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United Airlines
Indianapolis, Indiana

Nancy Clark Burton, M.P.H., M.S., C.I.H.
Robert E. McCleery, M.S.P.H.

PREFACE

The Hazard Evaluations 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 employer 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.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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Highlights of the NIOSH Health Hazard Evaluation

Exposures in Aircraft Lavatory Cleaning Room

In 1998 and 1999, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at the United Airlines maintenance facility in Indianapolis, Indiana, to look at exposures to infectious agents and chemicals during the cleaning, overhauling, and repair of aircraft lavatory tanks and hardware.

What NIOSH Did

We took air samples for sodium hydroxide, total particulates, and volatile organic compounds (VOCs). We checked bulk samples of solution from stored lavatory tanks and recently used aircraft tanks for bacteria.

We looked at the ventilation system and local exhaust controls for the machines.

What NIOSH Found

Bacteria were found in bulk samples, but no sign of organisms that cause intestinal disease was found.

Employee exposures to total particulates and VOCs were low.

Laboratory bacteria did not grow in blue water. Bacteria of the same species from the tank bulk samples did grow in blue water showing that some organisms that can cause infections in humans can live in the blue water.

What United Airlines Managers Can Do

Continue to provide training on the proper use of personal protective equipment (PPE) and importance of personal hygiene practices.

Increase the exhaust ventilation for the spray hood.

Install additional local exhaust ventilation over the vise and sinks.

Maintain cleaning room under negative air pressure.

Consider using local exhaust ventilation for epoxy application process.

Check that all employees are up-to-date on tetanus-diphtheria shots.

What United Airlines Employees Can Do

Wash hands frequently especially before eating, drinking, or smoking and after removing gloves.

Use PPE when needed.

Clean the floors of the aircraft lavatory cleaning room on a regular basis.

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National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report HETA 98-0203-2778
United Airlines
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Nancy Clark Burton, M.P.H., M.S., C.I.H.
Robert E. McCleery, M.S.P.H.

SUMMARY

In April 1998, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) concerning the cleaning, overhauling, and repair of aircraft lavatory tanks and hardware at the United Airlines maintenance facility in Indianapolis, Indiana. The HHE request stated that employees were concerned over potential exposures to infectious microorganisms during the cleaning of aircraft lavatories. In response to this request, an initial site visit was conducted on September 22, 1998, to look at the cleaning and overhaul processes, ventilation systems and controls, and job activities. The tanks and parts are removed, pressure-cleaned, soaked, and/or scraped, depending upon the amount of debris that is present. Environmental monitoring was conducted on April 3, 1999, which included the collection of area and/or personal breathing zone (PBZ) air samples for volatile organic compounds (VOCs), sodium hydroxide mist, and total particulates in the cleaning room and an adjacent floor board cutting area. Bulk samples of fluid in stored lavatory tanks that had been stored for two years and recently used lavatory tanks were analyzed for human enteric pathogenic bacteria.

The two stored tank samples contained *Corynebacterium spp*., Gram-negative bacteria, and *Providencia rettgeri*. The recently used aircraft lavatory samples contained *Morganella morganii*, *Providencia rettgeri*, and *Proteus penneri*. To determine the effectiveness of the fresh toilet deodorant mixture (“blue water”) to inhibit growth, inoculation/culture studies were performed. Isolates of *Morganella morganii*, *Proteus penneri*, and *Providencia rettgeri* from the bulk samples grew after being inoculated into the fresh toilet deodorant mixture, suggesting that some organisms are able to overcome the hostile environment created by the “blue water.” The levels of total particulates and VOCs in air samples were low and were well below current occupational exposure limits. Sodium hydroxide, a major component in the soaps, was not detected in the air samples. The cleaning room was under positive pressure relative to the rest of the work area during the site visit, and there were areas of little air movement near the employees’ workstations.

The detection of enteric bacteria in the bulk samples of recently used “blue water” indicates there is a potential for occupational exposure to possibly infectious organisms which may become aerosolized or may contaminate wounds. No organisms were found in the bulk samples that can cause intestinal disease. Recommendations to minimize occupational exposures to microorganisms and chemical agents through the use of general and local exhaust ventilation systems, changes in work practices such as using a disinfectant, and the use of personal protective equipment are included in this report.

