U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT HE 77-41-505

GENERAL AMERICAN TRANSPORTATION CORPORATION
MASURY, OHIO

JULY 1978

I. TOXICITY DETERMINATION

The National Institute for Occupational Safety and Health (NIOSH)conducted a Health Hazard Evaluation April 4-7, and June 7-9, 1977, at the General American Transportation Corporation located in Masury, Ohio. The following determinations are based upon (1) environmental sampling, (2) evaluation of engineering controls, (3) observation of work practices, (4) review of the workplace and materials used, (5) medical evaluation by interviews and physical examinations, (6) review of employees' health records, (7) follow-up with private physicians regarding health problems of interest, and (8) review of pertinent literature.

A. Environmental

Personal and area samples were collected over 8-hour work shifts to determine the airborne concentrations of emissions released during welding, plasma arc cutting, air arc repairing, chipping, gouging, tank cleaning, and grinding. Results of the sampling indicated that 24 of the 52 employees monitored were over-exposed to various contaminants including iron oxide fume, copper fume, nickel, chromium metal, chromium (VI), vanadium, fluoride, and/or total particulate. While 11 of the 24 employees were excessively exposed to a single substance, 13 were excessively exposed to a multiple of substances (from 2 to 5 substances). Samples collected for aluminum, zinc oxide fume, magnesium oxide fume, manganese (including 15 minute samples to assess the ceiling concentration), ozone, sulfur dioxide, nitrogen dioxide, and carbon dioxide were within acceptable limits.

Carbon monoxide (CO) concentrations measured when welding inside the railroad tank cars occasionally exceeded the NIOSH recommended ceiling of 200 parts per million (ppm). Also the breath samples collected on the welders did indicate an increased absorption of CO into the blood stream. Four (4) of the 10 non-smokers monitored had post-shift carboxy-hemoglobin (COHb) levels ranging from of 5.9 to 9.1%, which exceeded the NIOSH criterion of 5% COHb. Although this is not considered to be a hazardous range, it does indicate appreciable absorption of the contaminant.

Personal samples were taken to evaluate the airborne concentrations of fibrous glass during the application of rolled insulated materials. Results of the sampling revealed insignificant concentrations of fibrous glass, with all levels being less than 0.05 fibers per cubic centimeter of air.

Personal and area samples were collected for methylene bisphenyl isocyanate (MDI) and polymethylene polyphenyl isocyanate (PAPI) during the application of urethane foam. While the personal and area samples for MDI were within acceptable limits, the area sample taken for PAPI did indicate a potential for exposure. A concentration of 0.35 milligrams per cubic meter (mg/M^3) of PAPI was measured on the catwalk near the foam spray unit (Interior Foam and Paint Shop).

Instantaneous measurements were taken for carbon monoxide and formaldehyde in various areas around the Plant 3 Annealing Furnace and the F&D Annealing Furnace. Whereas the carbon monoxide concentrations were within acceptable criteria, the formaldehyde measurements did indicate a potential problem. Area measurements greater than 10 ppm of formaldehyde were recorded in locations where fibrous glass insulation was used to seal the furnace doors. The formaldehyde levels were apparently due to the release of resin materials used in the treatment of the fibrous glass.

B. Medical

Results of the physical examinations given to 85 employees revealed no abnormalities other than abrasions, and burns associated with welding and handling of heavy metal. Several employees did have high blood pressure and were referred to the company nurse for disposition. Also, during the private interviews 2 employees related past symptomatology consistent with metal fume fever. All other data collected including (1) review of the employees' company health records and chest X-rays, and (2) review of medical reports received from private physicians did not disclose any job related health problems.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address. Copies of this report have been sent to:

a. General American Transportation Corporation, Sharon, Pennsylvania

b. Authorized representatives of Locals 1534 and 2318, United Steelworkers of America

c. United Steelworkers of America, Pittsburgh, Pennsylvania

d. U.S. Department of Labor - Region V

e. NIOSH - Region V

For the purpose of informing the approximately 1,000 "affected employees" the employer shall promptly "post" for a period of 30 calendar days, the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20 (a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669 (a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether a substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received six such requests from various authorized representatives of Locals 1534 and 2318, United Steelworkers of America, regarding exposures to dust, fumes, smoke, and gases (primarily from welding and plasma arc cutting), to isocyanate vapors, and to X-ray radiation. Occupations of the exposed employees included welders, burners, fitters, grinders, general laborers, X-ray operators and helpers, maintenance personnel, painters, lift-truck operators, cranemen, and blasters. The requests alleged that lung disorders, cardiac insufficiencies, and over-exposure to X-ray radiation were possibly occurring at the facility.

