NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2005-0091-2957
Health Hazard Evaluation Summary Report: Air Contaminant and Noise Exposures among Transportation Security Administration (TSA) Baggage Screeners at Four International Airports

April 2005

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

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.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Mark M. Methner, Lisa J. Delaney, and Randy L. Tubbs of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies. Analytical support was provided by DataChem Laboratories and Ardith Grote, Division of Applied Research and Technology. Desktop publishing was performed by Robin Smith and Ellen Blythe. Editorial assistance was provided by Ellen Galloway.

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Highlights of the NIOSH Health Hazard Evaluation

Health Hazard Evaluation Summary Report: Air Contaminant and Noise Exposures among Transportation Security Administration (TSA) Baggage Screeners at Four International Airports

During 2004, NIOSH conducted health hazard evaluations of baggage screening areas at four airports (Palm Beach [PBI], Miami [MIA], Dulles [IAD], and Baltimore [BWI] International Airports) at the request of the Transportation Security Administration (TSA). Employees were concerned about exposure to diesel exhaust, carbon monoxide, and noise. We measured levels of air contaminants and noise in the passenger checked baggage screening areas.

What NIOSH Did

- We took air samples for carbon monoxide (CO), oxides of nitrogen, diesel exhaust, and hydrocarbons.
- We measured noise levels.
- We observed workplace conditions.

What NIOSH Found

- On average, air contaminant concentrations of diesel exhaust, CO, and oxides of nitrogen were very low and within recommended levels.
- All airport baggage screening areas relied on mechanical and natural ventilation. One airport (IAD) also had an automated CO detection system that increased ventilation in the baggage screening areas when CO reached a certain level.
- All screening areas had pedestal-mounted fans for additional worker comfort.
- Floor-mounted intake vents were often blocked with trash/debris (IAD).
- Drain lines from the L3 screening machines were improperly routed into the floor-mounted ventilation intake ducts (IAD).
- Airline employees often left tugs idling when not in use (All airports).
- Twenty-one percent of the noise samples exceeded acceptable limits.
- Airline tugs can run on several different types of fuel sources.
- Some airline tugs appeared to be "out of tune," idled erratically, and generated high levels of exhaust products (All airports).

What TSA Managers Can Do

- Work with airlines to make sure tugs are maintained and kept in good running order to keep emissions low (All airports).
- Post signs to remind tug operators to turn off tugs when not in use (All airports).
- Improve housekeeping practices, especially in the floor vent areas (IAD).
- Reroute cooling drain lines from L3 machines away from the floor vents, to a more suitable receptacle (IAD).
- Repeat noise surveys to more fully evaluate and verify exposures (All airports).
- Request airport maintenance staff to repair cracks in floors and noisy baggage handling equipment as soon as possible.

What the TSA Employees Can Do

- Report changes in noise levels to TSA management (All airports).
- Use trash receptacles to keep work areas free of debris (All airports).
- Report improper tug operation to TSA Management (All airports).

What To Do For More Information:

We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2005-0091-2957

Health Hazard Evaluation Summary Report: Air Contaminant and Noise Exposures among Transportation Security Administration (TSA) Baggage Screeners at Four International Airports HETA #2005-0091-2957 April 2005

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SUMMARY

In January 2004, the National Institute for Occupational Safety and Health (NIOSH) received health hazard evaluation (HHE) requests from the United States Department of Homeland Security, Transportation Security Administration (TSA) related to checked baggage screening operations at the following four international airports: Palm Beach, Florida (PBI); Miami, Florida (MIA); Washington-Dulles, Virginia (IAD); Baltimore-Washington, Maryland (BWI). TSA expressed concern about health hazards from exposure to contaminants found in exhaust emissions of tug and jet engines and noise from tugs, jets, conveyors, and baggage carousels. Health problems reported at the four airports included respiratory distress, dizziness, possible hearing loss, and headaches. NIOSH investigators conducted site visits at the four airports, collecting general area and personal breathing zone (PBZ) air samples for carbon monoxide (CO), nitrogen dioxide (NO_2), nitric oxide (NO), diesel exhaust particulate (measured as elemental carbon [EC]), and volatile organic compounds (VOCs). Full-shift personal noise monitoring was also conducted. This report is a composite of the individual reports issued under HHE #s 2004-0100, 2004-0101, 2004-0130, 2004-0146.

A total of 72 PBZ samples were collected for EC, a surrogate for diesel exhaust; concentrations ranged from 1 to 26 micrograms per cubic meter ($\mu g/m^3$). There are no NIOSH or Occupational Safety and Health Administration (OSHA) exposure limits for EC; however, the California Department of Health Services recommends keeping exposure levels below 20 $\mu g/m^3$. While four PBZ samples exceeded 20 $\mu g/m^3$, the average exposures across all four airports were 11 $\mu g/m^3$.

A total of 40 PBZ samples were collected for both NO and NO_2. "Trace" concentrations of NO were measured at MIA, IAD, and BWI (defined as between 0.03 parts per million [ppm] and 0.7 ppm). These values correspond to the Minimum Detectable Concentration [MDC] and the Minimum Quantifiable Concentration [MQC]. Trace concentrations of NO_2 were also measured at these airports (between 0.02 ppm [MDC] and 0.8 ppm [MQC]). Concentrations of NO and NO_2 were "not detectable" at PBI (defined as below 0.15 ppm [MDC]). Similar results were obtained for 21 full-shift general area air samples using the same sampling method. Measurements made with direct-reading instruments yielded similar results. None of the NO and NO_2 samples exceeded their respective NIOSH Recommended Exposure Limit (REL), American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), or the OSHA Permissible Exposure Limit (PEL) (25 ppm for NO; 3 ppm for NO_2).

A total of 61 full-shift exposure measurements for CO were collected using direct-reading instruments. PBZ exposures ranged from 1 to 5 ppm (full-shift time-weighted average [TWA]) and from 1 to 16 ppm (15-

minute short-term exposures). Instantaneous peak values ranged from 176 ppm to 333 ppm. No average exposure values exceeded any occupational exposure limit (NIOSH REL = 35 ppm; ACGIH TLV =25 ppm; OSHA PEL = 50 ppm).

The dominant VOCs identified within the baggage screening areas of all surveyed airports were isopropyl alcohol, toluene, and low molecular weight hydrocarbons. A total of 20 general area air samples were collected; concentrations ranged from "none detected" (below the MDC; isopropyl alcohol and low molecular weight hydrocarbons – 0.1 mg/m^3; toluene – 0.02 mg/m^3) to "trace" (below the MQC; isopropyl alcohol and low molecular weight hydrocarbons – 0.5 mg/m^3; toluene – 0.05 mg/m^3 but above the MDC). All measurements were well below any occupational exposure limit.

Gasoline-powered tug tailpipe emissions for hydrocarbons (HC), CO, and oxides of nitrogen (NO_x) were measured at two airports while the tugs idled. Tailpipe concentrations of these compounds were as follows: HC ranged from 20 ppm to 1700 ppm; CO ranged from zero ppm to 86,500 ppm; NO_x ranged from zero ppm to 52 ppm. The majority of the tugs' engines ran poorly.

None of the measured noise doses from the 56 full-shift samples exceeded the OSHA 8-hour PEL. However, each airport had a few workers with exposures above the NIOSH REL. This finding led to recommendations for additional noise assessments and changes in airport equipment and facility structure. Additionally, the interim use of hearing protection devices as part of a hearing conservation program is recommended unless measured noise doses do not exceed the NIOSH REL, or the use of engineering or administrative controls have been effective in reducing worker exposure to below the NIOSH REL.

