HETA 91-090-2175
JANUARY 1992
CAISSON PLATOON
FT. MYER, VIRGINIA

NIOSH Investigators:
Alan Echt, MPH, CIH

I. SUMMARY

On February 26-28, and September 11-12, 1991, the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) at the Caisson Platoon, Building 236, Fort Myer, Virginia. This survey was conducted in response to a request from an industrial hygiene technician with the Walter Reed Army Medical Center. Specifically, the request concerned soldiers' exposures to air contaminants while cleaning the stables, levelling the grain bin, and working in the tack room. In addition, NIOSH was asked to evaluate exposures experienced by the blacksmith in the performance of his duties, and to investigate the means by which smoke from the blacksmith shop enters the tack room while the blacksmith's forge is operating.

On February 27, 1991, exposure monitoring was performed to measure dust exposures while cleaning the stables, and solvent exposures while dyeing leather in the tack room. The results of dust sampling were not in excess of relevant exposure criteria. However, time-weighted average (TWA) exposures for methylene chloride and 2-ethoxyethanol for the soldier dyeing leather were 4.9 parts per million (ppm) and 5.7 ppm, respectively, for the 17-minute task. NIOSH recommends that exposure to these compounds be limited to the lowest feasible level.

On February 28, 1991, one personal breathing zone (PBZ) air sample for total dust was collected while a soldier levelled grain in the grain bin. The TWA exposure for this brief (six minutes) task was 27.5 milligrams per cubic meter (mg/m^3). While this concentration does not exceed applicable exposure criteria as an 8-hour TWA, under no circumstances should excursions in worker exposure levels exceed 5 times the TWA exposure limit. The NIOSH Recommended Exposure Limit (REL) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for grain dust (oats, wheat, and barley) is 4 mg/m^3 as an 8-hour TWA.

Following gravimetric analysis, particulate samples were submitted for endotoxin analysis. Endotoxin results did not exceed the exposure limits recommended in the literature. Sampling for metal dust and fume was performed in the blacksmith shop and tack room on February 28, 1991. No overexposures were noted, although the presence of metal particulate in the tack room indicated that forge emissions were entering this room. Length of stain diffusion tubes were used to sample for ammonia in the blacksmith shop on February 28, 1991, and in the stables on September 12, 1991. No ammonia was detected. On September 12, 1991, sampling was performed for total and respirable dust during stable cleaning. Results did not reveal exposures in excess of applicable criteria.

The problem of forge emissions entering the tack room is easily solved by minor modifications and repairs to the forge flue. Several safety hazards were noted in the blacksmith shop related to welding.

On the basis of the data obtained during the investigation, the NIOSH investigators determined that soldiers dyeing leather in the tack room are exposed to methylene chloride and 2-ethoxyethanol in excess of the NIOSH REL. These exposures can be reduced through substitution of less hazardous ingredients in leather dyes, lacquers, and spray paints, or through the use of local exhaust ventilation. In addition, the soldier levelling grain in the grain bin is exposed to grain dust for a brief excursion of nearly 7 times the REL. This exposure can be controlled through the use of engineering controls, such as a vibratory shaker applied to the outside of the bin, thus eliminating the need to enter the grain bin to level the grain.

Keywords: SIC 0752 (Animal Specialty Services, Except Veterinary) horses, stables, blacksmiths, farriers, endotoxin, grain dust, straw, welding, tungsten carbide, methylene chloride, 2-ethoxyethanol

II. BACKGROUND

On February 26-28, and September 11-12, 1991, the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) at the Caisson Platoon, Building 236, Fort Myer, Virginia. This survey was conducted in response to a request from an industrial hygiene technician with the Walter Reed Army Medical Center. Specifically, the request concerned soldiers' exposures to air contaminants while cleaning the stables, levelling the grain bin, and working in the tack room. In addition, NIOSH was asked to evaluate exposures experienced by the blacksmith in the performance of his duties, and to investigate the means through which smoke from the blacksmith shop enters the tack room while the blacksmith's forge is operating.

At the time of the first site visit, the Caisson Platoon was made up of one officer, forty-two soldiers, and thirty-four horses used in ceremonies such as weddings, parades, and funerals. Various breeds are represented among the horses in the platoon, including English Shires and Lippizans. Horses were stabled in building 236 at the time of the initial visit. At the time of the second visit, the platoon had acquired additional horses, and an adjacent exercise building had been converted into a barn for the English Shires.

The blacksmith crafts horseshoes from angle iron or heats and forms ready-made shoes, performs the farriering required for the horses, and does the metal work necessary to maintain the two caissons and one carriage used by the platoon. The blacksmith primarily uses a coal forge, although a gas-fired forge is also located in his very cramped quarters. Use of the coal forge requires one and a half to two tons of soft (bituminous) coal a year. The blacksmith also does some arc and oxy-acetylene welding, including brazing a tungsten carbide compound (horseshoe borium) onto the soles of horseshoes, to form cleats, which provide wear resistance and improved traction on slick surfaces such as icy pavement or manhole covers. Exhaust ventilation is provided by a propeller-type wall fan, and a tube axial fan in the ductwork above the forge. This latter fan is not used. A self-contained welding exhaust machine is available, but reportedly does not work well. No mechanical make up air is provided.

