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SUMMARY

A request to the National Institute for Occupational Safety and Health (NIOSH) for a health hazard evaluation (HHE) was received from the United Steelworkers of America in December, 1990. The request, made on behalf of employees of Union Tank Car Company, Cleveland, Texas, concerned worker exposures to hazardous residues and other substances during railroad tank car repair. Specific areas of concern among employees at this facility were: arc gouging and welding, and gas welding and cutting on railroad cars (particularly inside the buildings); interior sweeping and cleaning of chlorine cars; handling ceramic fiber and fiberglass insulation; exposure to airborne dust during baghouse emptying; acute exposure incidents during welding and cutting on an acrolein car and after backflow of contaminants into the supplied breathing air system; and scraping and buffing of asbestos-containing gaskets. The primary health symptom which had been reported was respiratory irritation.

Two NIOSH site visits were made for this HHE. The purpose of the first site visit, on February 19-21, 1991, was to measure employee exposures and to establish the level of reported symptoms of respiratory and skin irritation among workers potentially exposed to isocyanates. On the basis of the preliminary findings, NIOSH investigators conducted a followup site visit, on January 29-31, 1992, for additional environmental monitoring, and biological monitoring for inorganic arsenic and cadmium.

During the initial visit, seven workers were sampled during gas welding and cutting, and air arc gouging on chlorine cars. Because the sampling periods were less than the full shift, 8-hr time-weighted averages (TWAs) were extrapolated for the highest exposures by assuming no other exposure during the workshift. Three of seven extrapolated 8-hr TWA iron oxide exposures (range: 5.6-6.4 mg/m^3) exceeded the NIOSH Recommended Exposure Limit (REL)-TWA of 5 mg/m^3. Three of seven extrapolated 8-hr TWA arsenic exposures (range: 12-14 µg/m^3) exceeded the OSHA Permissible Exposure Limit (PEL)-TWA of 10 µg/m^3, and four actual TWAs exceeded the NIOSH REL-Ceiling of 2 µg/m^3 (range: 17-23 µg/m^3). Two of the overexposures, for both iron oxide and arsenic, were during air arc gouging, and one was during gas welding and cutting. None of the seven extrapolated 8-hr TWA lead and chromium (metal) exposures exceeded the respective exposure criteria. Ten area samples were collected with impingers during cutting and burning on foam-insulated chlorine cars; no isocyanates were detected in the samples, below the minimum detectable concentration (MDC) of 1.7 µg/m^3. Fifteen exposures were measured for fiberglass during insulation handling, all of the measured values were well below the NIOSH REL of 3 fibers/cc. Potential worker exposures to asbestos and polyisocyanate foam decomposition products were identified with sampling of bulk materials. The most frequently reported symptoms among workers potentially exposed to isocyanates were eye, mouth and throat irritation; however, equivalent levels of irritation symptoms were reported among unexposed workers.

During the followup visit, twelve workers were sampled during welding and air arc gouging, and interior sweeping. Ten of 12 arsenic exposures exceeded the NIOSH REL-Ceiling of 2 $\mu g/m^3$, and five of 12 were above the OSHA PEL-TWA of 10 $\mu g/m^3$. Four of 12 iron oxide exposures exceeded the NIOSH REL-TWA of 5 mg/m^3. All of the personal breathing zone (PBZ) exposures measured for cadmium, chromium (metal), chromium VI, lead, and nickel were below the respective exposure criteria. Results of bulk sampling indicated that one of four paint samples analyzed contained zinc chromate, a potential source of chromium VI exposure; however, due to analytical interferences air sampling for chromium VI was inconclusive. Six of 19 short-term arsenic exposures measured exceeded the NIOSH REL-Ceiling of 2 $\mu g/m^3$; the highest (range: 89-240 $\mu g/m^3$) were during carbon air arc gouging. Bulk material sampling indicated that the arsenic was probably a trace constituent of the tank car steel. Nineteen samples for nitrogen dioxide (NO_2) and carbon monoxide (CO) were collected during carbon air arc gouging, welding, and torch cutting. Twelve of 19 NO_2 exposures (range: <0.38 to 4.5 ppm) were equal to, or exceeded the OSHA PEL-short-term exposure limit (STEL) and the NIOSH REL-STEL of 1 ppm. None of the 19 short-term CO exposures (range: <5 to 70 ppm) or the 13 hydrogen cyanide exposures measured (range: <0.09 to 3.1 ppm) exceeded the respective evaluation criteria.

A total of 25 employees, all males, submitted urine samples for arsenic and chromium evaluation. All of the urinary arsenic (range: 2 to 14 µg/g creatinine) and chromium (range: <1 to <7µg/g creatinine) concentrations were below the respective American Conference of Governmental Industrial Hygienists Biological Exposure Indices. Three of 25 workers had urinary inorganic arsenic concentrations which exceeded those usually seen in the general population (<10 µg/L), suggesting occupational exposure.

Environmental monitoring indicated that during arc gouging, welding, cutting, and interior sweeping on railroad tank cars, worker exposures to arsenic, iron, nickel, and nitrogen dioxide were a health hazard. Exposures to other contaminants, including isocyanates, chromium, and asbestos were a potential health hazard during car maintenance activities surveyed. Urine testing suggested occupational exposure to arsenic among some workers tested. Recommendations are provided for installation of engineering controls, and improved respiratory protection and administrative controls to prevent both routine overexposures and acute exposure incidents.

KEYWORDS: SIC 4789 (transportation services, not elsewhere classified), railroad car repair, tank cars, arsenic, chromium, welding, cutting, air arc gouging, isocyanates.

INTRODUCTION

A request to the National Institute for Occupational Safety and Health (NIOSH) for a health hazard evaluation (HHE) was received from the United Steelworkers of America office in Pittsburgh, Pennsylvania in December, 1990. The request, made on behalf of employees of Union Tank Car Company, Cleveland, Texas, concerned worker exposures to hazardous residues and other substances during railroad tank car repair. According to the local union president, specific areas of concern among employees at this facility included: arc gouging and welding, and gas welding and cutting on sulfur and polyisocyanate foam-insulated chlorine cars (particularly inside the buildings); interior sweeping and cleaning of chlorine cars; handling ceramic fiber and fiberglass insulation; exposure to airborne dust during baghouse emptying; acute exposure incidents during welding and cutting on an acrolein car and after backflow of contaminants into the supplied breathing air system; and scraping and buffing of asbestos-containing gaskets. The primary health symptom which had been reported was respiratory irritation, and at least one worker had reported health problems from a previous exposure to acrolein.

Two NIOSH site visits were made for this HHE. The purpose of the first site visit, on February 19-21, 1991, was to measure employee exposures in the areas of concern and to establish the level of reported symptoms of respiratory and skin irritation. On the basis of the preliminary findings, NIOSH investigators conducted a followup site visit, on January 29-31, 1992, for additional environmental monitoring of selected contaminants in the areas of concern, and medical monitoring of workers exposed to arsenic and cadmium. An interim report, dated September 24, 1991, with findings from the initial visit and interim recommendations, was provided to the union and management. Following the second visit, employee notification letters were provided to workers who participated in the medical monitoring.

BACKGROUND

The Union Tank Car Company (UTC) facility in Cleveland, Texas, refurbishes, repairs, and performs routine maintenance on railroad tank cars. At the time of the initial NIOSH site visit, the workforce consisted of 237 full-time employees (48 salaried) over three shifts per day, with most on the first and second shifts. The number of workers was reduced to 164 full-time employees (47 salaried) at the time of the second NIOSH visit. On-site facilities included an outdoor car cleaning station (known as the "LPG rack"), three buildings for maintenance interior work, a paint shop, and outdoor and indoor areas for abrasive blasting. UTC has operated this facility since 1978.

Railroad tank cars which arrive for servicing are either customer-owned or leased from UTC. UTC's car repair customers represent a number of industries, including chemical and agricultural product producers. Approximately 800 commodities are reportedly transported by UTC customers, ranging from non-toxic food products to highly toxic industrial chemicals, such as acrolein. Tank cars of one type, such as cars used to transport chlorine or sulfur, may arrive in large batches for scheduled maintenance. According to management representatives, tank cars which arrive for repair are generally "empty" as defined by the Resource Conservation and Recovery Act[1], that is, no more than one inch of residue in the bottom, or 0.3 percent by weight of the total capacity of the container remains.

A manifest which is attached to the cars upon arrival identifies the car contents and the amount of residue. Cars delivered for maintenance are inspected and cleaned by UTC at the facility prior to maintenance work. UTC has specific written tank car cleaning instructions, which include confined space entry procedures, for many of the products transported. The instructions call for ventilation and testing of the atmosphere inside the tank cars for oxygen deficiency, explosive atmosphere, and where applicable, specific hazardous materials; prior to worker entry.

Tank cars may undergo a variety of repair and refurbishment processes at the facility, including oxyacetylene gas torch or electric arc welding and cutting, air arc gouging with carbon electrodes, removal and replacement of insulation material, removal of interior and exterior coatings by abrasive blasting, pressure head and valve repair, and interior and exterior spray painting. The coatings used to repaint cars are specified by the UTC's customers; reportedly the formulations required change frequently. A ventilation system is used in the abrasive blasting areas to collect dust and fines in an exterior baghouse. Reportedly, the baghouse dust is emptied into trucks for transportation to a disposal site quarterly, or sooner if it becomes full. Workers reported that they were exposed to airborne dust during this operation.

During welding and cutting, and air arc gouging, constituents of the tank car surface coatings, surface contaminants, metal alloy components, and product residues may be volatilized, potentially exposing car repairers and welders to a complex mixture of compounds.[2] During welding and cutting on chlorine cars, which are double-walled cars insulated with a polyisocyanate foam (Isofoam®, I.P., Inc., Elkton, MD), the foam may be ignited, exposing workers to smoke containing thermal decomposition products. This smoke has been found to contain potentially toxic substances, including 4,4'-methylenediphenyl isocyanate (MDI), a respiratory and dermal sensitizer.[3] The ventilation provided inside the three general maintenance buildings consisted of passive roof openings, with axial wall fans in some areas.

