HETA 92-0288-2454
OGDEN AVIATION
NEWARK AIRPORT, NEW JERSEY

PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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 Act of 1970, 20 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

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Ogden Aviation
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SUMMARY

On June 8, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from the Machinists Union, District Lodge 141, at Ogden Aviation located in Newark Airport. The request was prompted by employees' observations of what they believed to be excessive cancer cases among employees at the site. NIOSH medical and industrial hygiene investigators conducted a site visit on November 17-19, 1992. NIOSH investigators evaluated the operation, interviewed employees and management, and reviewed safety and health programs. On October 12-16, 1993, NIOSH investigators returned to Ogden Aviation to take measurements of polynuclear aromatic compounds (PNAs), volatile organic compounds (VOCs) and carbon monoxide (CO). At that time a questionnaire was also administered to the employees concerning skin contact with jet fuel.

NIOSH investigators identified two fatalities from lung cancer since 1990 and cases of lymphoma, throat, and prostate cancer, as well as two cases of emphysema, both in employees under 35 years of age. Based on available data, there is no reason to suspect an excess of cancer at this site. According to the union officials, all of the employees with respiratory illness and lung cancer were cigarette smokers. Workers reported that skin contact with jet fuel was common; 76% of workers reported that they "usually" got jet fuel on their hands, 64% said they "usually" got jet fuel on their arms, and 36% said they usually got jet fuel on their face.

Results of both the personal breathing zone (PBZ) and general area (GA) samples were below Occupational Safety and Health Administration (OSHA) Permissible Exposure Levels (PEL) for all compounds measured. In most cases, measurements were below the minimum quantifiable concentration for the sampling technique. However, several refuelers and ramp mechanics had exposure to carbon monoxide above the NIOSH ceiling limit because they are required to perform duties in close proximity to exhaust from various flightline vehicles (i.e., refueling vehicles, airline support vehicles, and aircraft) during times of heavy vehicle activity.

Air sampling results suggest that the potential for inhalation exposure to petroleum naphthas, PNAs, and VOCs were minimal on the days of the evaluation, although detectable exposure to benzo(a) pyrene, a carcinogen, was found in the shop maintenance bay. However, several refuelers and ramp mechanics had excessive exposure to carbon monoxide. The potential for skin absorption of jet fuel existed and was of concern as a potential source of exposure to aromatic compounds and other jet fuel constituents. Recommendations include improvements in worker training, use of chemical-resistant gloves, and improvements in the respirator fit-testing program.

Keywords: 4581 (airports, flying fields, and airport terminal services) jet refuelers, jet fuel, kerosene, airports

INTRODUCTION

On June 8, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from the Machinists Union, District Lodge 141, at Ogden Aviation located in Newark Airport. The request was prompted by employees' observations of what they believed to be excessive cancer cases among employees at the site. NIOSH medical and industrial hygiene investigators conducted an initial site visit on November 17-19, 1992. NIOSH investigators evaluated the operation, interviewed employees and management, and reviewed safety and health programs. On October 12-16, 1993, NIOSH investigators returned to Ogden Aviation to take measurements of polynuclear aromatic compounds (PNAs), volatile organic compounds (VOCs), and carbon monoxide. At that time a questionnaire was also administered to the employees concerning skin contact with jet fuel. An interim report was issued in March, 1993.

BACKGROUND

Employees at Ogden Aviation are involved in the refueling of commercial aircraft at Newark Airport in Newark, New Jersey. There are 267 employees working at the site. A breakdown of employees by job title is given in Table 1.

The refueling process at the Newark Airport is accomplished either by tank truck, for smaller (commuter) aircraft, or by connection by hose to underground fueling points known as hydrants, for the larger jet aircraft. Each gate has at least one fueling hydrant, from which fuel passes from the underground pipe into a truck containing pumps, valves and a filter, and then into the aircraft. The fuelers are responsible for these procedures as well as filling the tank trucks with fuel at the tank farm. Properly filling a large jet aircraft requires the employee's concentration to prevent overfilling and to prevent the aircraft from becoming unbalanced due to the weight of the fuel. The monthly consumption of jet fuel, supplied by Ogden Aviation at Newark Airport, is approximately 42 million gallons.

Employee concerns were centered around exposure to Jet Fuel A. This fuel is predominantly kerosene, and is 90% aliphatic hydrocarbons. According to a spokesperson for the supplier, the aromatic component of their jet fuel consists of benzene (35 ppm), toluene (1000 ppm), xylenes (1000 ppm), naphthalene (1000 ppm), cumene and C9 aromatics (1000 ppm).

Mechanics

Mechanics are responsible for maintenance and repair of equipment and trucks, both in the field and in the repair shop. Most of the mechanics work in the repair shop, where they do major repair work and preventive maintenance on tank trucks and pump trucks. Outside mechanics, known as ramp mechanics, are responsible for non-routine maintenance and repair of items that break down during the refueling operation. Approximately seven workers are assigned to perform these activities and work primarily on the flight ramp. Ramp mechanics have to make quick repairs in the field, to prevent loss of time during refueling so as not to delay scheduled departures. Turn-around time for smaller aircraft may be as short as 30 minutes. Potential sources of chemical exposures included fuel-contaminated parts, exhaust from aircraft and support vehicle engines, and spilled fuel.

Mechanics are also responsible for repairs and maintenance of the pipeline that supplies the fuel to the refueling hydrants and are required to drain water from these lines. This procedure entails entering an underground chamber known as the fuel "isolation pit," where valves are located for this purpose. These isolation pits meet both the NIOSH and Occupational Safety and Health Administration (OSHA) definition of confined space.[1] A description of the NIOSH classification of different confined spaces is given in Table 2, and a summary of requirements for entry can be found in Table 3. Ogden Aviation was cited by OSHA in August 1990, for confined space violations relating to entry of the fuel "isolation pits," particularly relating to the use of respirators. OSHA found there were no written standard protocols for safe use of respirators in dangerous atmospheres in the event of an emergency, that the supplied air respirators were not approved for IDLH (immediately dangerous to life and health) entry and did not have an escape provision (that is, an escape bottle), and that the company did not monitor for the percent of oxygen and concentrations of organic vapors prior to entry into either the tanktrucks or isolation pits. The present respiratory protection program was reviewed by NIOSH investigators and appeared to satisfy compliance with OSHA requirements. One deficiency was noted involving the use of respirators. According to our review, a test environment was not provided to employees in which the respirators could be fit tested.