The saddle shop is located on the second floor of building 236. The saddle shop is divided into three rooms: a storeroom, the central area, and the tack room, which is tucked under the eaves over the blacksmith shop. The saddle shop supplies troops and horses with saddles, blankets, tack, exercise equipment, and clothes. The Caisson Platoon manufactures their own tack. The central area contains a large table for working on leather, a heavy duty sewing machine, a riveter, and other leather working equipment. Chemicals used in leather work are stored in wall lockers in the central area. The chemicals include dyes, spray paint, and lacquer. There were no material safety data sheets on hand for the hazardous materials used in the saddle shop. The tack room is ventilated only by its door, and by a window air conditioner mounted in one wall (not an outside wall). The soldier dyeing leather wears vinyl examination gloves supplied by the veterinary technician.

The second floor of the building also houses the grain room, which includes the grain bin and space for straw and hay storage. At the time of the February site visit, 15 tons each of straw and hay were used every thirty days. Five tons of grain are consumed every thirty days. Grain is blown into the bin from delivery trucks. The bin empties via a chute to the ground floor. A soldier enters the bin about once a week to level the grain with a rake or shovel. Entry is achieved via a sliding window in the side of the grain bin, which is 8 feet above floor level. The grain bin is 12 feet high, and capable of holding up to 10 tons of grain. It is possible for a soldier to be engulfed in the portion of the bin above the chute. There is no confined space entry program to address this hazard.

At the time of the initial site visit, stables were cleaned thoroughly by soldiers (GIed) every five days. All of the old straw bedding was removed from stalls, stall floors were cleaned with acid and germicide, and new straw bedding laid down. Because of cold weather and the hazard icy surfaces pose to horses and soldiers alike, GIing the stables during the site visit consisted of removing old bedding, applying lime to wet spots, and laying down fresh straw. At the time of the September site visit, the NIOSH investigators learned that the use of straw bedding had been superseded by the use of poplar chip bedding in March. The stable had not been GIed since this transition was completed. The stable cleaning process now consists of picking out wet material, liming wet spots, and putting down fresh wood chips. GIing poplar chip bedding was planned for a before and after winter cycle. Horses have stopped coughing since the transition, and the stable cleaning process is much faster, produces far less waste, and complaints of dustiness by the soldiers have ceased. Seven hundred and twenty 30-pound bags of fresh poplar chips were on hand, equal to about a two-month supply. In the summer months pesticides such as repellants and fumigants are used to control flies.

III. INDUSTRIAL HYGIENE EVALUATION

On February 27, 1991, monitoring was performed to measure dust exposures while cleaning the stables, and solvent exposures while dyeing leather in the tack room. Ten personal breathing zone (PBZ), partial period consecutive samples for total dust were collected over the entire work shift for five of the ten soldiers cleaning the stables. Samples collected during the first period represent total dust exposures while removing old bedding and cleaning stalls. Samples collected during the second period represent total dust exposures while spreading straw for new bedding. The ten samples were collected on 37 millimeter (mm) diameter, 5 micron (µm) pore size polyvinyl chloride (PVC) filters in two-piece cassettes, using personal sampling pumps calibrated at a flow rate of 2 liters per minute (ℓ/min). The sampling media were analyzed for total dust by gravimetric analysis according to NIOSH Method 0500, with the following modifications: 1) The filters were stored in an environmentally controlled room (21 ± 3 °C and 40 ± 3% relative humidity) and were subjected to the room conditions for a long duration for stabilization. Therefore, the method's eight- to sixteen-hour time for stabilization between tare weighings was reduced to five to ten minutes. 2) The filters and backup pads were not vacuum desiccated.[1] Following gravimetric analysis, the filters were submitted to NIOSH, Division of Respiratory Disease Studies, in Morgantown, West Virginia, for endotoxin analysis.

Also on February 27, 1991, one PBZ and two general area air (GA) samples were collected for organic vapor while a soldier was dyeing leather in the tack room. The GA samplers were placed on the shelf in the tack room, with the sampling media suspended directly in front of, and approximately two feet from, the soldier's head. The samplers ran for the length of the task, approximately seventeen minutes. Samples were collected on solid sorbent media (SKC® lot 120 charcoal tubes) using personal sampling pumps calibrated at a flow rate of 200 milliliters per minute (ml/min). One of the GA sample charcoal tubes was submitted for qualitative analysis of volatile organic compounds by gas chromatography-mass spectroscopy (GC-MS). Based upon the results of this analysis, the remaining charcoal tubes were analyzed using a combination of NIOSH Methods S49, 1300, 1400, 1450, and 1501.[1] In addition, to further enhance the recovery of oxygen-containing compounds from the charcoal media, 4% (by volume) butyl carbitol was added to the desorption solvent, carbon disulfide.