Keywords: SIC Code 4581 (Airports, Flying Fields, and Airport Terminal Services), airplane lavatory cleaning and overhaul, sodium hydroxide, “blue water”, volatile organic compounds, particulates, microbial contamination, *Morganella morganii*, *Providencia rettgeri*, *Proteus penneri*.

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INTRODUCTION

In April 1998, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) concerning the cleaning, overhauling, and repair of aircraft lavatory tanks and hardware at the United Airlines (UA) maintenance facility in Indianapolis, Indiana. The HHE request stated that employees were concerned about potential exposures to infectious microorganisms during the cleaning of lavatory units; some of which had been stored for two years at another location. In response to this request, an initial site visit was conducted on September 22, 1998, to look at the cleaning and overhauling processes, and job activities. Environmental monitoring was conducted on April 3, 1999.

BACKGROUND

After five years of operation, aircraft are taken out of service to undergo heavy maintenance, which includes major overhauls of engines and other mechanical equipment. The seats, latches, and floor coverings are also replaced. The UA maintenance facility was opened in 1994, with construction of the interior shop area finished in the middle of 1995. The adjacent area in the interior shop makes floor boards using a computerized saw with local exhaust ventilation.

There are 64 employees in the interior shop; they work one of two shifts - 6:00 a.m. to 4:30 p.m. or 2 p.m. to 10:30 p.m. Individuals (up to four employees at a time, depending on work load) rotate through the lavatory cleaning jobs with the exception of one employee who does it on a continuous basis.

Two types of lavatory tanks are cleaned and repaired at this facility - circulating systems (majority) and vacuum pump systems (a few per month). The fixtures are stainless steel, and the circulating system tank is fiberglass with an epoxy coating. Honey Bee™ Deodorant 20C ("blue water"), which contains a quaternary amine base, is used in the toilets on the aircraft.

The maintenance work is scheduled so that the interior shop knows when to expect the incoming tanks. Lavatory tanks are pumped out in the hangers and rinsed with water by maintenance staff. The tanks and attached hardware are removed from the aircraft, placed in plastic bags, and sent to the Lavatory Cleaning Room (see Figure 1). Personal protective equipment (PPE) available for employees to use when working in the cleaning room includes: Tyvek® suits; powder-free latex gloves; disposable overalls, sleeves, aprons, and booties; disposable particulate respirators; face-shields; and Bullard™ supplied-air hoods. PPE usage varies between employees.

Employees take the tanks out of the bags and/or boxes and place them completely inside one of the two free-standing spray stations. The spray stations are enclosed on three sides and air is exhausted from the rear. The tanks and hardware are taken apart, and a mixture of water and soap (Honey Bee Cleaner 76 McGean-Rohco, Inc., which has a basic pH chemical composition) is sprayed under pressure on the parts to remove solid material.

Solids that remain on the pumps and screens are scraped out by hand. Parts with larger amounts of residue are sometimes soaked in Mikroklene, a detergent disinfectant that contains iodine, phosphoric acid, and ethylene glycol monobutyl ether as active ingredients. Occasionally, employees scrape out the material over a large trash barrel or use a vise in the cleaning room. Hardware pieces are soaked in hot water and soap baths to remove more material. CLE3006-10 ARDROX 2410-B Heavy Duty Alkaline Cleaner is used in the soap bath; sodium hydroxide is the main active agent.

After initial cleaning in the spray station, the tanks are placed in the Typhoon® machine for a two-hour wash cycle, a 20-minute rinse cycle, and drying. The machine runs ideally at 160 degrees Fahrenheit (°F) with 10 percent (%) soap (ARDROX 1820LF hard surface cleaner, which contains triethanolamine, alcohol alkoxylate, and a quaternary ammonium chloride). The machine has a local exhaust ventilation system. At the time of the site visit, the exhaust system was not always used because it reportedly cooled down the process and made it less effective.