Ramp mechanics also had to change the fusible links on the hydrants. (The fusible links are devices that are designed to shut off fuel flow in case of fire.) Changing these devices requires an employee to place his head into the hydrant pit for up to ten minutes. These pits usually have fuel residue on the bottom and ventilation is nonexistent. No respiratory protection was used, and employees doubted whether it would be possible to use, since the opening to the hydrant pit was very narrow.

General engine/vehicle maintenance

Approximately 31 general maintenance personnel were responsible for preventive maintenance inspections, general vehicle repair, and vehicle fluid replenishing/replacement. Maintenance activities were accomplished in the maintenance garage, which consisted of nine bays with a capacity for nine tank trucks or 18 hydrant carts. The primary activities potentially involving chemical exposures (skin contact and inhalation) were related to using the parts cleaning vat (which contained a predominately branched chain, saturated C9-C12 hydrocarbon solvent), draining vehicle fuel tanks, and changing and cleaning the aviation fuel filters.

Maintenance of the trucks involved potential exposure to a variety of organic materials since the procedure included draining the gasoline tanks, changing the engine oil, and changing the filter for the jet fuel being pumped from the hydrant pits. Mechanics also had to provide maintenance on the tank trucks that involved entering the tanks. Presently, the fuel is removed from the tank trunk before employees enter the truck.

Previously, employees reported that they would enter the tanks while fuel was still present. Employees would stand in the residual fuel and if the fuel level was too high, they would stand on crates. No respiratory protection was provided. In addition, employees reported fuel would occasionally get in their eyes and would frequently get on their hands.

Pump room maintenance

Pump room maintenance personnel are responsible for servicing hydrant pumps and related equipment. At the time of the NIOSH site visit, one individual was currently assigned to perform these duties. These activities are accomplished in a room located within the maintenance garage. The primary activities involving potential chemical exposures (dermal and inhalation) were working with fuel contaminated parts, degreasing associated equipment, and cleaning fuel filters.

Fuelers

Fuelers are responsible for filling the aircraft with fuel. For jet aircraft, this involves attaching hoses from the fuel hydrants to a truck (known as the hydrant truck) and then attaching a hose to the underside of the aircraft's wing. For smaller, propeller driven aircraft, fueling is done from a tank truck. A hose is attached directly from the tank truck to the airplane. For these smaller planes, the attachment is located above the wing, requiring the fueler to use a ladder for access. Approximately 114 personnel are assigned to perform these activities. Potential chemical exposures occur during connecting/ disconnecting the fuel couplings to the aircraft and from working near aircraft and aircraft support vehicles whose engines are running.

Tank farmer

Tank farmers are responsible for the storage, supply and discharge of aviation fuel to the airport's fuel distribution system. Approximately 11 personnel are assigned to perform these activities. Aviation fuel is received from off-site fuel lines and is temporarily stored in 24 above-ground tanks (12 with a 500,000 gallon capacity and 12 with a 350,000 gallon capacity) prior to distribution within the airport. Exposure to the aviation fuel might occur during the daily sumping and dip stick checks of the contents of tanks.

Employee concerns

A common report of many interviewed employees, regardless of job title, was skin contact with the fuel. Employees reported experiencing "fuel baths," when most of their clothing would become saturated with fuel. After a "fuel bath" employees would immediately shower and change their clothing. Employees also reported coming in contact with all fluids during the truck maintenance procedure. Of particular concern was gasoline dripping from the gas tanks of the trucks, which at times would come in contact with the employees' skin and clothing.

Employees also expressed concern about being sprayed by fluids while planes were being washed or de-iced during the refueling process. They also reported having seen lavatory trucks improperly emptying their contents into fuel hydrants or storm sewers.

Employees, particularly those working at Terminal C, also expressed concern about inhaling jet exhaust as well as the exhaust from other service vehicles while working on the airplanes. When not refueling aircraft, the Ogden employees were instructed to park their vehicle in front of a blast fence in an area that is directly behind the area where departing aircraft start their engines. Employees told us that exposure to jet exhaust at this location was most acute in the evening, when the larger aircraft, loaded for transoceanic flights, were departing at one time. When possible, employees moved their trucks to an unoccupied area away from the fence, but it was not always possible to do so. Employees also reported that the refueling operation brought them in direct contact with the exhaust from other vehicles such as motorized ramps for loading luggage, tractors carrying the luggage, and service vehicles such as catering trucks.

METHODS

EXPOSURE ASSESSMENT

Two site visits were conducted at Ogden Aviation in Newark, New Jersey. The NIOSH evaluation in November 1992, was a walkthrough visit to observe workpractices and to determine the potential for chemical exposures through inhalation and skin contact. The NIOSH evaluation from October 12-15, 1993, was conducted to quantitatively assess the potential for exposure to aircraft and vehicular fuels and their combustion products through bulk sampling, personal breathing zone, and area air sampling.

Air sampling was performed on October 13-14 during mid-shift operations (2:00 to 10:00 p.m.). Air sampling was either personal breathing zone (PBZ) or general area (GA). PBZ samples were selected for those job categories most likely to receive the highest airborne chemical exposures. PBZ samples were collected on eight refuelers, three shop mechanics, two ramp mechanics, and one utility sumper. GA samples were collected at five locations including the shop maintenance bay, the employee breakroom, terminal B3/C1, terminal C1/C2, and upwind of the airport (background). Air samples were analyzed for benzene solubles, carbon monoxide (CO), petroleum naphthas, and polynuclear aromatic hydrocarbons (PNAs). All PBZ samples were collected and analyzed for petroleum naphthas and benzene solubles. Due to equipment constraints, not all personnel wore CO monitors. All GA samples were collected and analyzed for petroleum naphthas, benzene solubles, CO, and PNAs.

Benzene Solubles: Twenty seven PBZ samples and ten GA samples were collected and analyzed following a modification of NIOSH Method 5023.[2] Sampling was primarily conducted to determine the relative combustion product emission levels in different areas, and to provide information that could be useful for establishing baseline exposure data. Air samples were collected using a battery-operated sampling pump which drew air through a teflon (PTFE) laminated membrane filter at a flowrate of 2.0

liters per minute (lpm). The sampling pumps were calibrated before and after sampling. The teflon filters were extracted, dried, and weighed gravimetrically. The analytical limit of detection (LOD) for this method was 0.05 milligrams (mg) per sample. Based on an average sample volume of 960 liters (L) for this sample set, the minimum detectable concentration (MDC) was 0.05 mg per cubic meter of sampled air (mg/m^3).