On February 28, 1991, one PBZ air sample for total dust was collected while a soldier levelled the grain in the grain bin. The sample was collected for the length of the task (six minutes) on a 37 mm diameter, 5 µm pore size PVC filter in a two-piece cassette, using a personal sampling pump calibrated at a flow rate of 2 ℓ/min. The sampling media were analyzed for total dust by gravimetric analysis according to NIOSH Method 0500, with the same modifications previously noted. Following gravimetric analysis, the filter was submitted to NIOSH, Division of Respiratory Disease Studies, in Morgantown, West Virginia, for endotoxin analysis.

Samples submitted for endotoxin analysis were extracted in non-pyrogenic water, and tested in the kinetic *Limulus* amoebocyte lysate (LAL) assay according to the manufacturer's recommendations (QCL-1000, Whittaker Bioproducts). Results were reported in terms of endotoxin units (EU) that were compared to the laboratory standard, EC-5. A conversion factor of 10 EU/ng was used.

Sampling for metal dust and fume was performed in the blacksmith shop and tack room on February 28, 1991. Two full-shift GA air samples for metals were collected; one in the blacksmith shop next to the forge, and one at the work bench in the tack room to determine whether or not forge emissions enter the tack room. In addition, one full-shift, PBZ sample for metals was collected on the soldier helping the blacksmith. The soldier spent the sampling period forging and working horseshoes. Samples were collected on 37 mm diameter, 0.8 µm pore size mixed cellulose ester (MCE) filters using personal sampling pumps calibrated to 2 ℓ/min. The sampling media were analyzed for metals according to NIOSH Method 7300.[1] Length of stain diffusion tubes (ammonia 20/a-D,National Drager) were used to sample for ammonia in the blacksmith shop on February 28, 1991, and in the stables on September 12, 1991.

Respirable dust samples were also collected on February 27 and 28, 1991. The results are not reported here, however, because the air sampling pumps were not calibrated to the flow rate recommended for use with the 10 mm nylon cyclone (1.7 ℓ/min). Instead, the pumps were operated at 2 ℓ/min, which would result in an underestimate of the true respirable dust exposure. Also, the results of sampling conducted in the blacksmith shop for oxides of nitrogen are not reported due to problems in sample analysis.

On September 12, 1991, sampling was performed for total and respirable dust present during stable cleaning. Eight PBZ samples for total dust were collected for the length of the task. Samples were collected on 37 mm diameter, 5 µm pore size PVC filters using personal sampling pumps calibrated to 2 ℓ/min. The sampling media were analyzed for total dust in accordance with NIOSH Method 0500, with the modifications noted above. Nine PBZ samples were collected for respirable dust for the length of the task. Samples were collected on 37 mm diameter, 5 µm pore size PVC filters using 10 mm nylon cyclones and personal sampling pumps calibrated to 1.7 ℓ/min. Samples were analyzed for respirable dust according to NIOSH Method 0600 with the same modifications noted above for NIOSH Method 0500.

IV. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to ten hours a day, forty hours a week for a working lifetime without experiencing adverse health effects. However, it is important to note that not all workers will be protected from adverse health effects 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 substance may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These combined effects are often not considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are the following: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the US Department of Labor (OSHA) Permissible Exposure Limits (PELs), and 3) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs).[2,3,4] The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; in contrast, the NIOSH-recommended exposure limits are primarily based upon the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that employers are legally required to meet those levels specified by an OSHA PEL.

A time-weighted average exposure level (TWA) refers to the average airborne concentration of a substance during a normal eight- to ten-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from brief high exposures.

Isopropyl acetate, hexone, ethyl acetate, n-butyl acetate, toluene, ethanol, methylene chloride, and 2-ethoxyethanol were identified as air contaminants resulting from the use of lacquers and dyes in the tack room.

Isopropyl Acetate

Occupational exposure to isopropyl acetate may result in eye and mucous membrane irritation. In humans, exposure to isopropyl acetate at 200 ppm caused eye irritation, with nose and throat irritation appearing at higher levels.[5]

The OSHA PEL and ACGIH TLV for isopropyl acetate is 250 ppm, with a short-term exposure limit of 310 ppm.[3,4] NIOSH testified that a lower PEL would be appropriate for this chemical to protect exposed workers from eye and respiratory irritation.[5]

Hexone (Methyl Isobutyl Ketone)

Hexone irritates the eyes, mucous membranes, and skin. Exposures of 80 to 500 ppm produced weakness, loss of appetite, headache, sore throat,and nausea.[6] Exposure of rats to 200 ppm of hexone for two weeks produced kidney damage and increased liver weights. Repeated or prolonged skin contact may cause defatting of the skin with primary irritation and desquamation.[6] The NIOSH REL, OSHA PEL, and ACGIH TLV for hexone is 50 ppm as an 8-hour TWA, with a short-term exposure limit of 75 ppm.[2,3,4]

