest detection limit and was the most commonly detected acid. The highest airborne concentration of nitric acid was 0.1 mg/m^3, which is much less than the OSHA PEL-TWA or NIOSH REL-TWA of 5 mg/m^3. With the exceptions of one PBZ air sample (0.29 mg/m^3) and one STEL area sample (3.1 mg/m^3) HCl was not detected. These sample results were below the NIOSH REL and OSHA PEL ceiling limit of 7 mg/m^3. Sulfuric acid was also not detected or was detected in trace concentrations at less than 0.09 mg/m^3, which is below the OSHA PEL-TWA or NIOSH REL-TWA of 1 mg/m^3. Line breaking and replacement of components such as pumps and valves were not performed by maintenance personnel during this evaluation. There is a potential for higher exposures to acids while performing those tasks. Prior to this HHE, three workers had been splashed with HCl when a pressurized line ruptured.

Air sampling results for Cr(VI) collected on PVC filters are presented in Table A3. We collected 4 PBZ air samples for Cr(VI) from welding fumes on mill operators, 2 on end finishers, and 2 on end welders. Results for Cr(VI) collected on quartz filters are presented in Table A4. A treated quartz filter was used in this area to prevent the Cr(VI) from being reduced to Cr(III). We collected a total of 15 PBZ air samples on employees working near the hot dip and galvanizing areas and on two maintenance workers. The highest airborne concentration of Cr(VI) 0.3 $\mu g/m^3$ was obtained on a sample collected on a galvanizing line worker. All other Cr(VI) samples were less than 0.1 $\mu g/m^3$, which is below the NIOSH REL-TWA of 1 $\mu g/m^3$ and the OSHA PEL-TWA of 5 $\mu g/m^3$.

Air sampling results for elements in welding fumes are presented in Table A5. We collected a total of 15 PBZ air samples on employees working near the mills, threading, or hot dip areas. We also collected two GA air samples by the mills and threading area. The air samples collected on employees potentially exposed to welding fumes or zinc were analyzed for 31 elements, primarily metals. The predominant metals detected, iron and zinc, were present in all 16 air samples. The concentrations of iron ranged from 0.02 to 0.38 mg/m^3; concentrations that were much lower than the NIOSH REL-TWA of 5 mg/m^3 and the OSHA PEL-TWA of 10 mg/m^3. Zinc concentrations which ranged from 0.01 to 1.5 mg/m^3, were below the NIOSH REL-TWA (for zinc oxide dust or fume) of 5 mg/m^3 and OSHA PEL-TWA of 5 mg/m^3 for zinc oxide fume. Other elements detected in quantifiable concentrations (but well below their respective OELs) included aluminum, barium, calcium, copper, magnesium, manganese, molybdenum, silver, and titanium. Although an exposure limit for total welding fumes has not been established by either OSHA or NIOSH, NIOSH recommends maintaining exposures to welding fumes as low as technically feasible [NIOSH 1988, 2005].

Noise

Personal noise exposure measurement results are presented in Table A6. Of the 35 personal noise exposure measurements, 33 exceeded the NIOSH REL of 85 dBA, which is equivalent to a noise dose of 100%. The noise dose for 29 noise measurements was greater than 200% (two times greater than the NIOSH REL). The noise dose for 16 measurements exceeded 500% (five times the NIOSH REL). Because OSHA measures noise using a different criteria than NIOSH, only 6 measurements exceeded the OSHA PEL and 29 measurements exceeded the OSHA AL. Although the NIOSH REL for noise is not a legally enforceable regulatory standard, NIOSH considers it to be more protective in the prevention of hearing loss than OSHA's noise exposure limits. Table 2 provides a summary of noise measurement results for each job title.

Metal impact is a substantial source of noise in the production area. Specifically, metal conduit rolling into or dropping onto other pieces of conduit during processing causes impact noise. Impact noise also occurs when conduit strikes stop plates (end finisher) or other pieces of metal on the production equipment. The production equipment itself also generates noise when it is running.

Table 2: Range of Personal Noise Dosimetry Measurements

Department	Job Title	Number of Measures	Percent Dose OSHA AL[a]	Percent Dose OSHA PEL[b]	Percent Dose NIOSH REL[c]
Galvanizing	Bundler	2	90.8–113.3	73.7–97.3	620.0–961.5
Hot Dip	Extractor	2	160.2–217.3	131.9–191.9	2536.4–5961.1
	Operator	1	205.6	186.5	4215.7
	Laborer	1	90.8	45.4	649.3
	Loader	2	66.9–123.1	51.4–116.5	356.2–837.1
Maintenance	Maintenance	4	19.8–95.9	8.5–79.0	93.3–1491.1
Shipping	Material Handler	6	55.1–77.9	33.4–49.3	214.3–565.3
Threading	Packaging Op.	2	48.0–73.7	23.7–39.5	170.1–876.7
	Saw Operator	2	77.9–104.2	57.4–77.9	418.7–552.4
	Inspector	1	58.2	38.4	303.0
Welding	Bander	4	83.5–211.4	67.8–197.2	578.5–1635.5
	End Finisher	3	41.2–155.8	33.0–141.4	148.1–1712.8
	Mill Operator	2	44.8–69.7	16.3–39.0	155.1–317.3
	Utility	1	15.0	59.9	46.7

[a] OSHA AL = A dose = 50% (an 8-hour TWA of 85 dBA, using a 5 dB exchange rate).

[b] OSHA PEL = A dose = 100% (an 8-hour TWA of 90 dBA, using a 5 dB exchange rate).

[c] NIOSH REL = A dose = 100%(an 8-hour TWA of 85 dBA, using a 3 dB exchange rate).

In the hot dip department a high level of impulse noise is created when the steam cannon is activated. Of particular note were the noise exposures of the operators and extractors in the hot dip department, which ranged from 99 dBA to 102 dBA based on NIOSH measurement criteria. Sound level and octave band measurements taken in this area show that peak levels are sometimes greater than 136 dB when the steam cannon is activated. Because of noise monitoring equipment limitations, these values may actually underestimate the true peak noise level from the steam cannon [Kardous 2004].

Most employees wore one of the following four types of hearing protection: E-A-R® Classic® (NRR 29), Moldex Purafit® (NRR 35), Howard Leight Laserlight® (NRR 32), or Bilsom® Thunder® T3H (NRR 27) earmuffs. We observed that some workers did not wear earplugs properly. Specifically, the foam ear plugs had not been inserted deeply enough into the ear canal. Improperly worn or inserted earplugs reduce the effectiveness of the earplug.

We observed that some workers were not wearing any hearing protection. When asked about the reason for not wearing hearing protection, one worker responded that the noise did not seem too loud and was not as loud as noise levels experienced in a previous job. We also observed some contract welders near the zinc kettle and steam cannon who were not wearing hearing protection.

Audiometric testing is done offsite by BaptistWorx when workers are hired and then repeated on a yearly basis. Republic Conduit began operations and hired most of the workforce in 2005 and 2006. At the time of our evaluation most workers had only received baseline hearing tests. However, 56 production workers had a baseline audiogram and subsequent yearly audiogram. Of these, five workers had an STS. OSHA defines an STS as a change in an employee's hearing threshold, relative to the baseline audiogram, of an average of 10 dB or more at 2000, 3000, and 4000 Hz in one or both ears. The occurrence of a STS indicates that workers exposed to high noise levels are not adequately protected either because they are not wearing hearing protection or are not properly wearing hearing protection.