> The NIOSH investigators determined that a hazard does not exist from exposure to EC, CO, CO_2, NO_2, NO, or VOCs. Some tug emissions were elevated when compared to ambient levels and could contribute to an increase in air contaminants in some baggage areas. There was little evidence of a serious noise problem. However, additional noise analyses may be useful in characterizing worker exposure in areas where the NIOSH REL was exceeded. Also, changes in the maintenance of baggage handling equipment (conveyors) and repairing cracks in the concrete floors are needed to reduce unnecessary noise. Additionally, the interim use of hearing protection devices is recommended for workers whose noise doses exceed the NIOSH REL. Other recommendations for maintaining the air quality and further reducing noise exposures are provided in the Recommendations Section of this report.

Keywords: SIC 4581 (Airports, Flying Fields, and Terminal Services) diesel exhaust, nitrogen dioxide, nitric oxide, carbon monoxide, noise, airport, screeners, Transportation Security Administration, volatile organic compounds, respiratory, headache, dizziness, HHE Report # 2004-0100-2946, HHE Report # 2004-0101-2953, HHE Report # 2004-0130-2945, HHE Report # 2004-0146-2947.

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INTRODUCTION

In January, 2004, the National Institute for Occupational Safety and Health (NIOSH) received requests from the Transportation Security Administration (TSA) to conduct health hazard evaluations (HHEs) at four international airports: Palm Beach, Florida (PBI), Miami, Florida (MIA), Washington-Dulles, Dulles, Virginia (IAD) and Baltimore-Washington (BWI), Linthicum, Maryland. The requests asked NIOSH to evaluate health hazards from exposure to contaminants found in the emissions of tug and jet engine and to evaluate the noise levels generated from tugs, jets, conveyor belts, and baggage carousels in the checked baggage screening area. The requests indicated that some employees had experienced health problems possibly related to the work environment, including respiratory distress, dizziness, possible hearing loss, and headaches. In response to the requests, NIOSH investigators conducted initial site visits in early 2004. From April through July 2004, NIOSH investigators returned to each of the four airports to conduct noise monitoring and area and personal breathing zone (PBZ) air sampling for carbon monoxide (CO), nitrogen dioxide (NO_2), nitric oxide (NO), diesel exhaust (measured as elemental carbon [EC]), and volatile organic compounds (VOCs).

BACKGROUND

Transportation Security Administration (TSA)

On November 19, 2001, the Aviation and Transportation Security Act (ATSA) [49 CFR Parts 1500 et al.[1]], which established TSA within the Department of Transportation, was signed into law. The law required TSA to hire and train federal security employees to inspect all passengers and property for explosives and incendiaries before boarding and loading onto the airplane. This rulemaking transferred the Federal Aviation Administration rules governing civil aviation security to TSA. A December 31, 2002 deadline was established for airports and TSA to implement this law.

Baggage Screening/Baggage Transfer

In 1975 the Federal Aviation Administration (FAA) adopted rules regarding the use of cabinet X-ray systems to screen carry-on baggage. Since 1975, the number of X-ray screening machines has increased as detection capability has improved. One of the most significant equipment improvements over the past 25 years has been the introduction of computed-aided tomography (CAT) X-ray scanning machines to detect explosive materials in carry-on and checked baggage. In 1994, the FAA approved the use of CAT machines as certified explosive detection systems (EDS); in the fall of 1995, they began installing these X-ray screening machines. Carry-on baggage is examined using less powerful X-ray machines typically located at passenger check points. However, for checked baggage TSA workers use more elaborate (and more powerful) EDS equipment to create a three-dimensional image of the checked bag. Two companies manufacture EDS machines in the TSA system: L3® and CTX InVision®. In the four airports involved in this NIOSH study only the L3® 3DX™ 6000 units were in use.

After passengers check their bags at the ticket counter, a series of conveyor belts delivers bags to the various screening areas. TSA screeners manually load the bags onto another conveyor belt that transfers the baggage to an explosive detection system (EDS) machine. Additional screening, if necessary, is accomplished via analysis using an explosive trace detection (ETD) system. After examination, bags are loaded onto a carousel that routes each bag to the appropriate terminal location where airline personnel transfer the bags to carts attached to tugs for transport to the aircraft.

A large number of bags are handled and screened daily during “push” time periods when numerous flights from various airlines depart the airport within a narrow timeframe. During these time periods tug traffic and the potential for exposure to combustion products are highest.

At each airport, individual airlines maintain and operate their own tugs. The tugs' fuel source varies by airline and includes diesel, gasoline, propane, and electricity. Large, pedestal-mounted fans are typically located near EDS machines to increase air movement and provide comfort to workers in the bag screening areas. General exhaust ventilation is provided in each of the baggage screening areas we surveyed. A unique ventilation system that is automatically controlled via CO sensors is used at IAD.

Palm Beach International Airport (PBI)

PBI began operations with one small runway in 1936. The most recent expansion (1988) created 560,000 square feet of terminal space. The terminal includes 3 concourses, 25 passenger gates and a two-story concession mall. This facility serves nearly six million passengers each year. Sixteen commercial and commuter airlines operate from this airport.

Approximately 85 full- and part-time TSA screeners work at PBI. Full-time employees work an 8-hour shift and part-time employees work a 4-hour shift. All checked passenger bags are screened in one large area. The baggage screening area at PBI is open to the tarmac and consists of 14 carousels and nine L3 3DX™ 6000 EDS machines. During peak travel periods, more than 350,000 bags are screened monthly.

Miami International Airport (MIA)

MIA is the 15th busiest airport in the United States and ranks third in international passenger travel. Each year, MIA serves nearly 29.6 million passengers. The terminal includes eight concourses with 107 gates. Fifty-two commercial and commuter airlines operate out of the airport.

Approximately 171 full- and part-time screeners are employed by TSA at MIA. Approximately 80% of all passenger bags are screened in the checked bag area adjacent to the various ramps serving the aircraft. The remaining 20% are screened at the passenger terminal area.

Washington-Dulles International Airport (IAD)

Built to accommodate up to six million passengers per year, IAD began operations in 1962. The first expansion was completed in November 1977 with the widening of the jet parking ramp. In 1982, new passenger waiting areas were added to the upper level, and a new baggage make-up area was added to the lower level. Midfield Concourses C and D, five cargo buildings, a hotel located on airport property, and economy parking lots were added through the 1980s. The main terminal was expanded in 1996. In 1998, the first permanent concourse was completed, and a concourse for regional aircraft opened in 1999. Today, IAD serves more than 55,000 passengers a day and nearly 20 million passengers a year via 38 airlines.

Approximately 120 full- and part-time screeners work for TSA at IAD. Full-time employees work an 8-hour shift and part-time employees work a 4-hour shift. During the 2 days NIOSH conducted air sampling, IAD screened approximately 50,000 checked passenger bags. The baggage area was originally designed as a location for airline employees to pick up and drop off checked passenger bags using tugs.

Baltimore-Washington International Airport (BWI)

BWI began operations in 1950 and is currently operated by the Maryland Aviation Administration, part of the Maryland Department of Transportation. The airport covers approximately 3600 acres and accommodates domestic and international flights. The passenger terminal covers 1.4 million square feet, has 69 gates, and consists of 4 concourses. BWI services 55 carriers and averages 648 flights per day. In 2003, approximately 54,000 passengers were processed each day. The largest carrier at the airport is Southwest Airlines. BWI is considered the 24th busiest airport in North America (based on annual passenger load). Approximately 241 full- and part-time baggage screeners employed by TSA work at BWI.