Company representatives indicated that complaints have been received from workers over a number of years regarding exposures during maintenance on sulfur cars. The conditions of concern reportedly occurred when welding or cutting took place on more than one sulfur car inside one of the buildings, particularly on the older cars built in the 1960's. Reportedly, an irritating smoke containing sulfur dioxide was produced when sulfur solid residues on the car are ignited.

EVALUATION DESIGN AND METHODS

ENVIRONMENTAL

During the first site visit on February 20-21, 1991, personal breathing zone (PBZ) and area air samples were collected during the first shift, primarily during periods of highest work activity. During the sampling periods, work practices were observed. Processes sampled were (analytes in parentheses):

- gas and arc welding and cutting, and air arc gouging, on foam-insulated chlorine cars (isocyanates, metals, hydrogen cyanide, nitrous oxides, carbon monoxide)
- interior sweeping of chlorine cars (chlorine, metals)
- valve gasket replacement and fiber insulation handling (asbestos, fibers)
- welding and cutting on a sulfur car (sulfur dioxide)*

Bulk materials were sampled to determine potential worker exposures to hazardous materials. Processes sampled were (analytes in parentheses):

- baghouse dust (metals)
- valve gaskets, fibrous glass (asbestos)
- poly-isocyanate foam insulation (thermal decomposition products)

A walkthrough survey was conducted, during which the breathing air system was inspected, workers who perform maintenance on tank car pressure heads were interviewed and observed, and three workers involved in a February 1989 acute exposure incident involving acrolein were interviewed.

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* NIOSH investigators had planned to sample exposures during welding and cutting on older sulfur cars inside the maintenance buildings conditions did not occur during this investigation.

During the followup visit, on January 30, 1992, PBZ and area air samples were collected during the first and second shifts to measure full-shift and short-term (15-min) exposures to selected contaminants. Processes sampled were those in which worker overexposures to arsenic and other metals had been measured during the initial visit. Processes sampled were (analytes in parentheses):

- gas and arc welding and cutting, and air arc gouging on foam-insulated chlorine cars (metals, hydrogen cyanide, nitrogen dioxide, carbon monoxide).

- interior sweeping of chlorine cars (metals)

UTC job categories which were represented in the NIOSH personal sampling conducted during this evaluation were Car Repairman 1, 2, and 3; and Certified Welder.

Air Samples

Sampling and analytical methods used in this evaluation are summarized in Table 1; the NIOSH analytical methods referenced are described in the *NIOSH Manual of Analytical Methods, Third Edition*.[4] Each of the laboratory methods has a limit of detection (LOD) and limit of quantitation (LOQ), which are determined for each sample set in the laboratory. The minimum detectable concentration (MDC) and minimum quantifiable concentration (MQC) for a given sample can be determined by dividing the LOD and LOQ, respectively, by an appropriate sample volume. The MDC or MQC for laboratory methods are reported with the results. For methods using direct-reading instruments, the manufacturer's LOD or MDC is reported in Table 1.

PBZ and area samples were collected with the specified sampling media connected via plastic tubing to portable battery-operated personal sampling pumps. The pumps were calibrated immediately before and after sampling with a mass flowmeter which had been calibrated with a primary standard (bubble flowmeter). The means of the measured pre- and post-sampling flow rates were used to calculate sample volumes. PBZ samples were collected in workers' breathing zones by attaching the media on the workers' shirt collars; except that for workers wearing welding facemasks the samples were collected in the facemasks. Area air samples for asbestos were collected with electric-powered high-flow pumps connected to a laboratory-calibrated critical orifices (flow rates of 8.25 and 8.9 liters per minute (L/min)).

Bulk Material Samples

Polyisocyanate Foam Insulation.
A sample of foam insulation from a chlorine car in the shop was collected on the first site visit. A qualitative analysis of volatile organic compounds (VOCs) produced by the ignited foam was

performed in the laboratory to determine potential worker exposures. Milligram amounts of the sample were placed in a ceramic boat, and heated in a quartz/Pyrex-lined microcombustion furnace set to 360°C. The effluents were sampled for 30 min periods--10 min with the oven at temperature, and 20 min after the oven was turned off, with both charcoal and ORBO-23® sorbent tubes at flow rates of 0.1 and 0.05 L/min, respectively. Front and back sections of the charcoal tubes were analyzed separately, using 1 mL carbon disulfide for desorption, followed by gas chromatography flame-ionization detector (GC-FID) with a 30-meter column, and gas chromatography with mass spectrometry detection (GC-MSD). Front and back sections of the ORBO-23 samples were analyzed separately, using 1 mL toluene in an ultrasonic bath for 60 min, followed by GC-MSD using a 15-meter column.

Valve Gaskets, Gasket Dust, and Fiberglass Insulation.
Bulk samples were collected on the first site visit of valve gaskets and gasket dust in the buffing area; and of fiberglass insulation to determine potential sources of asbestos exposure. After ensuring homogeneity of the samples, representative portions of each sample were immersed in Cargille liquids and analyzed for percent asbestos by polarized light microscope (PLM) at a magnification of 100X.

Baghouse Dust.
Bulk samples were collected on the first site visit to determine if the material was potentially hazardous. Three replicate aliquots from each sample were weighed and placed in separate vessels, then wet-ashed with concentrated nitric and perchloric acids. The resulting residues were dissolved in a dilute solution of the same acids, and analyzed for 30 metals by inductively coupled argon plasma, atomic emission spectroscopy (ICP/AES)--NIOSH Method 7300.

Tank Car Paints, Polyisocyanate Foam Insulation, and Chlorine Car Interior Dust. Bulk samples were collected on the followup visit. The samples were analyzed to identify potential sources of previously measured arsenic and chromium exposure. Samples were analyzed by ICP/AES--NIOSH Method 7300 (see digestion procedure above).

MEDICAL

During the initial site visit, first and second shift employees present (on February 20 and 21, 1991) were asked to complete a self-administered questionnaire. The purpose of the questionnaire was to determine the prevalence of potentially work-related respiratory and skin symptoms. The questionnaire addressed specific symptoms, including those associated with MDI exposure; and demographic, medical, smoking, and work history information. Specific questions were asked regarding the presence of respiratory symptoms and skin irritation that occurred during the past month, and whether the symptoms occurred while at work, home, or both.

During the followup visit urine samples were collected from employees thought to have the highest potential exposure to arsenic and chromium. Workers who spent the largest proportion of time welding or arc gouging were identified by the union representative and invited to participate. The urine samples were analyzed for arsenic, chromium, and creatinine levels. (The creatinine concentration is not related to any occupational exposures; it is used to standardize the concentrations of arsenic and chromium). On the day the sample was collected, each participant completed a brief questionnaire which asked how many days during the present week he had spent most of the day welding.

The urine samples were collected near the end of the work week (Thursday) so that they would reflect cumulative occupational exposure for that week. For chromium, the ACGIH recommends that specimens be collected at the end of the work shift.[5] However, because the workers do not shower and/or change clothes at the end of the work shift, we chose to collect the specimens at the beginning of the work shift, prior to the employees entering the work area, to avoid contaminating the specimen with arsenic or chromium from the workers' clothes. The urine samples were collected privately by each individual and transferred into preservative-containing plastic bottles supplied by the laboratory. The samples were shipped by overnight mail to the laboratory for analysis of inorganic arsenic and its metabolites (methylarsonic acid and cacodylic acid) and chromium. Arsenic found in fish and seafood is primarily organic, so by measuring only inorganic rather than total arsenic, the interference of dietary arsenic is reduced.[6]

EVALUATION CRITERIA

GENERAL

As a guide to the evaluation of exposures to chemical and physical agents in the workplace, NIOSH employs criteria which are intended to suggest levels of airborne 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 important to note, however, 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 below the evaluation criteria. Some substances are absorbed by direct contact with the skin and mucous membranes, or by ingestion, and thus the overall exposure may be increased above measured airborne concentrations. Evaluation criteria change over time as new information on the toxic effects of an agent become available.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs)[7], the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)[8], and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs)[9]. Employers are required to comply with the OSHA PELs, and other OSHA standards.

These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over an entire 8-hour (PEL-TWAs, TLV-TWAs) or up to 10-hour (REL-TWAs) workday. Concentrations are usually expressed in parts per million (ppm), milligrams per cubic meter (mg/m^3), micrograms per cubic meter ($\mu g/m^3$), or fibers per cubic centimeter (fibers/cc). To compare results with the NIOSH REL-TWAs and OSHA PEL-TWAs, it is sometimes useful to extrapolate an equivalent 8-hr TWA exposure for sampling times of shorter than 8-hr duration. In extrapolating an 8-hr TWA, an assumption is made that there was no other exposure to the compound of interest over the remainder of the 8-hr work-shift.

In addition, for some substances there are short-term exposure limits (STELs) or ceiling limits, i.e., NIOSH REL-Ceiling (15 min), which are measured over a 15-minute period unless otherwise specified; and are intended to supplement the TWA limits where there are recognized toxic effects from short-term exposures. NIOSH has defined a number of substances as potential occupational carcinogens; these are substances which are known to initiate or promote cancers in humans or one or more experimental mammalian species. NIOSH policy regarding exposure to potential carcinogens is that occupational exposures should be reduced to the lowest feasible limit (LFL).

SPECIFIC SUBSTANCES

A list of the substances for which exposures were evaluated in this survey is presented in Table 2. The table presents the applicable occupational exposure criteria (NIOSH, OSHA, and ACGIH) and a brief description of the primary health effects that one or more of the exposure limits are designed to prevent. More detailed discussions of arsenic, chromium, and diisocyanates are provided below.

