NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2000-0423-2858
Ogden Aviation Services
St. Louis, Missouri

August 2001

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

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

This report was prepared by Bradley King and Jeffery Heff of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by John McKernan. Analytical support was provided by DataChem Laboratories. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

NIOSH Publications Office
4676 Columbia Parkway
Cincinnati, Ohio 45226
800-356-4674

After this time, copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

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

Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Evaluation of Exposure to Jet Fuel and Aircraft Exhaust

This Health Hazard Evaluation was performed in response to a request from employees at Ogden Aviation Services located at Lambert-St. Louis International Airport in St. Louis, Missouri. There were concerns over possible central nervous system and respiratory health effects due to exposure to compounds in jet fuel as well as to aircraft exhaust.

What NIOSH Did

We took air samples to measure airborne concentrations of major jet fuel compounds such as benzene, toluene, and xylene.

We took air samples to measure carbon monoxide concentrations.

We interviewed workers about health problems that might be related to work.

We reviewed workplace illness and injury logs and health records.

What NIOSH Found

All employees' exposures were below the occupational exposure limits for the jet fuel compounds.

Workers refilling the gas-tank truck at the tank farm had the highest exposure.

All employees' exposures were below the full-shift exposure limits for carbon monoxide; for two employees, exposure exceeded the ceiling limit for carbon monoxide once during their shift.

What Ogden Aviation Services Managers Can Do

Make sure that the truck exhaust tube is used and/or the garage doors are fully opened when trucks are running in the maintenance garage.

Provide a more protective engineering control for refilling the gas-tank truck and ensure that the control is used during every refilling.

What the Ogden Aviation Services Employees Can Do

Wear proper personal protective equipment to protect your skin.

Wash areas of the body that come in contact with jet fuel as soon as possible.

Avoid the exhaust area of refueling and pump trucks as well as jet engines.

Report all potentially work-related health symptoms and concerns to appropriate Ogden health care personnel.

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 #2000-0423-2858

Health Hazard Evaluation Report 2000-0423-2858
Ogden Aviation Services
St. Louis, Missouri
August 2001

Bradley King
Jeffery E. Hess, M.D.

SUMMARY

In September of 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from employees at Ogden Aviation Services located at Lambert-St. Louis International Airport in St. Louis, Missouri. The employees expressed concerns that potential exposure to jet fuel and aircraft exhaust may be related to health symptoms such as headache and respiratory problems. On October 19, 2000, an initial site visit was performed by a NIOSH industrial hygienist and medical officer to conduct opening talks with management, union officials, and employees, as well as to observe the work area and practices. A return visit was completed December 11 and 12, 2000, during which quantitative sampling was performed for major compounds of the jet fuel, such as benzene, toluene, and xylene. Carbon monoxide (CO) exposure was also monitored. Confidential interviews with employees were held to discuss possible work-related health concerns.

Results of the personal breathing zone sampling for jet fuel compounds were below applicable exposure limits set by the Occupational Safety and Health Administration (OSHA). The same was true for the sampling conducted to determine full-shift CO exposures. Two individuals, however, each had one peak exposure above the NIOSH recommended ceiling limit for CO, most likely resulting from their proximity to exhaust from a running refueling truck.

Results of the confidential employee interviews and questionnaires, regarding previous employment, medical history, dermatitis, respiratory symptoms, and personal protective equipment use, revealed that employees reported respiratory and physical symptoms that are consistent with, but not specific for, workplace exposure to jet fuel vapor and jet exhaust.

Concentrations of jet fuel compounds were found to be well below established occupational exposure limits. However, NIOSH recommends exposure to carcinogenic compounds, such as benzene, be kept to the lowest feasible levels. Therefore, recommendations are made in this report concerning proper work practices such as hygienic practices, personal protective equipment use, and engineering control use, to minimize exposure to such compounds.

Concentrations of carbon monoxide in air were found to be above the ceiling limits for occupational exposure for two workers, most likely attributable to exposure to truck exhaust inside the mechanics' garage. Exposure to carbon monoxide for all other workers was below occupational exposure limits. Recommendations for the prevention of carbon monoxide exposure are made in this report.

Keywords: SIC 4581 (Airports, Flying Fields, and Airport Terminal Services), jet fuel, benzene, toluene, xylene, carbon monoxide, airplane refueling, jet, airport, aircraft exhaust

Table of Contents

INTRODUCTION

In September 2000, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from employees of Ogden Aviation Services located at Lambert-St. Louis International Airport, in St. Louis, Missouri. The request cited concerns over exposures to jet fuel and its components such as benzene, toluene, ethylbenzene, and xylene, as well as to jet exhaust during refueling services. Primary health effects were reported as respiratory problems and headaches; heart problems, cancer, diabetes and rashes were also reported. An initial site visit was conducted on October 19, 2000, when a NIOSH industrial hygienist and a medical officer held an opening conference with management, employees, and union officials, and performed a walk-through inspection of areas at the airport where Ogden employees work. Qualitative sampling was performed to help identify major compounds of concern for further sampling. On December 11 and 12, 2000, two NIOSH industrial hygienists and the medical officer returned to Ogden Aviation Services to conduct industrial hygiene and medical surveys.