METHODS

Upon receipt of the HHE requests, additional information regarding suspected environmental contaminants was obtained from the TSA Occupational Safety and Health manager at the TSA headquarters in Washington, DC and from TSA management at each airport. During the initial site visits NIOSH investigators obtained an overview of the operation and layout of the baggage screening areas and developed the environmental monitoring strategy.

Diesel Exhaust (Elemental Carbon)

Full-shift PBZ air samples for elemental carbon (EC), a surrogate for diesel exhaust particulate, were collected on 37-millimeter quartz fiber filters (closed face) using SKC® AirChek® 2000 sampling pumps. We monitored a total of 72 screeners among the four airports. Flow rates of approximately 2.5 liters per minute (Lpm) were used to obtain the samples. The sampling pumps were calibrated before and after each sampling event against a primary standard (BIOS® Dry-Cal) to verify flow rate. The filters were placed in the workers' breathing zone and connected via Tygon® tubing to the sampling pump. Screeners wore the sampling pump and filter for the entire work shift; after collection the samples were analyzed in accordance with NIOSH Method 5040.[2] With this technique, a representative punch-out of the filter is heated and analyzed for EC using a thermal optical analyzer.

Nitrogen Dioxide (NO_2) and Nitric Oxide (NO)

Full-shift PBZ air samples for NO_2 and NO were collected on sorbent tubes containing oxidizer plus a triethanolamine-treated molecular sieve in tandem using SKC® Pocket Pumps®. We monitored a total of 40 screeners among the four airports. In addition to the PBZ samples, 21 general area air samples were collected. Flow rates of approximately 0.050 Lpm and 0.20 Lpm were used to collect the PBZ and general area air samples, respectively. Each sampling pump was calibrated before and after each sampling event against a primary standard (BIOS® Dry Cal) to verify flow rate. The sorbent tubes were placed in the workers' breathing zone and connected via Tygon® tubing to the sampling pump. Screeners wore the sampling pump and filter for the entire work shift. After collection, the samples were analyzed in accordance with NIOSH Method 6014.[2]

In addition to sorbent tube sampling, NO_2 concentrations were measured using the Biosystems Toxilog Ultra®, a direct reading instrument equipped with electrochemical sensors that log average exposures, maximum 15-minute short-term exposures, and maximum peak exposures. These instruments were operated in a passive diffusion mode with a 30-second sampling interval. They were clipped to the belt of 23 screeners for personal monitoring and worn for the entire work shift. Stored data were downloaded to a laptop computer after sampling. Calibration of these monitors was accomplished before and after sampling according to the manufacturer's specifications.

Carbon Monoxide (CO)

Carbon monoxide exposures were evaluated using two instrumentation types: the Biosystems Toxilog Ultra® and the Q-TRAK® Plus indoor air quality (IAQ) monitor model 8552/8554. The Toxilog Ultra® is a real-time, data-logging, passive CO monitor that logs average exposures, maximum 15-minute short-term exposures, and maximum peak exposures. These instruments were operated in a passive diffusion mode with a 30-second sampling interval. We collected a total of 61 full-shift personal samples by attaching the instrument to each worker's belt.

The Q-TRAK® device measures CO in real-time, and measurements were taken throughout the baggage areas during the work shift. Instrument calibration for both the Toxilog Ultra® and the Q-TRAK® was completed according to the manufacturer's recommendations.

Volatile Organic Compounds (VOCs)

To screen for VOCs, we collected a total of 20 general area air samples within the baggage screening areas across all four airports using thermal desorption (TD) tubes attached by Tygon® tubing to SKC® Pocket Pumps® calibrated at a flow rate of 0.05 Lpm. The tubes contain three beds of sorbent material (a front layer of Carbopack Y™, a middle layer of Carbopack B™, and a back section of Carboxen 1003™). They are qualitatively analyzed with a Perkin-Elmer ATD 400 automatic thermal desorption system interfaced directly to an HP5890A gas chromatograph with an HP5970 mass selective detector according to NIOSH Method 2549.[2]

To analyze specific VOCs, (based on the results of the TD samples), full-shift general area air samples were simultaneously collected on charcoal tubes attached by Tygon® tubing to SKC® Pocket Pumps® calibrated at a flow rate of 0.2 Lpm. The charcoal tubes were quantitatively analyzed for isopropanol, benzene, toluene, xylenes, trimethylbenzenes, total low molecular weight hydrocarbons (hydrocarbons eluting before toluene), and total high molecular weight hydrocarbons (hydrocarbons eluting after toluene) using a Hewlett-Packard model 5890A gas chromatograph equipped with a flame ionization detector according to NIOSH Methods 1300, 1400, 1501, and 1550 with modifications.[2]

Tailpipe Emissions

A random spot check of tailpipe emissions from gasoline-powered tugs operating at MIA and IAD was performed using a GasLink LT™ Emissions analyzer. This instrument measures hydrocarbons (HC), CO, CO_2, and oxides of nitrogen (NOx) in real time. As they operated gasoline-powered tugs in the traffic lanes of the various screening areas, drivers were asked to stop momentarily while emissions from the idling tug were measured and recorded.

Noise

TSA employees were asked at the beginning of their work shift to wear noise monitoring devices on each of the 2 days of sampling at each airport. The employees wore the devices for the entire work shift, through lunch and breaks. Area noise measurements were taken around EDS screening machines in the areas where employees worked and in a tunnel from the Southeast baggage basement area at IAD that led up to the tarmac.

Quest® Electronics Model Q-300 Noise Dosimeters were used to collect the daily noise exposure measurements from participating employees. The Quest dosimeters collect data so that one can directly compare the information with the three different noise criteria used in this survey, the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) and Action Level (AL), and the NIOSH Recommended Exposure Limit (REL). The dosimeter was secured on the workers' belts and the dosimeter's microphone attached to their shirts, halfway between the collar and the point of the shoulder. A windscreen provided by the dosimeter manufacturer was placed over the microphone during recordings. After data collection, the noise information was downloaded to a personal computer for interpretation with QuestSuite® Professional computer software and the dosimeters were reset for the next day. The dosimeters were calibrated before and after the work shift according to the manufacturer's instructions.

The spectral area noise measurements were made with a Larson-Davis Laboratory Model 2800 Real-Time Analyzer and a Larson-Davis Laboratory Model 2559 ½-inch random incidence response microphone. The analyzer allows for the analysis of noise into its spectral components in a real-time mode. The ½-inch-diameter microphone's frequency response range (± 2 decibels [dB]) from 4 Hertz (Hz) to 21 kilohertz (kHz) allows for the analysis of sounds in the region of concern. One-third octave bands, consisting of center frequencies from 25 Hz to 20 kHz, were integrated for 30 seconds and stored in the analyzer for later analysis for the baggage screening areas. Because of the shorter nature of the noise exposure in the tunnel at IAD, the analyzer was set at a 10-second integration period for these measurements. The analyzer was placed on a tripod with the microphone located at ear level for a standing employee in each tested area.