Arsenic

Exposure to inorganic arsenic can produce dermatitis (skin inflammation), keratoses (horny growths on the skin), peripheral neuropathies (diseases of the nerves of the extremities), peripheral vascular diseases (diseases of the arteries and veins of the extremities), and cancer of the skin, liver, and lungs.[6] Arsenic is absorbed primarily via inhalation and ingestion. Oral ingestion from contaminated hands may result in absorption of toxicologically significant amounts of arsenic.[10]

Inorganic arsenic is eliminated from the body through metabolism and urinary excretion. The total amount excreted in urine accounts for about 60% of the absorbed amount. Inorganic arsenic metabolites appear in urine shortly after the start of exposure. The concentration rises slowly during the first days of the exposure, and then levels off.[6] If a worker's exposure on following days is similar, the arsenic concentration in urine remains more or less the same.

The ACGIH has proposed a Biological Exposure Index (BEI) for arsenic. The BEI is 50 micrograms per gram (µg/g) of creatinine* for inorganic arsenic metabolites in urine measured in workers at the end of the workweek.[6] The current ACGIH TLV-TWA of 200 $\mu g/m^3$ for inorganic arsenic is primarily intended to prevent overt systemic effects of exposure, and does not reflect arsenic's potential to cause cancer. ACGIH has proposed a TLV-TWA of 100 $\mu g/m^3$ for inorganic arsenic, with the designation of confirmed human carcinogen.[8] Both NIOSH[7] and OSHA [29 CFR 1910.1018]** consider inorganic arsenic to be a potential occupational carcinogen. The NIOSH REL (ceiling limit) is 2 $\mu g/m^3$, and the OSHA PEL-TWA is 10 $\mu g/m^3$.

Sources of non-occupational exposure to arsenic are drinking water, food and polluted air.[11] Cigarette smoking is also a source of exposure to arsenic (12 to 42 µg/cigarette).[12] Therefore, arsenic is found in the urine of people who have no occupational exposure to arsenic. Concentrations of inorganic arsenic and its metabolites in the urine of the general population are usually below 10 µg/L (generally equivalent to µg/g creatinine) in European countries, but slightly higher in the United States.[13] Given the NIOSH REL for arsenic, biological monitoring by urinalysis is of little value in determining whether or not workers' arsenic exposures exceeded the REL, as normal levels of arsenic in urine could easily mask the contribution of occupational exposures near the REL.

Chromium VI

The toxicity and solubility of chromium compounds, that contain chromium in the Cr^{2+}, Cr^{3+}, or Cr^{6+} valence state, vary greatly, but those that contain chromium VI (Cr^{6+}) are of greatest health concern. Chromium VI compounds include lead chromate and zinc chromate pigments, chromic acid, and soluble compounds such as those used in chromium plating. Some chromium VI compounds are severe irritants of the respiratory tract and skin, and some (including chromates)

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*Since arsenic concentrations in urine are dependent on urine output, they are normalized with reference to creatinine c the same sample. Creatinine is usually excreted from the body in urine at a constant rate.

** *Code of Federal Regulations.*

have been found to cause lung cancer in exposed workers.[14] Allergic dermatitis is one of the most common effects of chromium toxicity among exposed workers.

The ACGIH BEIs for chromium VI are a 10 µg/g of creatinine increase during the work shift, and 30 µg/g of creatinine when measured in exposed workers at the end of the workweek.[5] These recommended BEIs apply only to operations where water soluble chromium VI fume is present. The BEIs represents levels that are likely to be found in biological samples collected from healthy workers who have inhalation exposure to water soluble chromium VI at the current TLV-TWA of 50 $\mu g/m^3$. The NIOSH REL-Ceiling for chromates, based on designation as a potential occupational carcinogen, is 1 $\mu g/m^3$.

Non-occupational sources of exposure to chromium include food, water, air, and cigarette smoking. Persons not occupationally exposed generally have very low urinary levels, less than 1 µg/L.

Isocyanates

Isocyanates, including MDI, cause irritation to the skin, mucous membranes, eyes and respiratory tract. Worker exposure to high concentrations may result in chemical bronchitis, chest tightness, nocturnal dyspnea (shortness of breath during sleep), pulmonary edema (fluid in the lungs), and death.[15,16]

The most debilitating health effects from exposure to MDI and other diisocyanates are respiratory and dermal (skin) sensitization. Development of this sensitization can depend on the type of exposure, the exposure concentration, the route of exposure, and individual susceptibility. After sensitization, any exposure, even to levels below occupational exposure limits, may produce symptoms and allergic responses which may be life-threatening. The symptoms of both respiratory and dermal sensitization may develop immediately or several hours after exposure (in someone already sensitized), after the first few months of exposure, or may be delayed in onset until after several years of exposure.[17,18,19] The only effective treatment for the sensitized worker is cessation of all diisocyanate exposure. In respiratory sensitization, the response is an asthmatic reaction characterized by coughing, wheezing, shortness of breath, and tightness in the chest; this phenomenon has traditionally been referred to as "isocyanate asthma."[20]

RESULTS AND DISCUSSION

INITIAL VISIT

Environmental Sampling

Welding, Cutting and Gouging--Chlorine Cars

Personal air sampling results for selected metals are shown in Table 3. PBZ exposures were measured for seven workers representing Car Repairman (1, 2, and 3) and Certified Welder job categories. The samples were collected during gas welding and cutting, and air arc gouging on chlorine cars. Ranges for PBZ exposures (irrespective of respirators) to selected metals of potential health significance were: arsenic (ND-23 µg/m^3), iron (1.1-11 mg/m^3), lead (ND-15 µg/m^3), chromium (ND-8.7 µg/m^3), and nickel (ND-12 µg/m^3). Other elements measured (see Table 1"--metals") were either not detected or were at insignificant levels. It was assumed, because the primary processes were welding and arc gouging, that the iron exposures were in the form of iron oxide fume.[21]

Four of seven arsenic exposures measured exceeded the NIOSH REL-Ceiling of 2 µg/m^3 (range: 17-23 µg/m^3). The arsenic sample results are TWAs for 131-409 min sampling periods, and thus do not preclude the possibility that 15-min ceiling levels were much higher. Arsenic, which NIOSH considers to be a potential occupational carcinogen, is an ingredient in some metal alloys and color pigments used for industrial coatings.[22,23]

Because the sampling periods were less than the full shift, 8-hr TWAs were extrapolated for the highest exposures by assuming no other exposure during the workshift. Since that assumption was not always valid, the extrapolated 8-hr TWAs reported should be considered minimum values.

Three of seven extrapolated 8-hr TWA iron oxide exposures (range: 5.6-6.4 mg/m^3) exceeded the NIOSH REL-TWA of 5 mg/m^3. Three of seven arsenic exposures (range: 12-14 µg/m^3) exceeded the OSHA PEL-TWA of 10 µg/m^3. Two of the overexposures, for both iron oxide and arsenic, were during air arc gouging, and one was during gas welding and cutting. None of the seven extrapolated 8-hr TWA lead and chromium (metal) exposures exceeded the respective exposure criteria. The valence state of the chromium was not determined (that requires a separate analytical method). Four of seven chromium exposures may have exceeded the NIOSH REL of 1 µg/m^3 for chromium VI, if the chromium present was in the form of chromates. Chromates are found in industrial paints, and have been found to be potential occupational carcinogens.[24]

Results of grab sampling for nitrous fumes ($NO+NO_2$), CO, and HCN during cutting on a chlorine car are shown in Table 4. Direct-reading grab samples were collected at two locations near a Car Repairman torch cutting on the side of a car; the ranges for results were: $NO+NO_2$ (<2-6.5 ppm) , CO (35-110 ppm), and HCN (>2-2 ppm). The short-term exposures measured did not exceed the NIOSH RELs-Ceiling (15 min) of 200 ppm and 4.7 ppm for CO and HCN, respectively. There is no exposure criteria for total nitrous fumes. However, the $NO+NO_2$ measurements indicate that the NIOSH REL-Ceiling (15 min) for NO_2 of 1 ppm may have been exceeded in three of eight samples (range: 4-6.5 ppm).

Ten area samples were collected with impingers during cutting and burning on foam-insulated chlorine cars on February 20 and 21, 1991. No isocyanates were detected in the samples, less than the MDC of 1.7 µg/m^3 (based on a sample volume of 180 L).

All workers who were sampled were wearing single-use respirators under their welder's facemasks on the days of the survey. According to the company, workers are required to wear high-efficiency particulate air (HEPA) filter respirators (3M® 9920) during arc gouging, but not during torch cutting. These respirators do not protect against exposures to gases (i.e. NO_2) and organic vapors, and are not recommended by NIOSH for protection against potential occupational carcinogens.

Chlorine Car-Interior Sweeping

Results for PBZ exposures to selected metals are shown in Table 3. PBZ sampling, which included all of the workers' interior sweeping during the shift, was conducted on two workers, both Car Repairman 3 job category.

Both arsenic exposures measured (irrespective of respirators) exceeded the NIOSH REL-Ceiling (15 min) of 2 µg/m^3. These exposures were 280 and 135 µg/m^3.

Because the PBZ sampling periods were less than full-shift (50 and 207 min), 8-hr TWAs were extrapolated for the highest exposures by assuming no other exposure during the workshift. Since that assumption was not always valid, the extrapolated TWAs reported here (which are irrespective of respirator use) should be considered minimum values.

Both extrapolated 8-hr TWA exposures to arsenic (29 and 57 µg/m^3) exceeded the OSHA PEL-TWA of 10 µg/m^3. Both extrapolated 8-hr TWA nickel (19 and 38 µg/m^3) and iron (14 and 28 mg/m^3) exposures exceeded the respective NIOSH REL-TWAs of 15 µg/m^3 and 5 mg/m^3. NIOSH considers arsenic and nickel to be potential occupational carcinogens. Neither PBZ exposure for lead and chromium exceeded the NIOSH RELs of <100 µg/m^3, and 500 µg/m^3, respectively. However, the valence state of the chromium detected was not determined (that requires a separate analytical method). Both samples may have exceeded the corresponding NIOSH REL of 1 µg/m^3 if the chromium was in the form of chromates (chromium VI), which are found in industrial paints.