BACKGROUND

Since 1954, Ogden Aviation Services has been providing refueling operations on a contract basis to the airlines that fly into and out of Lambert-St. Louis International Airport. Currently, Ogden Aviation pumps approximately 1.2 million gallons of Jet Fuel A every day from their storage tank farm (which has a maximum capacity of 1.5 million gallons) located directly south of the airport. Underground pipes direct the fuel from the tank farm to individual hydrants located at each gate of the airport for refueling the planes.

Of Ogden's 180 employees, approximately 150 perform duties that have potential exposure to jet fuel. These 150 employees work as mechanics, utilitymen, and fuelers.

Twenty-two individuals work as mechanics, who are responsible for scheduled and non-routine maintenance of Ogden equipment. This can include maintenance on pump and fueling trucks, including engine work, bodywork, welding, etc. This work is performed in the mechanics' garage, located on airport property, as well as on the tank farm.

Five individuals are utilitymen, who are responsible for general work, in particular sump pumping the hydrant pits in which the fuel hydrants are located at the gates, as well as sump pumping the tanks and vehicles. The below-grade hydrant pits are approximately three to four feet deep, with hinged metal lids that are level and flush with the tarmac; rainwater, leaked jet fuel, and other liquids can collect in these pits and necessitate being pumped out. It takes two to three minutes to pump a full pit. Depending on weather conditions, 10 - 20 pits may be pumped a day. There are approximately 150 hydrant pits at the airport, with 110 actively being used.

One hundred fifteen individuals are fuelers, who are responsible for refueling planes. Refueling jet airplanes requires driving a fueling truck to the jet, attaching a truck-based hose to the fuel hydrant located in a hydrant pit at the gate and attaching another truck-based hose to the jet fuel tanks. The pressure under which the fuel is kept in the pipelines transfers the fuel through the truck hoses to the jet and gauges the number of gallons of fuel that was transferred. Typically, the whole refueling process for a jet can take between 20 and 30 minutes. For turbo prop planes, the fuelers pump fuel directly from a fuel truck to the tanks of the plane rather than from the underground hydrants. Fifteen to twenty minutes are usually needed to refill a typical turbo-prop airplane. The number of planes refueled by each individual can vary from approximately 5 to 10 per shift.

METHODS

Industrial Hygiene

On the initial site visit conducted on October 19, 2000, a walk-through survey was conducted to observe work practices and conditions at Ogden as well as to perform preliminary, qualitative sampling. These samples included bulk samples of the liquid in various hydrant pits, as well as personal breathing zone air samples using thermal desorption tubes.

During the initial visit, three bulk samples were taken of the liquids which had collected in hydrant pits at various airport gates, for analysis of volatile organic compounds. Concerns had been raised for these liquids as potential sources of exposure to utilitymen who sump pump these liquids out of the hydrant pits, mechanics who may have to fix the hydrants, or fuelers who use the hydrants in the pits to refuel planes. Samples were collected by pouring some of the liquid into forty-milliliter glass screw-cap vials, preventing introduction of air bubbles within the vial. The vials were completely filled so as not to create a headspace above the liquid in the vial, and sealed. Analysis was performed by gas chromatography/mass spectrophotometry according to the Environmental Protection Agency (EPA) method 8260B. [1]

Also during the initial site visit, qualitative air sampling was performed on several personnel of different work categories for identification of airborne volatile organic compounds present. Thermal desorption tubes were worn by six utilitymen, fuelers, and mechanics. Tubing connected the sampler and a personal sampling pump which allowed air to be drawn through the sampling train at a calibrated flow rate of 30 milliliters per minute (ml/min). Analysis of the desorption tubes for captured volatile organic compounds was performed using a Perkin-Elmer ATD 400 thermal desorption system interfaced directly to a gas chromatograph with mass selective detector (TD-GC-MSD).

Quantitative industrial hygiene sampling was performed on the return site visit on December 11 and 12, 2000, for compounds identified by the qualitative sampling during the previous visit. Two shifts were sampled: the 6:00 AM - 2:00 PM shift on December 11, and the 2:00 PM - 10:00 PM shift on December 12. Fifteen personal breathing zone (PBZ) samples were collected during each shift for benzene, toluene, xylene, and total hydrocarbons. These samples were collected using solid sorbent (coconut shell charcoal) tubes and low-flow pumps calibrated to provide a volumetric flow rate of 200 ml/min. Analysis of the samples was conducted using a combination of the conditions from the 4th edition NIOSH Manual of Analytic Methods (NMAM), methods 1501 and 1550 with modifications.[2] The sorbent tubes were analyzed using gas chromatography with flame ionization detection. Bulk samples of Jet Fuel A were provided along with the air samples to quantitate the total hydrocarbon results. The calculated minimum detectable concentrations (MDCs) are 0.001 parts per million (ppm) for benzene, 0.003 ppm for xylene, 0.001 for toluene, and 0.12 ppm for total hydrocarbons. Minimum quantifiable concentrations (MQCs) for each analyte include 0.004 ppm for benzene, 0.008 ppm for xylene, 0.003 ppm for toluene, and 0.48 ppm for total hydrocarbons. These were calculated using the analytic limits of detection (LODs) and limits of quantitation (LOQ) and a sample volume of 84 liters.

Measurements were also collected for carbon monoxide, a component of incomplete fuel combustion, present in the jet exhaust and fueling and pump truck exhaust. Numerous individuals from both shifts wore a passive diffusion monitor, the Biosystems Inc. ToxiUltra Gas Detector, which recorded carbon monoxide (CO) concentrations during the workshift. One reading was taken every 30 seconds by each monitor. The recorded measurements were then downloaded to a computer. The monitor measures CO concentrations from 0-500 parts per million (ppm). Calibration of these monitors was performed before and after sampling according to the manufacturer's specifications.