Ventilation

We used smoke tubes to visualize airflow currents. Smoke released near doors in the administrative and breakroom areas flowed rapidly into the production area, indicating that the production area was under negative pressure relative to those two areas. This is a favorable condition because it means that air contaminants released in the production area will not flow into the administrative area. Smoke released near the galvanizing tanks flowed up to the exhaust fans. Smoke released by the hot dip enclosure and the remetalizer flowed into their respective enclosures, indicating they were both under negative pressure. Despite missing several enclosure panels, which may reduce the effectiveness of the tank's exhaust ventilation system, smoke released into the chromic acid tank flowed into the enclosure. The tank farm located within the plant near the hot dip area was under positive pressure, an undesirable condition because if a leak occurred the vapors could disperse into the rest of the plant. The HCl hot dip enclosure had a variable air flow exhaust system to maintain the enclosure under negative pressure when conduit was transferred in and out of the tanks.

We observed an accumulation of dust in the threading area, indicating that the local exhaust ventilation system was ineffective or needed maintenance.

The mills are not enclosed, and local exhaust ventilation is not used (Photo 1). Republic Conduit had applied for a construction permit in September 2006 to install an exhaust system on the mills and was awaiting approval by the Louisville/Metro Air Pollution Control District.

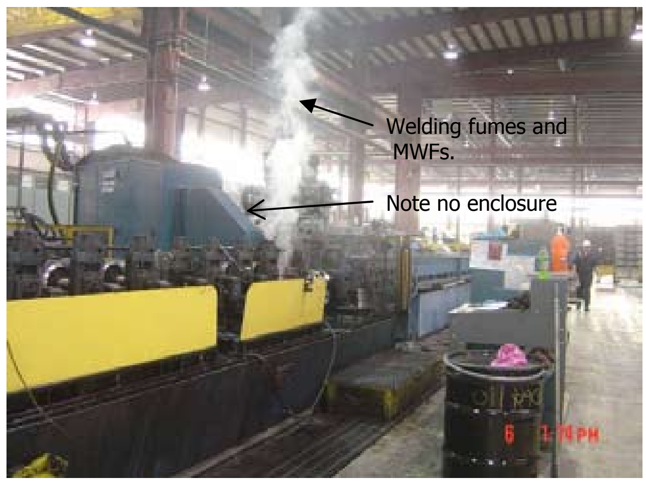

Photo 1: Mill forms conduit out of sheet metal and welds the seam

Respiratory Protection Program

The written respiratory protection program was not site specific. For example, it did not specify the type of respiratory protection required for hazardous operations such as cleaning tanks or entering the HCl hot dip enclosure. Additionally, the respirator program noted that the use of supplied air respirators was required for line breaking, but a source of Grade D breathing air was not available at the facility.

Employee Interviews

During the initial site visit, November 2006, we interviewed 13 (21%) of 71 employees working first and second shift in the hot dip, galvanizing, maintenance, and welding areas. Employees interviewed reported a job tenure of 2 months to 1 year. Two of the workers interviewed reported acute upper respiratory symptoms and exacerbation of asthma symptoms related to a brief exposure to acid during a leak. Four other employees interviewed reported back pain, skin irritation, lacerations, and smashing injuries. Along with health symptoms, general safety issues such as personnel not following proper procedures for confined space entry and lockout/tagout were reported.

The symptoms reported by the 13 workers interviewed and those on the OSHA 300 Log of Work-Related Injuries and Illnesses were not associated with a specific causative agent. However, some of these symptoms (e.g., eye, nose and throat irritation, skin irritation, and respiratory system distress) are consistent with acid exposure and could be caused or exacerbated by short-term exposure to acids, even if exposures are not above the OELs [NIOSH 1981, 2005]. Of the 21 entries for injuries or illnesses on the OSHA Logs in 2006, 2 of the mechanics reported throat irritation from exposure to chemical vapors. Other entries included 6 crushing/smashing injuries, 6 lacerations, 4 sprains/strains, and 2 fractures. The occupation most often listed for these injuries was end finisher.

Employee Survey

During the March 2007 site visit we provided all production employees a survey form with questions about workplace exposures and use of PPE. Although the survey had only 41% participation from the workforce and, thus, may not represent the entire workforce, we were able to obtain useful information from it. Workers were concerned about potential hazards within their work areas. Mill operators were concerned about welding fumes; threaders and hot dip operators about zinc oxide; and workers at the galvanizing line about acids. Thirty-five of the respondants said they have smelled acid in their work area, and 16 said they have had skin contact with acids. All respondants said they wear assigned PPE. With few exceptions, respondants said they were familiar with MSDSs and that they had been informed about chemical hazards in their workplace. Other concerns mentioned to us by several surveyed workers included employees not following LOTO rules; containers being unlabeled or mislabeled; forklift operators driving too fast; kerosene or gas powered heaters being used in inadequately ventilated work areas; entering acid tank farms without pre-entry air testing and without training on the potential tank entry hazards; and removing conduit from acid baths without donning the proper PPE. Some individual employees mentioned that smoke would fill the facility during maintenance on the screw feeders on the hot dip kettles, and that the spill warning light was not functioning on the hot dip pit. Although we did not check the validity of all of these comments, we are providing this information because some of these concerns may warrant management attention.

Observations

During this HHE we observed the following work practices that could result in serious injuries and/or property damage:

- Three employees were performing repair/maintenance work on a mill but only one lock was used to "lockout" and prevent start-up of the mill during repair. Each employee working on the equipment is required to place a lock on the energy source [CFR 1996].
- We noted that the containment doors on the zinc kettle were not always lowered to prevent molten zinc from splattering onto nearby unprotected workers.
- We observed fluids which had spilled onto the workplace floor, increasing the risk that employees may slip or fall.
- We saw some forklift operators not wearing their seat belts, and several drivers appeared to be traveling too fast and did not consistently use the forklift horn to signal when they were backing up.
- An employee using a 40-ton overhead crane to move a metal coil was observed standing too close to the load. In the event of failure or excessive swing of the load the operator would be at risk of injury.

Conclusions

Our noise dosimetry results indicate that Republic Conduit workers are at risk of hearing loss from exposure to high noise levels in the production areas, and from our review of hearing test records, some employees have already experienced hearing loss. While employees used hearing protection, some wore it improperly. Metal impact was the main noise source near the mills, and impulse noise produced by the steam cannon was the main noise source near the hot dip area. Ear plugs alone cannot provide adequate protection from the high impulse noise levels in the hot dip area.

Employees working near the mills may be at risk of developing respiratory problems from exposure to MWF mist. Three employees were exposed to airborne MWF concentrations at or above the NIOSH REL. Only one or two of the five mills were operating on the days we sampled for MWFs, so the number of overexposed employees may increase when more mills operate and the production rate increases. Workers were not overexposed to airborne acid mist, metals, or Cr(VI) during the NIOSH evaluation; however, overexposure to acids could occur when removing components or disconnecting lines from a system containing concentrated acid (line breaking).