It should be noted that X-ray radiation is a physical agent and as such, NIOSH was unable to investigate this alleged hazard under the Health Hazard Evaluation Program. The regulations as outlined under Title 42, Part 85 limit the investigative activities to chemical and biological agents.

IV. HEALTH HAZARD EVALUATION

A. Demographic/Background Data

The Health Hazard Evaluation covered various operations in Plants 1, 2, and 3 at the General American Transportation Corporation (GATX). The environmental evaluation primarily involved the monitoring of employee exposures to emissions released from the cutting, processing, and welding of mild steel, stainless steel, and aluminum. Other operations monitored included the insulation of tank cars with fibrous materials and isocyanate foams, and the evaluation of an irritating effluent released during the annealing process.

The manufacturing process at GATX basically involved the fabrication of railroad tank cars with other activities consisting of the repair of tank cars, the building of pressure vessels, ball mills, and kilns, and heavy fabrication work. These processes were located in a variety of buildings covering approximately 725,000 square feet of floor space with ceiling heights ranging from 17 to 62 feet. The total work force was comprised of 1030 production personnel and 80 administrative personnel distributed over 3 shifts.

B. Process Description

1. Fabrication of Carbon Steel/Stainless Steel Railroad Tank Cars

Shell plates composed of either carbon steel or stainless steel are received in flat form. The carbon steel shell plates are edge prepped and cut to size with plasma arc or oxyfuel torches, whereas the stainless steel plates are machine prepped with a plane. The shell plates are rolled into cylinders, tacked with stick electrodes, then welded using a submerged arc process. The end pieces for the tanks are cut into circles (using the aforementioned process) and hot pressed to form the tank heads. Depending upon the size of the tank to be fabricated, various cylinders are assembled together to form the tank shell. The tank end heads are then placed onto the shell and welded with a submerged arc.

Submerged arc welding is performed on the interior and exterior seams of the shell assembly. Prior to welding on the shell exterior, the tacks used to temporarily bond the cylinders together are removed by air-arc gouging. After completion of the submerged arc process, the seams are visually patched and ground in preparation for X-raying. Any defects detected in the seams are repaired using a stick electrode.

After the basic shell of the tank is completed, various fittings, fixtures, and pads are welded to the assembly. This process may involve tack welding with stick electrodes, flux-cored arc welding shielded with carbon dioxide, and stick/wire electrode welding (for stainless steel). Some of these operations entail considerable welding time and may include both interior (i.e., manways) and exterior welding on the tank car. After these welds are inspected and any repairs made (using stick electrodes), the tank car is stress relieved in an annealing furnace. The gears, yoke, and coupler assembly are then applied prior to having the tank car hydrotested and gauged for capacity.

Some of the tank cars are insulated with a fiber material (reported to be fibrous glass) or with a urethane foam. When insulating with the fibrous material, rolls of the material are manually wrapped around the outer wall of the tank. An outer metal shell (jacket) is applied over the insulation. This jacket is welded onto the tank using a wire electrode shielded with a gas mixture of 98% argon, 2% oxygen. Cars which require foam insulation are jacketed and welded using the same process prior to insulation. Either polymethylene polyphenylisocyanate (PAPI), methylene bisphenyl isocyanate (MDI), or occasionally toluene diisocyanate (TDI) are injected inside the void area surrounding the tank car. These urethane foams are also used in forming barrier molds inside the tank and for insulating around the bolsters and sills of the tank. The barrier molds are formed by manually pouring the urethane material into the molds, whereas the bolsters and sills are manually sprayed. The isocyanates are stored in a closed system and pumped to a nozzle where the activator and resin are mixed.

The final phase involves the application of valves, platforms, walkways, ladders, rails, and pipes for the brakes and air cylinders. The railroad tank car is then prepared for painting and stenciling. After painting, the tank car is given a final inspection, weighed, and shipped.