Medical

During the December 2000 site visit, the NIOSH medical officer conducted confidential interviews with 16 serially selected employees from first and second shift rosters provided by the company. The interview consisted of questions regarding previous employment, medical history, dermatitis, respiratory symptoms, and personal protective equipment use. In addition, interviewed individuals were given the opportunity to ask questions and voice additional concerns.

Along with employee interviews, the Occupational Safety and Health Administration Logs and Summary of Occupational Injuries and Illnesses (OSHA 200 logs) from January 1, 1998 through December 31, 2000 were reviewed.

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

Volatile Organic Compounds

Volatile organic compounds (VOCs) describe a large class of chemicals which are organic (i.e., containing carbon) and have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. These compounds are emitted in varying concentrations from numerous sources including, but not limited to, combustion sources, adhesives, solvents, paints, cleaners, waxes, and cigarettes. While in some instances it may be useful to identify some of the individual chemicals which may be present, the concept of total volatile organic compounds (TVOC) has been used in an attempt to predict certain types of health effects.[6] The use of this TVOC indicator, however, has never been standardized. Some researchers have compared levels of TVOCs with human responses (such as headache and irritative symptoms of the eyes, nose, and throat). However, NIOSH, OSHA, and ACGIH currently have not set specific exposure criteria for total volatile organic compounds, including the total hydrocarbon mixture of Jet Fuel A. A similarly refined petroleum solvent for which exposure limits have been set and which the Jet Fuel A Material Safety Data Sheet (MSDS) recommends as a guide, is Stoddard Solvent. NIOSH has set the most protective exposure limit for this substance at 350 milligrams per cubic meter (mg/m^3) as a TWA for up to a 10-hour work shift.[?] ACGIH set its 8-hour TWA exposure limit at 525 mg/m^3 (or 100 ppm), while OSHA set its PEL at 2900 mg/m^3.[?,?]

It should be emphasized that the highly variable nature of these complex VOC mixtures can greatly affect their irritancy potential. Considering the difficulty in interpreting TVOC measurements, caution should be used in attempting to associate health effects (beyond nonspecific sensory irritation) with specific TVOC levels.

Benzene

Benzene is an aromatic organic hydrocarbon containing a six carbon ring with alternating double bonds. Benzene was formerly an important solvent especially in the rubber and surface coating industries, but now it is rarely used as a solvent because of its toxicity. It is, however, present as a trace contaminant in gasoline and other petroleum solvents.[7] Acute inhalation exposure to high concentrations of benzene can cause drowsiness, fatigue, nausea, vertigo, narcosis, and other symptoms of central nervous system (CNS) depression as noted with excessive exposure to other aromatic hydrocarbons.[?,8,9] However, the most remarkable health effects associated with benzene exposure are chronic effects due to repeated exposure to low concentrations over many years.[8, 24]

Benzene is classified by the International Agency for Research on Cancer (IARC) as a known human carcinogen and has been associated with irreversible bone marrow injury and the development of hematopoietic toxicity, including aplastic anemia and leukemia in humans.[9,10,11] NIOSH classifies benzene as a human carcinogen, and recommends that occupational exposures be controlled to prevent employees from being exposed to concentrations greater than 0.1 parts per million (ppm), determined as a TWA concentration for up to a 10-hour work shift in a 40-hour work week. NIOSH further recommends a 15-minute STEL of 1.0 ppm.[?] Although NIOSH has established these guidelines which should not be exceeded, the Institute still urges that exposures be reduced to the "lowest feasible level" (LFL) because it is not possible to establish thresholds for carcinogens which will protect

100% of the population. The OSHA PEL is 1 ppm for an 8-hour TWA with a 15-minute STEL of 5 ppm. However, the PEL does not apply to "... storage, transportation, distribution, dispensing, sale, or use of gasoline, motor fuels, or other fuels containing benzene subsequent to its final discharge from bulk wholesale storage facilities, except operations where gasoline or motor fuels are dispensed for more than four hours per day in an indoor location..."[?] The current ACGIH TLV is 0.5 ppm as a confirmed human carcinogen, with a skin notation indicating that skin absorption can contribute to the overall dose.[?]

Toluene

Toluene is a colorless, aromatic organic liquid containing a six carbon ring (a benzene ring) with a methyl group (CH3) substitution. It is a typical solvent found in paints and other coatings, and used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals. It is also an ingredient of gasoline, ranging from 5% to 22%.[10,12]

Inhalation and skin absorption are the major occupational routes of entry. Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Since it is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids from the skin which can cause drying, fissuring, and dermatitis.[8, 24,13] The main effects reported with excessive (inhalation) exposure to toluene are CNS depression and neurotoxicity.[8, 24] Studies have shown that subjects exposed to 100 ppm of toluene for six hours complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication (narcosis).[14,15,16] No symptoms were noted below 100 ppm in these studies. There are a number of reports of neurological damage due to deliberate sniffing of toluene-based glues resulting in motor weakness, intention tremor, ataxia, as well as cerebellar and cerebral atrophy.[17] Recovery is complete following infrequent episodes, however, permanent impairment may occur after repeated and prolonged glue-sniffing abuse. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination, and unconsciousness.[18,19]