Ethyl Acetate

Ethyl acetate is an irritant to the respiratory tract. At very high concentrations it produces narcosis in animals; severe exposures to humans can be expected to have the same effect. Rarely, exposure may cause sensitization resulting in inflammation of the mucous membranes and eczematous eruptions (a red, blistery, scaly rash).[6] The NIOSH REL, OSHA PEL, and ACGIH TLV for ethyl acetate is 400 ppm as an 8-hour TWA.[2,3,4]

n-Butyl Acetate

An eye and mucous membrane irritant, n-butyl acetate at high concentrations causes narcosis in animals. In humans, n-butyl acetate affected the throat at a concentration of 200 ppm, at 300 ppm severe throat irritation occurred. The majority of subjects complained of eye and nose irritation as well.[6] The NIOSH REL, OSHA PEL, and ACGIH TLV for n-butyl acetate is 150 ppm as an eight-hour TWA, with a short-term exposure limit of 200 ppm.[2,3,4]

Toluene

Toluene is a central nervous system depressant. Subjects exposed to 100 ppm of toluene for 6 hours in an environmental chamber complained of eye and nose irritation and, in some instances, headache, dizziness, and a feeling of intoxication.[6] However, no significant differences were noted in performance on a battery of neurobehavioral tests. Symptoms were not noted at 10 or 40 ppm. Repeated or prolonged contact with liquid toluene defats the skin, causing fissuring, drying, and dermatitis.[6] The NIOSH REL, OSHA PEL, and ACGIH TLV for toluene is 100 ppm as an 8-hour TWA, with a short term exposure limit of 150 ppm.[2,3,4]

Ethanol

Chronic exposure to ethanol vapor may result in irritation of the mucous membranes, headache, and symptoms of central nervous system depression. Ethanol is not appreciably irritating to the skin. Ethanol splashed in the eye causes immediate burning and stinging, with reflex closure of the lids.[6] The NIOSH REL, OSHA PEL, and ACGIH TLV for ethanol is 1000 ppm as an 8-hour TWA.[2,3,4]

Methylene chloride

Contact with methylene chloride is irritating to the skin. Prolonged contact may cause severe burns. Carbon monoxide is a metabolite of methylene chloride, leading to elevated levels of carboxyhemoglobin in exposed individuals. One case report suggested that people with cardiovascular disease may be at greater risk because of the induced hypoxia.[6] Methylene chloride is a mild central nervous system depressant and an eye and respiratory tract irritant.[6]

Because methylene chloride has been shown to induce increased numbers of benign and malignant neoplasms in rats and mice, it meets the criteria provided in the OSHA cancer policy for classifying a substance as a potential occupational carcinogen; therefore, NIOSH recommends that methylene chloride be considered a potential human carcinogen in the workplace.[7]

NIOSH recommends that exposures to methylene chloride in the workplace be reduced to the lowest feasible limit.[2] OSHA is in the process of rulemaking on methylene chloride.[3] The ACGIH TLV for methylene chloride is 50 ppm as an 8-hour TWA. ACGIH considers methylene chloride to be a suspected human carcinogen.[4]

2-Ethoxyethanol (Cellosolve)

2-Ethoxyethanol is a mild irritant of the eyes and has caused lung and kidney injury in animals at very high concentrations.[6] Toxic amounts are readily absorbed through the skin of rabbits.[6] NIOSH recommends that 2-ethoxyethanol be regarded in the workplace as having the potential to cause adverse reproductive effects in male and female workers. These recommendations are based on the results of several studies that have demonstrated dose-related embryotoxicity and other reproductive effects in several species of mammals exposed by different routes of administration. Exposure of male animals resulted in testicular atrophy and sterility. In each case, the animals had been exposed at concentrations at or below the OSHA PEL.[8]

NIOSH recommends that exposures in the workplace be reduced to their lowest feasible concentration.[2] OSHA is in the process of rulemaking.[3] The ACGIH TLV for 2-ethoxyethanol is 5 ppm as an 8-hour TWA.[4]

Straw dust

For the purposes of this study, straw is considered a nuisance dust. The current OSHA PEL for nuisance dust (particulates not otherwise regulated) is 15 mg/M^3 for total dust and 5 mg/m^3 for the respirable fraction.[4] The ACGIH TLV for nuisance dust (particulates not otherwise classified) is 10 mg/m^3. These criteria were established to minimize mechanical irritation of the eyes and nasal passages, and to prevent visual interference. NIOSH has not developed specific criteria for total and respirable particulates.