The tanks are removed, and the tops cut off using a saw. The inside of the tank is scraped and the top layer of resin removed using a heat gun. An epoxy resin (a mixture of CG 1304 Hardener which contains diethylenetriamine, bisphenol A, aminoethylpiperazine, and CG 1304 Resin ,which contains pentabromobiphenyl oxide and triaryl phosphate) is applied to the inside of the tanks, and the tops replaced. The Bullard™ supplied-air hoods are used when applying the epoxy resin.

The company was in the process of modifying the ventilation system and reorganizing work areas in the cleaning room during both site visits. The ventilation system for the cleaning room was designed as a one-pass system, with exhaust directly to the outside. The room was designed to be under negative pressure with regard to the rest of the facility. The supply air comes from a recirculating ventilation system that serves other portions of the maintenance facility, including the tank epoxy resurfacing area. The recirculating system is set to operate at 76°F in the summer and 72°F in the winter, with a relative humidity of 60%. These conditions are necessary for the plastic/epoxy curing area. The air handlers are computerized, and the pressure drop across the filters is monitored to determine when filters need to be changed.

A baseline physical examination is required for all employees in the interior shop and every five years after that. The medical department administers a health status questionnaire annually to determine if the employee can be medically cleared for respirator use, including disposable, half-face, and supplied air types. All employees participate in an annual respirator training and fit testing program.

METHODS

Bulk Microbial Samples

Two bulk samples of fluid were collected in sterile containers from the lavatory tank of a 737-700 airplane that was pulled out of service into the hanger for minor repairs. It had not flown for two days. Two additional bulk fluid samples were collected from the older tanks that were stored in the Interior Shop and had not been used in at least two years. The samples were sent by overnight mail to a contract laboratory to be analyzed for human enteric pathogenic (disease-causing) bacteria. Aliquots of the bulk samples were streaked on sheep blood agar plates and incubated at 35 degrees Celsius (°C) for 24 to 48 hours. The taxa and rank of the collected microorganisms were determined by morphological characteristics.

"Blue water" crystals and the formula for making the solution were provided to the laboratory by UA to make controls and conduct additional experiments. Laboratory cultures (1-2 $x10^8$ colony forming units per milliliter of fluid [CFU/mL]) of *Salmonella spp*. and *Escherichia coli* were inoculated into fresh "blue water" and incubated at 13°C and 23°C to represent some of the operating temperatures of the aircraft. The solutions were cultured on sheep blood agar plates, incubated at 35°C for 18-24 hours, and counted. Isolates of *Morganella morganii*, *Proteus penneri*, and *Providencia rettgeri* from the bulk samples, and laboratory isolates of *Morganella morganii* and *Proteus penneri* (1-2 $x10^8$ CFU/mL), were inoculated into fresh "blue water" and incubated at 23°C. The solutions were cultured on sheep blood agar plates, incubated at 35°C for 18-24 hours, and counted.

Volatile Organic Compounds

Four area air samples (two during heat gun usage and epoxy application, one in the cleaning room, and one directly outside the cleaning room) were collected on thermal desorption tubes containing three beds of sorbent material using a flowrate of 0.05 liters per minute (Lpm). Prior to analysis, the samples were dry-purged with helium to remove water. The samples were analyzed for volatile organic compounds (VOCs), which were com-ponents of the epoxy system and some of the soaps, using a Perkin–Elmer automatic thermal desorption system interfaced directly to a gas chromatograph and a mass selective detector.

Sodium Hydroxide

Sodium hydroxide was a component in the soaps and cleaning agents used in the cleaning room. One personal breathing zone (PBZ) and four area air samples (three inside and one outside the lavatory cleaning room) were collected on one-micrometer (µm) polytetrafluoroethylene (PTFE) membrane filters with stainless steel backup screens using a flowrate of 2.0 Lpm. The samples were analyzed for alkaline dust and mist by acid-base titration according to NIOSH Method 7401[1] with the following modifications. To cover each filter, 75 milliliters (mL) of water and 5 mL of sulfuric acid (H_2SO_4) were added to the filter. To do the titration, 5 mL of 0.02 normal (N) H_2SO_4 was used in conjunction with 0.02 N sodium hydroxide. The analytical limit of detection (LOD) was 80 micrograms (µg) per sample, which is equivalent to a minimum detectable concentration (MDC) of 0.11 milligrams per cubic meter (mg/m^3), assuming a sample volume of 728 liters. The limit of quantitation (LOQ) was 300 µg, which is equivalent to a minimum quantifiable concentration (MQC) of 0.41 mg/m^3, assuming a sample volume of 728 liters.