The NIOSH REL for toluene is 100 ppm for an 8-hour TWA. NIOSH has also set a recommended STEL of 150 ppm for a 15-minute sampling period.[?] The OSHA PEL for toluene is 200 ppm for an 8-hour TWA.[?] The ACGIH TLV is 50 ppm for an 8-hour exposure level.[?] Like benzene, this ACGIH TLV carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

Xylene

Xylene is a colorless, flammable organic liquid with a molecular structure consisting of a benzene ring with two methyl (CH3) substitutions. Xylene is used in paints and other coatings, as a raw material in the synthesis of organic chemicals, dyes, and pharmaceuticals, and it is an ingredient of gasoline and many petroleum solvents.[7]

The vapor of xylene has irritant effects on the skin and mucous membranes, including the eyes and respiratory tract. This irritation may cause itching, redness, inflammation, and discomfort. Repeated or prolonged skin contact may cause erythema, drying, and defatting which may lead to the formation of vesicles. At high concentrations, repeated exposure to xylene may cause reversible damage to the eyes.[8, 24] Acute xylene inhalation exposure may cause headache, dizziness, incoordination, drowsiness, and unconsciousness.[20] At high concentrations, exposure to xylene has a narcotic effect on the CNS, and minor reversible effects on the liver and kidneys.[8, 24,21]

The current OSHA PEL, NIOSH REL, and ACGIH TLV for xylene are 100 ppm over an

8-hour TWA. In addition, OSHA and NIOSH have published STELs for xylene of 150 ppm averaged over 15 minutes.[?,?,?]

Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless, tasteless gas which can be a product of the incomplete combustion of organic compounds. CO combines with hemoglobin and interferes with the oxygen carrying capacity of blood. Symptoms include headache, drowsiness, dizziness, nausea, vomiting, collapse, myocardial ischemia, and death.[8, 24] The NIOSH REL for carbon monoxide is 35 ppm for a 10-hour TWA. NIOSH also recommends a ceiling limit of 200 ppm which should not be exceeded at any time during the workday.[?] The OSHA PEL for carbon monoxide is 50 ppm for an 8-hour TWA.[?] The ACGIH TLV for carbon monoxide is 25 ppm as an 8-hour TWA.[?]

RESULTS

Industrial Hygiene

Analysis for volatile organic compounds in bulk samples of liquids taken during the initial site visit from the inside of three hydrant pits at various gates of the airport showed the presence of four major VOCs in two of the three hydrant pits. Most likely the result of leaked jet fuel, these VOCs were benzene, toluene, xylene, and ethylbenzene, and were found in hydrant pits at gates A-10 and A-18. Tables 1A, 1B, and 1C show these results.

Multiple compounds were detected on the thermal desorption tubes used during sampling on the initial site visit. The most predominant were aliphatic hydrocarbons, benzene, toluene, xylene, alkyl benzenes, and naphthalenes, all consistent with petroleum-based fuels. Using these qualitative results, quantitative sampling was performed on the return site visits using solid sorbent (coconut shell charcoal) tubes for benzene, toluene, xylene, and 'total hydrocarbons'. 'Total hydrocarbons' is the sum of all hydrocarbons detected minus the individually requested analytes (benzene, toluene, and xylene). Tables 2 and 3 show the quantitative results for the full shift personal breathing zone sampling collected on December 11 and 12, 2000. The range of exposures of the workers to benzene over the two shifts was 0.001 ppm to 0.032 ppm. For xylene, the range of exposures was 0.003 ppm to 0.431 ppm. The range of exposures to toluene was 0.001 ppm to 0.136 ppm. All exposure levels for these individual compounds were well below the NIOSH, OSHA, and ACGIH criteria levels. The range of exposures to total hydrocarbons was 0.98 mg/m^3 to 53.97 mg/m^3. No occupational exposure limits have been set for total hydrocarbon exposures by NIOSH, OSHA, or ACGIH. A similarly refined petroleum solvent whose exposure limits the Jet Fuel A Material Safety Data Sheet (MSDS) recommends as a guide is Stoddard Solvent. During the days the sampling was conducted, the total hydrocarbon exposures resulting from the jet fuel were well below those limits set for Stoddard Solvent by NIOSH, OSHA, and ACGIH.

Table 4 shows the TWA and peak carbon monoxide concentrations for the full-shift sampling performed on December 11 and 12, 2000. CO monitors were worn by fuelers, utilitymen, and mechanics on both days. All of the full-shift TWA concentrations were below the OSHA PEL of 50 ppm, the NIOSH REL of 35 ppm, and the ACGIH TLV of 25 ppm. NIOSH has also set a recommended ceiling limit of 200 ppm for CO, which is the exposure concentration which should not be exceeded during any part of the work day. On December 12, two employees were exposed to levels of CO above this ceiling limit. One, a fueler, was exposed to a peak of 223 ppm, while a utilityman was exposed to a peak of 392 ppm. Of the individuals under the ceiling limit, only one (another fueler) received an exposure close to the ceiling limit, at 156 ppm.

Medical

All 16 serially selected Ogden employees agreed to be interviewed. Interviewed were 11 first-shift and 5 second-shift employees; of these employees, 12 worked as fuelers, 2 worked as mechanics, 1 worked as a utilityman, and 1 had worked both as a mechanic and a fueler. The length of employment at Ogden Avation Services for these individuals ranged from 10 months to 32 years.