Grain Dust

Grain dust, regardless of its origin, is an extremely complex dust. Its composition reflects such factors as contamination, humidity, age, and cleanliness of the grain. Handling grain or exposure to grain dust has been associated with symptoms such as cough, dyspnea, and wheezing, as well as disorders such as asthma, chronic bronchitis, dermatitis, rhinitis, and conjunctivitis.[9] The NIOSH REL and ACGIH TLV for grain dust (oats, wheat, and barley) is 4 mg/m^3 as an 8-hour TWA.[2,4] There is no OSHA PEL for grain dust.

Endotoxin

Endotoxin is a component of the outer membrane of Gram-negative bacteria, encountered in the environment as part of whole cells, large membrane fragments, or in macromolecular aggregates (free endotoxin). High airborne endotoxin concentrations have been associated with processing vegetable fibers and fecal materials in agriculture and waste treatment.[10] Endotoxin causes fever and malaise, changes in white blood cell counts, respiratory distress, and shock.[11] A powerful nonspecific stimulant to the immune system, endotoxin may be anticarcinogenic.[11] In experimental studies, inhalation of both free and membrane-bound endotoxin produced effects including fever, cough, diffuse aches, nausea, and acute airflow obstruction.[12] In epidemiologic studies, however, correlations between endotoxin and symptoms have not been demonstrated.[13]

Occupational exposure criteria have not been established for endotoxin by NIOSH, OSHA, or ACGIH.[2,3,4] Exposure limits have been suggested in the literature based on acute changes in pulmonary function.[14] Rylander has suggested 8-hour time-weighted average concentrations: 1) for the decline in Forced Expiratory Volume in one second (FEV_1) over a workshift of 100-200 nanograms (ng) of endotoxin/m^3, 2) for chest tightness, 300-500 ng/m^3, and 3) for fever, 500-1,000 ng/m^3.[15] An 8-hour TWA threshold for endotoxin of 10 ng/m^3 has also been recommended by one author based upon a decline in FEV_1 for individuals sensitized to cotton dust.[16]

V. RESULTS

The results of the organic vapor samples collected during leather dyeing are presented in Table 1. Eight-hour TWAs were calculated assuming no further exposure for the remainder of the day. Actual TWAs represent the exposures that occurred while the task was performed. These results indicate that exposures to methylene chloride and 2-ethoxyethanol exceed the NIOSH REL of lowest feasible concentration.[2] However, they do not exceed the OSHA PEL or the ACGIH TLV.[3,4] The use of flammable liquids in a small space in a historic wood-framed structure poses an additional hazard, compounded by the fact that the tack room is located directly above the blacksmith's forge. When the flue for the forge was installed, gaps were left between the sheet metal and the ceiling joists, providing a pathway for flammable vapors to reach the forge in the event of a flammable liquid spill. Air purifying respirators are not an appropriate control measure for methylene chloride-containing products.[17] If acceptable alternative products are available, leather dyes and lacquers which do not contain methylene chloride or 2-ethoxyethanol should be substituted for those now in use. Leather dyeing should be performed in a location equipped with local exhaust ventilation. The soldier working in the tack room wore vinyl medical examination gloves which may not be resistant to solvents. Suitable solvent-resistant gloves should be provided. Flammable liquid storage practices should be investigated to ensure that they do not present a fire hazard.[18]

Results of total and respirable particulate samples collected while the stables were cleaned on February 27 and September 12, 1991, did not exceed applicable evaluation criteria for nuisance dusts.[3,4] Eight-hour TWA exposures for total dust on February 27 ranged from 0.17 to 1.3 mg/m^3, with a mean of 0.67 mg/m^3. Eight-hour TWA exposures for total dust on September 12 ranged from 0.094 to 0.45 mg/m^3, with a mean of 0.22 mg/m^3. Eight-hour TWA exposures for respirable dust on that date ranged from 0.013 to 0.099 mg/m^3, with a mean of 0.040 mg/m^3.

The soldier levelling the grain in the grain bin was exposed to grain dust, measured as a total particulate, at a concentration of 27.5 mg/m^3 for the 6 minute duration of the task. While this concentration does not exceed applicable exposure criteria as an 8-hour TWA, under no circumstances should excursions in worker exposure levels exceed 5 times the TWA exposure limit.[4] The NIOSH REL and ACGIH TLV for grain dust (oats, wheat, and barley) is 4 mg/m^3 as an 8-hour TWA.[2,4] Therefore, the soldier levelling the grain bin should be provided with a half mask, air purifying respirator with dust and mist filters and dust goggles or a full facepiece air purifying respirator equipped with dust and mist filters. The disposable respirators in use at the time of the original site visit are not acceptable, as they are not NIOSH approved.[19] Only respirators approved by NIOSH and the Mine Safety and Health Administration are allowed under the OSHA respiratory protection standard (29 CFR 1910.134).[20] Approved disposable respirators would be acceptable, provided that they are used as part of a complete respiratory protection program, as required by the OSHA respiratory protection standard.[20] In addition, the grain bin meets the NIOSH definition of a confined space.* Loose, granular material stored in bins and hoppers, such as grain, can engulf and suffocate a worker.[21] The loose material can crust or bridge over in a bin and break loose under the weight of a worker.[21] A confined space entry program should be established to govern entry into the grain bin. Alternatively, a mechanical vibratory shaker, such as those used in railroad hopper car unloading, could be used to level the grain in the bin without requiring a soldier to enter the grain bin.