We found that required or recommended procedures for several health and safety programs were not being followed, and employees were concerned about their health and safety. For example, the written confined space entry guidelines did not address hazards associated with each confined space, while the written respiratory protection program did not list the type of respiratory protection required for each hazardous operation. Regarding the LOTO program, we noted that not all employees had placed a lock to isolate the energy source when working on the same machine. Finally, during our interviews and survey, workers were concerned about receiving emergency response training so they would be prepared in the event of another acid tank spill, inadequate PPE, lack of timeliness in providing chemical suits and respirators, poor ventilation in acid rooms and zinc kettle areas, lack of training and identification of chemicals used in the plant, poor use of lock-out procedures, and lack of safety lines for the fall protection program.

Recommendations

We encourage you to review the standards and publications mentioned in our recommendations and conduct a self assessment to ensure 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. Improve the existing hearing conservation program.

   a. Continue to require hearing protection in the production areas. Supervisors should be responsible and held accountable for ensuring the proper use of hearing protection in their work area. Hearing protection use should also be required for outside contractors.

   b. Due to the high peak noise levels and TWA noise exposures that exceed 100 dBA for employees working at the steam cannon or as hot dip operators, require that they use dual hearing protection (i.e., the combination of insert-type earplugs and earmuffs) while the steam cannon is in operation.

   c. Implement a hearing loss prevention program for all employees in job titles that have noise exposure levels greater than the NIOSH REL of 85 dBA. We recommend using the NIOSH REL for determining which employees to include in a hearing conservation program. Refer to the NIOSH document "Preventing Occupational Hearing Loss: A Practical Guide" for more detailed information. This document (NIOSH publication number 96-110) is available on the NIOSH website at [http://www.cdc.gov/niosh/96-110.html].

   d. Review and track hearing loss at all audiometric test frequencies. Specifically, NIOSH recommends using a confirmed 15-dB hearing threshold shift at any frequency to determine whether employees have experienced a STS.

2. Implement noise control measures to reduce impact noise. Consult with an experienced noise control engineer for help in investigating these and other noise control options.

   a. Reduce the distance that metal conduit rolls or drops before striking other conduit.

   b. Decrease the speed at which conduit rolls before striking other conduit.

c. Add rubber or nylon damping on the pick-ups on the E-Galv loader arms.

d. Construct a partial enclosure or barrier at the steam cannon to reduce operator noise exposure.

e. Increase the thickness of the metal stop plates at the end finisher to dampen noise created when conduit strikes the plate.

f. Replace metal pickups on the end finisher chain conveyor with nylon pick-ups.

3. Enclose the mills and install local exhaust ventilation to reduce exposures to MWFs. If the concentration of MWFs is not reduced below the NIOSH REL then workers must continue using respiratory protection.

4. Assess each confined space. Include in the written procedures an inventory of all confined spaces, their location, associated hazards (air contaminant and physical hazards), entry procedures, PPE required, LOTO/isolation requirements, atmospheric testing requirements, and mode of entry and egress, including emergency egress in accordance with OSHA Standard 29 CFR 1910.146 *Permit-required Confined Spaces* [Permit-required confined spaces - 1910.146]. Appendix D includes a list of recommendations to reduce risks associated with confined space entry. We also recommend that implementing incident response training for every employee in the plant, and coordinate training and communication with the local emergency service.

5. Update the written respiratory protection program so that it specifies what type of respiratory protection is required for each hazardous operation performed at the facility. The written program should include a change-out schedule for cartridges. OSHA's *Small Entity Compliance Guide* provides guidelines for what is required in the written program. This guide is available online at [http://www.osha.gov/Publications/secgrev-current.pdf].

6. Use supplied air respirators or a SCBA for protection against concentrations of nitric acid that exceed the NIOSH REL unless the respirator manufacturer specifies that the cartridges provide protection against nitric acid.

7. Provide workers a source of Grade D air or SCBAs for line breaking. The JSA we were provided required the use

of supplied air respirators for line breaking but a source of Grade D breathing air was not available at the facility during our evaluation.

8. Use a supplied-air respirator or SCBA with a full-face mask, gloves and protective clothing for line breaking until it is determined through air sampling that a lower level of respiratory protection is adequate. Butyl rubber or neoprene gloves and Saranex, Barricade, or Responder suits are suitable for HCl (<37%) and nitric acid (<70%) [Forsberg and Mansdorf 2007].
9. Investigate why dust accumulates in the threading area. A particle counter can be used to trace leaks in the ventilation system and to identify the point of dust generation. The cloth seals on waste drums in the baghouse were torn, allowing zinc oxide dust to escape. These seals must be maintained and replaced when necessary.
10. Rinse off chemical protective gloves and store them in a clean area when not in use.
11. Implement these recommendations to improve employee safety:
    a. Operate forklifts at a safe speed.
    b. Use safety belts when driving a forklift.
    c. Use forklift horns when approaching intersections and to signal that the forklift is backing up.
    d. Cleanup fluids that have spilled onto the production floor.
    e. Keep doors on the zinc kettle lowered to prevent splashing or splattering of molten zinc.
    f. Review the OSHA LOTO Standard 29 CFR 1910.147, The control of hazardous energy (lockout/tagout). - 1910.147, to ensure that procedures specified by OSHA are followed.
    g. Instruct crews of workers who service or maintain equipment that each authorized employee must affix a personal LOTO device to the group lockout device, group lockbox, or comparable mechanism when work is started. The LOTO device can only be removed when the authorized employee stops working on the machine or equipment being serviced or maintained [29 CFR 1910.147(f)(3)(ii)(D)].

Recommendations (continued)

h. Stand at least as far away from a load suspended by an overhead crane as the distance of its height in case the load drops from the crane and tips over. The load should also be kept at that same distance away from any other employees.

i. Ensure that all tool rests and tongue guards on abrasive wheel grinders are maintained at the appropriate distance from the grinding wheel.

j. Instruct workers to use a tool to move conduit and not place their hands between pipes.

12. Encourage workers who are experiencing respiratory problems, skin irritation, or other health problems to report exposures they feel may be work-related to the site health and safety manager. Because the work-relatedness of certain health concerns may be difficult to establish, each person with possible work-related health problems needs to be fully evaluated by a physician, preferably one familiar with occupational medicine. A complete evaluation including a full medical and occupational history, a medical exam, a review of exposures, diagnostic tests if warranted, and complete follow-up to note the progress of the affected worker should be conducted as determined by the attending physician.
13. Meetings with employees and management should be convened on a regular basis to address health and safety issues. We recommend that you establish a health and safety committee to address employee health and safety concerns.

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Appendix A: Tables

Table A1: PBZ Air Sampling Results for MWFs (March 6-7, 2007)				
Department	Job Title	Sample Time Minutes	Concentration mg/m³ Total Thoracic Particulate Mass[a]	Concentration mg/m³ Extracted MWF
Maintenance	Maintenance	418	0.37	0.18
	Maintenance	469	0.28	0.16
	Maintenance	441	0.30	0.16
	Maintenance	475	0.29	0.17
	Maintenance	431	0.31	0.16
	Maintenance	445	0.17	ND[b]
	Maintenance	464	0.22	0.22
	Maintenance	425	0.23	ND
Welding	Bander	430	0.33	0.22
	Bander	463	0.31	0.19
	Bander	490	0.38	0.26
	Bander	431	0.30	0.21
	End Finisher	159	0.23	ND
	End Finisher	469	0.40	0.35
	End Finisher	434	0.23	0.15
	End Welder	367	0.24	0.15
	Materials Handler	496	0.25	0.11
	Materials Handler	447	0.22	0.16
	Mill Operator	599	0.50	0.32
	Mill Operator	561	0.40	0.24
	Utility	489	0.34	0.22
NIOSH REL-TWA			0.40	

[a] The NIOSH REL-TWA for MWF aerosols of 0.4 mg/m³ of air is based on the total thoracic particulates and not the extractable fraction of MWF. The total particulates includes all dust and other aerosols in the air (such as welding fumes) in addition to the MWFs. The extractable fraction represents the portion of the sample that was MWFs.