Employees stated that fuel spills or drips onto their hands and work clothes while performing work duties. Fourteen employees stated that they always wear gloves when working with fuel or have the potential of getting fuel on their hands, while the other two stated they infrequently or never wear gloves. These two employees work as mechanics and are frequently unable to wear gloves while working due to the type of tasks they perform. All employees stated that the company provided gloves for use while working with jet fuel. Overall, employees felt that the gloves were not fully protective against jet fuel exposure when worn. Employees stated that hand exposure to fuel occurred frequently (5), sometimes (5), almost never (5), and never (1), while clothing exposure occurred less frequently. Some employees stated that they carry rags in their fuel pump truck and use them to wipe fuel off their hands. Several employees stated that fuel sometimes drips or splashes into their eyes or mouth. All employees stated that hand washing facilities and eye wash stations were not readily accessible around the flightline area, often resulting in a prolonged period of time between exposure and removal of the fuel. Employees infrequently sought an eye wash station or faucet to flush the fuel out of their eye because facilities were not readily accessible. Employees did not routinely wear protective eye wear or goggles while performing refueling tasks. A majority of the employees stated that they had experienced being drenched with fuel soaking more than 50% of their clothing down to the skin, commonly refered to as a "fuel bath." Most stated that this type of exposure occurred infrequently and resulted in the skin feeling like it was burning. Employees stated that the only place available to remove wet clothing, shower, and change was the maintenance building.

8 of the 16 employees stated that they had experienced skin problems (including dermatitis and eczma); in most cases the individual attributed the skin problem to fuel exposure. None of the individuals interviewed reported a current skin condition or rash for which they were receiving medical treatment. Skin examinations were performed on 10 of the 16 employees; none had existing dermatitis or eczema. None of the interviewed employees had a history of skin cancer. Employees did report that they felt exposure to jet fuel vapors resulted in a variety of symptoms, including headache, lightheadness, irritation of the mucous membranes of the eye, watery eyes, and dizziness. These symptoms were reported to be experienced equally during jet refueling and pit sumping activities and occurred most frequently during hot weather. Some employees reported respiratory and/or sinus symptoms (such as sinus congestion, shortness of breath, bronchitis, and mucous membrane irritation) they felt were related to jet fuel vapor exposure.

All but three of the OSHA 200 log entries reviewed documented musculoskeletal injuries. One entry documented an allergic reaction to an unspecified substance while another entry documented an unspecified foreign object in the eye, both of which occurred in individuals working as fuelers. One final entry documented dermatitis of the hands in an employee working as a utility worker. No other information concerning these entries was available.

Discussion and Conclusions

Exposure Evaluation

For the two days of sampling at Ogden Aviation Services in December 2000, quantitative results were obtained which assessed the levels of workers' respiratory exposure to major components of Jet Fuel A such as benzene, toluene, and xylene. The air concentrations measured for all the employees sampled were below all applicable exposure limits of NIOSH, OSHA, and ACGIH. When evaluated by specific worker groups, a pattern can be seen in the levels of exposures to which each group was exposed. Those with the least amount of respiratory exposure to individual compounds and 'total hydrocarbons' were the fuelers and utilitymen. The average TWA concentration of benzene to which the fuelers were exposed was 0.008 ppm and to 'total hydrocarbons' was 4.55 mg/m^3. Likewise, the average TWA concentration of benzene to which utilitymen were exposed was 0.006 ppm and to 'total hydrocarbons' was 4.80 mg/m^3. These concentrations can be contrasted to those of the mechanics and those individuals specifically working at the tank farm filling the gasoline-tank trucks which refuel Ogden gas-powered equipment and trucks. The TWA concentration of benzene to which the mechanics were exposed was 0.012 ppm, a level similar to the other two groups, but an increase was observed in average 'total hydrocarbon' concentration level, at 18.85 mg/m^3. Further increases can be seen in those workers who filled the gas-tank trucks at the tank farm. The average concentration of benzene to which they were exposed was 0.031 ppm and the average 'total hydrocarbon' concentration was 26.74 mg/m^3. Furthermore, the one individual performing this work on the first day of sampling did not use the engineering control that had been developed for this job while the individual on the second day did use it. This control consisted of a clear plastic plate which fit over the hole in the top of the refueling truck. This plate reduced the size of the hole through which volatile compounds can rise to the area where the worker is standing on top of the truck; also, a flexible tube ran from the plate, with the intention of directing these fumes off to the side of the truck. This control appeared to be ineffective during our sampling; the exposure levels were very similar for the individual who used it and for the one who didn't.

Respiratory exposure is only one pathway through which workers may be exposed to these compounds; dermal exposure can also be important. Thus it must be kept in mind that the total exposure for all these workers is not only determined by how much was inhaled, but also how much may have been absorbed through the skin. All of the workers evaluated have the potential for dermal contact with the jet fuel. Examples of dermal exposure include utility workers with exposure to leaked jet fuel in the hydrant pits, fuelers with contact with the fuel during the refueling process, and contact from jet fuel-covered parts that the mechanics must handle when fixing broken equipment. Workers are given seven pairs of pants, seven short-sleeve and seven long-sleeve shirts, as well as jackets and raingear, for which Ogden provides optional weekly laundering through a outside, contracted company. Dermal exposure can be minimized by the use of such clothing, proper personal protective equipment, and personal hygiene practices.