Total Particulates

Because the amount of dust generated during the floor board cutting operation was of concern to the employees, five area air samples (two inside and one outside the lavatory cleaning room and two inside the floor board cutting area) were collected for total particulates on pre-weighed polyvinyl chloride (PVC) filters (37-millimeter [mm] diameter, 5-µm pore size) using a flowrate of 2.0 Lpm. The samples were analyzed for total particulate weight by gravimetric analysis according to NIOSH Method 0500[2] with an LOD of 0.020 milligrams (mg) per sample, which is equilivant to an MDC of 0.027 mg/m^3, assuming a sample volume of 728 liters.

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 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though 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 criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases 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 workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95-596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended STELs or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Microbial and Infectious Agents in Sewage

There are no specific occupational health criteria that address occupational exposure to microbial and infectious agents in wastewater and sewage. Individuals who work with human waste can be exposed to a wide variety of microbial (including infectious) agents and inorganic and organic compounds.[6] Human waste has been associated with the spread of several infectious diseases including cholera, hepatitis A, salmonella, typhoid fever, shigellosis, and amebic dysentery.[7,8] The usual mode of transmission is ingestion following inhalation of contaminated mists or dust or oral contact with contaminated hands or other objects. There are four major types of human pathogenic organisms found in wastewater and sewage sludge: (1) bacteria, (2) viruses, (3) protozoa, and (4) helminths (parasitic worms).[9] Examples of pathogens potentially found in wastewater and sewage sludge are presented in Table 1. The following presents in more detail different diseases/conditions that have been associated with working in the sewage handling industry.

Three confirmed cases of giardiasis among sewage workers were documented in Great Britain; these cases had no other risk factors or history of exposure besides their occupation.[10] Interviews with the affected employees revealed that they did not use PPE and did not have access to shower facilities to remove contamination after exposure to raw sewage.

Hepatitis A virus (HAV) infection is spread through the fecal-oral route and can live for at least two weeks in the environment. Several studies in other countries have found an increased occu-pational risk of acquiring HAV infection among sewer treatment workers.[11,12,13,14] Two recently completed serologic studies in the United States compared the prevalence of anti-HAV antibody among sewage workers to other municipal employees.[15,16] Neither study found a statistically increased prevalence among sewage workers, although one study had an odds ratio of 2.[15]

Some studies have been conducted to look at the environmental survival potential of human immunodeficiency virus (HIV). Two studies were able to show the presence of HIV nucleic acid in sewage but did not address viability of the virus.[17,18] An additional study looked at the viability of HIV in primary and secondary effluent using peripheral blood mononuclear cells; the investigators did not recover infectious HIV from either water stream.[19] No epidemiologic evidence implicates occupational exposure to sewage or ingestion of contaminated water as a source of HIV infection.

One study looked at immunoglobulin G antibodies to *Helicobacter pylori*, which has been associated with gastritis, stomach and duodenal ulcers, and gastric cancer; the organism has been isolated from human waste.[20] The investigation found no increased risk of infection with *Helicobacter pylori* among sewer workers.

Endotoxin, which is a compound from the outer cell wall of Gram–negative bacteria, has been found in many occupational environments, including grain storage; composting; swine, dairy and poultry farming; bulk cotton processing; waste disposal; and sewer plants.[21,22] A variety of symptoms including chest tightness, cough, shortness of breath, fever, and wheezing have been reported among sewer workers exposed to endotoxin. Endotoxin can persist in the environment for long periods of time.