PBZ and area air sampling results for chlorine during interior sweeping are shown in Table 5. Area and PBZ samples were collected during three periods (41-101 min) in which a single Car Repairman swept the interior of a chlorine car. The concentrations of chlorine measured ranged from ND (<2 µg/sample) to 0.008 mg/m^3; the latter result being between the LOD and LOQ. All three area concentrations and PBZ exposures measured exposures were well below the NIOSH REL-TWA of 1.5 mg/m^3, and the NIOSH REL-Ceiling of 3 mg/m^3 for chlorine.

Workers performing chlorine car interior sweeping were wearing supplied-air respirators on the day of the survey, but stated that use of these respirators was not required during this activity.

Welding and Cutting--Sulfur Tank Cars

UTC had no welding and cutting on older sulfur cars inside the maintenance buildings, the condition of concern in the HHE request, scheduled during the NIOSH visits. Reportedly, these work conditions occur at unpredictable and infrequent intervals. Two workers were welding or cutting on a newer (built in 1980's) sulfur car outside the building; and a total of 14 PBZ and area samples were collected for sulfur dioxide. Results of quality control samples in the sulfur dioxide sample set were not within acceptable limits; therefore these sulfur dioxide results are not valid and will not be reported.

Baghouse Dust

The results of the analyses of two bulk samples of baghouse dust for 30 trace elements are shown in Table 6. The samples were collected of dust accumulated directly underneath the exterior blasting baghouse hopper. The primary trace elements detected (and respective concentration ranges) were: iron (20.4-22.6%), barium (3.55-3.88%), calcium (2.17-2.41%), zinc (1.42-1.46%), chromium (0.41-0.46%), aluminum (0.24-0.31%), and lead (0.29-0.33%). Other elements were either measured as less than 0.30% of the sample or were not detected (less than LOQ of 0.01%). Since the baghouse collects dust from abrasive blasting rooms, it is likely that some of the metals detected, such as barium, zinc, lead, and chromium, were from the industrial steel coatings which were removed from tank cars by abrasive blasting. The presence of concentrations in the percent range of these potentially toxic elements indicates that handling the baghouse dust is a potential health hazard for workers.

Fiber Insulation Handling

Results of PBZ sampling for fiberglass and ceramic fibers are shown in Table 7. Fifteen PBZ exposures were measured for four workers in the Car Repairman job category. Exposures measured were TWAs for work periods (54-109 min) during installation of fiberglass insulation, and replacement of ceramic fiber insulation. The exposures ranges measured were: 0.017 (value between LOD and LOQ) to 0.39 fibers/cc for fiberglass installation; and 0.26 to 0.61 fibers/cc for ceramic fiber insulation replacement. All of the measured values were well below the NIOSH REL-TWA for fibrous glass of 3 fibers/cc. Currently there are no evaluation criteria for exposure to ceramic fibers.

Three of the air samples with detectable concentrations of fibers were selected for subsequent analysis for asbestos fibers by TEM (NIOSH Method 7402). In two of the three samples, a single asbestos fiber was identified by TEM, indicating the possible presence of airborne asbestos (see Table 7). However, to positively confirm the presence of asbestos in an air sample, a minimum of three fibers must be identified[3]. Asbestos was not detected in one bulk sample of new fiberglass insulation collected during the installation of fiberglass insulation on a tank car, it was composed exclusively of fibrous glass. The source of any asbestos detected in this area may have been an adjacent work area, the valve gasket replacement area (see below).

Valve Gasket Replacement

Five valve gasket bulk samples were collected from different sizes of gaskets and submitted for asbestos analysis by PLM. All were found to be 90% chrysotile asbestos, indicating a potential health hazard due to airborne asbestos exposure during gasket buffing and valve cleaning. Two samples of dust collected on the desk top in the buffing area were 1% chrysotile asbestos; the remainder of the samples was primarily rubber and metal fragments.

Area concentrations, and PBZ exposures for three workers (Valve Repairman and Car Repairman job categories) were measured during valve gasket buffing, and valve cleaning and reassembly. The gasket buffing process generated large amounts of dust, which necessitated short-term sampling for asbestos to reduce the overloading of filters with particulate matter. Three to eight samples of 8 to 98 minutes duration were collected for each worker sampled. A total of 32 air samples were submitted for asbestos analysis by PCM, and if appropriate TEM. None of the samples contained detectable levels of fibers (limit of detection 7 fibers/mm^2). However, the sampling results were inconclusive (and may include "false negatives"); high total dust levels necessitated short-term sampling, and nine of the 32 samples were so heavily overloaded with particulate matter that fibers could not be counted. Analysis of fiber samples collected in an adjacent area in the same building indicated the possible presence of airborne asbestos (fiber insulation handling, above). Asbestos exposures have been documented among workers cutting and handling asbestos-containing gaskets in the oil industry[25].

On the day of the survey the valve repairman wore a supplied air respirator during the periods of gasket buffing.

Polyisocyanate Foam Thermal Decomposition Products

To measure potential exposures when the foam insulation (Isofoam®) used in chlorine cars is ignited, a sample was collected and submitted for laboratory analysis of thermal decomposition products. A qualitative analysis, by GC-MSD, of VOCs released when a sample of the foam was heated to 360° C (680° F) was performed.

The primary compound identified on the charcoal tube sample of effluents were benzene isothiocyanate, trichlorofluoromethane (Freon 11), chloroethane, and dioctyl phthalate (DOP). In addition to these components, alkyl dioxanes and dioxolanes, aniline, phenols, glycol ethers including butyl cellosolve, benzene, toluene, carbon tetrachloride, chlorobenzene, and xylene were detected.

The primary compound detected on the ORBO-23 tube sample of effluents was acetaldehyde. Propanal was also identified, plus possible traces of formaldehyde and acrolein. Other (non-aldehyde) compounds identified included numerous glycol ethers, aniline, an p,p' methylene dianiline (MDA). The presence of MDA is a good indication that the original foam was a MDI-based polyisocyanate.

Walkthrough Survey

A walkthrough survey was conducted February 20-21, 1991, to address the concerns regarding the adequacy of the plant's breathing air supply system, an acute exposure incident involving acrolein, and tank car pressure head cleaning and repair.

Adequacy of the Breathing Air Supply System

Four oil-lubricated electric high-pressure compressors supplied compressed air to power tools, breathing air lines, abrasive blasting and spray painting lines, and the car cleaning area (known as the LPG rack). At the cleaning area, tank cars were pressurized after a water rinse as part of the cleaning process. Reportedly, an incident had occurred several years ago after compressed air was used to pressurize an ammonia tank car. An unplanned shut down of the facility's air compressors resulted in backflow of residual pressurized ammonia gas into the breathing air supply lines overnight. The next morning, when the breathing air was used workers were reportedly exposed to ammonia.

At the time of our survey, a check valve system was in use to prevent backflow of contaminated air from pressurized cars into the breathing air lines. According to an employee, the current practice is to manually test the check valves prior to connection of a car to the compressed air system; and to replace the valve immediately if it fails the backflow pressure check.

Breathing air supply lines in the three buildings were equipped with continuous-operation carbon monoxide alarms (Mine Safety Appliances #478850), which were set to sound an alarm at 20 ppm. Reportedly, the alarms are calibrated monthly with 20 ppm calibration gas obtained from the manufacturer. At their terminus, supply lines were equipped with pressure-reducing regulators and a filter housing with high-efficiency particulate air (HEPA) and organic vapor filters. The filters were reportedly changed when an odor is noticed, or every 2-3 months.

Three air compressors were located in the compressor room, one of which was in operation on the days of the survey. Air intakes on two of the compressors were ducted to the roof, however the remote air intake duct on the compressor which was in operation was disconnected. Another compressor was located in a detached compressor house. The air intake for that compressor was located inside the house, and the house had roof vents for outside air. All of the compressors were equipped with air dryers at or near the beginning of the high-pressure outflow.

Acute Exposure Incident During Cutting on an Acrolein Car

NIOSH was requested to investigate an acute exposure incident which occurred at the plant on February 22, 1989. Management representatives, and the three employees who were involved in this incident were interviewed. Reportedly, a double-walled, foam-insulated tank car that had been used to transport acrolein or acrylic acid had arrived for maintenance. The car had been cleaned using the normal procedures, and appeared to be empty upon visual inspection. However, while a worker was cutting the inner stainless steel wall of the tank with an air arc gouger he hit a liquid residue that had apparently leaked from the interior of the car into the insulated space between the inner and outer walls at the bottom of the car. The worker was wearing a single-use dust/mist respirator. An acute exposure occurred when the liquid residue ignited and sprayed out of the car. The worker was reportedly splashed with burning liquid, and he, along with two nearby workers, was reportedly exposed to highly irritating vapors. Several workers were hospitalized after the incident. Immediately after the incident, one of the affected workers collected a sample of the liquid and submitted it to the plant safety manager for analysis.

The workers involved in the incident were reportedly not informed of the sample results. During the NIOSH site visit, a company representative reported that a sample of the liquid from the bottom of the tank car had been analyzed after the incident, confirming that it was acrolein. The UTC written procedure for the cleaning of acrylic acid cars was reviewed. It did not contain procedures for cutting the steel jackets off the cars, and a company representative stated that the company currently did not have written procedures for cutting jackets on any tank cars.

Tank Car Pressure Head Cleaning/Repair

A walkthrough survey was conducted of the pressure head cleaning area, and two workers who had performed this task 8 months and 4 years, respectively, were interviewed. The pressure head is a short circular stack about 3 feet in diameter and 1-2 feet high that sits at the top of a tank car. The heads weigh about

1800 lbs; an overhead crane is used to move them. The 1-2 inch-thick steel lid (known as the "silver dollar") of the pressure head contains a number of bolts, valves and fittings that must periodically be replaced due to corrosion of the metal surfaces. Almost all of the work in the pressure head cleaning area is conducted inside the building.

The heads arriving for cleaning are mainly from cars used to transport chlorine, ethylene oxide, vinyl chloride and LPG. Reportedly, before disassembly, the heads are washed with water, then solid residues are removed first by hand scraping and then burning with an oxyacetylene torch. The heads are heated with the torches in order to remove corroded fittings or bolts. Both workers stated that occasionally liquid residues are caught under a bolt or fitting. These residues may be vaporized by torch heating, or when a bolt is cut off with the torch. One worker reported no health problems related to this work; the other worker stated that periodically noxious or irritating vapors resulted from torch heating of the pressure head, causing him to step outside for fresh air. Neither worker wore a respirator while heating or cutting the pressure head on the day of the survey. One worker stated that a supplied-air respirator is available in this area, but that it was missing a regulator at the time of the survey.