An important factor to consider is the environmental weather conditions during the time sampling took place. The average temperature at the St. Louis Airport on December 11, 2000 was 26˚F, while on December 12, 2000, the average temperature was 12˚F. At these temperatures, compounds found in the jet fuel are less likely to volatilize. As the temperature increases during the summer months, the airborne concentrations of the volatile compounds may also increase. Additionally, dermal exposure during the summer months may increase due to the layers of clothes and jackets worn during the winter which may provide protection during the winter months from skin exposure to the jet fuel.

TWA concentrations showed that all employees monitored for CO exposures were below the NIOSH, OSHA, and ACGIH exposure limits. However, two individuals did have peaks, at 392 ppm and 223 ppm, above the ceiling limit of 200 ppm recommended by NIOSH. A third had a peak nearing this ceiling limit at 156 ppm. The utilityman who recorded the peak of 392 ppm and the fueler with the peak of 156 ppm had their peaks within 10 minutes of each other at the very end of their shifts. These two individuals reported that at the end of their shifts, they were talking together when their carbon monoxide alarms sounded. They reported being in the maintenance garage while standing next to a running truck when this occurred. At the time, the garage doors were closed and an exhaust tube was not in use. This tube is supposed to be attached to the tailpipe of trucks when they are running in the garage and leads under the garage doors, thus directing the exhaust outside. It is possible that the fueler with the peak of 223 ppm may also have been exposed to carbon monoxide from the exhaust of a running truck during his shift due to the requirement to keep the refueling trucks running during airplane refueling.

Health Effects

While some studies have demonstrated the development of dermal neoplasms in experimental animals upon repeated dermal application of fuel over the animal's lifetime,[22] there were no studies associating exposure to jet fuel and cancer. Studies have demonstrated that exposure to jet fuel vapor or jet stream exhaust is associated with upper and lower respiratory symptoms. The specific symptoms related to jet fuel vapor and jet exhaust noted in one such study included cough with phlegm and runny nose.[23] The study did not demonstrate any association between such exposures and development of symptoms consistent with asthma (breathlessness, wheeze, or shortness of breath). Ogden employees exposed to jet fuel did report cough with mucous production but did not report noting runny nose symptoms. All respiratory symptoms reported by the Ogden employees could be due to many different factors; they are not specific for jet fuel exposure. Non-respiratory symptoms reported by Ogden employees such as headache, lightheadedness, or dizziness are consistent with carbon monoxide exposure from jet engine exhaust,[24] inhalation of evaporated kerosene or naphthalene components of the jet fuel,[25,26] and exposure to any other hydrocarbon contained within the jet fuel. However, it should be noted that these symptoms are common in the general population and could be due to other exposures or factors unrelated to a specific work exposure.

Overall, Ogden employees reported physical and respiratory symptoms that are consistent with exposure to jet fuel vapor or jet exhaust exposure, although the reported symptoms are not specific to jet fuel or jet exhaust. Furthermore, the number of individuals reporting respiratory and physical symptoms is consistent with workplace exposure to jet fuel vapor and jet exhaust. The employees interviewed consistently reported a temporal association between their various exposures to jet fuel and the reported respiratory, dermal, and physical symptoms.

Information reported by Ogden employees suggests that they experience frequent dermal contact with jet fuel, even though none of the employees interviewed had a work-related skin problem at the time of the interviews. It would appear that the gloves currently being used are protecting workers from fuel exposure-related dermatitis. This evaluation was performed during the winter. Employees reported that dermal changes typically developed during the hot summer months when less clothing is worn and more skin is exposed. Several employees were concerned that accessible facilities were not available allowing them to quickly wash jet fuel off their hands or flush out of their eyes following exposure. Employees were also using dirty rags to wipe fuel off their hands.

RECOMMENDATIONS

1. The individuals with the respiratory exposures to the highest concentrations of benzene and 'total hydrocarbons' of all the workers sampled were those filling the gas-tank truck at the tank farm. An engineering control has been developed for these workers. However, sampling shows it may not be as effective as intended, and Ogden should consider developing one that will be more protective. It might be helpful to involve workers in the selection and design of this control so that it will be something they use. Workers should be instructed to use it each time they perform the refilling of the tank.

2. While trucks are operated in the garage, the exhaust tube should be attached to the tailpipe to direct the exhaust to the outside of the garage. Opening the garage doors is also a recommended practice.

3. When the work clothes become wet or saturated with jet fuel, the workers should change that item of clothing as soon as possible to avoid prolonged skin contact with the fuel. Employees should use the weekly cleaning service Ogden provides for their work clothes rather than laundering them at home.

4. Employees should wash skin with mild soap and water as soon as feasibly possible after skin contact. Regular maintenance of wash stations, showers, and eyewash stations is essential.

5. Open barrels of waste fuel were present in the maintenance garage. The waste fuel is collected in these barrels during routine maintenance of pump trucks which might require a draining of any excess fuel. These partly-filled barrels should be tightly covered during those times not in use to prevent compounds in the jet fuel from volatilizing and building up in the garage maintenance area, particularly when the garage doors are closed.

6. All workers should avoid, when possible, the exhaust area of the running trucks and equipment and of the planes' engines. Even in the outdoor environment, truck or jet exhaust could cause a spike in the levels of CO exposure if the worker stands in that area for an extended period of time.