The following bacteria were identified in the bulk samples. There are no reports in the literature that these organisms have been associated with adverse health effects in the working environment. *Corynebacterium spp*. are Gram-positive rods that are a commonly found as part of the normal flora of the skin and upper respiratory tract.[23] They are also found in the environment. It is difficult to distinguish between non-pathogenic and pathogenic *Corynebacterium spp*. *Morganella morganii* is an oxidase-negative, facultative anaerobic, Gram-negative rod that is a member of the family of Enterobacteriaceae.[23] This organism is found in the feces of humans, dogs, other mammals, and reptiles. *Morganella morganii* is the only species of the genus. It is considered an opportunistic secondary invader (immunocompromised persons are more susceptible to these organisms).

Proteus spp. is an oxidase-negative, facultative anaerobic, Gram-negative rod that is a member of the family Enterobacteriaceae.[23] Members of this genus are found in the intestines of humans and a wide variety of animals, manure, soil, and polluted waters. *Proteus spp*. can cause urinary tract infections. *Providencia spp*. are oxidase-negative, facultative anaerobic, Gram-negative rods that are also members of the family Enterobacteriaceae.[23] *Providencia spp*. bacteria have been associated with opportunistic infections.

Sodium Hydroxide

Sodium hydroxide is used in the soaps and cleaning agents at this facility. It is very corrosive and a severe irritant of the eyes, mucous membranes, and skin.[24] Sodium hydroxide, as a solid or concentrated solution, can cause rapid destruction of tissue on contact. There is one case report where severe obstructive airway disease was associated with chronic exposure to sodium hydroxide mist.[25] ACGIH has a ceiling level of 2 mg/m^3 for sodium hydroxide.[4] NIOSH and OSHA have not established any standards for exposure to sodium hydroxide.

RESULTS/DISCUSSION

Bulk Microbial Samples

The results from the microbial analysis of the bulk fluid solutions are presented in Table 2. The two stored tank samples contained 2.3×10^7 and 2.8×10^7 CFU/mL. The two stored tank samples contained *Corynebacterium spp*., oxidase-positive non-fermentative Gram-negative rods, oxidase-negative non-fermentative Gram-negative rods, and *Providencia rettgeri*. The presence of Gram-negative rods indicates that endotoxin exposure is possible. The two samples collected from the aircraft lavatory contained 3.3×10^6 and 2.5×10^6 CFU/mL of solution. The aircraft lavatory samples contained *Morganella morganii*, *Providencia rettgeri*, and *Proteus penneri*.

Salmonella spp. and *Escherichia coli* laboratory cultures did not grow at zero time (i.e. adding the culture to the solution and plating out immediately) in fresh "blue water" at 13°C and 23°C. Isolates of *Morganella morganii*, *Proteus penneri*, and *Providencia rettgeri* from the bulk samples survived being inoculated into the fresh "blue water" at 23°C. At 0.01 and 0.1 mL of solution per plate, *Morganella morganii* grew 34 CFU/plate and 74 CFU/plate, respectively. When cultured on plates, *Proteus penneri* and *Providencia rettgeri* solutions at the same dilutions grew too many colonies to count. Laboratory isolates of *Morganella morganii* and *Proteus penneri* did not grow at zero time in fresh "blue water" at 23°C. Based on these results, some of the organisms found in the aircraft lavatories are able to survive in the deodorant solution. However, the traditional indicator organisms of fecal contamination (*E. coli* and *Salmonella spp*.) did not.

Volatile Organic Compounds

Several compounds were detected on the thermal desorption tubes, most at trace levels. The major compounds identified on the tubes were isopropanol, acetone, toluene, limonene, ethylene glycol monobutyl ether, butoxypropanol, methyl ethyl ketone, and hexane. Other compounds detected included ethanol, chlorofluorocarbons, methyl isobutyl ketone, methyl pyrrolidinone, tetrahydrofuran, tributyl phosphate, propylene glycol, xylene, various aliphatic hydrocarbons, siloxanes, pinenes, and dichlorobenzamine. The majority of the compounds detected are from the soaps used in cleaning the lavatory units, generated during heat scraping, or from the application of the resin coating.