Medical

All first and second shift employees were invited to complete the self-administered questionnaire; 122 of the total workforce of 237 (51%) completed the questionnaire. Eighty-four (69%) worked in Buildings 1, 2, or 3, and the remaining 38 (31%) worked in other areas. One hundred nineteen (98%) participants were male, three were female. The workers ranged in age from 20 to 62 years old, with the average age being 35 years. Persons working in Buildings 1, 2, and 3, who were potentially exposed to isocyanates (Group A), were compared with respect to demographics, smoking history, and respiratory symptoms to other, presumably unexposed workers (Group B). Six maintenance workers were excluded from the comparison because they spend time in all areas of the plant. The groups were comparable with respect to the average number of years employed at UTC, age, and smoking history. Thirty-three percent of Group A were smokers, as compared to 27 percent of Group B. Group A employees were slightly younger (average = 35 years) than Group B (average = 37) and had been employed at the company for a shorter time period, an average of 6.5 years and 7.7 years, respectively.

Symptoms reported on the questionnaire are presented in Table 8. Only symptoms that occurred at work, or both at work and home were considered to be potentially work related. The most frequently reported symptom in Group A was eye irritation (48%), while in Group B it was cough (43%). In decreasing order of frequency, the other reported symptoms were: mouth or throat irritation, shortness of breath, wheezing, chest pain or tightness, and persistent skin rash. Group A employees reported more eye irritation, mouth or throat irritation, wheezing, and chest pain or tightness, while Group B employees reported slightly more shortness of breath and skin rash.

Six workers reported that they had at one time received a medical diagnosis of asthma; three were diagnosed prior to beginning work at UTC, one was diagnosed after beginning work, and dates of diagnosis were not available for the remaining two. Two of the six workers reported having used an inhalant or bronchodilator in the past month. Twelve (15%) Group A workers and five (16%) Group B workers who had never been diagnosed with asthma reported experiencing at least two of the following symptoms suggestive of asthma while in the workplace: wheezing, chest pain or tightness, and shortness of breath.

The questionnaire results should be considered inconclusive due to several limitations. The purpose of this screening questionnaire was not to provide definitive diagnoses, but to aid in deciding if further NIOSH evaluation of workers was warranted. Equivalent levels of self-reported symptoms suggestive of asthma were found in those thought to be potentially exposed to MDI (Group A), and those thought to be unexposed (Group B). Fifty-one percent of all employees participated, so it is possible that the symptom rates of the entire workforce may be decidedly different from the rates reported by those who completed the questionnaire. Workers who had experienced respiratory symptoms may have been more likely to complete the questionnaire than those who had not had symptoms. Lastly, the processes involved in refurbishing railroad tank cars involved a variety of respiratory irritants, so it is not surprising that symptoms were reported, even in the absence of exposure to MDI.

Since sampling for MDI at the facility indicated that exposures were below the limit of detection, medical monitoring for MDI exposure was not undertaken. However, air sampling results showed that workers were potentially overexposed to arsenic and chromium; urine monitoring of those workers for chromium and arsenic was done during the next site visit.

FOLLOWUP VISIT

Environmental Sampling

Full-shift Sampling, Chlorine Car Maintenance

The results of full-shift area and PBZ sampling for metals are presented in Table 9, page 1. Twelve workers representing Car Repairman and Certified Welder job categories were sampled during welding and air arc gouging, and interior sweeping. Ten of 12 PBZ arsenic exposures measured (for welding and gouging, and sweeping activities) exceeded the NIOSH REL-Ceiling of 2 $\mu g/m^3$, and five of 12 arsenic exposures exceeded the OSHA PEL-TWA of 10 $\mu g/m^3$. Four of 12 iron oxide exposures exceeded the NIOSH REL-TWA of 5 $\mu g/m^3$, but all were below the OSHA PEL-TWA of 10 .

All of the PBZ exposures measured for cadmium, chromium (metal), chromium VI, lead, and nickel were below the respective exposure criteria. However, the MQC for chromium VI in four of the 12 samples was higher than the NIOSH REL due to color interference; we cannot determine if those exposures were less than the NIOSH REL. Results of bulk sampling indicated that one of four paint samples analyzed contained zinc chromate, a potential source of chromium VI exposure (see below).

The full-shift area concentrations for arsenic, cadmium, chromium, chromium VI, iron oxide, lead, and nickel were not detected, or well below the respective exposure criteria, in both area samples collected.

All workers who were sampled during gouging and interior sweeping, and some who were sampling during welding and cutting, wore HEPA-filter respirators. Workers who were welding, cutting and gouging also wore welding facepieces.

Short-term Sampling, Chlorine Car Maintenance

- Metals.
  The results of short-term (15-min) PBZ sampling for metals are presented in Table 9, page 2. Nineteen samples were collected, representing the Car Repairman and Certified Welder job categories, during carbon air arc gouging, welding, and torch cutting. Three consecutive samples were collected for six workers, and one additional sample was collected on another worker. Ranges for short-term PBZ exposures (irrespective of respirators) to selected metals

of potential health significance were: arsenic (ND-240 $\mu g/m^3$), cadmium (ND, <2 $\mu g/m^3$), chromium metal (ND-164 $\mu g/m^3$), chromium VI (ND-17 $\mu g/m^3$), iron oxide (0.2-167 mg/m^3), lead (ND-44 $\mu g/m^3$), and nickel (ND-76 $\mu g/m^3$). Other elements were either not detected or were at insignificant levels.

Six of 19 short-term arsenic exposures exceeded the NIOSH REL-Ceiling of 2 $\mu g/m^3$; all were during welding or gouging. The highest short-term arsenic exposures, 89-240 $\mu g/m^3$, were during carbon air arc gouging on the draft seal of car number UTLX640392. The amount of arsenic in a bulk paint sample collected from this car could not be accurately determined due to analytical interferences (see below). Short-term exposures to chromium metal, iron oxide, lead and nickel were also highest during carbon air arc gouging, however, short-term exposure limits have not been established for these metals.

- Gases (NO_2, CO, and HCN).
  The results of short-term (15-min) sampling and grab sampling for CO during the sample periods are shown in Table 10. Nineteen samples were collected, representing the Car Repairman and Certified Welder job categories, during carbon air arc gouging, welding, and torch cutting. Three consecutive samples were collected for six workers, and one additional sample was collected on another worker. Ranges for short-term PBZ exposures were: NO_2 (ND to 4.5 ppm), and CO (ND <5 to 70 ppm). Twelve of 19 NO_2 exposures were equal to, or exceeded the OSHA PEL-STEL and the NIOSH REL-STEL of 1 ppm. None of the CO exposures exceed the NIOSH REL-Ceiling and the OSHA PEL-Ceiling of 200 ppm.

  The results of short-term (15-min) sampling for HCN are shown in Table 11. Thirteen samples were collected, representing the Car Repairman and Certified Welder job categories, during carbon air arc gouging, welding, and torch cutting. The range for short-term HCN exposures was ND to 3.1 ppm; the highest exposure, and the only one greater than 0.1 ppm, was during welding on a chlorine car. None of the 13 exposures exceeded the NIOSH-REL- and OSHA-PEL-STELs of 5 ppm.

Bulk Sampling for Selected Metals

The results of bulk sampling tank car paints, interior sweepings, and foam insulation for selected metals are presented in Table 12. All of the material samples, which were collected from cars undergoing maintenance, contained iron (5,000-530,000 ppm). Varying amounts of iron oxide residue from the car surfaces adhered to the paint and insulation samples when they were collected, and the interior sweepings were primarily residue from corrosion of the steel tank interior.

The results for arsenic were inconclusive in three of four paint samples, the foam insulation sample, and one of two interior sweepings samples due to analytical interferences. The only arsenic detected was in chlorine car interior sweepings (150 ppm). It is likely that arsenic was a trace constituent of the steel alloy used to construct the car.

All of the bulk materials were a potential source of chromium (range: 11-20,000 ppm)--the valence state was not determined. The black paint sample contained significant quantities of both zinc (35,000 ppm) and chromium (20,000 ppm), indicating that it is likely the paint contained zinc chromate ($ZnCrO_4$), a potential source of chromium VI exposure. The four paint samples contained relatively low levels of lead (range: ND-350 ppm); none exceeded the Consumer Product Safety Commission lead limit for consumer paints of 600 ppm. Nickel concentrations were quite low in paints (11-27 ppm), and much higher in chlorine car interior sweepings (880-1100 ppm).

Medical

A total of 25 employees, all males, submitted urine samples for arsenic and chromium evaluation. All employees who were invited to participate did so. Thirteen (52%) of the workers reported that they were welding for "most of the day" for the three days prior to the testing. Table 13 shows the mean (average), standard deviation, and range of urinary arsenic and chromium values. No inorganic arsenic or chromium was detected in a water sample taken from the water fountain in the office of the Union Tank Car facility.

Urinary inorganic arsenic concentrations ranged from 2 to 14 μg/g creatinine (all were below the ACGIH BEI for arsenic of 50 μg/g creatinine). Three of 25 workers had urine concentrations of inorganic arsenic which exceeded those usually seen in the general population (less than 10 μg/L).* Given the high airborne arsenic exposures measured during this evaluation, it is likely that these urinary levels were due to occupational exposure.

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* On average, urinary concentrations in μg/L approximately equal those in μg/g creatinine.

Urine concentrations of chromium for all 25 workers were at or below the analytical limit of detection (≤ 1 µg/L) and the typical general population level (< 1 µg/L). Standardized urine chromium concentrations ranged from less than 1 to less than 7 µg/g creatinine (all were below the ACGIH BEI of 30 µg/g creatinine).