Carbon Monoxide: Ten PBZ and nine GA air samples were collected using a passive diffusion monitor (Toxilog Atmospheric Monitor, Model 54-1800) which recorded CO concentrations during the workshift (one sample collected per minute). The recorded measurements were downloaded to a personal computer. The monitor measures CO concentrations from 0-999 parts per million (ppm) with a display resolution of 0.1 to 1.0 ppm. Calibration of these monitors was accomplished before and after sampling according to manufacturer's specifications.

Petroleum Naphthas: Twenty-seven PBZ samples and ten GA samples were collected and analyzed according to NIOSH Method 1550 with modifications.[2] Air samples were collected using a battery-operated sampling pump which drew air through a solid sorbent (coconut shell charcoal) tube at a flowrate of 0.2 lpm. The sampling pumps were calibrated before and after sampling. The sorbent tubes were analyzed using gas chromatography with flame ionization detection. Bulk samples of the jet A fuel was provided along with the air samples to quantitate the results. The LOD for this method was 0.01 mg/sample. Based on an average sample volume of 96 L for this sample set, the MDC was 0.1 mg/m^3. The analytical limit of quantitation (LOQ) for this sample set was 0.033 mg/sample which equates to a minimum quantifiable concentration (MQC) of 0.34 mg/m^3 based upon an average sample volume of 96 L.

Polynuclear Aromatic Hydrocarbons: Ten GA samples for PNAs were collected in several locations within the main facility and flightline. As with benzene-solubles, sampling was conducted to determine PNA concentrations in different areas, and to provide information that could be useful for establishing baseline exposure data. PNAs were collected and analyzed according to NIOSH Method 5506 with modifications.[2] Air samples were collected using a battery-operated sampling pump which drew air through a PTFE laminated membrane filter (to collect PNAs adsorbed onto airborne particles), connected in series via Tygon tubing to a solid sorbent tube (Orbo 43, Supelco, Inc.), which is used to collect the gaseous PNAs. The sampling pumps were calibrated to operate at a flow rate of 2 L/min. The samples were analyzed for 17 PNAs by high performance liquid chromatography. A list of the PNAs is provided in Table 4. Identification of the PNAs in the sample set was based upon retention times only. The analysis was not confirmed by gas chromatography/mass spectroscopy (GC/MS). Table 4 also provides the LOD, MDC, LOQ, and MDQ for the analysis of PNAs on the filters. For the analysis of PNAs on the sorbent tubes, the LOD, MDC, LOQ, and MQC are provided in Table 5.

MEDICAL EVALUATION

The medical evaluation on the site visit of November 1992 consisted of:

1. Confidential medical interviews with 12 employees selected either by the union or management.

2. Review of employer medical records of workers, identified by the union as either having a significant medical history or having deceased within the last three years.

3. Review of the OSHA 200 logs

A self-administered questionnaire was administered on the return visit of October 13 and 14, 1993, to all workers present at work on those days to evaluate the extent of skin exposure to jet fuel.

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 from eight to ten hours a day, forty hours a week, for a working lifetime without experiencing adverse health effects. However, it is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous 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 to the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing 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 Criteria Documents and Recommended Exposure Limits (RELs); (2) the US Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs); and (3) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs).[3,4,5] The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; in contrast, the NIOSH-recommended exposure limits are primarily based upon the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

Employees working in the maintenance bay and on the flightline can be exposed to a variety of chemical substances including petroleum fuels and their combustion products. The evaluation criteria for the chemical constituents which characterize these potential exposures are presented in the following paragraphs. It should be kept in mind that the NIOSH REL is a time-weighted average (TWA) airborne concentration for up to a 10-hour workday during a 40-hour workweek. The OSHA PEL and ACGIH TLV differ slightly from the NIOSH REL in that the TWA concentration is limited to an 8-hour workday during a 40-hour workweek. Some substances have recommended short-term exposure limits (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from brief high exposures. *Unless otherwise noted, NIOSH RELs, ACGIH TLVs, and OSHA PELs will refer to TWA concentrations.*

Benzene-Solubles: Concentrations of polynuclear aromatic hydrocarbons can be determined by using solvents such as benzene to extract these and other compounds from samples of airborne particulate. This analysis yields the solvent-soluble portion of the particulates (referred to here as benzene-solubles). The benzene-soluble method is non-specific; it simply measures gravimetrically the benzene-soluble portion of sampled particulate matter. This method is often used as an index of exposure to the particulate fraction of petroleum combustion product emissions. Evaluation criteria are available to gauge worker exposures to benzene solubles (coal tar pitch volatiles) encountered around coke ovens and in petroleum asphalt fumes.[3,4,5] However, the benzene-soluble particulate portion of these emissions are not equivalent to the benzene-soluble portion of vehicle exhaust emissions. Therefore, occupational exposure limits to coal tar pitch volatiles are not applicable to the benzene-soluble portion of diesel exhaust emissions.

Carbon Monoxide: Carbon monoxide (CO) is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials such as, natural gas or petroleum fuels. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea. These initial symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. Coma or death may occur if high exposures continue.[6,7,8,9,10]

The NIOSH REL for CO is 35 ppm with a ceiling exposure limit of 200 ppm.[3] The NIOSH REL of 35 ppm is designed to protect workers from health effects associated with carboxy-hemoglobin (COHb) levels in excess of 5%.[6] Currently, the OSHA PEL is 50 ppm. OSHA had lowered the PEL to 35 ppm, with a ceiling limit of 200 ppm in 1989 under the Air Contaminants Standard.[4] OSHA is currently enforcing the 50 ppm standard; however, some states operating their own OSHA approved job safety and health programs may continue to enforce the lower limit of 35 ppm. The ACGIH TLV is 25 ppm.[5]

Petroleum Naphthas: Petroleum naphtha is a general term used to describe a class of complex hydrocarbon mixtures. Petroleum naphtha is composed mainly of aliphatic hydrocarbons (as distinguished from coal tar naphtha, which is a mixture composed primarily of aromatic hydrocarbons).[11,12] Petroleum naphthas are further characterized by the boiling range of the mixture. Typically, the larger hydrocarbon chain lengths equate to a higher temperature distillation fraction. Common names for some typical petroleum distillate mixtures in order of increasing temperature of boiling range are: petroleum ether, rubber solvent, varnish makers' and painters' (VM & P) naphtha, mineral spirits, Stoddard solvent, and kerosene.[13] Boiling ranges of these mixtures overlap; therefore, some of these mixtures contain the same hydrocarbons but in different proportions. Ogden refueling and maintenance personnel are primarily exposed to jet aircraft fuel (also known as jet A). According to the material safety data sheet information, jet A has a boiling point range of 149-300^oC and is composed of paraffinic hydrocarbons (50% by weight), cycloparaffins (33%), and aromatic hydrocarbons (17%). Synonyms for this fuel include kerosene and diesel fuel No. 1.