Sodium Hydroxide

The personal and area air sampling information for sodium hydroxide is shown in Table 3. Sodium hydroxide was not detected in the air samples at an MDC of 0.11 mg/m^3, as was expected since little spraying of the soap solution was done on the day of the environmental monitoring.

Total Particulates

The area air sampling information for total particulates is given in Table 4. Total particulate concentrations were low, ranging from non-detectable to 0.04 mg/m^3 in the cleaning room and floor board areas. This was expected since there was minimal activity in the cleaning room on the day the environmental monitoring was conducted.

Observations

During the site visit, the cleaning room area was not under negative pressure relative to the rest of the work area. The vise and trash barrel were in the middle of the work area and did not have exhaust ventilation. Smoke generated by chemical smoke tubes at the exhaust grilles showed that the main ventilation system was working. However, there were little air movement where the employees stand while working. The hoods for the spray stations were working, but visible spray still entered the general work area.

The floor in the cleaning room was dirty and, according to employees, had not been cleaned for several weeks. According to the material safety data sheets (MSDSs), the soaps used in the cleaning room are skin, eye, and respiratory tract irritants. There was also concern over small cuts on their bodies that occasionally become infected. Endotoxin exposure was not monitored during this HHE but could be an issue when exposed to aerosolized material since some of the identified bacteria were Gram-negative organisms. The employee in the cleaning room used Tyvek® overalls and latex gloves when working with the lavatory tanks during our visit. The employee reported using additional PPE, including eye protection when doing more extensive cleaning. The employee who was applying the epoxy to the lavatory tank wore a Bullard™ supplied-air hood.

CONCLUSIONS

Employees may be exposed to microorganisms during the cleaning of aircraft lavatory tanks and components which may become aerosolized or may contaminate wounds. No organisms were found in the bulk samples that have been associated with intestinal disease. Additional laboratory studies of standard laboratory cultures of *Salmonella spp*., *Escherichia coli*, *Morganella morganii*, and *Proteus penneri* showed that the fresh toilet deodorant mixture ("blue water") was able to inhibit the growth of these organisms. However, isolates of *Morganella morganii*, *Proteus penneri*, and *Providencia rettgeri* from the bulk samples grew after being inoculated into the fresh toilet deodorant mixture, suggesting that some organisms are able to adapt to the hostile environment created by the mixture.

The air concentrations of total particulates and VOCs were low and were well below current occupational exposure limits. Sodium hydroxide, a major component in the soaps, was not detected at the analytical LOD. The ventilation system was not operating under negative pressure during the site visit and there were areas of little air movement by the work stations. The epoxy work was done in the main work area, which is served by the recirculating ventilation system. Since this same system supplies air to the cleaning room, these employees may be exposed to chemicals generated during the epoxy work.

RECOMMENDATIONS

The following recommendations are provided to help minimize exposure to wastewater and sewage and increase employee awareness of the importance of good hygiene and the appropriate use of PPE while at work.

(1) Appropriate PPE should be required for all jobs likely to result in exposure to sewage or wastewater. This PPE should include goggles, face shields, liquid–repellant coveralls, and gloves. Respirators, preferably an N95 respirator or better, may also be used to reduce inhalation exposure to microbial contaminants.

(2) Nitrile gloves should be used to prevent hand exposures to microbial and chemical contaminants and reduce the prevalence of latex in the working environment. Latex material does not protect skin from exposures to chemicals. Employees should remove and dispose of soiled PPE (such as gloves) in designated areas to avoid contaminating other objects or parts of the facility with soiled PPE. Hands should be washed after gloves are removed and before eating and drinking.

(3) To reduce the risk of exposures to microbial contaminants in the cleaning room, the floors should be cleaned on a regular basis using an Environmental Protection Agency (EPA)-registered chemical disinfectant.

(4) The amount of pressure used to spray the soap under the spray hoods should be reduced to prevent mist from escaping. A properly designed local exhaust ventilation hood should be installed, behind the vise and sinks that are used to remove solid material, to collect generated material and chemical vapors. The ventilation system for the cleaning room should be maintained under negative pressure relative to the rest of the work area to contain microbial and chemical contaminates.