[b] ND = not detected (below the minimum detectable concentration).

Table A2: Air sampling Results for Acids (March 6-7, 2007)					
Department	Job Title	Sample Time (Minutes)	Concentration mg/m^3 HCl	Nitric Acid	Sulfuric Acid
		PBZ Air Samples			
Hot Dip	Extractor	440	ND[a]	0.025	ND
	Laborer	356		0.054	Trace
	Laborer		Pump failed		
	Operator	308	0.29	Trace[b]	Trace
	Operator	497	ND	0.025	Trace
Laboratory	Lab Tech	460	ND	Trace	Trace
	Lab Tech	431	ND	0.032	Trace
Galvanizing Line	Operator	498	ND	0.054	Trace
	Operator	625	ND	0.052	Trace
	Operator	620	ND	0.032	Trace
	Operator	607	ND	Trace	Trace
	Operator	523	ND	Trace	Trace
	Operator	640	ND	ND	Trace
	Operator	649	ND	Trace	Trace
	Operator	456	ND	Trace	Trace
Maintenance	Maintenance		Pump failed		
	Maintenance	426	ND	ND	ND
	Maintenance	420	ND	0.038	Trace
	Maintenance	441	ND	0.028	ND
	Maintenance	405	ND	Trace	ND
	Maintenance	445	ND	Trace	Trace
		Area Air samples			
Hot Dip	HCl Enclosure	15	ND	ND	ND
Hot Dip	HCl Enclosure	21	3.1	ND	ND
NIOSH REL-TWA				5	1
NIOSH REL-C			7		
NIOSH STEL				10	
OSHA PEL-TWA					1
OSHA PEL-C			7	5	
MDC[c]			0.068	0.0075	0.015
MQC[d]			0.23	0.024	0.20

[a] ND = not detected (below the MDC).
[b] Trace = result was between the MDC and MQC.
[c] MDC = Minimum detectable concentration calculated by dividing the method limit of detection by the highest sample volume collected (0.133 m^3).
[d] MQC = Minimum quantifiable concentration calculated by dividing the method limit of quantification by the highest sample volume collected (0.133 m^3).

Table A3: PBZ Air sampling Results for Cr(VI) on PVC Filters (March 6-7, 2007)

Department	Job Title	Sample Time (Minutes)	Concentration µg/m^3
Welding	Mill Operator	500	Trace[a]
Welding	Mill Operator	500	Trace
Welding	Mill Operator	505	0.026
Welding	Mill Operator	562	Trace
Welding	End Finisher	429	0.040
Welding	End Finisher	556	0.026
Welding	End Welder	615	Trace
Welding	End Welder	558	Trace
NIOSH REL-TWA			1
OSHA PEL-TWA			5
OSHA AL			2.5
MDC[b]			0.0066
MQC[c]			0.023

[a] Trace = Sample result was between the MDC and MQC.
[b] MDC = Minimum detectable concentration calculated by dividing the method limit of detection by the highest sample volume collected (1.2 m^3).
[c] MQC = Minimum quantifiable concentration calculated by dividing the method limit of quantification by the highest sample volume collected (1.2 m^3).

Table A4: PBZ Air sampling Results for Cr(VI) on Quartz Filters (March 6-7, 2007)			
Department	Job Title	Sample Time (Minutes)	Concentration mg/m^3
Hot Dip	Extractor	438	Trace[a]
Hot Dip	Extractor	415	0.047
Hot Dip	Extractor	474	ND[b]
Hot Dip	Operator	509	0.071
Hot Dip	Operator	496	0.039
Hot Dip	Laborer	435	0.051
Hot Dip	Laborer	443	Trace
Maintenance	Maintenance	468	ND
Maintenance	Maintenance	476	ND
Galvanizing	Operator	607	ND
Galvanizing	Operator	646	Trace
Galvanizing	Operator	636	Trace
Galvanizing	Operator	616	Trace
Galvanizing	Spray Machine Operator	498	Trace
Galvanizing	Spray Machine Operator	639	Trace
NIOSH REL-TWA			1
OSHA PEL-TWA			5
OSHA AL			2.5
MDC[c]			0.0077
MQC[d]			0.038

[a] Trace = Sample result was between the MDC and MQC.
[b] ND = not detected (below the MDC).
[c] MDC = Minimum detectable concentration calculated by dividing the method limit of detection by the highest sample volume collected (1.3 m^3).
[d] MQC = Minimum quantifiable concentration calculated by dividing the method limit of quantification by the highest sample volume collected (1.3 m^3).

Table A5: Air Sampling Results for Elements from Welding Fumes (March 6-7, 2007)

Sample Type	Department	Job Title	Sample Time (minutes)	Concentration μg/m³					
				Cu	Fe	Mn	Sr	Ti	Zn
PBZ[b]	Welding	Mill Operator	500	4.8	11	0.65	0.016	0.059	23
		Mill Operator	505	ND[a]	63	0.45	0.012	0.038	15
		Utility	428	5.8	380	5.2	0.071	0.44	27
		Utility	489	ND	140	1.2	0.078	0.13	19
		End Welder	559	0.37	180	0.88	0.040	0.24	17
		End Welder	611	0.82	220	1.2	0.030	0.15	21
		End Welder	474	0.28	67	1.2	0.013	0.088	7.7
		Welding Extras	562	0.22	87	0.48	0.011	0.048	11
		Welding Extras	557	0.87	10	0.64	0.013	0.091	27
	Threading	Packaging Operator	391	ND	19	0.16	ND	0.027	250
		Inspector	398	ND	56	9.3	0.022	0.51	160
		Packaging Operator	441	0.47	19	1.1	ND	0.048	130
	Hot Dip	Laborer	415	ND	23	0.34	0.020	0.093	580
GA[c]	Welding	Mill Line 4	502	0.42	220	1.4	0.022	0.059	17
		Mill Line 5	229			Pump failed			
	Threading	Remetalizer	455	ND	23	0.53	0.78	0.099	1450
NIOSH REL-TWA				1000	5000	1000		LFC[d]	5000
OSHA PEL-TWA				1000	10000			15000[e]	5000
OSHA PEL-Ceiling						5000			
ACGIH TLV						200	0.50[f]		

[a] ND = not detected (below the minimum detectable concentrations for copper and strontium of 0.16 and 0.0082 μg/m³ respectively).
[b] PBZ = personal breathing zone air sample.
[c] GA = general area air sample.
[d] LFC = Lowest feasible concentration.
[e] The OEL indicated is for titanium dioxide. The laboratory results were reported as titanium.
[f] The OEL indicated is for strontium chromate. The laboratory results were reported as strontium.
Comments:
(1) Cu = copper; Fe = iron; Mn = manganese; Sr = strontium; Ti = titanium; Zn = zinc.
(2) The following elements were not detected in any of the air samples: beryllium, lead, lithium, selenium, tellurium, thalium; tin, yttrium, and zirconium.
(3) The following elements were detected, but at concentrations which were 100 times (or more) below their respective OELs: cadmium, chromium, cobalt, magnesium, molybdenum, silver, and vanadium.
(4) One area sample collected by mill 4 contained 0.6 μg of nickel, which is 25 times less than the NIOSH REL of 15 μg/m³.