Workplace Observations

Environmental control of the baggage screening areas we surveyed relies mainly on mechanical dilution ventilation. All four airports utilized pedestal-type fans in the screening areas to provide worker comfort during periods of elevated temperatures. The ventilation system at PBI consisted of a series of ducts containing internal fans that drew air from ground level near the screening areas and discharged it outside. The baggage screening area was partially enclosed with one side open to the tarmac. The ventilation systems used at the screening areas at MIA consisted of numerous overhead ducts with internal fans to move the air and exhaust it outside. Visual inspection of the systems at MIA revealed crushed ducts and inoperable fans. These physical conditions varied in severity from terminal to terminal (some ducts were dented, while others were severely crushed, collapsed, or separated from adjacent ducts). Given the damaged condition of the various ventilation systems within the baggage screening areas at MIA, their functionality and effectiveness remains unknown. The ventilation system at BWI was similar to those at PBI and MIA in that it utilized general dilution ventilation controlled thermostatically. The majority of air movement was achieved through ducts, fans, intakes, and exhaust vents.

At IAD, a unique ventilation system was in use. All baggage screening areas utilized a general dilution ventilation system remotely controlled by a computerized CO sensor system. As CO levels rise from approximately 2–3 ppm, variable speed blowers activate and increase the volumetric flow rate of the entire system until 15 ppm is reached, at which time the fans run at 100% capacity.

Vinyl gloves were available to all employees. Isopropanol was the only chemical used by screeners to periodically clean the table tops where manual bag inspection and ETD processing occurred. No formal written hearing protection program was in place at any of the four airports surveyed. However, hearing protection (disposable foam ear plugs) was available at PBI, MIA, and IAD.

In general, housekeeping in the screening and ramp areas was poor. Many areas were cluttered, creating a trip hazard. Oil leaking from tugs may increase the possibility of a worker slipping and falling. Cracks in the concrete floors and uneven walking surfaces also created a trip hazard for employees. In addition, tugs pulled empty metal carts over cracks in the floor, resulting in “cart bounce,” which created unnecessary noise. Other unnecessary noise emanated from stationary sources such as squeaking conveyor systems and audible alarms triggered by bag jams on conveyors. If the jam was not attended to promptly, the alarm continued sounding, exposing all screeners to the noise.

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 criteria. 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 RELs,[3] (2) the American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the OSHA PELs.[5] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

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 91-596, 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 its 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 STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Diesel Exhaust (Elemental Carbon)

Diesel engines function by combusting liquid fuel without spark ignition. A mixture of air and fuel is introduced into the combustion chamber, and ignition is accomplished by the heat of compression. The emissions from diesel engines consist of a complex mixture that includes gaseous and particulate fractions. The composition of the mixture varies greatly with fuel and engine type, load cycle, maintenance, tuning, and exhaust gas treatment. The gaseous constituents include carbon dioxide, sulfur dioxide (SO_2), CO, NO, NO_2, and VOCs (e.g., ethylene, formaldehyde, methane, benzene, phenol, acrolein, and polynuclear aromatic hydrocarbons).[6,7,8,9] The particulate fraction (soot) is composed of solid carbon cores, produced during the combustion process, which tend to combine to form chains of particles or aggregates. The largest of these are in the respirable range (more than 95% are less than 1 micron in size).[10] Estimates indicate that as many as 18,000 different substances resulting from the combustion process may be adsorbed onto these particulates.[11] The adsorbed material contains 15%–65% of the total particulate mass and includes compounds such as polynuclear aromatic hydrocarbons, a number of which are known mutagens and carcinogens.[4,5,12,13]

Many of the individual components of diesel exhaust are known to have toxic effects, including: (1) pulmonary irritation from oxides of nitrogen; (2) irritation of the eyes and mucous membranes from SO_2, phenol, sulfuric acid, sulfate aerosols, and acrolein; and (3) cancer in animals from polynuclear aromatic hydrocarbons. Several studies confirm an association between exposure to whole diesel exhaust and lung cancer in rats and mice.[5] Limited epidemiological evidence suggests an association between occupational exposure to diesel exhaust emissions and lung cancer in humans.[14] The agreement of current toxicological and epidemiological evidence led NIOSH in 1988 to recommend regarding whole diesel exhaust as a "potential occupational carcinogen," as defined in the OSHA's Cancer Policy ("Identification, Classification, and Regulation of Potential Occupational Carcinogens," 29 CFR 1990).[5] Accordingly, NIOSH recommends controlling exposures to the lowest feasible concentration. Although OSHA and ACGIH have exposure limits for some of the individual components of diesel exhaust (i.e., NO_2, xylene, and CO), no exposure limits have been established for whole diesel exhaust. The California Department of Health Services Hazard Evaluation System & Information Service (HESIS) recommends keeping exposures to diesel exhaust particles (measured as EC) below 20 micrograms per cubic meter ($\mu g/m^3$). This value was based on a risk assessment performed by the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment that determined exposures to diesel particulate over a working lifetime of 20 $\mu g/m^3$

would create an excess lung cancer risk of one in a thousand.[15]

Nitrogen Dioxide (NO_2)

Nitrogen dioxide gas is an irritant to the mucous membranes; inhalation may cause severe coughing, possibly accompanied by mild or transient headache. The following health effects were observed in humans exposed to NO_2 for 60 minutes: at 100 parts per million (ppm), pulmonary edema and death; at 50 ppm, pulmonary edema with possible subacute or chronic lesions in the lungs; and, at 25 ppm, respiratory irritation and chest pain.[16,17] The effects of chronic low exposures are not well characterized in humans, but NO_2 would be expected to have an irritant effect upon the general mucosal surfaces and on the lower respiratory tract.[16] Chronic exposures to 0.2 ppm with daily excursions to 0.8 ppm in mice caused decreased pulmonary function. This gas has not been shown to have teratogenic, mutagenic, or directly carcinogenic effects.[17] The NIOSH REL for NO_2 is 1 ppm as a 15-minute STEL.[3] The OSHA ceiling concentration is 5 ppm.[5] The ACGIH TLV-TWA is 3 ppm and the TLV-STEL is 5 ppm.[4]

Nitric Oxide (NO)

Nitric oxide, a colorless gas, converts spontaneously in air to NO_2. The oxidation rate occurs more rapidly at higher NO concentrations.[18] Therefore, it is difficult to identify the effects of NO exposures without considering the concomitant effects of NO_2. NO is a component of photochemical smog with ambient air concentrations reaching as high as 2.65 ppm.[19] The most common occupational exposures to NO occur when it is formed as a byproduct in the preparation of nitrosylcarbonyls and nitric acid, tobacco smoke, and from combustion of propane, diesel, and gasoline engines.[16] In humans exposed to NO between 10 ppm and 40 ppm, significant lung vasodilation effects were observed.[17] A comparative analysis of inhaled and exhaled breath in humans after exposure to NO at concentrations of 5, 1, 0.5, and 0.33 ppm showed 85% to 93% retention in the body.[18] Animal studies indicate that NO has an affinity for ferrous hemoglobin, which normally transports oxygen in the blood. The two substances react to form nitrosyl hemoglobin, a compound incapable of oxygen transport.[18] This toxic action resembles that of CO. Exposures to mice to 5000 ppm for 6 to 8 minutes and to 2500 ppm for 12 minutes were lethal.[17] Both NIOSH and OSHA have established a TWA exposure criterion of 25 ppm for NO.

Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials such as gasoline or propane fuel. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea; symptoms advance to vomiting, loss of consciousness, and collapse with prolonged or high exposures. If the exposure level is high, loss of consciousness may occur without other symptoms. Coma or death may occur if high exposures continue.[4,17,20,21,22,23] The display of symptoms varies widely from individual to individual, and may occur sooner in susceptible individuals such as young or aged people, people with preexisting lung or heart disease, or those living at high altitudes.