(5) Local exhaust ventilation should be used for the epoxy application process, with exhaust to the outside.

(6) Since employees are concerned about injuries that become infected, management should use this opportunity to encourage all employees to be up-to-date on tetanus-diphtheria immunizations.

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Table 1
Examples of Pathogens Potentially Found in Wastewater and Sewage Sludge[9]
United Airlines, Inc.
Indianapolis, Indiana
HETA 98-0203-2778

Organism	Disease or Symptoms
Bacteria	
Campylobacter jejuni	**Gastroenteritis**
Escherichia coli	**Gastroenteritis**
***Salmonella* sp.**	**Salmonellosis (food poisoning), typhoid fever**
***Shigella* sp.**	**Bacillary dysentery**
Vibrio cholerae	**Cholera**
***Yersinia* sp.**	**Acute gastroenteritis (including diarrhea, abdominal pain)**
Enteric Viruses	
Astroviruses	**Epidemic gastroenteritis**
Caliciviruses	**Epidemic gastroenteritis**
Enteroviruses–Coxsackieviruses	**Meningitis, fever, hepatitis, pneumonia, etc.**
Enteroviruses–Echoviruses	**Meningitis, diarrhea, fever, paralysis, etc.**
Enteroviruses–Polioviruses	**Poliomyelitis**
Hepatitis A virus	**Infectious hepatitis**
Norwalk viruses	**Epidemic gastroenteritis with severe diarrhea**
Reovirus	**Respiratory infections, gastroenteritis**

Table 1 - Continued
Examples of Pathogens Potentially Found in Wastewater and Sewage Sludge[9]
United Airlines, Inc.
Indianapolis, Indiana
HETA 98-0203-2778

Organism	Disease or Symptoms
Protozoa	
Balantidium coli	Diarrhea and dysentery
Cryptosporidium	Gastroenteritis
Entamoeba histolytica	Acute enteritis
Giardia lamblia	Giardiasis (including diarrhea, abdominal cramps, weight loss)
Toxiplasma gondii	Toxoplasmosis
Helminth Worms	
Ascaris lumbricoides	Abdominal pain, digestive and nutritional disturbances, restlessness, vomiting,
Ascaris suum	May produce symptoms such as chest pain, coughing, and fever
Hymenolepsis nana	Taeniasis
Necator americanus	Hookworm disease
Taenia saginata	Abdominal pain, anorexia, digestive disturbances, insomnia, nervousness
Taenia solium	Abdominal pain, anorexia, digestive disturbances, insomnia, nervousness
Toxocara canis	Abdominal discomfort, fever, muscle aches, neurological symptoms
Trichuris trichiura	Abdominal pain, anemia, diarrhea, weight loss

Table 2
Bulk Microbial Samples
United Airlines, Inc.
Indianapolis, Indiana
HETA 98–0203-2778

Sample Location	Total Bacteria Concentrations (CFU/mL)*	Taxonomic Rank
Stored Tank	2.3×10^7	*Corynebacterium spp*. 52% Oxidase-Positive Non-Fermentative Gram - Negative Rods 48% *Providencia rettgeri* 0.001%
Stored Tank	2.8×10^7	Oxidase-Positive Non-Fermentative Gram - Negative Rods 68% Oxidase-Negative Non-Fermentative Gram -Negative Rods 32% *Providencia rettgeri* 0.003%
Fresh Tank	3.3×10^6	*Morganella morganii* 76% *Providencia rettgeri* 24%
Fresh Tank	2.5×10^6	*Proteus penneri* 44% *Morganella morganii* 32% *Providencia rettgeri* 24%

*** CFU/mL = Colony forming units per milliliter of fluid**

Table 3
Sodium Hydroxide Air Sampling Results
United Airlines, Inc.
Indianapolis, Indiana
HETA 98–0203-2778