The results of endotoxin samples collected while soldiers cleaned the stables on February 28, 1991 ranged from 75.8 ng/m^3 for a 106 minute sample to 120 ng/m^3 for a 136 minute sample. Results for samples collected while new bedding was laid down ranged from 3.5 ng/m^3 for a 107 minute sample to 20.1 ng/m^3 for a 109 minute sample. Eight-hour time weighted average endotoxin exposures for GIing the stable, which included removing soiled bedding and laying down fresh bedding ranged from 5.4 ng/m^3 to 37.3 ng/m^3, with a mean of 21.7 ng/m^3. These values are less than the criteria suggested by Rylander.[15]

The result of the endotoxin sample collected while the soldier levelled grain in the grain bin was 2300 EU/m^3, or 230 ng/m^3, for the 6 minutes sampled. Assuming no further endotoxin exposure for the remaining 474 minutes of an 8-hour work day, the 8-hour TWA endotoxin exposure for that soldier was 2.9 ng/m^3. This is less than the symptom-based criteria suggested by Rylander, and the criteria recommended for individuals sensitized to cotton dust by Castellan et al.[15,16] It is still prudent, however, to provide respiratory protection to the soldier levelling the grain bin, based upon his brief but intense excursion above the TWA criteria for dust discussed earlier.[4]

---

* A confined space is a space which has any one of the following characteristics:

- !limited openings for entry and exit
- !unfavorable natural ventilation
- !not designed for continuous worker occupancy.[21]

Metal dust and fume samples were below all relevant exposure criteria.[2,3,4] Aluminum, calcium, iron, phosphorous, and zinc were detected on the sample collected in the tack room. NIOSH recommends the use of local exhaust ventilation for welding operations.[22] A drawing of a simple welding bench is provided (Figure 1).[23] Some hazards related to metal working were noted in the blacksmith's shop. Although the blacksmith wore eye protection while welding, neither the blacksmith nor his helper wore eye protection at other times (until the NIOSH investigators provided safety glasses to them), even though they are at risk for potential eye injuries resulting from hammering metal, exposure to sparks from the forge, and from infrared radiation from the forge. Oxygen and acetylene bottles were stored together. They should be separated by at least 20 feet or by a noncombustible barrier at least five feet high having a fire-resistance rating of at least 30 minutes.[24] A welding curtain was not in use to shield the blacksmith's helper from ultraviolet rays from arc welding. If a welding curtain can not be used due to space restrictions, the helper should be provided with suitable eye protection.[24] The grinder in the blacksmith's shop was not equipped with appropriate guards. Some of these problems result from the fact that the blacksmith's shop is too small to accommodate all of the tools of his trade and up to two draft horses. Task lighting appeared to be inadequate for the blacksmith to perform his job without difficulty. The drain gutter in the floor was not working. No ammonia was detected in the blacksmith's shop on February 28, 1991 or in the stables on September 12, 1991.

One portion of the request for this health hazard evaluation asked NIOSH to investigate how forge emissions entered the tack room and suggest means to correct this problem. Based upon the results of this investigation and observations made by NIOSH investigators, three factors seem to contribute to forge emissions entering the tack room: 1) stack height relative to the height of the roof, 2) weather cap design, and 3) stack installation.

From the ground it appears that the top of the stack is level with the row of windows and louvers that make up the side walls of the attic of Building 236. When viewed from the attic, the top of the stack is at eye level with these building openings. Therefore, forge emissions could enter the building through these openings under the proper wind conditions.

The weather cap on the top of the stack forces emissions to travel downward, and interferes with the natural draft by which the stack operates (the tube axial fan in the stack is not used). Weather cap design contributes further to forge emissions entering the attic space.

Finally, where the stack passes through the ceiling of the blacksmith shop (behind a knee wall in the tack room), gaps are present between the sheet metal around the stack and the joists. These gaps permit dust, smoke, and hot gases to enter the tack room. This can be seen by the soot that has collected on the horizontal surfaces behind the knee wall, and was confirmed by the results of air sampling conducted for trace metals in the tack room. There was no process in the tack room that generated the metal dust or fume detected in those samples, therefore they must have come from the blacksmith shop.