Effects from exposure to refined petroleum solvents are primarily acute, unless significant amounts of substances that have chronic toxicity are present, such as benzene or glycol ethers. Epidemiologic studies have shown that exposure to similarly refined petroleum solvents (i.e., mineral spirits, Stoddard solvent) can cause dry throat, burning or tearing of the eyes, mild headaches, dizziness, central nervous system depression, respiratory irritation, and dermatitis.[10, 13]

There are no evaluation criteria specifically for jet A. However, several evaluation criteria can be used for comparison (based on similar boiling points and chemical makeup) to assess airborne exposures. The NIOSH REL for kerosene is 100 milligrams per cubic meter of air (mg/m^3). The NIOSH REL for Stoddard solvent is 350 mg/m^3, with a ceiling limit (15 minute exposure duration) of 1800 mg/m^3.[3] The OSHA PEL for Stoddard solvent is 2900 mg/m^3.[4] The ACGIH TLV for Stoddard solvent is 525 mg/m^3.[5]

Polynuclear Aromatic Hydrocarbons: Polynuclear aromatic compounds are chemical species that consist of two or more fused aromatic rings. They are often associated with the incomplete combustion or pyrolysis of organic matter, especially coal, wood, and petroleum products. Acute toxicity is rarely associated with PNAs. Certain PNAs are considered carcinogenic, whereas others are not. Individual PNA measurements serve to indicate the presence of known or suspected carcinogens or other genotoxic compounds in the workplace, which would dictate additional control measures. Eight PNAs were identified as a result of air sampling which included naphthalene, acenaphthylene, fluorene, phenanthrene, fluoranthene, pyrene, benzo (a) pyrene (B[a]P) and benzo (ghi) perylene.

Naphthalene is a primary irritant of the eyes with symptoms occurring at 75 mg/m^3. Other symptoms include headaches, confusion, and nausea.[11] The NIOSH REL, ACGIH TLV and OSHA PEL for naphthalene are all 50 mg/m^3, with 15-minute STEL of 75 mg/m^3.[3,4,5] No occupational exposure criteria currently exist for acenaphthylene, fluorene, phenanthrene, fluoranthene, pyrene or benzo (ghi) perylene. Acenaphthylene is a weak skin irritant and sensitizer, with a low level of systemic toxicity.[14] The IARC concluded that there was no evidence to show carcinogenicity in pyrene and fluoranthene and inadequate data to evaluate the carcinogenicity of fluorene, phenanthrene, and benzo (ghi) perylene in experimental animals.[15]

A great amount of literature exists which demonstrates the carcinogenicity of B[a]P. In all animal species tested to date (mouse, rat, hamster, rabbit, guinea pig, duck, newt, dog, monkey), B[a]P has proven carcinogenic.[9] There is no specific NIOSH REL or OSHA PEL for B[a]P although both agencies refer to evaluation criteria for coal tar pitch volatiles (B[a]P is a potential chemical compound in this mixture).[3,4] No quantifiable ACGIH TLV exists for B[a]P although it has been designated a suspected human carcinogen.[5]

RESULTS

ENVIRONMENTAL SAMPLING

PBZ and GA air samples were collected during mid-shift (2:00-10:00 p.m.) operations on October 13-14, 1993. Weather conditions on October 13 were as follows: sunny, winds from the northwest (range five to ten knots), average temperature of 56°F (range 49 to 62°F), and average relative humidity of 36% (range 28 to 44%). Weather conditions on October 14 were as follows: cloudy, light winds from the northeast (less than five knots), average temperature of 56°F (range 54 to 58°F), and average relative humidity of 68% (range 60 to 75%). Light precipitation was noted on October 14. General area samples were taken upwind of the airport on both days to determine background concentrations of sampled chemical constituents. Observations made of work activities during this visit were consistent with the initial survey conducted in November 1992. The airport layout and GA sample locations are shown in Figure 1.

Petroleum Naphthas: The results of PBZ and GA samples collected and analyzed for petroleum naphthas are presented in Table 6 and Table 7, respectively. As stated, jet A was used to quantitate the sample results. It is interesting to note that jet A is also used to fuel the diesel vehicles. According to Ogden personnel, the diesel vehicles appear to run well on the jet fuel, and it is more economical. PBZ sampling results for individuals working on the flightline (aircraft refuelers, ramp mechanics, and one utility sumper) ranged from 0.4 to 7.7 mg/m^3. PBZ sampling results for shop mechanics working within the maintenance bay ranged from 3.0 to 7.7 mg/m^3. GA sampling results ranged from none detected (upwind of the terminal) to 9.0 mg/m^3 (shop maintenance bay). All TWA results were well below applicable evaluation criteria.

Carbon Monoxide: The results of PBZ and GA samples collected for CO are presented in Table 8. All PBZ and GA sample results were below applicable evaluation criteria as a TWA. However, five of ten PBZ and one of nine GA sampling results were above the ceiling limit of 200 ppm established by NIOSH. All PBZ samples which exceeded the ceiling limit occurred on the flightline (refuelers and ramp mechanics). The one GA sample which exceeded the ceiling limit occurred in the shop maintenance bay. Figures 2 through 7 graphically show the CO monitoring results as a function of time for those samples that exceeded the ceiling limit. Observations of the aircraft refuelers and ramp mechanics confirm these results that workers are required to perform duties in close proximity to various flightline vehicle exhausts (i.e., refueling vehicles, airline support vehicles, and aircraft).

Benzene Solubles: The results of PBZ and GA air sampling for benzene solubles are presented in Table 6 and Table 7, respectively. An anomaly was the sample result from a refueler who had the highest sample results (1.05 and 0.52 mg/m^3). His results were two to five times higher than the next highest result (0.22 mg/m^3). This anomaly may be related to the fact he was a moderate smoker. As stated previously, this method is non-specific with regards to the combustion source (i.e., combustion of tobacco versus petroleum fuel). Excluding this anomaly, PBZ air sampling results for individuals working on the flightline (aircraft refuelers, ramp mechanics, and one utility sumper) ranged from none detected to 0.22 mg/m^3. PBZ sample results for shop mechanics working within the maintenance bay ranged from none detected to 0.14 mg/m^3. GA sampling results ranged from none detected to 0.12 mg/m^3 in the shop maintenance bay. It is interesting to note that smoking was allowed in the breakroom and that the sample results ranged from none detected to 0.1 mg/m^3. Since no evaluation criteria exists, this information can serve to establish baseline exposure data.