CONCLUSIONS

ROUTINE OPERATIONS

- Results indicated that during carbon air arc gouging, welding, and cutting on foam-insulated tank cars arsenic, iron oxide, and NO_2 exposures were a health hazard. Other exposures, including HCN, foam thermal decomposition products, and chromium VI, were a potential health hazard.

- Results of urine monitoring of workers potentially exposed to arsenic suggested that some workers may have occupational exposure (all were below the ACGIH criteria for occupational exposure).

- A questionnaire survey of workers found the same frequency of self-reported symptoms suggestive of asthma among workers thought to be potentially exposed to MDI and those thought to be unexposed. However, results were inconclusive due to the relatively low participation rate (51%) and the presence of numerous other respiratory irritants in the workplace.

- Results indicated that during interior sweeping and cleaning of chlorine cars, arsenic, iron, and nickel exposures were a health hazard. The exposures to chlorine during this process were not a health hazard.

- Results indicated that a potential health hazard exists in the gasket sanding and buffing area, due to the presence of asbestos in valve gaskets. No airborne asbestos was detected during sanding and buffing, however, results were inconclusive due to high dust levels in the gasket room.

- Worker exposures to glass fibers during insulation handling did not represent a health hazard. Currently, there are no evaluation criteria for the exposures to ceramic fibers measured. Sampling results indicated the possible presence of airborne asbestos during insulation handling; the most likely source appeared to be the adjacent gasket sanding and buffing operation.

- Results indicated that the baghouse dust was a potential health hazard to workers exposed to it, due to the presence of toxic metals including barium, chromium, lead, and zinc.

- Workers are potentially exposed to hazardous contaminants during tank car pressure head cleaning due to torch heating of liquid residues and surface coatings (actual exposures were not measured).

- No conclusion can be made regarding worker exposures during welding and cutting on older sulfur cars; as it was not possible to sample during the conditions of concern in the HHE request.

EXPOSURE INCIDENTS

- Procedures and engineering controls (backflow prevention valves) established after the incident involving ammonia in the breathing air lines should prevent a similar incident in the future. However, the breathing air system is still subject to contamination due to operator error(s) by its physical connection to sources of toxic materials, such as the car cleaning area.

  It did not appear that UTC has instituted procedures or engineering controls to prevent a reoccurrence of the acrolein exposure incident. This type of accident could only be prevented by developing procedures to safely check for toxic or flammable materials between the walls of double-walled tank cars prior to any welding or cutting on the cars

RECOMMENDATIONS

The recommendations presented below are designed to reduce employee exposures on a routine basis, and prevent acute exposure incidents of the type that have reportedly occurred at this facility in the past.

1. Wherever feasible, portable local exhaust ventilation should be installed to reduce worker exposures to hazardous gases, fumes, and ignited foam thermal decomposition products during air arc gouging, welding, and cutting on foam-insulated tank cars. Portable exhaust should be readily movable so

that workers can adjust the exhaust inlet to capture contaminants at the source as they change positions on a tank car. For example, portable local exhaust may be provided by using multiple overhead flexible ducts with a system for holding the inlets in desired locations, connected to a central plenum exhausted to an appropriate dust collection system, or outside. At minimum, a design meeting the ACGIH recommendation in *Industrial Ventilation, 19th ed.*--"Welding Bench-portable exhaust" should be used.[26]

2. Worker exposures to arsenic, iron, and nickel during interior sweeping of chlorine cars should be reduced to the extent feasible with engineering controls. To reduce dust generation, the debris can be removed by vacuuming rather than sweeping with broom and dustpan. The vacuum should be equipped with a HEPA filter, or other appropriate dust collection system. General dilution ventilation should be provided to the car interior during this process.

3. Until worker exposures to arsenic and nickel (both potential occupational carcinogens) are reduced below the NIOSH REL with engineering controls, appropriate respiratory protection should be used by workers welding, cutting, and air arc gouging; and during interior sweeping of chlorine cars. NIOSH recommends that workers exposed to potential occupational carcinogens be provided the most reliable and protective respirators; either supplied-air respirators with a full facepiece operated in pressure demand or other positive pressure mode, or self-contained breathing apparatus with a full facepiece operated in pressure demand or other positive pressure mode.

4. Until worker exposures to NO_2 are reduced below the NIOSH REL with engineering controls, appropriate respiratory protection should be provided to, and used by, workers welding, cutting, and air arc gouging. The minimum level of respiratory protection (assuming no other more toxic exposure) should be supplied air respirators, with continuous flow mode.

5. To reduce the potential for exposure to asbestos during valve repair, install a local exhaust ventilation system in the gasket buffing area. The exhaust system should be located to capture dust from asbestos-containing gaskets, and should include an appropriate dust and fiber collection system, such as a HEPA filter, to prevent contamination of surrounding areas with airborne asbestos. Until local exhaust ventilation is installed, appropriate respiratory protection for a potential occupational carcinogen (see above) should be required and used during gasket buffing.

6. To prevent possible contamination of the breathing air system with hazardous materials, air compressor(s) designed for breathing air supply should be dedicated to the breathing air supply system. The integrity of the breathing air supply system should not be subject to operator actions or errors. The location of air compressor intakes should be reviewed to ensure they provide a continuous source of uncontaminated outside air.

7. The company's procedures for initial inspection and testing of tank cars which may have contained toxic or flammable materials should be modified to include a check for leakage of hazardous materials beyond the inner wall of double-walled tank cars. For example, a small hole could be made (with non-sparking tools) at an appropriate location to allow access between the walls of the tank for direct-reading testing equipment. If toxic or flammable materials are detected, the source should be identified and removed before proceeding with welding, cutting, or gouging. The procedure should be required, and made available in writing to all affected workers.

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4. OSHA Region VI
5. NIOSH Denver Region

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

Table 1, Page 1
Air Sampling and Analytical Methods
Union Tank Car, HETA 91-053

Analyte	LOD per sample	Sampling and analytical methods
Asbestos, and other fibers		Samples collected on 25-mm mixed cellulose ester filters in open-faced, non-conductive cassettes with a flow rate of 2.0 L/min . Analysis by phase contrast microscopy (PCM)--NIOSH Method 7400, with subsequent identification of asbestos fibers by transmission electron microscopy (TEM)--NIOSH Method 7402, and fibrous glass by polarized light microscopy (PLM).
Carbon Monoxide	10 ppm	Direct-reading grab measurements were made with Draeger Carbon Monoxide 10/a detector tubes.
Carbon Monoxide	6 ppm (8 hrs)	Direct-reading time-weighted average measurements were made with Draeger Carbon Monoxide 50/a-D diffusion tubes.
Chlorine	2.0 μg	Samples were collected on 25-mm, 0.45-μm pore size silver membrane filters in opaque cassettes with a flow rate of 1.0 L/min; analysis by ion chromatography--NIOSH Method 6011.
Hydrogen Cyanide	2 ppm	Direct-reading grab measurements were made with Draeger Hydrogen Cyanide 2/a detector tubes.
Hydrogen Cyanide	0.3 μg	Samples collected on sorbent tubes (soda lime, 600 mg/200 mg) with a flow rate of 0.2 L/min; analysis by visible absorption spectrophotometry--NIOSH Method 6010.
Isocyanates	0.3 μg	Samples collected in 25-mL glass midget impingers with a solution of 1-(2-methoxyphenyl)-piperazine in toluene, at a flow rate of 1.0 L/min. Analysis by high-performance liquid chromatography with ultraviolet light and electrochemical detectors--NIOSH Method 5521.
Metals	0.1-10 μg[A,B]	Samples collected on 37-mm, 0.8 μm pore size cellulose ester membrane filters in clear cassette holders with a flow rate of 2.0 L/min. Analysis for 30 elements by inductively coupled argon plasma, atomic emission spectroscopy--NIOSH Method 7300.
Nitrogen Dioxide	0.01 μg	Samples collected with diffusion tubes (Palmes tube with three triethanolamine-treated screens), analysis by visible absorption spectrophotometry--NIOSH Method 6700.

NOTES:

[A] LOQ varied with analyte. Specific minimum quantifiable concentrations are reported with results.

[B] Analytes were Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Pt, Se, Sr, Te, Ti, Tl, V, Y, Zn, Zr.

Table 1, Page 2
Air Sampling and Analytical Methods
Union Tank Car, HETA 91-053

Analyte	LOD per sample	Sampling and analytical methods
Nitrous Oxides	2 ppm	Direct-reading grab measurements were made with Draeger Nitrous Fumes (NO + NO2) 2/a detector tubes.
Sulfur Dioxide	0.02 mg[c]	Samples collected with two 37-mm cassette filter holders connected by a short piece of plastic tubing containing a 0.8 μm pore size cellulose ester membrane filter (front cassette) and a cellulose filter saturated with a potassium hydroxide (KOH) solution (back cassette), at a flow rate of 1.0 L/min. Analysis by ion chromatography--NIOSH Method 6004.

NOTES:
[c] Quality control samples for this set were not within acceptable limits, results not reported.

Table 2, Page 1
Summary of Selected Occupational Exposure Limits and Health Effects
Union Tank Car, HETA 91-053

Substance (units)	NIOSH REL-TWA	OSHA PEL-TWA	ACGIH TLV-TWA	Primary Health Effects*
Acrolein (ppm)	C 0.3	C 0.3	C 0.3	Irritation of the eyes, nose, throat, lungs, and skin. It may cause skin burns; death can occur rapidly if high concentrations are inhaled.
Arsenic ($\mu g/m^3$)	C 2	10	100^	Chronic exposure can cause weakness, nausea, vomiting, diarrhea, skin and eye irritation, hyperpigmentation, thickening of the palms and soles (hyperkeratosis), contact dermatitis, and skin sensitization. Inorganic arsenic is a carcinogen.
Asbestos (fibers/cc)	LFL	0.2	0.2^	Asbestosis, lung cancer, and mesothelioma.
Cadmium ($\mu g/m^3$)	LF	5	2^	Irritation of the lungs, lung and kidney damage, prostate and respiratory cancer.
Chlorine (ppm)	0.5	0.5	0.5	Irritation of the eyes, mucous membranes, and skin; severe exposures cause pulmonary edema and death.
Chromium, metal (mg/m^3)	0.5	1	0.5	Dermatitis from chromic salts, impairment of lung function (relatively non-toxic compared to other forms of Cr).
Chromates, as Cr^{6+} ($\mu g/m^3$)	C 1 as Cr	100 as CrO_3	50 as Cr	Respiratory system cancer. Some chromium VI (Cr^{6+}) compounds are severe irritants of the skin and respiratory systems, and cause sensitization dermatitis, kidney damage, asthma, and pulmonary edema.
Fibrous glass (fibers/cc)	3		10 mg/m^3	Skin, eye, and respiratory system irritation; fibrotic lung changes.
Hydrogen Cyanide (mg/m^3)	C 5	C 5	C 11	Rapid death due to metabolic asphyxiation. Less severe exposures cause weakness, headache, confusion, fatigue, and other central nervous system effects.