The NIOSH REL for CO is 35 ppm for an 8-hour TWA exposure, with a ceiling limit of 200 ppm that should not be exceeded.[18,20] The ACGIH recommends an 8-hour TWA TLV of 25 ppm.[4] The OSHA PEL for CO is 50 ppm for an 8-hour TWA exposure.[5] The immediately dangerous to life or health concentration (IDLH) is 1200 ppm. The IDLH exposure condition "poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment."[24]

Volatile Organic Compounds (VOCs)

This is a large class of organic chemicals (i.e., containing carbon) that have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. VOCs are emitted in varying concentrations from numerous indoor sources including carpeting, fabrics, adhesives, resins, solvents, paints, cleaners, waxes, cigarettes, and combustion sources.

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.[25] 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 20,000 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 higher frequency components.[26]

The A-weighted decibel (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 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. It should be noted that 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)[27] 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. 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: Dose = 100 X $(C_1/T_1 + C_2/T_2 + ... + C_n/T_n)$, where C_n indicates the total time of exposure at a specific noise level and T_n indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, workers are allowed up to 100% of their daily noise dose. Doses greater than 100% exceed the OSHA PEL.

The OSHA regulation has an action level (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 (in its Criteria for a Recommended Standard,[28]) and the ACGIH[4] propose exposure criteria of 85 dBA as a TWA for 8 hours, 5 dB less than the OSHA standard. These criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, 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. According to the NIOSH REL, 12-hour exposures must be 83 dBA or less.

RESULTS

Air Sampling Results

The air sampling results for diesel exhaust (EC) are shown in Table 1. A total of 72 PBZ air samples were collected in various baggage screening areas at the four airports. Concentrations ranged from 1 µg/m^3 to 26 µg/m^3 with an average concentration of 11 µg/m^3. Four samples exceeded 20 µg/m^3 (three samples collected at IAD [22, 25, 26 µg/m^3] and one at BWI [24 µg/m^3]). The range of average air concentrations was relatively narrow (6 µg/m^3 to 14 µg/m^3). The highest average EC concentration occurred at IAD, while the lowest occurred at PBI.

The air sampling results for NO and NO_2 appear in Table 2. We collected a total of 40 PBZ samples; average values for PBZ NO concentrations measured at MIA, IAD, and BWI were "trace" (defined as between 0.03 ppm and 0.7 ppm). These values correspond to the MDC and the MQC. "Trace" concentrations of NO_2 were also measured at these airports (between 0.02 ppm [MDC] and 0.8 ppm [MQC]). Concentrations of NO and NO_2 were "not detectable" at PBI (defined as below 0.15 ppm [MDC]). The highest NO measurement obtained from all PBZ samples occurred in the Southeast baggage basement at IAD (0.38 ppm). The highest NO_2 measurement obtained was 0.33 ppm (MIA). None of the samples collected exceeded their respective 8-hour TWA occupational exposure limit (25 ppm for NO; 3 ppm for NO_2). We collected a total of 21 general area air samples for NO and NO_2 in the center of the screening areas; values for both compounds were either "none detected" (value was less than the MDC of 0.01 ppm) or "trace" (value was between the MDC and the MQC of 0.4 ppm and 0.6 ppm, respectively).

Air sampling exposure data for NO_2 collected using the Toxilog Ultra® device appear in Table 3. We measured a total of 23 full-shift TWA and 15-minute short-term exposures to NO_2 with the Toxilog Ultra® device. Average TWA exposures were non-detectable. The short-term exposure levels ranged from zero ppm to 0.2 ppm (MIA). Average instantaneous peak concentrations ranged from 0.4 ppm to 1.7 ppm.

We collected a total of 61 full-shift TWA exposures to CO using the Toxilog Ultra® device (Table 4). The average exposure across all airports was 3 ppm, with a range of 0.6 ppm (BWI) to 5.3 ppm (MIA). Average 15-minute short-term exposures ranged from 1 ppm to 16 ppm with a range of 3 ppm to 32 ppm. Average instantaneous peak exposures ranged from 37 ppm to 106 ppm.

The dominant VOCs qualitatively identified on the TD tubes and subsequently analyzed quantitatively via charcoal tubes included isopropyl alcohol, toluene, and total low molecular weight hydrocarbons. We collected 20 air samples across the four airports. Values for isopropyl alcohol ranged from "none detected" (less than the MDC of 0.1 mg/m^3) to 0.76 mg/m^3. Values for toluene ranged from "none detected" (less than the MDC of 0.02 mg/m^3) to 0.17 mg/m^3. Values for total low molecular weight hydrocarbons ranged from "none detected" (less than the MDC of 0.1 mg/m^3) to 1.1 mg/m^3. A summary of the data collected for these compounds appears in Table 5.

Tug Emissions

As gasoline-powered tugs operated in the traffic lanes of the baggage screening areas, drivers were asked to stop momentarily while emissions from the idling tug were measured and recorded. We evaluated 13 tugs (five at MIA; eight at IAD). Across the two airports, HC concentrations ranged from 20 ppm to 1700 ppm. CO values ranged from 0.04% (400 ppm) to 8.7% (87,000 ppm) while NOx values ranged from zero ppm to 52 ppm. For comparison, the highest general area air concentrations of HC, CO, and NO_x were 90 ppm, zero percent, and zero ppm, respectively for MIA (air was sampled when no tugs were present). For IAD, the general area air concentrations of HC, CO, and NO_x were 70 ppm, 0%, and 0 ppm, respectively. The majority of the tugs ran roughly and had an unstable idle. One particular tug operating in the West baggage screening area of IAD emitted heavy black soot that deposited on the analyzer's probe. This tug also emitted a strong odor that was irritating to the eyes, nose and throat of the emission analyzer operator. Diesel-powered tug emissions were not evaluated during this survey because the instrument can only operate accurately with a single sensor designed to detect emissions from a specific type of engine (i.e., gasoline only, diesel only, etc.) Sensors specific to diesel engines were not used because they must be installed and calibrated by the manufacturer. Data collected during the gasoline-powered tug spot measurements appear in Table 6.

Instantaneous environmental measurements for carbon dioxide, CO, temperature, and relative humidity were collected using the Q-TRAK® direct-reading instrument. A summary of all measurements, grouped by airport, appears in Table 7.

Noise

A total of 56 TSA screeners wore noise dosimeters for their work shift. The screeners were generally assigned to one screening machine, although a few employees worked in two areas during their shift. The noise "percent dose" results are summarized and presented as averages and ranges in Table 8. The data are categorized according to two different noise criteria: the OSHA PEL and the NIOSH REL. The OSHA criteria use a 90 dBA criterion and 5-dB exchange rate for the PEL. The NIOSH criterion differs from OSHA in that the criterion is 85 dBA, the threshold is 80 dBA, and it uses a 3-dB exchange rate.

The median 8-hr OSHA PEL (percent dose) ranged from 1.9% (BWI) to 5.5% (MIA) with an all-airport median of 3.3%. The median 8-hr NIOSH REL (percent dose) ranged from 37% (BWI) to 89% (MIA) with an all-airport median of 60%. When the dosimeter data were compared to the OSHA PEL, no worker's dose exceeded the criterion. However, when the dosimeter data were compared to the NIOSH REL, all airports had at least one worker whose dose exceeded the criterion. In two instances the OSHA AL was exceeded (one screener at PBI; one screener at IAD).