Table A6: Personal Noise Dosimetry Results (March 6-7, 2007)

Department	Job Title	Sample Time (minutes)	OSHA AL		OSHA PEL		NIOSH REL	
			Dose	dBA	Dose	dBA	Dose	dBA
Galvanizing	Bundler	627	113.3%	90.9	97.3%	89.8	961.5%	94.8
Galvanizing	Bundler	632	90.8%	89.3	73.7%	87.8	620.0%	92.9
Hot Dip	Hot Dip Extractor	416	217.3%	95.6	191.9%	94.7	5961.1%	102.7
Hot Dip	Hot Dip Extractor	474	160.2%	93.4	131.9%	92.0	2536.4%	99.0
Hot Dip	Hot Dip Operator	432	205.6%	95.2	176.5%	94.1	4215.7%	101.2
Hot Dip	Hot Dip Laborer	265	90.8%	89.3	45.4%	84.3	649.3%	93.1
Hot Dip	Hot Dip Loader	611	66.9%	87.1	51.4%	85.2	356.2%	90.5
Hot Dip	Hot Dip Loader	662	123.1%	91.5	116.5%	91.1	837.1%	94.2
Maintenance	Maintenance	477	54.3%	85.6	39.0%	83.2	399.8%	91.0
Maintenance	Maintenance	475	19.8%	78.3	8.5%	72.2	93.3%	84.7
Maintenance	Maintenance	476	95.9%	89.7	79.0%	88.3	1491.1%	96.7
Maintenance	Maintenance	464	28.7%	81.0	13.4%	75.5	109.7%	85.4
Shipping	Material Handler	496	61.6%	86.5	33.4%	82.1	282.7%	89.5
Shipping	Material Handler	628	72.7%	87.7	46.7%	84.5	565.3%	92.5
Shipping	Material Handler	408	77.9%	88.2	49.3%	84.9	448.7%	91.5
Shipping	Material Handler	448	55.1%	85.7	30.8%	81.5	214.3%	88.3
Shipping	Material Handler	453	60.7%	86.4	39.0%	83.2	356.2%	90.5
Shipping	Material Handler	448	63.3%	86.7	43.5%	84.0	303.0%	89.8
Threading	Packaging Operator	400	73.7%	87.8	39.5%	83.3	876.7%	94.4
Threading	Packaging Operator	448	48.0%	84.7	23.7%	79.6	170.1%	87.3
Threading	Saw Operator	357	104.2%	90.3	77.9%	88.2	552.4%	92.4
Threading	Saw Operator	383	77.9%	88.2	57.4%	86.0	418.7%	91.2
Threading	Threader Operator	401	87.1%	89.0	60.7%	86.4	356.2%	90.5
Threading	Threader Operator	446	72.7%	87.7	59.9%	86.3	373.0%	90.7
Threading	Threading Inspector	398	58.2%	86.1	38.4%	83.1	303.0%	89.8
Welding	Bander	430	84.7%	88.8	69.7%	87.4	620.0%	92.9
Welding	Bander	465	83.5%	88.7	67.8%	87.2	578.5%	92.6
Welding	Bander	431	211.4%	95.4	197.2%	94.9	1635.5%	97.1
Welding	Bander	490	113.3%	90.9	92.0%	89.4	745.8%	93.7
Welding	End Finisher	163	41.2%	83.6	16.7%	77.1	148.1%	86.7
Welding	End Finisher	469	155.8%	93.2	141.4%	92.5	1712.8%	97.3
Welding	End Finisher	382	52.1%	85.3	33.0%	82.0	276.3%	89.4
Welding	Mill Operator	654	69.7%	87.4	39.0%	83.2	317.3%	90.0
Welding	Mill Operator	561	44.8%	84.2	16.3%	76.9	155.1%	86.9
Welding	Utility	429	15.0%	76.3	59.9%	86.3	46.7%	81.7
Noise Exposure Limits			50%	85	100%	90	100%	85

Air samples for MWFs, metals, and Cr(VI) were collected using SKC Air Check® 2000 air sampling pumps with a sampling train consisting of Tygon® tubing connected to the inlet port of the pump and the sample media. For acids, low flow SKC Pocket Pumps® were used. Each pump was calibrated before and after use. The sampling media was attached to the employee's lapel within the breathing zone (breathing zone is defined as an area in front of the shoulders with a radius of 6 to 9 inches). The specific analytical methods, flow rates, and sample media used are discussed below.

Metalworking Fluid Air Samples

NIOSH investigators collected 21 PBZ air samples for MWFs using 37-mm closed-faced three-piece cassettes containing a tared 2-µm pore-size PTFE filter and the supporting pad and a sampling rate of 1.6 Lpm. The sampling train consisted of a cassette, a BGI thoracic cyclone, and Tygon tubing connecting the sampling assembly to a personal pump. The samples were analyzed by gravimetric analysis for the thoracic fraction of MWF particulates per NIOSH Method 5524 [NIOSH 2006].

Hexavalent Chromium

NIOSH investigators collected 23 full-shift PBZ air samples for Cr(VI) on 37-mm diameter, 5.0-µm pore size PVC or quartz filters at a flow rate of 2 Lpm. Where there was a potential for the presence of acid mist, quartz filters were used to prevent reduction of the Cr(VI) to trivalent chromium [Ashley et al. 2003]. The samples were analyzed for Cr(VI) by ion chromatography with post-column derivatization and ultraviolet detection per NIOSH Method 7605 [NIOSH 2006].

Acids

NIOSH investigators collected 21 full-shift PBZ and 2 short-term (15-minutes) GA air samples for acid mists on silica gel tubes at a flow rate of 0.2 Lpm. The samples were analyzed for hydrochloric acid, nitric acid, and sulfuric acid using ion chromatography per NIOSH Method 7903 [NIOSH 2006].

Metals/Elements

NIOSH investigators collected 12 PBZ and 4 GA full-shift air samples on 37-mm diameter cassettes with 0.8-µm pore size mixed cellulose ester filters at a flow rate of 2.0 Lpm. The samples were analyzed using inductively coupled argon plasma-atomic emission spectroscopy per NMAM Method 7300 [NIOSH 2006].

Noise

NIOSH investigators collected 35 full-shift, personal noise exposure measurements while workers performed typical daily activities. Quest Technologies (Oconomowoc, Wisconsin) NoisePro® series dosimeters were used to measure personal noise exposure. The noise dosimeters were attached to the wearer's belt or pocket, and a small remote microphone was fastened to the wearer's shirt at a point midway between the ear and the outside of the shoulder. A small windscreen provided by the dosimeter manufacturer was placed over the microphone during measurements to reduce or eliminate artifact noise generated by an object bumping against the microphone or wind blowing across the microphone. The dosimeters were removed upon completion of the work shift.

Real-time noise measurements were collected at several work stations or pieces of equipment using a Quest Technologies SoundPro® Model SE/DL sound level meter. The instrument was equipped with a 0.5-inch free-field Type 2 electret microphone. The microphone has a frequency response range (± 2 dB) from 20 Hertz to 17 kilohertz.