*Source: *Proctor and Hughes' Chemical Hazards of the Workplace, 3rd ed.*
C Ceiling limit.
^ Notice of intended change.
LFL Lowest feasible limit.

Table 2, Page 2
Summary of Selected Occupational Exposure Limits and Health Effects
Union Tank Car, HETA 91-053

Substance (units)	NIOSH REL-TWA	OSHA PEL-TWA	ACGIH TLV-TWA	Primary Health Effects*
Methylene bisphenyl isocyanate (MDI) (ppm)	0.005	C 0.02	0.005	Irritation of the skin, mucous membranes, eyes, and respiratory tract. Respiratory and dermal sensitization.
Iron Oxide	5	10	5	Benign pneumoconiosis (relatively non-toxic).
Lead (μg/m³)	<100	50	150	Weakness, irritability, gastrointestinal disturbance, reproductive and central nervous system effects, developmental effects, neuromuscular disfunction, kidney damage.
Nickel, metal (μg/m³)	15	1000	50^	Sensitization dermatitis, asthma, pneumoconiosis, cancer of the lung, sinus, and nasal passages.
Nitrogen Dioxide (ppm)	1	1	5	Respiratory irritation, severe exposures cause pulmonary edema and death.

*Source: *Proctor and Hughes' Chemical Hazards of the Workplace, 3rd ed.*
C Ceiling limit.
^ Notice of intended change.
LFL Lowest feasible limit.

Table 3
PBZ Results for Selected Metals
Union Tank Car, Cleveland, Texas

February 20-21, 1991
HETA 91-053

Job Title	Work Activity	Location	Sampling Period Start	Sampling Period Stop	Time (min)	Arsenic (µg/m³)	Chromium (µg/m³)	Iron (mg/m³)	Lead (µg/m³)	Nickel (µg/m³)
Car Repairman 1*	welding and cutting	chlorine car	8:16	15:05	409	ND	ND	3.2	ND	ND
Car Repairman 1*	welding and cutting	chlorine car	8:17	15:06	409	17 [14]	4.9	7.4 [6.3]	ND	2.4
Car Repairman 2	welding and cutting	chlorine car	9:20	15:12	352	ND	1.4	1.3	ND	ND
Car Repairman 3	welding and cutting	chlorine car UTLX 28816	12:43	14:54	131	ND	ND'	1.1	ND	3.8
Car Repairman 3*	arc gouging	chlorine car UTLX28616	8:48	14:44	282	21 [12]	7.1	11 [6.4]	1.8	7.1
Certified Welder	arc gouging	chlorine car UTLX81073	8:28	11:25	177	23 [8.3]	8.7	10 [3.6]	14	12
Certified Welder *	arc gouging	chlorine car UTLX82663	8:43	14:58	295	22 [13]	6.9	9.3 [5.6]	10	10
Car Repairman 3	sweeping	chlorine car	13:49	14:39	50	280 [29]	30	130 [14]	30	180 [19]
Car Repairman 3*	sweeping	chlorine car U-28703	9:25	14:02	207	135 [57]	15	66 [28]	2.4	91 [38]
				NIOSH REL-TWA		2[1]	500[3]	5	< 100	15[2]
				OSHA PEL-TWA		10[2]	1000[3]	10	50	1000
				ACGIH TLV-TWA		100[2]	500[3]	5	150	50[2]
				MQC (assuming 600-liter sample volume)		8	2	0.002	2	2

NOTES:
*Combined TWA for two consecutive samples, did not include lunch break.
ND = Not detected, less than the MQC.
[ ] Extrapolated 8-hr TWA, assuming no other exposure.
MQC = Minimum quantifiable concentration.

[1]Ceiling limit, carcinogen.
[2]Carcinogen.
[3]As chromium metal.

Table 4
Grab Air Sampling for Gases*
Union Tank Car, Cleveland, Texas

February 20, 1991
HETA 91-053

Job Title	Work Activity	Location	NO + NO2 (ppm)	CO (ppm)	HCN (ppm)
Car Repairman	torch cutting	chlorine car--3 ft. above worker	4	80	
Car Repairman	torch cutting	chlorine car--3 ft. above worker	4	35	
Car Repairman	torch cutting	chlorine car--3 ft. above worker	< 2	110	
Car Repairman	torch cutting	chlorine car--3 ft. above worker	< 2		
Car Repairman	torch cutting	chlorine car--floor level	6.5	60	2
Car Repairman	torch cutting	chlorine car--floor level	< 2		2
Car Repairman	torch cutting	chlorine car--floor level	< 2		< 2
Car Repairman	torch cutting	chlorine car--floor level	< 2		
MQC			2	10	2

*Direct-reading detector tube measurements (see Table 1).

Table 5
Air Sampling for Chlorine*
Union Tank Car, Cleveland, Texas

February 20-21, 1991
HETA 91-053

Date	Job Title	Sampling Period Begin	End	Time (min)	Chlorine (ppm)
2/20/91	Car Repairman 3	9:23	11:07	104	ND
2/20/91	Car Repairman 3	12:20	14:02	102	ND
2/21/91	Car Repairman 3	13:50	14:35	45	ND
2/20/91	Area--inside car	9:23	10:25	62	ND
2/20/91	Area--inside car	12:21	13:56	95	ND
2/21/91	Area--inside car	13:50	14:39	49	ND
NIOSH REL-TWA					0.5
OSHA PEL-TWA					0.5
ACGIH TLV-TWA					0.5
MDC 60-liter sample volume)					0.01

* Sampling during interior sweeping of chlorine cars.
ND Not detected, less than the MDC.

Table 6
Analysis of Baghouse Dust for Selected Elements
Union Tank Car, Cleveland, Texas

February 20-21, 1991
HETA 91-053

	Concentration, Percent by Weight	
Element*	**Sample 1**	**Sample 2**
aluminum, Al	0.24	0.31
arsenic, As	ND	ND
barium, Ba	3.55	3.88
calcium, Ca	2.17	2.41
cadmium, Cd	ND	ND
cobalt, Co	0.02	0.02
chromium, Cr	0.46	0.41
copper, Cu	0.03	0.03
iron, Fe	20.4	22.6
magnesium, Mg	0.24	0.24
manganese, Mn	0.18	0.21
sodium, Na	0.03	0.04
nickel, Ni	0.02	0.02
phosphorus, P	0.17	0.20
lead, Pb	0.29	0.33
strontium, Sr	0.04	0.04
titanium, Ti	0.07	0.09
zinc, Zn	1.42	1.46
zirconium, Zr	0.02	0.02
LOQ	0.01	0.01

ND Not detected, less than the LOQ.
* Other elements which were not detected: Ag, Be, La, Li, Mo, Pt, Se, Te, Tl, V, Y.

Table 7
PBZ Air Sampling Results for Fibers
Union Tank Car, Cleveland, Texas

February 20, 1991
HETA 91-053

Job Title	Work Activity	Sampling Period Begin	End	Time (min)	Fibers/cc
Car Repairman 2	Installing fiberglass insulation--ground level	7:40	9:20	100	(0.017)
	Installing fiberglass insulation--ground level	9:22	10:20	58	(0.056)[1]
	Installing fiberglass insulation--ground level	10:20	11:25	65	(0.059)
	Installing fiberglass insulation--ground level	12:10	13:08	58	(0.086)
	Installing fiberglass insulation--ground level	13:08	14:18	70	(0.055)
Car Repairman 3	Installing fiberglass insulation--top of car	7:54	9:22	88	(0.16)[1]
	Installing fiberglass insulation--top of car	9:22	10:16	54	(0.27)
	Installing fiberglass insulation--top of car	10:16	11:25	69	0.39
	Installing fiberglass insulation--top of car	12:12	13:13	61	(0.10)
	Installing fiberglass insulation--top of car	13:13	14:16	63	(0.20)
Car Repairman 3	Installing fiberglass insulation--top of car	7:56	9:18	82	(0.23)
	Installing fiberglass insulation--top of car	9:18	10:16	58	(0.21)[2]
	Installing fiberglass insulation--top of car	10:16	11:29	73	0.38
	Installing fiberglass insulation--top of car	12:19	13:16	57	(0.091)
	Installing fiberglass insulation--top of car	13:16	14:19	63	(0.098)
Car Repairman 3	Replacing ceramic fiber insulation	7:34	9:23	109	0.26
	Replacing ceramic fiber isulation	9:25	10:24	59	0.61
NIOSH REL-TWA (fiberglass)					3

LOD 7 fibers/mm^2/filter
LOQ 100 fibers/mm^2/filter

Result semi-quantitative; between the LOD and the LOQ.
[1]Subsequent analysis by TEM, possible asbestos fiber in sample.
[2]Susbsequent analysis by TEM, no asbestos fibers identified in sample.

Table 8
Reported Symptoms Experienced in the Previous Month‡
Union Tank Car, Cleveland, Texas

February 20-21, 1991
HETA 91-053

Symptoms	Group A* (83 workers)	Group B** (33 workers)
Eye Irritation	40 (48%)	10 (30%)
Cough	37 (45%)	14 (43%)
Mouth or Throat Irritation	34 (41%)	8 (24%)
Shortness of Breath	18 (22%)	10 (30%)
Wheeze	16 (19%)	4 (12%)
Chest Pain or Tightness	13 (16%)	2 (6%)
Persistent Skin Rash	5 (6%)	4 (12%)

‡ Symptoms experienced at work; or both at work and at home.