Sample Location	Sampling Time	Sample Volume (Liters)	Concentration (mg/m^3)*
Personal			
Mechanic	7:14 a.m. - 11:24 a.m.	500	ND**
Area			
Table Outside Cleaning Room	7:20 a.m. - 1:24 p.m.	728	ND
Cleaning Room - Sidewall on Electrical Box	7:17 a.m. - 1:21 p.m.	728	ND
Cleaning Room - Center on Unused Equipment	7:19 a.m. - 1:19 p.m.	720	ND
Cleaning Room - Back Wall on Tool Cart	7:15 a.m. - 1:17 p.m.	724	ND
Minimum Detectable Concentration (MDC)		728	0.11
Minimum Quantifiable Concentration (MQC)		728	0.41

* mg/m^3 = milligrams per cubic meter
** ND = not detected at MDC

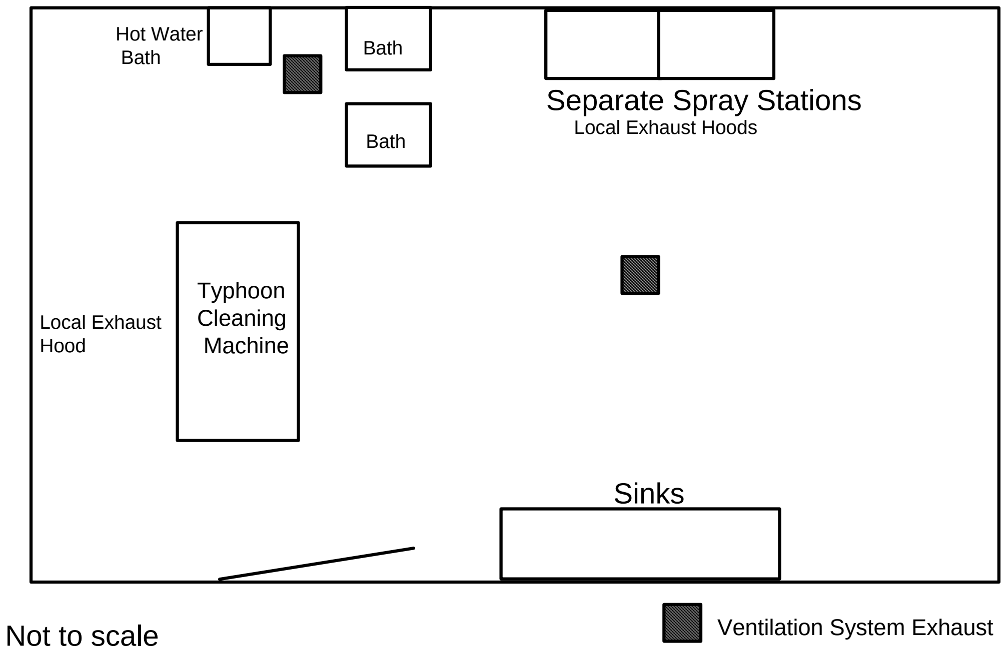
ACGIH has a ceiling level of 2 mg/m^3 for NaOH.

Table 4
Particulates - Total Weight Air Sampling Results
United Airlines, Inc.
Indianapolis, Indiana
HETA 98–0203-2778

Sample Location	Sampling Time	Sample Volume (Liters)	Concentration (mg/m^3)*
Area			
Cleaning Room - Back Wall on Tool Cart	7:15 a.m. - 1:18 p.m.	726	0.04
Cleaning Room - Sidewall on Electrical Box	7:16 a.m. - 1:20 p.m.	728	0.04
Table Outside Cleaning Room	7:20 a.m. - 1:22 p.m.	724	ND**
Floor Board Machine	7:30 a.m. - 1:31 p.m.	718	ND
Floor Board Area on Table	7:31 a.m. - 1:30 p.m.	718	0.04
Minimum Detectable Concentration (MDC)		728	0.027
OSHA PEL			15
ACGIH TLV			10 (inhalable)

* mg/m^3 = milligrams per cubic meter
** ND = not detected at MDC

Figure 1 - Floor Plan
United Airlines Lavatory Cleaning Room
Indianapolis, Indiana HETA 98-0203-2778



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Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Web site at:
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