Noise measurement data collected using dosimeters and sound level meters were downloaded to a personal computer for interpretation with QuestSuite® Professional II for Windows® computer software. All noise monitoring equipment were calibrated before and after use according to the manufacturer's instructions.

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Appendix C: 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 workers 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 workers 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 worker 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 there are health effects from exposures over the short-term. 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, worker 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. 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].

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 use 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).

Metalworking Fluids

Metal removal processes generate a great deal of heat. MWFs are used during grinding, cutting, or boring of metal parts to cool and lubricate the cutting tools and the metal parts. The MWF also provides corrosion protection for the machined parts, prevents smoking, and increases the life of the cutting tools. MWFs help remove chips and fine metal and abrasive particles from the cutting zone. The MWF may contain a mixture of substances including biocides, corrosion inhibitors, metal fines, tramp oils, bacteria, and other biological contaminants [NIOSH 1998b].

Exposure to MWF can result from inhalation of the MWF aerosols, or from skin contact with the fluids due to settling of aerosols, contact with parts and equipment, and splashing. MWF may cause employees to experience respiratory problems if the airborne concentration is above the NIOSH RELs; some employees may experience health effects at concentrations below these limits [NIOSH 1998b]. Inhalation of MWF mist or aerosols may cause irritation of the throat, nose, and lungs resulting in symptoms such as sore throat, eye irritation, runny nose, nosebleeds, cough, wheezing, increased phlegm production, and shortness of breath. Exposure to MWF has also been associated with asthma, and smoking may worsen the respiratory effects of MWF aerosols. Adding excessive amounts of biocides to cutting fluids may cause skin and/or respiratory irritation.

Synthetic and semi-synthetic MWFs are diluted with water. Hence they can be a breeding ground for bacteria if an inadequate amount of biocide is added. High temperature and pH, and the presence of metals can favor bacterial growth. Levels of microbial contamination are an indication of the cleanliness or degree of maintenance of the MWF. However, adding too much biocide may result in biocide-resistant strains of bacteria. Inhalation of MWF aerosols containing bacteria may result in respiratory problems. Workers with broken skin may develop skin infections if they have contact with MWF contaminated with bacteria. When contaminated MWF is replaced, some of the bacteria may remain and proliferate within a short period if the system is not adequately cleaned. At this time there is insufficient health data to recommend a specific limit for bacterial or fungal contamination in MWFs.

NIOSH recommends limiting exposures to MWF aerosols to 0.4 mg/m^3 of air for the thoracic particulate mass or 0.5 mg/m^3 for the total particulate mass, as a TWA concentration for up to 10 hours per day during a 40-hour workweek. The REL is intended to prevent or greatly reduce respiratory disorders associated with MWF exposure. The sampling method used for this evaluation allows the extraction of MWF from total thoracic particulates. NIOSH considered proposing an REL based on the extractable fraction of MWF; however, there is currently insufficient scientific evidence that extractable MWF is superior to thoracic particulate aerosols as a predictor of adverse health effects from MWF [NIOSH 1998b]. Some workers have developed work-related asthma, Hypersensitivity pneumonitis, or other adverse respiratory effects when exposed to MWFs at concentrations below the NIOSH REL. Limiting exposure to MWF aerosols is also prudent because certain MWF exposures have been associated with various cancers. In addition, limiting dermal (skin) exposure is critical to preventing allergic and irritant disorders related to MWF exposure. In most metalworking operations, it is technologically feasible to limit MWF aerosol exposures to 0.4 mg/m^3 or less [NIOSH 1998b]. NIOSH also recommends medical monitoring for employees exposed to MWF [NIOSH 1998b]. Medical monitoring is needed for the early identification of workers who develop symptoms of MWF-related conditions such as hypersensitivity pneumonitis, asthma, and dermatitis. All workers exposed to MWF aerosol concentrations above a designated level (e.g., half the REL) should be included. NIOSH publication 98-102 Criteria for a Recommended Standard, Occupational Exposure to Metalworking Fluids, provides guidelines for administering a medical monitoring program [NIOSH 1998b].

Inorganic Acids

Acids are primary irritants of the skin and mucous membranes. Inhalation of acid mist generally causes immediate symptoms due to high solubility in mucous membranes [LaDou 1990]. HCl, nitric acid, and sulfuric acid have good warning properties due to their irritating effects and low odor thresholds. In a worker notification notice to steel workers NIOSH reported that exposure to acid mist may increase the risk of larynx and lung cancer [NIOSH 1991]. As with other chemicals health effects depend on the concentration of the acid, airborne concentration, work process, existing controls, and use of PPE.

HCl is irritating to the eyes, mucous membranes, and skin [ATSDR 2002]. The major effects of acute exposure are usually limited to the upper respiratory tract and are sufficiently severe to encourage prompt withdrawal from a contaminated atmosphere. Several studies suggest this protective response is so strong that humans have rarely been submitted to damaging concentrations [Grant 1986; Stevens et al.]. Inhalation exposure of male volunteers to HCl at concentrations between 50 and 100 ppm for one hour were reported as barely tolerable, and 10 ppm was the maximal concentration acceptable for prolonged exposure [Henderson and Haggard 1943]. Acute exposures causing significant trauma are usually limited to people who are prevented from escaping; in such cases, laryngeal spasm or pulmonary edema may occur. High concentrations of the gas cause eye irritation and may cause prolonged or permanent visual impairment. Exposure of the skin to a high concentration of the gas or to a concentrated solution of the acid will cause burns; repeated or prolonged exposure to dilute solutions may cause dermatitis. Erosion of the exposed teeth may occur from repeated or prolonged exposure [NIOSH 1981; Proctor et al. 1996]. Both the OSHA PEL and the NIOSH REL for HCl are 7 mg/m^3 for a 15-minute ceiling exposure [CFR 2006a; NIOSH 1988, 2005].

Nitric acid is a colorless, yellow, or red fuming liquid with a suffocating odor [NIOSH 2005]. Nitric acid is a corrosive liquid that severely irritates the skin and eyes upon contact. Nitric acid mist can irritate the nose, throat, and lungs and cause dental erosion. Lung irritation causes coughing and/or shortness of breath, and exposure to high concentrations can cause pulmonary edema (a build-up of fluid in the lungs). Ingestion of nitric acid will result in severe throat and stomach destruction. NIOSH and OSHA have set TWA exposure limits for nitric acid at 5 mg/m^3 [NIOSH 2005]. NIOSH and ACGIH also have set STELs at 10 mg/m^3 for this substance [NIOSH 2005, ACGIH 2007].

Sulfuric acid is a severe irritant to the eyes, mucous membranes, and skin. Concentrated sulfuric acid is a corrosive, which can cause severe burns on contact and eventually result in tissue scarring. Sulfuric acid mists can cause eye, nose, and throat irritation; respiratory irritation (such as cough and bronchoconstriction); and dental erosion. The extent of respiratory irritation depends on factors such as air concentration, particle size, temperature, and humidity [NIOSH 1974]. A number of epidemiologic studies have indicated that exposure to sulfuric acid mist and other acid mists are associated with cancer. After review of these studies, the International Agency for Research on Cancer determined that there is sufficient evidence that occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic [Ahlborg et al. 1981; Soskolne et al. 1984; 1992]. NIOSH and OSHA have established evaluation criteria for sulfuric acid at 1 mg/m^3 as a TWA to prevent dental erosion and the irritant effects of exposure [NIOSH 1992, 2005].