Polynuclear Aromatic Hydrocarbons (PNAs): Laboratory analysis for PNAs indicated trace exposures to several compounds including naphthalene, acenaphthylene, fluorene, phenanthrene, fluoranthene, pyrene, B[a]P, and benzo (ghi) pyrene. The GA sample results are presented in Table 9. Due to sample interference for the analysis of acenaphthylene, a less than (<) value was reported which was significantly higher than the MDC for the method.

The highest PNA concentrations occurred in the shop maintenance bay on October 14. These results included fluorene (0.07 µg/m^3 which was between the MDC and MQC), phenanthrene (0.54 µg/m^3), fluoranthene (0.22 µg/m^3), pyrene (0.03 µg/m^3 which was between the MDC and MQC) benzo (ghi) perylene (0.03 µg/m^3), and B[a]P (0.01 µg/m^3 which was between the MDC and MQC). Trace concentrations of PNAs were detected in all other areas including the air samples taken upwind of the airport. Although no evaluation criteria exists for these PNA compounds, this information will help to establish baseline information.

The only PNA compound which has an evaluation criteria is naphthalene which was detected in several locations. The highest concentrations occurred in the shop maintenance bay (8.2 and 15 µg/m^3) and the breakroom (2.3 and 2.9 µg/m^3). The highest concentration detected (15 µg/m^3) was more than 3000 times lower than all applicable evaluation criteria (50,000 µg/m^3).

MEDICAL EVALUATION RESULTS

NIOSH investigators interviewed 12 employees including mechanics, fuelers, and tank farmers. Headache was reported by three workers and nausea was reported by two workers as being associated with working with the jet fuel. No other symptom was reported by more than one worker. Most of the health effects noted by the union occurred in mechanics. The union safety steward reported two fatalities from lung cancer since 1990 and single cases of lymphoma, throat, and prostate cancer, as well as two cases of emphysema, both in employees under 35 years of age. According to the union officials, all of the employees with respiratory illness were cigarette smokers. During the site visit, NIOSH investigators also identified three cases of cardiomyopathy, with one resulting in death and the other two requiring heart transplantation.

A review of the OSHA 200 logs revealed a decreasing number of work related illnesses and injuries since 1989 (see Table 10). This decrease appears to be consistent with the employees' reports of increased emphasis on safety and health at the facility since an OSHA inspection in 1990. The majority of injuries were sprains and strains of the ankle and upper back, neck and knee injuries. Most of these injuries were sustained during fuel hook-up or around ladders or stairs. Many of the back injuries were sustained moving hoses during the fueling process.

Questionnaires were distributed in the Ogden Aviation breakroom to employees of the day and evening shifts as they ended their workshifts, took breaks, or ate lunch on the visit of October 13-14, 1993. Questionnaires were given to the supervisors for the night shift for distribution to night shift workers. A total of 134 questionnaires were returned. The participating employees represented all major job classifications at Ogden (Table 11) and had worked an average of nine years at Ogden Aviation.

Ninety-eight percent of the employees reported that they had skin contact with jet fuel; 86% of workers reported that they had jet fuel contacting their hands, 77% reported contact to their arms, and 71% reported jet fuel had contacted their face (Table 12). Seventy percent reported that they had experienced a "fuel bath" (defined on the questionnaire as "Fuel spraying over your entire body"). There was no statistically significant difference between job titles and the number of fuel baths reported by the employees (f=1.05 p=0.39). There was, however, a difference in whether a worker had ever experienced a fuel bath for different job titles (Table 13). Workers who classified themselves as ramp mechanics, tank farmers, or vehicle maintenance were more likely to have experienced a fuel bath than fuelers (chi-square= 12.09, p=0.012; Table 13). Ninety-nine percent of all respondents reported that they had "ever" had jet fuel on their clothing and 49 (48%) reported that they had "ever" had jet fuel on their underwear.

DISCUSSION

TOXICITY OF JET FUEL A

Jet Fuel A is predominantly kerosene and possesses similar toxicological properties to that compound. Acute overexposure to Jet Fuel A can produce central nervous system symptoms of headache, nausea, weakness, dizziness, loss of motor control and judgement, and at high exposures, loss of consciousness, coma, and death. Studies linking jet fuel to cancer are inconclusive. Human studies of exposure to military jet fuel have not consistently revealed excess cancers associated with exposure.[16] Siematycki et al.,[17] however, found an association between renal cancer and exposure to jet fuel. The International Agency for Research on Cancer (IARC) has determined that there is only limited evidence implicating petroleum naphtha as a carcinogen in animals and insufficient evidence associating exposure to petroleum naphtha and the development of cancer in humans.[18] However, depending upon the refining process, petroleum naphtha may sometimes contain varying amounts of aromatic hydrocarbons such as benzene and B[a]P, which are carcinogenic.

Jet engines were previously found to emit B[a]P in their exhaust at a calculated rate of 4 mg B[a]P/min.[19] This compound is a product of combustion and is found in automobile exhaust as well as cigarette smoke. Jet engines are most polluting during startup idle, which is the time that employees at Ogden would be in close proximity to them. The actual exposures to employees working at Newark Airport were all less than the minimum quantifiable concentration.

HEALTH EFFECTS

As noted previously, union officials identified three cases of lung cancer, one case of throat cancer and two cases of emphysema all in cigarette smokers. Further case identification was not attempted so it is possible that additional cases of cancer were not discovered. However, cigarette smoke, which contains B[a]P, is strongly associated with the development of lung cancer and emphysema. Any occupational B[a]P exposure would increase the exposure to this compound among cigarette smokers. Although B[a]P was measured in the work area on the days of the NIOSH investigation, the exposure to B[a]P was low and unlikely to substantially increase exposure.

Three cases of cardiomyopathy, two of which required heart transplantation and another that resulted in the death of an employee, were reported to NIOSH investigators. Exposure to jet fuel has not been implicated in the development of cardiomyopathy. The etiology of cardiomyopathy is usually unknown although cases have been attributed to ingestion of cobalt or lead,[20] alcohol abuse, and myocardial infections.[21] Cases of cardiomyopathy following solvent inhalation[22] or ingestion of hydrocarbons[23] have been reported. Cardiomyopathy has been reported in workers exposed to high levels of carbon monoxide (carboxyhemoglobin concentrations > 30%)[24, 25] The levels of carboxyhemoglobin among workers at Ogden Aviation is not known at this time. Although six workers had exposures that exceeded the ceiling value of 200 ppm, the TWA exposure for these workers was very low (<10 ppm), and it is implausible that their exposure would result in carboxyhemoglobin levels as high as 30%.