* Employees surveyed in Buildings 1, 2, and 3.
** Employees surveyed from other areas.

Table 9
PBZ and Area Results for Selected Metals, Page 1
Union Tank Car, Cleveland, Texas
January 30, 1992
HETA 91-053

Job Title	Work Activity	Loc.	Sampling Period Start	Sampling Period Stop	Time (min)	Arsenic (µg/m³)	Cadmium (µg/m³)	Chromium (µg/m³)	Chromium VI (µg/m³)	Iron (mg/m³)	Lead (µg/m³)	Nickel (µg/m³)
FULL-SHIFT SAMPLING												
Area--Building 1			16:20	23:40	440	ND	ND	ND	ND@	0.2	ND	0.3
Area--Building 3		A	16:30	23:45	435	ND	ND	ND	ND@	0.2	ND	0.4
Car Repairman 1			7:42	15:15	453	ND	0.1	0.8	**	0.7	ND	0.7
Car Repairman 1*	welding and gouging		15:45	23:26	461	3.4	ND	3.3	ND&	2.7	4.5	2.5
Car Repairman 1*	welding and gouging		15:49	23:26	457	3.9	ND	2.4	ND&	2.3	1.9	2.2
Car Repairman 2			7:22	15:16	474	11	ND	3.1	**	5.4	6.3	3.8
Car Repairman 2*	welding and gouging		15:46	23:26	460	13	ND	6.3	ND&	5.3	5.5	5.4
Car Repairman 3	gouging	B	7:13	15:12	479	11	ND	3.7	**	0.1	4.2	4.3
Car Repairman 3	welding and gouging	C	7:17	15:04	467	6.4	ND	2.4	**	3.7	ND	6.5
Car Repairman 3*	gouging	B	7:15	15:05	469	17	ND	12	**	11	5.4	5.9
Car Repairman 3*	sweeping interior	C	15:37	23:15	458	11	ND	4.1	ND&	7.0	2.2	12
Certified Welder			7:19	15:06	467	ND	0.4	1.5	**	1.1	1.1	6.6
Certified Welder			7:28	15:07	459	3.3	0.1	1.1	**	0.8	ND	4.0
Certified Welder*			7:26	15:05	457	9.2	ND	3.0	0.5	5.7	3.7	2.3
					NIOSH REL-TWA	2[1]	10[2]	500[3]	1[2]	5	<100	15[2]
					OSHA PEL-TWA	10[2]	5[2]	1000[3]	100[2]	10	50	1000
					ACGIH TLV-TWA	100[2]	50[2]	500[3]	50	5	150	50[2]
					MQC (assuming 900-liter sample volume)	2	0.1	0.5	see notes	0.0	2	0.2

Locations:
A. on UTLX642469, "B" track
B. draft seal
C. chlorine car

NOTES:
*Combined TWA for two consecutive samples, did not include lunch break.
ND = Not detected, less than the minimum quantifiable concentration (MQC).
@ the respective MQC equals 0.2 µg/m³.
& the respective MQC equals 6 µg/m³ (samples were diluted 1:25 to eliminate color interference).
** Unable to determine accurately due to interference.

[1]Ceiling limit, carcinogen.
[2]Carcinogen.
[3]As chromium metal.

Table 10
Short-term Air Sampling For NO2 and CO
Union Tank Car, HETA 91-053

January 30, 1992

Job Title	Work Activity	Location	Sampling Period Start	Stop	Time (min)	NO2 (ppm)	CO[1] (ppm)
Short-term sampling							
Car Repairman 1	arc gouging	draft seal, UTLX640392	9:55	10:10	15	1.1	10
Car Repairman 1	arc gouging	draft seal, UTLX640392	10:10	10:25	15	4.5	70
Car Repairman 1	arc gouging	draft seal, UTLX640392	10:25	10:40	15	ND	8
Car Repairman 1	welding	chlorine car UTLX82620	10:02	10:17	15	0.76	--
Car Repairman 1	welding	chlorine car UTLX82620	10:17	10:32	15	ND	--
Car Repairman 1	welding	chlorine car UTLX82620	10:32	10:41	'9	ND	--
Car Repairman 1	welding--6011 stick		23:09	23:24	15	ND	0-5
Car Repairman 1	welding-70 wire	stiffener plate,	16:50	17:07	17	1.0	<5
Car Repairman 1	welding-70 wire	stiffener plate,	18:47	19:02	15	ND	25
Car Repairman 1	welding-70 wire	stiffener plate,	19:03	19:18	15	1.1	10
Car Repairman 2	torch cutting	LP gas car UTLX805056	17:47	18:04	17	1.3	5
Car Repairman 2	torch cutting	LP gas car UTLX805056	18:04	18:19	15	2.3	5
Car Repairman 2	torch cutting	LP gas car UTLX805056	18:20	18:35	15	ND	7
Car Repairman 2	cutting/welding--70 wi	welding on car jacket	21:40	21:59	19	3.0	--
Car Repairman 2	cutting/welding--70 wi	welding on car jacket	22:24	22:40	16	2.8	<5
Car Repairman 2	cutting/welding--70 wi	welding on car jacket	22:46	22:59	13	3.9	<5
Certified Welder	arc gouging	draft seal, UTLX640074	10:53	11:08	15	2.3	--
Certified Welder	arc gouging	draft seal, UTLX640074	11:08	11:24	16	4.3	--
Certified Welder	arc gouging	bottom cover plate,	11:25	11:41	16	2.1	--
				OSHA PEL -STEL		1	200
				NIOSH REL - STEL		1	200
				MDC (assuming 15-min sample)		0.38	
Full-shift sampling							
Car Repairman 2	welding and cutting	Building 2	7:20	15:15	475	0.08	--
Certified Welder	welding and cutting		7:15	15:05	470	0.11	--
Certified Welder	welding and cutting		7:25	15:05	460	0.25	--
Certified Welder	welding and cutting		7:28	15:06	458	0.15	--
				OSHA PEL -STEL		1	
				NIOSH REL - STEL		1	
				MDC (assuming 460-min sample)		0.01	

[1]Grab measurements made during sampling periods with detector tubes.

-- No measurement taken.

Table 11
Short-term PBZ Sampling for HCN
Union Tank Car, Cleveland, Texas

January 30, 1992
HETA 91-053

Job Title	Work Activity	Location	Sampling Period Start	Sampling Period Stop	Time (min)	HCN[1] (ppm)
Car Repairman 1	arc gouging	draft seal, UTLX640392	9:55	10:10	15	ND
Car Repairman 1	arc gouging	draft seal, UTLX640392	10:10	10:25	15	ND
Car Repairman 1	arc gouging	draft seal, UTLX640392	10:25	10:40	15	ND
Car Repairman 1	welding	chlorine car UTLX82620	10:02	10:17	15	2.8
Car Repairman 1	welding	chlorine car UTLX82620	10:17	10:32	15	(0.03)
Car Repairman 1	welding	chlorine car UTLX82620	10:32	10:47	15	(0.03)
Car Repairman 2	torch cutting	cutting car jacket	22:24	22:40	16	ND
Car Repairman 2	torch cutting	cutting car jacket	22:41	22:59	18	ND
Car Repairman 2	torch cutting	jacket, UTLX805056	17:47	18:04	17	(0.02)
Car Repairman 2	torch cutting	jacket, UTLX805056	18:04	18:19	15	ND
Car Repairman 2	torch cutting	jacket, UTLX805056	18:20	18:35	15	ND
Certified Welder	arc gouging	draft seal, UTLX640074	23:08	23:24	16	(0.05)
Certified Welder	arc gouging	bottom cover plate,	23:25	23:41	16	(0.03)
				OSHA PEL - STEL		4.7
				NIOSH REL - STEL		4.7
				ACGIH TLV - Ceiling		10
				MDC (assuming 3-liter sample)		0.09

[1]Values reported are field blank corrected.
ND Not detected, less than the MDC.
( ) Value approximate, uncorrected sample value was between the LOD (0.3 μg) and the LO

Table 12
Bulk Sampling for Selected Metals
Union Tank Car, Cleveland, Texas

January 30, 1992
HETA 91-053

Tank Car Number	Chlorine Car[1]	Bulk Material	Arsenic (ppm)[2]	Cadmium (ppm)[2]	Chromium (ppm)[2]	Iron (ppm)[2]	Lead (ppm)[2]	Nickel (ppm)[2]	Zinc (ppm)[2]
UTLX640392	no	blue paint		ND	38	89,000	ND	26	47
UTLX82620	yes	black paint		ND	20,000	20,000	14	27	35,000
UTLX640074	no	blue paint		ND	44	49,000	59	18	86
UTLX805056	no	paint	ND	ND	32	5,000	350	11	30
UTLX82620	yes	Isofoam insulation		ND	11	63,000	ND	11	ND
UTLX28049	yes	sweepings, interior	150	ND	340	17,000	88	880	67
UTLX28049	yes	sweepings, interior	**	ND	380	530,000	**	1100	**
		LOQ	10	1	1	1	2	1	2

Notes:

[1]Indicates if car was used to transport chlorine, and Isofoam-insulated.
[2]parts per million by weight (10,000 ppm = 1%)

** Unable to accurately determine due to interferences.
ND = not detected, less than the limit of detection.
LOQ = limit of quantitation.

Table 13
Urinary Arsenic and Chromium Levels in 25 Employees
Union Tank Car, Cleveland, Texas
January 29, 1992

HETA 90-053

Metal	Mean (Average)[1]	Standard Deviation[1]	Range[1]	Normal Levels[2,3]
Inorganic Arsenic	4	3	<2-14	<10
Chromium	<1	<1	<1-<7	<1

[1]Values are reported as µg/g creatinine.
[2]Levels seen in the general population without occupational exposure.
[3]As µg/L (on average, urine concentrations in µg/L approximately equal those in µg/g creatinine).