Hexavalent Chromium

Cr(VI) compounds include lead chromate and zinc chromate pigments, chromic acid, and soluble compounds such as those used in chromium plating. Some Cr(VI) compounds are severe irritants of the respiratory tract and skin, and some (including chromates) have been found to cause lung cancer in exposed workers [Hathway and Proctor 2004]. Allergic dermatitis is one of the most common effects of chromium toxicity among exposed workers. Cr(VI) is corrosive and causes chronic ulceration and perforation of the nasal septum [IARC 1997]. Cr(VI) readily penetrates cell membranes and once inside the cell it is reduced to Cr(III). Once inside a cell Cr(III) has the capacity to cause DNA damage. NIOSH has identified Cr(VI) as a potential occupational carcinogen. The NIOSH REL for an up to 10-hour TWA exposure to airborne Cr(VI) is 1.0 µg/m^3 [NIOSH 2005]. In general industry, Cr(VI) is regulated by OSHA standard CFR 1910.1026. The OSHA PEL for Cr(VI) is 5 µg/m^3, and the AL is 2.5 µg/m^{3}calculated as an 8-hour TWA. Exceeding the AL triggers certain requirements such as periodic sampling and medical surveillance [CFR 2006b]. NIOSH considers all Cr(VI) compounds (including chromic acid) to be potential occupational carcinogens.

Noise

Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically [Berger et al. 2003]. While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components [Suter 1978].

The dBA is the preferred unit for measuring sound levels to assess worker noise exposures. The dBA scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels audible to the human ear. Because the dBA scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and hundredfold increase of sound energy, respectively. Noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The OSHA standard for occupational exposure to noise (29 CFR 1910.95) [CFR 2003] specifies a maximum PEL of 90 dBA for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dBA for no more than 4 hours, to 100 dBA for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dBA is allowed by this exchange rate. The duration and sound level intensities can be combined in order to calculate a worker's daily noise dose according to the formula:

$$\text{Dose} = 100 \times (C1/T1 + C2/T2 + \ldots + Cn/Tn),$$

where Cn indicates the total time of exposure at a specific noise level and Tn indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, a worker is allowed up to 100% of the daily noise dose. Doses greater than 100% are in excess of the OSHA PEL.

The OSHA regulation has an additional AL of 85 dBA; an employer shall administer a continuing, effective hearing conservation program when the 8-hour TWA value exceeds the AL. The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and record keeping. All of these requirements are included in 29 CFR 1910.95, paragraphs (c) through (o). Finally, the OSHA noise standard states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dBA, feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH [NIOSH 1998c] and ACGIH [ACGIH 2007] recommend an exposure criteria of 85 dBA as a TWA for 8 hours, which is 5 dB less than the OSHA standard. The criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. The 3-dB exchange rate used by NIOSH assumes that equal amounts of sound energy will produce equal amounts of hearing impairment regardless of how the sound energy is distributed in time [Driscoll 2000]. Using NIOSH criteria, a worker can be exposed to 85 dBA for 8 hours, but to no more than 88 dBA for 4 hours or 91 dBA for 2 hours. Twelve-hour exposures have to be 83 dBA or less according to the NIOSH REL.

Audiometric evaluations of workers are conducted in quiet locations, preferably in a sound-attenuating chamber, by presenting pure tones of varying frequencies at threshold levels (i.e., the level of a sound that the person can just barely hear). Audiograms are displayed and stored as tables or charts of the HL at specified test frequencies [ANSI 1996]. Zero dB HL represents the hearing level of an average, young individual with normal hearing. In OSHA-mandated hearing conservation programs, thresholds must be measured for pure-tone signals at the test frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz. Individual employee's annual audiograms are compared to their own baseline audiogram to determine the amount of STS that might have occurred between the two tests. Specifically, OSHA states that an STS has occurred if the average threshold values at 2000, 3000, and 4000 Hz have increased by 10 dB or more in either ear when comparing the annual audiogram to the baseline audiogram [CFR 2003]. The NIOSH-recommended threshold shift criterion is a 15-dB shift at any frequency in either ear from 500–6000 Hz measured twice in succession [NIOSH 1998a]. Practically, the criterion is met by immediately retesting an employee who exhibits a 15-dB shift from baseline on an annual test. If the 15-dB shift persists on the second test, a confirmatory follow-up test should be given within 30 days of the initial annual examination. Both of these threshold shift criteria require at least two audiometric tests. In cases where only one audiogram is available, a criterion has been proposed for single-frequency impairment determinations [Eagles et al. 1968]. It employs a lower fence (the amount of hearing loss necessary before a hearing handicap is said to exist) of 25 dB HL. With this criterion, any person who has a hearing level of 26 dB HL or greater at any single frequency is classified as having some degree of hearing loss. The degree of loss can range from mild (26–40 dB HL) to profound (>90 dB HL).

The audiogram profile is a plot of the hearing test frequencies (x-axis) versus the hearing threshold levels (y-axis). For many workers, the audiogram profile tends to slope downward toward the high frequencies with an improvement at the audiogram's highest frequencies, forming a "notch" [Suter 2002]. A notch in an individual with normal hearing may indicate the early onset of hearing loss. Although no universal criterion defines what constitutes a "notch," several mathematical models that attempt to identify notches are presented in the scientific literature [Dobie 2002; Niskar et al. 2001; Cooper 1976]. The relative strengths and weaknesses of these models have also been reviewed [Rabinowitz 2003]. For this evaluation, a notch is defined as the frequency where the hearing level is preceded by an improvement of at least 10 dB and followed by an improvement of at least 5 dB. The notch from occupational noise can occur between 3000 and 6000 Hz, depending on the frequency spectrum of the noise, and the anatomy of the individual's ear [ACOM 1989; Osguthorpe 2001]. It is generally accepted that a notch at 4000 Hz indicates occupational hearing loss [Prince et al. 1997]. On the other hand, some researchers have argued that the notch at 6000 Hz may not be a good marker for occupational hearing loss because it is widely seen in young adults and others with little documented occupational noise exposure [McBride 2001]. An individual may have notches at different frequencies in one or both ears [Suter 2002].

Confined Spaces

Confined spaces present a number of potential occupational hazards for the workers who must enter or work within or around these locations. The potential hazards associated with confined spaces can be grouped into three general categories: hazardous atmospheres, safety hazards, and exposure to physical agents. Hazardous atmospheres include oxygen deficient, explosive/flammable, toxic, and irritating atmospheres. Safety hazards may include mechanical trauma, electrocution, slips and falls, engulfment in materials, interference with communication, contact with sharp edges, and other hazards related to entering or exiting the space. Physical agents to which workers may be exposed while in confined spaces include thermal conditions (hot or cold), noise, vibration, and radioactive materials.

A confined space is defined by NIOSH as "an area which by design has limited openings for entry and exit, unfavorable natural ventilation which could contain (or produce) dangerous air contaminants, and which is not intended for continuous employee occupancy" [NIOSH 1987, 2007]. The NIOSH criteria for working in confined spaces further classify confined spaces based upon the atmospheric characteristics such as oxygen level, flammability, and toxicity. If any of the hazards present an immediately dangerous to life or health situation, the confined space is designated Class A. A Class B confined space has the potential for causing injury and/or illness, while in a Class C space the hazard potential would not require any special modification of the work procedure [NIOSH 1979].