7. Ogden should perform further sampling during the summer to determine the exposure levels under higher temperatures.

8. Ogden management should remain committed in monitoring reported health problems in a systematic manner to identify job duties or processes which may be associated with particular health effects. Ogden employees should report all potentially work-related health problems and safety concerns to the health and safety committee which meets once a month.

9. Appropriate personal protective equipment should be provided to and worn by all employees who are exposed to jet fuel. This would include gloves selected to provide appropriate resistance to penetration (breakthrough) of jet fuel, goggles or protective eye wear with side shields, equipping all fuel pump trucks with a portable eyewash bottles, and supplying each vehicle with a box of disposable absorbent towels.

10. In noisy work environments such as the airport, the noise levels can easily exceed exposure limits. Workers should maintain hearing protection at all times when working near running jet engines.

REFERENCES

1. EPA [2000]. SW-846 Manual of Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods, 3rd edition. Environmental Protection Agency Publication No. 955-001-00000-1.

2. NIOSH [1994]. Manual of Analytical Methods, 4th edition. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113.

3. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

4. ACGIH [1999]. 1999 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

5. CFR [1997]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

6. Molhave L, Nielsen GD [1992]. Interpretation and limitations of the concept "Total Volatile Organic Compounds" (TVOC) as an indicator of human responses to exposures of volatile organic compounds (VOC) in indoor air. Indoor Air, Vol. 2, pp 65-77.

7. ACGIH [1999]. Documentation of threshold limit values and biological exposure indices for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

8. Proctor NH, Hughes JP, Fischman ML [1989]. Chemical hazards of the workplace. 2nd ed. Philadelphia, PA: Van Nostrand Reinhold.

9. NIOSH [1974]. Criteria for a recommended standard: occupational exposure to benzene. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 74-137.

10. WHO [1989]. IARC monographs on the evaluation of carcinogenic risks to humans: occupational exposures to the petroleum refining; crude oil and major petroleum fuels. World Health Organization 45: 159-201. 1-8 March 1988.

11. NTP [1991]. Sixth annual report on carcinogens: 1991 summary. Research Triangle Park, NC: U.S. Department of Health and Human Services, National Toxicology Program.

12. ENVIRON Corporation [1990]. Summary report on individual and population exposures to

gasoline. Arlington, VA: ENVIRON Corporation. November 28.

13. NIOSH [1973]. Criteria for a recommended standard: occupational exposure to toluene. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 73-11023.

14. WHO [1981]. Recommended health-based limits in occupational exposure to select organic solvents. Geneva: World Health Organization, Technical Report Series No. 664.

15. Benignus VA [1981]. Health effects of toluene: a review. Neurotoxicology 2:567-568.

16. Anderson I, et al [1983]. Human response to controlled levels of toluene in six-hour exposures. Scand J Work Environ Health 9:405-418.

17. EPA [1983]. Health assessment document for toluene. NTIS. Washington, DC: Environmental Protection Agency.

18. Bruckner JV, Peterson RG [1981]. Evaluation of toluene and acetone inhalant abuse I. Pharmacology and pharmacodynamics. Toxicol Appl Pharmacol 61:27-38.

19. Bruckner JV, Peterson RG [1981]. Evaluation of toluene and acetone inhalant abuse II. Model development and toxicology. Toxicol Appl Pharmacol 61:302-312.

20. NIOSH [1975]. Criteria for a recommended standard: occupational exposure to xylene. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 75-168.

21. NIOSH [1977]. Occupational diseases: a guide to their recognition. Cincinnati, OH: National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-181.

22. Toxicology & Carcinogenesis Studies of Marine Diesel Fuel and JP-5 Navy Fuel in B6C3F1 Mice (Dermal Studies). Technical Report Series No. 310 [1986] NTIS Publication No. PB87-131678/AS U.S. Department of Health and Human Services, National Toxicology Program, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709.

23. Tunnicliffe WS, O'Hickey SP, Fletcher TJ, et. al [1999]. Pulmonary function and respiratory symptoms in a population of airport workers. Occup Environ Med 56:118-123.

24. Hathaway GJ, Proctor NH, Hughes JP, Fischman ML , eds. [1991]. Chemical hazards of the workplace. 3nd ed. New York, NY: Van Nostrand Reinhold, pp. 141-144.

25. Gosselin RE, Smith RP, Hodge HC [1984]. Clinical toxicology of commercial products. 5th ed. Baltimore, MD: Williams and Wilkins, p. III-223.

26. Gosselin RE, Smith RP, Hodge HC [1984]. Clinical toxicology of commercial products. 5th ed. Baltimore, MD: Williams and Wilkins, p. III-309.

Tables 1A, 1B, 1C
Results from Bulk Sampling of Liquids in Hydrant Pits
October 19, 2000

Table 1A: Gate C-7

Compound	Result (μg/L)	LOD (μg/L)	MOD (μg/L)
Benzene	ND	0.45	5.0
Toluene	ND	0.37	5.0
Ethylbenzene	ND	0.44	5.0
o-Xylene	ND	0.43	5.0
m, p-Xylene	ND	1.0	10.0
TPH - Gasoline	ND	53.4	1000

Table 1B: Gate A-10

Compound	Result (μg/L)	LOD (μg/L)	MOD(μg/L)
Benzene	4,000	900	10,000
Toluene	59,000	730	10,000
Ethylbenzene	55,000	890	10,000
o-Xylene	56,000	870	10,000
m, p-Xylene	97,000	2,000	20,000
TPH - Gasoline	6,100	53.4	1,000