VI. CONCLUSIONS

Based upon the results described earlier, soldiers dyeing leather in the tack room are exposed to methylene chloride and 2-ethoxyethanol in excess of the NIOSH REL of lowest feasible exposure. Improperly selected gloves may increase the risk of exposure to 2-ethoxyethanol. The soldier who enters the grain bin should be provided with respiratory protection and protected by a confined space entry procedure. While the soldiers cleaning the stables were not overexposed to nuisance dust or endotoxin, substitution of wood chips for straw bedding has resulted in reduced complaints of dustiness, less waste, and horses' coughing has resolved. Although the blacksmith and his helper are not overexposed to metal dust or fume, local exhaust ventilation should be provided for welding operations. There are a number of safety hazards in the shop that should be addressed, and if possible, a less crowded location should be found. The problem of forge emissions entering the tack room is easily solved by minor modifications and repairs to the forge flue.

VII. RECOMMENDATIONS

1. Substitute leather dyes and lacquers which do not contain methylene chloride or 2-ethoxyethanol for those used currently, if acceptable products are available. Relocate the tack room to a location equipped with local exhaust ventilation, designed to capture and remove hazardous vapors from the work area. Obtain suitable solvent-resistant gloves for soldiers working with leather dyes and lacquers. Investigate flammable liquid storage practices to ensure that they do not present a fire hazard. Obtain material safety data sheets for products used in Building 236 and establish a hazard communication program in accordance with the OSHA hazard communication standard, 29 CFR 1910.1200.[25]

2. Provide the soldier who levels the grain bin with appropriate eye and respiratory protection. Establish a confined space entry program to govern entry into the grain bin, and a respiratory protection program which complies with the OSHA respiratory protection standard, 29 CFR 1910.134.[20,21] As a minimum, when someone enters the grain bin, a standby person should be on hand to summon help in the event of an emergency.

3. Install a welding bench equipped with local exhaust ventilation in the blacksmith's shop. Ensure that adequate make-up air is provided. Provide appropriate eye protection for the blacksmith and his helper. Separate stored oxygen and acetylene bottles by at least 20 feet or by a noncombustible barrier at least five feet high having a fire-resistance rating of at least 30 minutes. Install appropriate guards on the grinder in the blacksmith's shop. Install adequate task lighting. Investigate an alternative location for a blacksmith shop large enough to accommodate all of the tools of the blacksmith's trade and the horses to be shod. Involve the blacksmith in the design of the new area.

4. Leaking acetylene cylinders are reportedly routinely supplied to the blacksmith shop. A cylinder that leaks, is bulged, has defective valves or safety devices, bears evidence of physical abuse, fire or heat damage, or detrimental rusting or corrosion, must not be used unless it is properly repaired and requalified as prescribed in U.S. Department of Transportation regulations (49 CFR Parts 100-199).[26]

5. Raise the stack from the forge above the roof line of Building 236. Replace the weather cap with a no-loss cap (Figure 2) and spark arrestor.[23] Seal the openings where the stack penetrates the floor above.

6. Investigate the use of pesticides, such as fly repellents and fumigants, to ensure that they are used safely.

VIII. REFERENCES

1. NIOSH (1989). Eller PM, ed. NIOSH manual of analytical methods. 3rd rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) publication No. 84-100.

2. CDC (1988). NIOSH recommendations for occupational safety and health standards 1988. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control; National Institute for Occupational Safety and Health. MMWR 37 (supp. S-7).

3. Code of Federal Regulations (1989). 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

4. ACGIH (1991). Threshold limit values and biological exposure indices for 1991-1992. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

5. NIOSH (1988). NIOSH testimony to the U.S. Department of Labor: testimony of the National Institute for Occupational Safety and Health on the Occupational Safety and Health Administration's proposed rule on air contaminants, August 1, 1988, OSHA Docket No. H-020. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

6. Proctor N, Hughes J, Fischman M (1988). Chemical hazards of the workplace. 2nd ed. Philadelphia, PA: J.B. Lipincott Company.

7. NIOSH (1986). Current intelligence bulletin 46: Methylene chloride. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-114.

8. NIOSH (1983). Current Intelligence Bulletin 39: The glycol ethers, with particular reference to 2-methoxyethanol and 2-ethoxyethanol: evidence of adverse reproductive effects. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 83-112.

9. NIOSH (1988). NIOH and NIOSH basis for an occupational health standard: grain dust. Cincinnati, OH: U.S. Department of Health and Human Services, Public

Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 89-126.

10. Rylander R, Morey P (1982). Airborne endotoxin in industries processing vegetable fibers. AIHAJ 43:811-812.

11. ACGIH (1989). Guidelines for the assessment of bioaerosols in the indoor environment. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

12. Pernis B, Vigliani E, Cavagna C, Finulli M (1961). The role of bacterial endotoxins in occupational diseases caused by inhaling vegetable dusts. Br J Ind Med 18:120-129.

13. Cinkotai F, Lockwood M, Rylander R (1977). Airborne microorganisms and prevalence of byssinotic symptoms in cotton mills. AIHAJ 38:554-559.

14. Jacobs RR (1989). Airborne endotoxins: an association with occupational lung disease. Appl Occup Environ Hyg 4:50-56.