The Fatality Assessment and Control Evaluation project conducted by NIOSH discovered three recurring confined space program inadequacies: lack of recognition of confined space hazards, lack of testing and evaluation of the confined space prior to entry (and continued monitoring during occupancy), and unplanned and inappropriate rescue procedures [NIOSH 1986]. Addressing each of these deficiencies could contribute to the prevention of confined space fatalities.

The OSHA confined space rule is a versatile "performance orientated" standard that allows some latitude for employers to interpret and apply the confined space program requirements specific to their establishments, providing the fundamental precautionary measures are implemented to prevent confined space injuries and deaths. On January 14, 1993, OSHA promulgated a final rule titled Permit-Required Confined Spaces, which outlines the minimum requirements for employers to ensure the safety of workers during confine space entry [CFR 1993]. The definition of a confined space determined by OSHA is any space that is large enough and configured to allow an employee to enter and perform work; has limited or restricted means of access into and egress from within; and is not designed for continuous employee occupancy.

OSHA further distinguishes confined spaces based on the potential of the space to pose hazardous exposure conditions and classifies these spaces as non-permit versus permit-required confined spaces. An

OSHA permit-required confined space must meet the above definition and have the potential to produce at least one of the following hazardous conditions:

- a hazardous atmosphere.
- a material that could engulf an entrant.
- an internal configuration such that an entrant could be trapped or asphyxiated.
- any other recognized serious safety or health hazard.

Welding Fumes/Metals

The effect of welding fumes on an individual's health can vary depending on the length and intensity of the exposure and the specific metals involved. Of particular concern are welding processes involving stainless steel, cadmium or lead-coated steel, and metals such as nickel, chrome, zinc, and copper. Fumes from these metals are considerably more toxic than those encountered when welding iron or mild steel. Epidemiological studies and case reports of workers exposed to welding emissions have shown an excessive incidence of acute and chronic respiratory diseases [NIOSH 1988]. These illnesses include metal fume fever, pneumonitis, pulmonary edema, and excessive incidence of lung cancer among welders.

The content of welding fumes depends on the base metal being welded, the welding process and parameters (such as voltage and amperage), the composition of the consumable welding electrode or wire, the shielding gas, and any surface coatings or contaminants on the base metal. The flux coating (or core) of the electrode/wire may contain up to 30 organic and inorganic compounds. In general, welding fume constituents may include minerals, such as silica and fluorides, and metals, such as arsenic, beryllium, cadmium, chromium, cobalt, nickel, copper, iron, lead, magnesium, manganese, molybdenum, tin, vanadium, and zinc [Welding Institute 1976; NIOSH 1988; Rekus 1990]. No PEL for total welding fumes has been established by OSHA; however, PELs have been set for individual welding fume constituents (e.g., iron, manganese) [CFR 2006a]. NIOSH has concluded that it is not possible to establish an exposure limit for total welding emissions because the composition of welding fumes and gases varies greatly, and the welding constituents may interact to produce adverse health effects. Therefore, NIOSH recommends controlling total welding fume to the lowest feasible concentration and meeting the exposure limit for each welding fume constituent [NIOSH 2005]. In addition to welding fumes, many other potential health hazards exist for welders. Welding operations can produce gaseous emissions such as CO, ozone, nitrogen dioxide, and phosgene (formed from chlorinated solvent decomposition) [Welding Institute 1976; NIOSH 1988; Rekus 1990]. Welders can also be exposed to hazardous levels of ultraviolet radiation from the welding arc if welding screens or other precautions are not used.

Zinc

Exposure to zinc concerned many workers at Republic Conduit. Zinc oxide may exist as a fume or dust, and at Republic Conduit it is found as a fume at the hot dip tank and as a dust in the threading area, remetalizing, baghouse, and vicinity of these areas. Inhalation of zinc oxide fume may cause an influenzalike illness called metal fume fever [Hathaway and Proctor 2004; NIOSH 1981]. Symptoms may include irritation of the throat, tightness of the chest, and a dry cough. Several hours after exposure symptoms may include chills, fatigue, headache, low back pain, muscle cramps, nausea, and vomiting. These symptoms are not produced when zinc oxide powder is inhaled. They only occur from exposure to recently generated fumes because particles tend to flocculate (bunch together) after generation, forming larger particles that are trapped by the upper respiratory tract and will not reach the lungs. Zinc oxide dust is considered a nuisance dust that has little or no effect on the lungs [Hathaway and Proctor 2004]. NIOSH has an REL-TWA of 5 mg/m^3 for zinc oxide dust and fumes. NIOSH also has a ceiling REL limit of 15 mg/m^3 for zinc oxide dust and an REL-STEL of 10 mg/m^3 for zinc oxide fumes [NIOSH 2005]. OSHA has a PEL-TWA of 5 mg/m^3 for zinc oxide fumes, 15 mg/m^3 for zinc oxide as total dust, and 5 mg/m^3 for zinc oxide respirable dust.

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Appendix D: Confined Space Entry Program

We offer the following recommendations to reduce risks associated with confined space entry at your facility [CFR 1993]:

1. Develop a checklist for each confined space that the Entry Supervisor can use to comply with entry requirements. 29 CFR 1910.146 Appendix C provides examples of permit required confined spaces and entry procedures. These examples may be used in conducting an assessment of your confined spaces. The methodology used to write the JSAs you provided us may also be used when assessing your confined spaces. Include safety precautions for welding or use of hazardous chemicals in confined spaces.
2. Label and secure confined spaces to prevent unauthorized entry.
3. The entry permit should specify the sequence for testing air contaminant hazards (e.g. it is critically important that oxygen level be measured first). The entry permit should also provide space to document initial and periodic air monitoring results.
4. If blowers are used to ventilate a confined space the attendant should ensure that contaminants such as exhaust from a forklift are not introduced into the confined space.
5. The entry permit should specify the emergency contact information and should also document that the Pleasure Ridge Park Fire Department has been contacted before actual permit space entry occurs.
6. The entry permit should specify the physical hazards in the space, the methods for controlling physical hazards, and document that physical hazards have actually been controlled.
7. The entry permit should specify the ventilation rate (i.e., minimum number of air changes per hour), when ventilation of the space is required.
8. Your written instructions for confined space entry state under Specific Procedures, "A minimum of two trained employees must be within line of site and verbal communication of one another outside of the confined space". The attendants should have visual or verbal communication with workers entering the confined space.
9. Plan and coordinate a practice rescue with the Pleasure Ridge Park fire department to ensure that timely rescue can be achieved in the event of an actual emergency in a confined space.
10. After revisions are made, we recommend that your written procedures be reviewed by a qualified safety professional such as a CIH, CSP, or registered safety engineer. You can also contact your state's OSHA Consultation Office for assistance in evaluating your health and safety programs. The OSHA Consultation Office services are free and they will not disclose your name, company name, or violations to their compliance office, however they will expect you to correct any violations of OSHA standards found.
11. Employee complaints about the effectiveness of the confined space program are grounds for reviewing the program.

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Acknowledgements and Availability of Report

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

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Copies of this report have been sent to employee and management representatives at Republic Conduit and the Kentucky State OSHA Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

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