Workplace Information

Environmental control for all baggage screening areas was accomplished mainly by mechanical, general dilution ventilation systems (via duct-mounted fans and discharge vents), although some airports (PBI, MIA) also relied on natural ventilation via prevailing winds. The baggage screening area at PBI is enclosed on three sides and opens to the tarmac. The baggage screening areas at MIA are mostly enclosed and located underneath the various terminals. The mechanical ventilation system at MIA was visibly damaged; its operational condition is unknown. At BWI, each baggage screening area was mostly enclosed, with openings to the outside environment via garage-type doorways. Depending on weather, these doors could be opened to provide additional natural ventilation.

IAD used a unique ventilation system. This system is remotely controlled by a computerized CO sensor system that utilizes 100% outside make-up air to ventilate the baggage screening areas. According to design, as CO levels rise, fans connected to a series of ducts begin to run at increasing speeds until the CO levels attain a concentration of 15 ppm. At that time the fans run at 100% of their maximum volumetric flow rate (approximately 27,000 cubic feet per minute [CFM]). This fan/duct configuration was also designed to keep the baggage basements under negative pressure relative to ambient pressure outdoors when the system is operating. Quarterly, airport maintenance staff used a direct-reading CO monitor to check CO sensors and calibrate them for accuracy. In one baggage screening area (East Baggage) the ventilation system consisted of intake vents mounted flush in the floor, covered with grating, and connected to duct work routed to an outside wall for discharge. However, many of the intake grates were obscured with debris, potentially reducing the efficiency and effectiveness of this system. In addition, some of the L3 machine condensate discharge lines drained into these floor-mounted intake vents, creating an environment conducive to mold/fungi growth and possibly contributing to contamination of the entire ventilation system.

The remaining three baggage screening areas at IAD utilized an outdoor air makeup inlet connected to a series of ceiling-mounted ducts with numerous discharge ports (vents) positioned along their length. No automatic CO sensors were noted for these systems. The operational efficiency and effectiveness of the mechanical ventilation systems were not evaluated. Additionally, each airport utilized large pedestal-type fans in each of the screening areas to provide some cooling relief to the workers when the ambient temperature and humidity increased.

Across airports and airlines, a variety of tugs and fuels are used (gasoline, diesel, propane, electricity). While we were unsuccessful in obtaining tug maintenance schedules and operating guidelines from the airlines, we observed that tugs were frequently left idling near TSA screeners while airline employees loaded and unloaded bags. Employees also reported that during cold weather, some tugs were started inside the baggage screening areas and allowed to run for extended periods of time while warming up. Finally, TSA employees reported that airline employees were more likely than usual to turn off tugs during our surveys.

In general, housekeeping in the baggage screening areas was poor across all the airports we studied. Some areas were cluttered with items that not only created a trip hazard, but often partially obscured the floor-mounted intake vents (IAD-East Baggage). Cracks in floors and uneven walking surfaces also created a trip hazard for employees. In addition, metal baggage carts pulled by tugs often passed over cracks in the concrete floor resulting in "cart bounce," which created unnecessary noise.

DISCUSSION

Air Contaminants

Of the 72 EC samples collected on TSA screeners, only four PBZ samples exceeded the California Department of Health Services (CDHS) Hazard Evaluation System and Information Service (HESIS) exposure limit recommendation of 20 $\mu g/m^3$ (IAD = 22, 25, 26 $\mu g/m^3$; BWI = 24 $\mu g/m^3$). In comparing the average EC values across airports, the range of data was relatively narrow. PBI had the lowest EC exposure (6 $\mu g/m^3$), while IAD had the highest (14 $\mu g/m^3$). Based on other NIOSH diesel exhaust studies[10], these EC levels are not unusually high. Exposure to diesel exhaust can vary depending on the presence or absence of diesel-powered tugs in the area and how the airlines operate and maintain their own tugs.

We collected a total of 40 PBZ samples each for NO_2 and NO across the four airports. Concentrations were well below their respective occupational exposure limits. For example, the single highest PBZ sample for NO (0.38 ppm collected at IAD) is still approximately 66 times less than the NIOSH REL. The highest PBZ sample for NO_2 was collected at MIA (0.33 ppm). Results from 21 general area air samples for NO and NO_2 were similar to the PBZ results, with IAD having the highest reading for NO (0.38 ppm) and for NO_2 (0.14 ppm).

Of the 61 full-shift CO samples, BWI had the lowest TWA exposure (0.6 ppm), while MIA had the highest (5.3 ppm). No TWA measurements exceeded the 8-hour TLV of 25 ppm or the NIOSH REL of 35 ppm. Peak exposures ranged from 2 ppm to 1150 ppm with an average of 65 ppm. The peak value of 1150 ppm, however, is considered suspect because the exposure occurred during the worker's lunch break, and results from other screeners in close proximity to this worker never exceeded 33 ppm. When the suspect value was removed from the data analysis, the average peak value was reduced to 27 ppm. None of the other measurements exceeded the OSHA ceiling limit of 200 ppm or approached the IDLH value of 1200 ppm. A total of 109 instantaneous general area CO concentrations were obtained at various times during each shift in the areas where TSA screeners worked (Table 7). The data collected via this method agreed with the Toxilog Ultra® instruments. Average CO readings ranged from 1.3 ppm to 9.7 ppm, with an overall average across airports of 4.1 ppm. BWI had the lowest average CO readings, while MIA had the highest.

Isopropanol is the only chemical used by TSA employees to periodically clean the table tops where manual bag inspection and ETD processing occurs. Vinyl gloves are available to all employees, and those who conducted internal bag inspections used them. Thermal desorption sampling for a variety of VOCs did not identify any unusual compounds, and concentrations of isopropanol, toluene, and low molecular weight hydrocarbons were well below any applicable occupational exposure limits (Table 5).

The tug exhaust emissions data (Table 6) indicate that most tugs ran poorly and emitted various levels of HC, CO and NO_x. IAD had two tugs that emitted more HC and CO than MIA's tugs, while NO_x concentrations were higher at MIA. Data from personal and general area air sampling do not show an inhalational hazard in the baggage screening areas. However, the potential exists for increased exposure to tug exhaust emissions if the tugs are not properly maintained or if properly maintained tugs do not procedurally operate under the same conditions encountered during the NIOSH survey (i.e., shut off tugs while loading/unloading). TSA management is working with the airlines on following manufacturer-recommended maintenance procedures for the tugs. During our surveys, airline employees were instructed to turn off the tug engines when loading/unloading baggage. This is important since TSA employees reported that airline employees often left the tugs idling while loading/unloading bags or when leaving the tug for short durations. Leaving the engine running unnecessarily contributes to increased emissions concentrations.

Environmental variables such as temperature, relative humidity, and CO_2 were similar across airports. The exception to this trend occurred at PBI, which was surveyed in April when the air temperatures were, on average, approximately 10°–14° cooler than the other three airports where surveys occurred during June and July (Table 7).

Ventilation

Baggage screening areas were mostly enclosed (except PBI), opening to the outside via a single doorway. Depending on the weather, screening areas may potentially be naturally ventilated. Although mechanical ventilation systems were present in the screening areas, one system (IAD) operated "on demand" when CO levels reached a specific set-point. This feature could potentially control CO and other tug emissions more effectively. The large pedestal-type fans in each screening area appeared to provide some cooling relief to the workers when the ambient temperature and humidity increased. However, the effectiveness of the pedestal-type fans in controlling airborne contaminants was not evaluated in this study.

IAD maintenance staff should address the issue of routing drain lines from the L3 machines to floor intake vents. By depositing water into the ventilation system the probability of creating an environment conducive to mold and fungus growth is high.