15. Rylander R (1987). The role of endotoxin for reactions after exposure to cotton dust. Am J Ind Med 12:687-697.

16. Castellan RM, Olenchock, SA, Kinsley KB, Hankinson JL (1987). Inhaled endotoxin and decreased spirometric values, an exposure response relation for cotton dust. N Engl J Med 317:605-610.

17. Nelson GO, Correia AN (1976). Respirator cartridge efficiency studies: VIII. summary and conclusions. AIHAJ 37 (9).

18. NFPA (1990). Flammable and Combustible Liquids Code. NFPA 30. Quincy, MA: National Fire Protection Association.

19. NIOSH (1990). NIOSH certified equipment list as of December 31, 1990. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 91-105.

20. Code of Federal Regulations (1989). 29 CFR 1910.134. Washington, DC: U.S. Government Printing Office, Federal Register.

21. NIOSH (1987). A guide to safety in confined spaces. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 87-113.

22. NIOSH (1988). Criteria for a recommended standard: welding, brazing, and thermal cutting. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 88-110.

23. ACGIH (1982). Industrial ventilation: a manual of recommended practice. 17th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

24. Code of Federal Regulations (1989). 29 CFR 1910.252. Washington, DC: U.S. Government Printing Office, Federal Register.

25. Code of Federal Regulations (1989). 29 CFR 1910.1200. Washington, DC: U.S. Government Printing Office, Federal Register.

26. Code of Federal Regulations (1989). 49 CFR Parts 100-199. Washington, DC: U.S. Government Printing Office, Federal Register.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by: Alan Echt, MPH, CIH
Industrial Hygienist
Industrial Hygiene Section

Field Assistance: Larry J. Elliott, MSPH
Supervisory Industrial Hygienist

Gregory A. Burr, CIH
Supervisory Industrial Hygienist

Eric J. Esswein, MSPH
Industrial Hygienist
Industrial Hygiene Section

Analytical Support: Methods Development Section
Measurements Research and Support Branch
Division of Physical Sciences and Engineering
Cincinnati, Ohio

DataChem Laboratories
Salt Lake City, Utah

Originating Office: Hazard Evaluation and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Industrial Hygiene Technician, Walter Reed Army Medical Center
2. Commanding General, USA Military District of Washington
3. Headquarters Commander, 3rd U.S. Infantry, The Old Guard
4. Commanding Officer, Caisson Platoon, H Company, 3rd U.S. Infantry, The Old Guard
5. Industrial Hygiene Division, U.S. Army Environmental Hygiene Agency
6. OSHA, Region III
7. NIOSH

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
Results of Air Sampling for Organic Vapors in the Tack Room
Saddle Shop, Building 236, Caisson Platoon
Ft. Myer, Virginia
February 27, 1991
HETA 91-090

Sample Description	Sample Duration	EtOH	MC	EtAc	IpAc	2-EE	MIBK	Toluene	BuAc	(minutes)
		8-hour TWA Results (ppm)								
Personal sample	17	19.6	0.17	0.25	0.10	0.20	0.17	0.05	(0.01)	
		Actual TWA Results (ppm)								
		554.3	4.9	7.0	2.8	5.7	4.9	1.5	0.4	
		8-hour TWA Results (ppm)								
Area sample	19	15.5	0.34	0.27	0.19	0.15	0.13	0.12	0.04	
		Actual TWA Results (ppm)								
		391.5	8.6	6.7	4.8	3.8	3.3	3.1	1.1	

Notes:
TWA: Time Weighted Average
STEL: Short Term Exposure Limit
ppm: Parts per million
EtOH: Ethyl Alcohol: NIOSH REL, OSHA PEL, ACGIH TLV: 1000 ppm 8-hour TWA
MC: Methylene Chloride: NIOSH REL: lowest feasible level; ACGIH TLV: 50 ppm 8-hour TWA
EtAc: Ethyl Acetate: NIOSH REL, OSHA PEL, ACGIH TLV: 400 ppm 8-hour TWA
IpAc: Isopropyl Acetate: OSHA PEL, ACGIH TLV: 250 ppm 8-hour TWA, 310 ppm STEL
2-EE: 2-ethoxyethanol: NIOSH REL: lowest feasible level; ACGIH TLV: 5 ppm 8-hour TWA
MIBK: Hexone: NIOSH REL, OSHA PEL, ACGIH TLV: 50 ppm 8-hour TWA, 75 ppm STEL
Toluene: NIOSH REL, OSHA PEL, ACGIH TLV: 100 ppm 8-hour TWA, 150 ppm STEL
BuAC: n-Butyl Acetate: NIOSH REL, OSHA PEL, ACGIH TLV: 150 ppm 8-hour TWA, 200 ppm STEL

Values in ( ) represent quantities of analyte between the limit of detection and the limit of quantitation, and should be considered trace concentrations with limited confidence in their accuracy.