In a previous study of aircraft refuelers, NIOSH investigators found high levels of CO occurring from exposures to exhaust from tank trucks while the workers were seated in the cab with the engine running, particularly during cold weather.[26] Our survey at Ogden Aviation was conducted in November 1993, before it was very cold, and we didn't observe workers remaining in the trucks with the engine running for long periods of time.

Carbon monoxide exposure has also been linked to arteriosclerotic heart disease. An excess of deaths from arteriosclerotic heart disease was discovered among bridge and tunnel workers who were exposed to carbon monoxide.[27] The effects of carbon monoxide exposure may also lead to behavioral and neuropsychiatric changes. Headache, nausea, weakness, dizziness, mental confusion and hallucinations may occur in individuals exposed to carbon monoxide at levels of 500 to 1000 ppm.[28]

The skin exposure of the workers to jet fuel has to be considered when evaluating the workers' total exposure as certain components of the jet fuel are absorbable by the skin. According to the manufacturer, the fuel is non-toxic when absorbed through the skin. However, the benzene component of jet fuel, although small, is absorbable through the skin but at a lower rate than from inhalation[29]. Absorption rates, in vitro, are about 0.1% and increase 10 to 100 times as dose increases.[30]

Skin contact with Jet Fuel A has been reported to lead to discoloration, swelling, feeling of heat and blistering. The Chevron Company Material Safety Data Sheet (MSDS) for Jet Fuel A states that jet fuel is a "moderate skin irritant so contact with the skin could cause prolonged injury to the affected area." Ogden Aviation provided workers with seven uniform changes per week and allowed employees to change during the day if necessary. Employees reported that this was not always possible as they could not leave aircraft unattended during refueling and could not leave the aircraft ramp area during peak hours.

CONCLUSIONS AND RECOMMENDATIONS

Air sampling results suggest that the potential for inhalation exposure to petroleum naphthas and petroleum combustion product emissions was minimal on the days of the evaluation. B[a]P, a carcinogen, was detected in the shop maintenance bay at levels below the minimum quantifiable concentration. However, several refuelers and ramp mechanics had CO exposures that exceeded the NIOSH ceiling limit of 200 ppm. These exposures occurred when workers performed duties in close proximity to various flightline vehicle exhausts (refueling vehicles, airline support vehicles, and aircraft) during times of heavy vehicle activity.

The potential for skin absorption of fuel is a concern. A majority of the refueling personnel are required to couple and uncouple fuel nozzles underneath the wing. Although the engineering controls significantly limit fuel spillage, a small amount of fuel absorbed onto the work clothing could result in a long-duration exposure to the skin. Company operating procedures call for a person splashed with fuel to immediately wash the affected area and change into fresh work clothing. This procedure is sometimes impractical during heavy refueling operations. Fuel exposures can be minimized through the conscientious use of personal protective equipment. Personal protective equipment worn by the refuelers and maintenance personnel included safety goggles, hearing protectors, chemical-resistant gloves, and steel-toed shoes.

1. The current company safety training program should be modified to increase worker awareness of potential exposures to vehicle exhaust emissions. Workers should be trained to avoid unnecessary exposure both from their vehicles and vehicles surrounding them during refueling and maintenance operations.

2. CO emissions should be further reduced through proper maintenance of vehicle engines and exhaust systems. Ogden Aviation and other airport vehicle operators should make sure to shut off their vehicle engines, when appropriate, to avoid unnecessary exposures to combustion exhaust emissions.

3. When skin exposure is likely, as is the case with refuelers, long gauntlet chemical-resistant gloves (i.e., gloves covering the forearms) should be worn. Several materials provide adequate protection including nitrile rubber, fluorocarbon rubber, and polyethylene.[31] This would aid in further reducing dermal contact from small spills which may occur during the workshift.

4. The designated smoking area in the breakroom is inadequate in preventing non-smoker exposure to environmental tobacco smoke. Environmental tobacco smoke contributes to particulate and gaseous contaminants and is suspected to increase the risk of developing lung cancer and heart disease.[32,33] For these reasons, exposures should be reduced to the lowest feasible concentration by (1) eliminating smoking in the building or, (2) modifying the existing smoking areas. If smoking is allowed in the building, a separate smoking area should be created which is under negative pressure with respect to adjacent areas and has a dedicated exhaust system (room air exhausting directly to the outside) providing 60 cubic feet per minute per person of outside air.[34]

5. To ensure compliance with OSHA requirements, qualitative or quantitative fit testing of respirators should be accomplished according to procedures described in 29 CFR 1910.1001, Appendix C or 1910.1025, Appendix D. NIOSH recommends quantitative fit testing to ensure an adequate face-piece-to-face seal. Additionally, unless there are qualified individuals within the company, the respiratory protection program should be thoroughly reviewed by an occupational health consultant.

6. Additional industrial hygiene sampling should be conducted in the fuel hydrant pits to measure worker exposure to jet fuel while they are changing the fusible links.

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1. Ogden Aviation
2. International Association of Machinists District Lodge 141
3. International Association of Machinists Local 1445
4. OSHA Region II

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.

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Table 1
NUMBER OF EMPLOYEES BY JOB TITLE
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Job Title	Number	Job Title	Number
fuelers	114	tank personnel	5
part time fuelers	28	maintenance	7
mechanics	38	fueling personnel	31
utility persons	15	parts personnel	4
tankmen	11	EWR management	5
administration	9		

Table 2
CONFINED SPACE CLASSIFICATION TABLE[1]
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Parameters	Class A	Class B	Class C
Characteristics	immediately dangerous to life - rescue procedures require the entry of more than one individual fully equipped with life support equipment - maintenance of communication requires an additional standby person stationed within the confined space	dangerous, but not immediately life threatening - rescue procedures require the entry of no more than one individual fully equipped with life support equipment - indirect visual or auditory communication with workers	potential hazard - requires no modification of work procedures - standard rescue procedures - direct communication with workers, from outside the confined space
Oxygen	16% or less *(122 mm Hg) or greater than 25% *(190 mm HG)	16.1% to 19.4% *(122 - 147 mm Hg) or 21.5% to 25% (163 - 190 mm Hg)	19.5 % - 21.4% *(148 - 163 mm Hg)
Flammability Characteristics	20% or greater of LFL	10% - 19% LFL	10% LFL or less
Toxicity	**IDLH	greater than contamination level, referenced in 29 CFR Part 1910 Sub Part Z - less than **IDLH	less than contamination level referenced in 29 CFR Part 1910 Sub Part Z

* Based upon a total atmospheric pressure of 760 mm Hg (sea level)

** Immediately Dangerous to Life or Health - as referenced in NIOSH Registry of Toxic and and Chemical Substances, Manufacturing Chemists data sheets, industrial hygiene guides or other recognized authorities.