Table 1C: Gate A-18

Compound	Result (μg/L)	LOD (μg/L)	MOD(μg/L)
Benzene	2,000	900	10,000
Toluene	40,000	730	10,000
Ethylbenzene	46,000	890	10,000
o-Xylene	54,000	870	10,000
m, p-Xylene	84,000	2,000	20,000
TPH - Gasoline	840,000	5,000	100,000

Table 2

Results from Charcoal Tube Sampling for Airborne VOCs
December 11, 2000

Sample Number	Worker Category	Benzene (ppm)	Xylene (ppm)	Toluene (ppm)	Total Hydrocarbons (mg/m^3)
1	Filled gas truck	0.032	0.028	0.052	29.95
2	Fueler	0.005	0.016	0.012	3.62
3	Fueler	0.004	0.012	0.013	1.47
4	Fueler	0.004	0.010	0.012	1.07
6	Fueler	0.013	0.031	0.028	3.22
9	Fueler	0.005	0.015	0.013	4.04
10	Fueler	0.008	0.022	0.024	1.76
11	Fueler	0.012	0.029	0.021	3.67
12	Fueler	0.007	0.015	0.012	5.82
13	Fueler	0.013	0.081	0.067	18.01
5	Utilityman	0.006	0.050	0.026	8.62
7	Utilityman	0.002	0.015	0.006	0.98
8	Mechanic (shop)	0.011	0.143	0.060	5.99
14	Mechanic (tank farm)	0.005	0.015	0.014	2.45
15	Mechanic (ramp)	0.008	0.157	0.057	53.97
	MDC	*0.001*	*0.003*	*0.001*	*0.12*
	MQC	*0.004*	*0.008*	*0.003*	*0.48*
	NIOSH REL	*0.1*	*100*	*100*	*350 **
	OSHA PEL	*1.0*	*100*	*200*	*2900 **
	ACGIH TLV	*0.5*	*100*	*50*	*525 **

*no exposure limits established for total hydrocarbons; used Stoddard Solvent exposure limits as a guide only

Table 3

Results from Charcoal Tube Sampling for Airborne VOCs
December 12, 2000

Sample Number	Worker Category	Benzene (ppm)	Xylene (ppm)	Toluene (ppm)	Total Hydrocarbons (mg/m^3)
16	Filled gas truck	0.030	0.073	0.078	23.53
17	Fueler	0.005	0.037	0.014	4.68
18	Fueler	0.007	0.021	0.015	4.88
19	Fueler	0.006	0.027	0.016	5.24
20	Fueler	0.005	0.079	0.012	2.61
22	Fueler	0.010	0.060	0.041	5.54
23	Fueler	0.010	0.043	0.036	5.45
24	Fueler	0.013	0.036	0.033	3.73
25	Fueler	0.010	0.045	0.041	3.81
26	Fueler	0.006	0.016	0.012	3.13
27	Fueler	0.003	0.017	0.009	4.74
21	Utilityman	0.010	0.082	0.039	4.81
28	Mechanic (tank farm)	0.003	0.046	0.013	2.55
29	Mechanic (ramp)	0.018	0.120	0.066	22.83
30	Mechanic (shop)	0.028	0.431	0.137	25.33
	MDC	*0.001*	*0.003*	*0.001*	*0.12*
	MQC	*0.004*	*0.008*	*0.003*	*0.48*
	NIOSH REL	*0.1*	*100*	*100*	*350 **
	OSHA PEL	*1.0*	*100*	*200*	*2900 **

Sample Number	Worker Category	Benzene (ppm)	Xylene (ppm)	Toluene (ppm)	Total Hydrocarbons (mg/m^3)
16	**Filled gas truck**	**0.030**	**0.073**	**0.078**	**23.53**
	ACGIH TLV	***0.5***	***100***	***50***	***525 ****

*no exposure limits established for total hydrocarbons; used Stoddard Solvent exposure limits as a guide only

Table 4

Results of Carbon Monoxide (CO) Sampling
December 11 and 12, 2000

Date	Worker Category	Time Weighted Average CO concentration (ppm)	Peak CO concentration (ppm)
12/11	**Fueler**	**2**	**26**
12/11	**Fueler**	**2**	**44**
12/11	**Fueler**	**5**	**37**
12/11	**Utilityman**	**3**	**61**
12/11	**Utilityman**	**3**	**43**
12/11	**Mechanic**	**5**	**58**
12/12	**Fueler**	**16**	**223**
12/12	**Fueler**	**1**	**128**
12/12	**Fueler**	**3**	**57**
12/12	**Fueler**	**6**	**156**
12/12	**Fueler**	**2**	**29**
12/12	**Utilityman**	**7**	**392**
12/12	**Mechanic**	**14**	**112**
	NIOSH REL	***35***	***200***
	OSHA PEL	***50***	**--**

Date	Worker Category	Time Weighted Average CO concentration (ppm)	Peak CO concentration (ppm)
	ACGIH TLV	*25*	--

SAFER • HEALTHIER • PEOPLE™

To receive NIOSH documents or information about occupational safety and health topics contact NIOSH at:

1–800–35–NIOSH (356–4675)
Fax: 1-513-533-8573
E-mail: pubstaff@cdc.gov
or visit the NIOSH web site at:
www.cdc.gov/niosh

SAFER • HEALTHIER • PEOPLE™