Noise

The daily noise exposures measured in the survey were less than the evaluation criteria. Overall, 21% of the doses that exceeded the NIOSH REL appeared to be the result of short-term, random events, such as contact between objects or dropping a hard container onto the concrete floor. No consistent pattern emerged in the short-term events in the data from multiple screeners when the data from the same area were reviewed over the same time period. This implies that these were localized events that did not affect the entire area. No employee dose exceeded the OSHA PEL, however, two screeners' doses exceeded the OSHA AL (one screener at PBI; one screener at IAD). There were deficiencies in airport facilities, such as cracks in flooring along with baggage conveyor equipment that was not working properly which led to excessive noise generation in these areas. No formal written hearing protection program is in place at any of the airports studied, and very few TSA employees were observed wearing hearing protection devices (HPDs).

CONCLUSIONS

An inhalational hazard from tug exhaust emissions did not exist at the time of the NIOSH visits. However, air contaminant concentrations may vary due to a number of factors. For example, dilution ventilation, and the use of pedestal-type fans can affect the air quality. Also, contaminant exposures could increase if tugs are not properly maintained, sit in idle mode for extended periods of time, or if tug traffic increases. Weather conditions may also affect contaminant concentrations. Thus, even though the contaminant levels were below relevant occupational exposure limits at the time of this survey, it is important to continue to work with the airlines to ensure that tugs are maintained according to standard operating procedures. This includes routine maintenance such as engine tune-ups, air filter changes, and oil/oil filter changes.

Generally, the noise exposures to which TSA employees are subjected during their work activities do not pose a serious risk for occupational noise-induced hearing loss. However, some TSA employees asked about the type of HPDs they might wear in their work area. As stated earlier, most of the surveyed baggage screening areas were not loud enough to warrant using HPDs to protect workers' hearing from occupational noise. Because of vehicle traffic in the baggage screening areas and the need to communicate with other employees, some HPDs could actually overprotect workers and lead to a loss of important auditory signals that workers need to perform their jobs. If workers choose to wear HPDs, TSA should educate their employees about the availability of flat spectrum, moderate attenuation devices, sometimes referred to as "musician earplugs." TSA management should also stress that the noise environments are not loud enough to necessitate using HPDs to reduce the risk of occupational noise-induced hearing loss in their employees. According to the NIOSH criteria document for occupational noise, whenever employees use HPDs, medical surveillance such as audiometric testing should be available to assure the employer of proper HPD function.[29] This should not encourage TSA to prohibit employees from voluntary hearing protection use in areas where noise exposures are at or near the NIOSH REL. Rather, it states that audiometric testing is advisable to ensure that employees are not showing changes in their hearing profiles over time. A mechanism is needed for employees to report perceived increases in noise levels in their work areas. Noise measurement surveys should be conducted if a consistent concern is expressed by the TSA workers.

RECOMMENDATIONS

1. Perform additional employee noise exposure measurements in the areas where the NIOSH survey found levels that approached or exceeded the REL evaluation criteria. If the criteria are consistently exceeded, then TSA management should implement a hearing conservation program that meets the OSHA requirements for employees working in this area.[27]

2. Develop a procedure for employees to report changes in their work environment to TSA management. The report should trigger an appropriate response to the perceived hazard. These results should then be communicated back to the affected employees in a timely manner.

3. Improve housekeeping in all screening areas.

4. Place signs in tug driving lanes to remind operators to shut off the engine when loading/unloading baggage.

5. Remove debris or other material blocking ventilation openings, especially in the East baggage screening area at IAD. Blocked or obscured intake vents diminish the overall efficiency and effectiveness of the entire ventilation system.

6. Create a procedure for employees to report changes in their work environment that result in loud or annoying noise exposures. The reporting mechanism should identify any loud baggage-handling machinery and ultimately lead to repairs that reduce or eliminate unnecessary noise.

7. Redirect the L3 machine cooling condensate lines at IAD so they do not drain into the floor-mounted intake vents. This practice encourages mold/fungi growth that could contaminate the entire ventilation system.

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Table 1
TSA – Four Airports
Personal Breathing Zone (PBZ) Diesel Exhaust (Elemental Carbon) Results (μg/m^3)

Location	Number of Samples	Mean	Std. Dev.	Minimum	Maximum
PBI	16	5.9	2.5	1.0	11
MIA	13	12	3.9	5.9	19
IAD	24	14	5.6	3.2	26
BWI	19	11	4.7	4.0	24
All Airports	**72**	**11**	**5.4**	**1**	**26**

MDC = Minimum Detectable Concentration (0.5 μg/m^3)
MQC = Minimum Quantifiable Concentration (0.9 μg/m^3)
μg/m^3 = micrograms per cubic meter of air
PBI = Palm Beach International Airport
MIA = Miami International Airport
IAD = Washington-Dulles International Airport
BWI = Baltimore-Washington International Airport

Table 2
TSA – Four Airports
Personal Breathing Zone (PBZ) and General Area Air Sample Results
Nitric Oxide (NO) and Nitrogen Dioxide (NO_2)

PBZ Samples

		Nitric Oxide (ppm)				Nitrogen Dioxide (ppm)			
Airport Code	**Number of Samples**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
PBI	8	ND	N/A	N/A	N/A	ND	N/A	N/A	N/A
MIA	13	0.08(Trace)	0.05	0.05(Trace)	0.16(Trace)	0.15(Trace)	0.10	0.05(Trace)	0.33(Trace)
IAD	10	0.17(Trace)	0.09	0.03(Trace)	0.38(Trace)	0.10(Trace)	0.02	0.07(Trace)	0.13(Trace)
BWI	9	0.11(Trace)	0.05	0.05(Trace)	0.19(Trace)	0.04(Trace)	0.01	0.03(Trace)	0.06(Trace)
All Airports	**40**	**0.13**(Trace)	**0.07**	**0.03**(Trace)	**0.38**(Trace)	**0.12(Trace)**	**0.07**	**0.03**(Trace)	**0.33**(Trace)
	MDC	0.03				0.02			
	MQC	0.65				0.81			

ND = None detected (value was < 0.15 ppm)
Trace = Value was found to be between the MDC and the MQC
ppm = parts per million
Nitric Oxide – NIOSH REL = 25 ppm
Nitrogen Dioxide – NIOSH REL = 3 ppm

General Area Air Samples

		Nitric Oxide (ppm)				Nitrogen Dioxide (ppm)			
Airport Code	**Number of Samples**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
PBI	2	ND	ND	ND	ND	ND	ND	ND	ND
MIA	1	0.10(Trace)	N/A	N/A	N/A	0.12(Trace)	N/A	N/A	N/A
IAD	9	0.18(Trace)	0.12	0.07(Trace)	0.38	0.09(Trace)	0.04	0.03(Trace)	0.14(Trace)
BWI	9	0.07(Trace)	0.05	0.01(Trace)	0.13(Trace)	0.04(Trace)	0.01	0.03(Trace)	0.06(Trace)
All Airports	21	0.13(Trace)	0.10	0.01(Trace)	0.38	0.07(Trace)	0.04	0.03(Trace)	0.15(Trace)
	MDC	0.01				0.01			
	MQC	0.37				0.59			

ND = None detected (value was < MDC)
Trace = Value was found to be between the MDC and the MQC
ppm = parts per million

Table 3
TSA – Four Airports
Nitrogen Dioxide (NO_2) Toxilog Ultra® Results (ppm)