Table 3
CHECK LIST OF CONSIDERATIONS FOR ENTRY, WORKING IN AND EXITING CONFINED SPACES[1]
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

ITEM		CLASS A	CLASS B	CLASS C
1.	Permit	X	X	X
2.	Atmospheric Testing	X	X	X
3.	Monitoring	X	O	O
4.	Medical Surveillance	X	X	O
5.	Training of Personnel	X	X	X
6.	Labeling and Posting	X	X	X
7.	Preparation			
	Isolate/lockout/tag	X	X	O
	Purge and ventilate	X	X	O
	Cleaning Processes	O	O	O
	Requirements for special equipment/tools	X	X	O
8.	Procedures			
	Initial plan	X	X	X
	Standby	X	X	O
	Communications/observation	X	X	X
	Rescue	X	X	X
	Work	X	X	X
9.	Safety Equipment & Clothing			
	Head protection			
	Hearing protection	O	O	O
	Hand protection	O	O	O
	Foot protection	O	O	O
	Body protection	O	O	O
	Respiratory protection	O	O	O
	Safety belts	O	O	
	Life lines, harness	X	X	X
		X	O	
10.	Rescue Equipment	X	X	X
11.	Recordkeeping/Exposure	X	X	

X = indicates requirement
O = indicates determination by the qualified person

Table 4
ANALYTICAL LIMITS FOR ANALYSIS OF POLYNUCLEAR AROMATIC HYDROCARBONS ON ZEFLUOR FILTERS
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Analyte	LOD µg/sample	LOQ µg/sample	MDC µg/m^3	MQC µg/m^3
Naphthalene	0.4	-	0.4	-
Acenaphthylene	0.3	-	0.3	-
Acenaphthene	0.3	-	0.3	-
Fluorene	0.05	-	0.05	-
Phenanthrene	0.02	0.065	0.02	0.068
Anthracene	0.02	0.042	0.02	0.044
Fluoranthene	0.03	0.069	0.03	0.072
Pyrene	0.02	0.048	0.02	0.050
Benzo (a) anthracene	0.02	0.048	0.02	0.050
Chrysene	0.02	0.044	0.02	0.046
Benzo (b) fluoranthene	0.03	-	0.03	-
Benzo (k) fluoranthene	0.02	-	0.02	-
Benzo (e) pyrene	0.02	-	0.02	-
Benzo (a) pyrene (B[a]P)	0.006	0.019	0.006	0.020
Indeno(1,2,3-cd)pyrene	0.03	-	0.03	-
Dibenz(a,h)anthracene	0.02	-	0.02	-
Benzo(ghi)perylene	0.009	0.029	0.009	0.030

Comments: LOD is the limit of detection. LOQ is the limit of quantitation. MDC is the minimum concentration, based upon the LOD and an average sample volume of 960 liters for this sample s the minimum quantifiable concentration, derived from the LOQ and the 960 liter sample volume. micrograms. µg/m^3 is the abbreviation for micrograms of analyte per cubic meter of sampled air. are calculated for only those analytes found in samples or in the quality control samples. The (-) s reporting without LOQ.

Table 5
ANALYTICAL LIMITS FOR ANALYSIS OF POLYNUCLEAR AROMATIC HYDROCARBONS ON SORBENT TUBES
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Analyte	LOD µg/sample	LOQ µg/sample	MDC µg/m^3	MQC µg/m^3
Naphthalene	0.4	1.3	0.4	1.4
Acenaphthylene	0.3	0.99	0.3	1.03
Acenaphthene	0.3	-	0.3	-
Fluorene	0.05	0.16	0.05	0.17
Phenanthrene	0.02	0.035	0.02	0.037
Anthracene	0.01	0.033	0.01	0.034
Fluoranthene	0.04	0.11	0.04	0.11
Pyrene	0.02	0.041	0.02	0.043
Benzo (a) anthracene	0.02	0.066	0.02	0.069
Chrysene	0.02	0.042	0.02	0.044
Benzo (b) fluoranthene	0.03	-	0.03	-
Benzo (k) fluoranthene	0.02	-	0.02	-
Benzo (e) pyrene	0.02	-	0.02	-
Benzo (a) pyrene (B[a]P)	0.02	0.066	0.02	0.069
Indeno(1,2,3-cd)pyrene	0.03	-	0.03	-
Dibenz(a,h)anthracene	0.02	-	0.02	-
Benzo(ghi)perylene	0.03	-	0.03	-

Comments: LOD is the limit of detection. LOQ is the limit of quantitation. MDC is the minimum detectable concentration, based upon the LOD and an average sample volume of 960 liters for this sample set. MQC is the minimum quantifiable concentration, derived from the LOQ and the 960 liter sample volume. µg means micrograms. µg/m^3 is the abbreviation for micrograms of analyte per cubic meter of sampled air. The LOQs are calculated for only those analytes found in samples or in the quality control samples. The (-) sign denotes reporting without LOQ.

Table 6
PERSONAL AIR SAMPLING RESULTS, BENZENE SOLUBLES AND NAPHTHAS
(milligrams per cubic meter)
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

JOB TITLE	AREA	DATE (mo/da/yr)	TIME (min)	BENZENE SOLUBLES	NAPHTHAS
Refueler 1	Term C	10/13/93	473	nd	7.7
Refueler 2	Term C	10/13/93	493	nd	4.8
Refueler 3	Term C	10/13/93	453	0.10	1.0
Refueler 4 *	Term C	10/13/93	483	0.06	0.4
Refueler 5	Term A	10/13/93	485	nd	0.6
Refueler 6 *	Term C	10/13/93	496	1.05	1.4
Refueler 7	Term C	10/13/93	487	nd	1.2
Refueler 8	Term A	10/13/93	485	0.20	2.6
Refueler 1	Term C	10/14/93	469	nd	3.8
Refueler 2	Term C	10/14/93	478	0.22	3.6
Refueler 3	Term C	10/14/93	480	0.14	1.4
Refueler 4 *	Term C	10/14/93	341	nd	0.9
Refueler 5	Term A	10/14/93	505	nd	1.3
Refueler 6 *	Term C	10/14/93	519	0.52	2.3
Refueler 7	Term C	10/14/93	489	nd	1.6
Refueler 8	Term A	10/14/93	330	0.14	2.0
Ramp Mechanic 1	Term A	10/13/93	536	0.15	2.1
Ramp Mechanic 2	Term C	10/13/93	538	nd	1.0
Shop Mechanic 1	Pump Rm	10/13/93	465	0.10	7.4
Shop Mechanic 2	Maint Bay	10/13/93	451	0.10	5.4
Shop Mechanic 3	Main Bay	10/13/93	486	0.09	5.7
Ramp Mechanic 1	Term A	10/14/93	541	0.08	1.1
Ramp Mechanic 2	Term C	10/14/93	529	0.10	0.7
Shop Mechanic 1	Pump Rm	10/14/93	482	nd	3.0
Shop Mechanic 2	Maint Bay	10/14/93	493	0.14	5.5
Shop Mechanic 3	Main Bay	10/14/93	488	nd	7.7
Utility Sumper	Term C	10/14/93	400	nd	5.9

Comments:
nd - indicates none detected
* - indicates tanker refuelers

Table 7
GENERAL AREA AIR SAMPLING RESULTS, BENZENE SOLUBLES AND NAPHTHAS
(milligrams per cubic meter)
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

LOCATION	**DATE** (mo/da/yr)	**TIME** (min)	**BENZENE SOLUBLES**	**NAPHTHAS**
Breakroom	10/13/93	405	nd	0.6
Shop Maint. Bay	10/13/93	475	0.12	5.7
Terminal B3/C1	10/13/93	478	0.09	[0.1]
Terminal C1/C2	10/13/93	473	0.06	[0.2]
Upwind of Airport	10/13/93	472	0.09	nd
Breakroom	10/14/93	473	0.10	1.1
Shop Maint. Bay	10/14/93	475	0.06	9.0
Terminal B3/C1	10/14/93	451	0.09	[0.3]
Terminal C1/C2	10/14/93	450	nd	nd
Upwind of Airport	10/14/93	448	nd	nd

Comments:
nd - indicates none detected
[ ] - values shown in brackets are between the minimum detectable concentration (0.1 mg/m3) and the minimum quantifiable concentration (0.34 mg/m3) based on an average sample volume of 96 liters

Table 8
AIR SAMPLING RESULTS, CARBON MONOXIDE
(parts per million)
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

	10/13/93			10/14/93		
Type of Sampling	**Time** (min)	**TWA**	**Ceiling**	**Time** (min)	**TWA**	**Ceiling**
PERSONAL SAMPLING						
Refueler 3	453	8	494	480	6	181
Refueler 6	496	4	251	519	5	305
Ramp Mechanic 1	536	6	505	541	4	26
Ramp Mechanic 2	538	4	133	529	3	241
Shop Mechanic 3	486	4	91	488	5	53
AREA SAMPLING						
Breakroom				473	2	4
Shop Maint. Bay	475	2	187	475	6	225
Terminal B3/C1	478	1	16	451	3	16
Terminal C1/C2	473	2	40	450	1	23
Upwind of Airport	472	nd	nd	448	3	32

Comments:
nd - indicates none detected
shaded areas indicate exposures which exceeded the NIOSH ceiling limit

Table 9
AREA AIR SAMPLING RESULTS, POLYNUCLEAR AROMATIC HYDROCARBONS
(micrograms per cubic meter)
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

LOCATION	DATE (mo/da/yr)	TIME (min)	Naphthalene	Acenaphthylene	Fluorene	Phenanthrene	Fluoranthrene	Pyrene	Benzo(a)pyrene	Benzo(ghi)perylene
Breakroom	13/10/93	405	2.3	<1.9	nd	0.07	nd	nd	nd	nd
Shop Maint. Bay	13/10/93	475	8.2	<3.8	nd	0.24	[0.08]	nd	nd	[0.01]
Terminal B3/C1	13/10/93	478	[0.86]	<3.6	nd	0.04	nd	nd	nd	nd
Terminal C1/C2	13/10/93	473	[0.58]	<2.4	nd	[0.03]	nd	nd	nd	nd
Upwind of Airport	13/10/93	472	[0.50]	<1.3	nd	nd	nd	nd	nd	nd
Breakroom	14/10/93	497	2.9	<2.5	nd	0.06	nd	nd	nd	nd
Shop Maint. Bay	14/10/93	475	15	<8.6	[0.07]	0.54	0.22	[0.03]	[0.01]	0.03
Terminal B3/C1	14/10/93	451	1.4	<5.3	nd	0.07	nd	nd	nd	nd
Terminal C1/C2	14/10/93	450	1.6	<5.3	nd	0.06	nd	nd	nd	nd
Upwind of Airport	14/10/93	448	[1.1]	<4.5	nd	0.06	nd	nd	nd	nd

Comments:
nd - indicates none detected
[ ] - values shown in brackets are between the minimum detectable concentration and the minimum quantifiable concentration (see Tables 1 and 2)
< values indicate sample interference and this value is the minimum detectable concentration above which nothing was detectable

Table 10
REPORTED INCIDENTS FROM OSHA 200 LOGS
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Year	Incidents	Time lost (days)
1989	89	621
1990	73	428
1991	31	199

Table 11
JOB TITLES OF QUESTIONNAIRE PARTICIPANTS
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Job Title	frequency	%
ramp mechanic	8	6
vehicle maintenance	13	10
tank farmer	10	8
fueler	88	67
other	13	10

Table 12
JET FUEL EXPOSURE TO SKIN
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Part of body	% usually	% ever
hands	76	86
arms	64	77
face	36	71
head	21	53
chest	8	34
legs	36	53
feet	17	34
other	3	6

Table 13
PERCENT OF WORKERS REPORTING A FUEL BATH "EVER"-BY JOB DUTY
Ogden Aviation, Newark, NJ, HETA 92-0288
October 13-14, 1993

Job Title	frequency	% of workers with job duty
ramp mechanic	7	88
vehicle maintenance	10	77
tank farmer	8	80
fueler	38	44
other	7	58
p*	0.012	

* the p value indicates the probability the differences between job titles are due to chance alone.