		TWA				STEL				Peak			
Airport Code	**Number of Measurements**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
PBI	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.1	1.5
MIA	6	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.4	1.2	1.8	0.2	4.9
IAD	6	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.6	0.3	0.2	1.0
BWI	6	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	1.7	1.5	0.3	4.4
All Airports	23	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.4	1.0	1.3	0.1	4.9

TWA = Time-Weighted Average = average airborne concentration of a substance during a normal 8- to 10-hour workday
STEL = Short-term exposure limit = 15-minute TWA exposure
Peak = Highest measured concentration during the work day
NIOSH REL = 3 parts per million (ppm)

Table 4
TSA – Four Airports
Carbon Monoxide (CO) Toxilog Ultra® Results (ppm)

		TWA (ppm)				STEL (ppm)				Peak (ppm)			
Airport Code	**No. of Measurements**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
PBI	14	1.0	3.2	0.0	12.0	1.1	1.6	0.0	6.0	106.2	300.7	16.0	1150.0
MIA	17	5.3	1.8	2.0	7.0	16.2	6.5	5.0	32.0	64.2	71.8	10.0	333.0
IAD	16	3.4	2.5	1.0	8.0	5.0	4.8	0.0	19.0	36.9	42.1	6.0	176.0
BWI	14	0.6	0.6	0.0	2.0	0.7	1.1	0.0	3.0	58.6	68.0	2.0	221.0
All Airports	61	2.7	2.9	0.0	12.0	6.2	7.7	0.0	32.0	65.4	151.8	2.0	1150.0

ppm = parts per million
TWA = Time-Weighted Average = average airborne concentration of a substance during a normal 8- to 10-hour workday
STEL = Short-term exposure limit= 15-minute TWA exposure
Peak = Highest measured concentrations during the work day
NIOSH REL = 35 ppm

Table 5
TSA – Four Airports
Volatile Organic Compounds – General Area Air Samples (mg/m^3)

Airport Code	Isopropanol	Toluene	Total Low Hydrocarbons
PBI	1.38	ND	ND
PBI	0.56	ND	ND
PBI	0.16 (Trace)	ND	ND
PBI	0.08 (Trace)	ND	ND
MIA	0.85	0.09	ND
MIA	0.35 (Trace)	0.07	ND
MIA	0.27 (Trace)	0.06	ND
MIA	0.43 (Trace)	0.12	ND
IAD	0.33 (Trace)	0.08	0.33 (Trace)
IAD	0.28 (Trace)	0.11	0.37 (Trace)
IAD	ND	0.05	ND
IAD	ND	0.07	ND
IAD	0.76	0.17	1.09
IAD	0.19 (Trace)	0.04 (Trace)	ND
BWI	0.57	0.06	ND
BWI	0.25 (Trace)	0.13	ND
BWI	0.82	0.06	ND
BWI	0.59	0.06	ND
BWI	0.55	0.02 (Trace)	ND
BWI	0.20 (Trace)	0.02 (Trace)	ND

MDC =	0.1 mg/m^3	0.02 mg/m^3	0.1 mg/m^3
MQC =	0.5 mg/m^3	0.05 mg/m^3	0.5 mg/m^3

ND = None detected (Value was below the MDC)
mg/m^3 = milligrams per cubic meter
Trace = Value was found to be between the MDC and the MQC

Table 6
TSA – Four Airports
Gasoline-powered Tug Tailpipe Emissions

Airport Code	Time	Tug ID	Location	HC (ppm)	CO (%)	NO_x (ppm)	Comments
MIA	6:40 AM	BTT-214	Area 62	95	0	0	Near gas tug exhaust
MIA	6:30 AM		Area 62	90	0	0	Ambient air
MIA	2:00 PM	Evergreen Eagle	Ramp A	26	0.04	52	Near gas tug exhaust
MIA	2:40 PM	3516 ASIG	Ramp A	140	0.13	20	Near propane tug exhaust
MIA	6:40 PM		Ramp A	70	0	0	Ambient air
IAD	9:25 AM	19859 AA	West Baggage	1600	8.65	0	Heavy black soot deposits on probe, Driver reports unit running poorly, strong odor, burning sensation in nose, throat and eyes
IAD	9:35 AM	14343 NW	West Baggage	77	2	3	Engine runs smoother than previous tug # 19859 AA
IAD	10:00 AM	80306 AA	West Baggage	570	0.62	1	
IAD	10:07 AM	380 Swiss	West Baggage	20	0.11	9	
IAD	4:55 PM	DHTD57	Southeast Baggage	442	0.09	7	Engine has audible "miss," runs rough at idle
IAD	4:57 PM	DHTD12	Southeast Baggage	640	0.05	0	Engine has audible "miss", runs rough at idle
IAD	5:00 PM	DH155	Southeast Baggage	1700	0.04	0	Runs poorly, vacillating idle
IAD	5:04 PM	DHTD59	Southeast Baggage	645	0.68	0	Smoother idle than any tug tested this day in the SE bag area

ppm = parts per million CO = Carbon Monoxide
HC = Hydrocarbons NO_x = Oxides of Nitrogen

Table 7
TSA – Four Airports
Environmental Conditions in Baggage Screening Areas

	CO_2					CO					Temp (F)					Rel. Hum. (%)				
Airport Code	No. of Measurements	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum	No. of Measurements	Mean	Std. Dev.	Minimum	Maximum	No. of Measurements	Mean	Std. Dev.	Minimum	Maximum	No. of Measurements
PBI	15	377.1	9.3	358.0	390.0	5.0	9.2	0.5	39.0	18	73.1	1.8	71.2	75.2	4	47.5	1.5	46	49	3
MIA	11	401.7	43.8	349.0	494.0	9.7	6.9	3.0	28.0	11	87.5	3.0	82.4	91.6	11	58.9	3.4	53.0	62.0	11
IAD	35	485.3	77.7	412.0	725.0	4.6	3.1	0.4	10.2	44	85.3	3.8	80.6	90.5	34	59.4	11.5	42.6	75.0	34
BWI	34	416.2	58.4	170.0	529.0	1.3	1.5	0.0	7.1	36	83.1	3.4	73.8	88.9	34	45.4	5.6	36.2	56.3	34
All Airports	95	433.8	73.0	170.0	725.0	4.1	5.3	0.0	39.0	109	84.1	4.5	71.2	91.6	83	53.1	10.8	36.2	75.0	82

Rel. Hum. = Relative Humidity in Percent
Temp = Temperature in degrees Fahrenheit
CO = Carbon Monoxide
CO_2 = Carbon Dioxide
PBI = Palm Beach International Airport
MIA = Miami International Airport
IAD = Washington-Dulles International Airport
BWI = Baltimore-Washington International Airport

Table 8
TSA – Four Airports
Personal Noise Dosimeter Data Medians and Ranges (% Dose)

		Median (Range)	Median (Range)
Airport ID	**Number of Samples**	**8-hr OSHA PEL (% Dose)**	**8-hr NIOSH REL (% Dose)**
PBI	15	3.1% (0.4 – 40)	42% (22 – 351)
MIA	13	5.5% (1.7 – 11)	89% (58 –158)
IAD	16	3.4% (0.2 – 33)	50% (15 – 1187)
BWI	12	1.9% (0.2 – 12)	37% (17 – 203)
All Airports	56	3.3% (0.2 – 40)	60% (15 – 1187)

PBI = Palm Beach International Airport
MIA = Miami International Airport
IAD = Washington-Dulles International Airport
BWI = Baltimore-Washington International Airport

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