2. Fabrication of Aluminum Railroad Tank Cars

The fabrication of an aluminum tank car is primarily the same as for a carbon steel or stainless steel car. The aluminum shell plates are edge prepped and cut to size with either plasma arc or oxyfuel torches. These plates are rolled and assembled in a similar fashion except that non-ferrous electrodes are used in the assembly (welding) process. The aluminum cars are also prepared for X-ray; however, a chipping process is used in lieu of air-arc gouging. After X-raying, the fittings and fixtures are applied and the tank is tested and gauged for capacity. From this point, the car proceeds through the same basic fabrication phases as the carbon steel or stainless steel tank cars.

3. Welding/Materials Handling Profile

The following list is a grouping of welding materials and processes commonly used at GATX.

Welding Processes

Submerged Arc Welding
Shielded Metal Arc Welding
Gas Metal Arc Welding
Flux-Core Arc Welding
Gas Tungsten Arc Welding
Electroslag Welding

Welding Materials (Includes Approximate Quantities Used in 1976)

Flux	446,160 lbs.
Submerged Arc Wire	272,546 lbs.
Stick Electrodes	258,200 lbs.
Flux Core Wire	438,780 lbs.
Aluminum and 0.045 Gas Metal Arc Wire	103,823 lbs.

Note: Environmental results (Tables 1-8) include types of electrodes (AWS Classification Number) and welding processes.

C. Environmental Controls

Contaminant generation was primarily controlled through means of mechanical dilution ventilation and natural air movement (convection currents, etc.). Occasionally, local exhaust ventilation was employed when processes involved welding, chipping, gouging, and/or grinding inside the tanks. The local exhaust consisted of an air ejection system (i.e., straight pipe or venturi type arrangement) which was positioned through a manway or other opening into the tank. The exhaust velocity at the face of a typical air ejector duct, with a two inch diameter, was approximately 6000 feet per minute (fpm) and decreased to approximately 100 fpm one foot from the duct. Since ducts were observed to be placed anywhere from one to several feet from the contaminant source, the efficiency of the system varied considerably.

The only other environmental control was a waterbed located directly below the plasma arc torches. This was used to help contain emissions released during the cutting of shell plates.

Since the nature of the fabrication process somewhat restricted usage of local ventilation controls, emphasis was placed on personal protective equipment. The protective equipment used at GATX included air supplied respirators, self-contained breathing apparatus, and a variety of air purifying respirators. A written respirator program has been developed by GATX outlining the proper care, maintenance, selection and use of respirators.

Processes in which respirators were observed in use (for those processes sampled) included tank cleaning, application of urethane foam, and welding. Whereas respiratory protection was continually worn during tank cleaning and foam application, it was less frequently worn when welding. Welders seldom wore respirators except when welding on the interior portion of the tank cars.

D. Evaluation Design and Methods

The initial environmental and medical survey was performed April 4-7, 1977. During the visit a walk-through survey of the facility was conducted, persons working in the plant were privately interviewed and examined regarding possible health problems, and air sampling was performed. A second visit was made June 6-9, 1977, to complete the environmental evaluation.

1. Air Sampling

Personal and area samples were collected to evaluate employee exposures. The personal sampler was attached to the employee's lapel (except when assessing welding exposures) in order that an air sample representative of the breathing zone could be collected. For evaluating exposures to welding emissions, the sampling media was placed inside the welding helmet at mouth level, approximately 2 inches from the breathing zone center line. Area samplers were positioned at specific locations in the work environment and generally within a distance of 3-5 feet from the worker's breathing zone. Each of the sampling data tables (Tables 1-11) include information denoting the type of samples collected - e.g., area or personal - and their location.

a. Iron, Copper, Manganese, Nickel, Chromium, Zinc, Vanadium, Magnesium, Aluminum, and Total Particulate:

These metals were collected on either 0.8 micron (u) mixed cellulose ester membrane filters or pre-weighed 5.0u VM-1 filters mounted in 3 piece closed face cassettes. The samples were collected at a flow rate of 1.5 liters per minute (lpm) using a Mine Safety Appliance* (MSA)

*Mention of commercial names or products does not constitute endorsement by NIOSH.

vacuum pump. The metals were analyzed by digesting and solubilizing the filters in a nitric acid solution and then aspirating their analyte into an atomic absorption spectrophotometer. Samples collected on VM-1 filters were analyzed gravimetrically to determine total milligrams of dust prior to digestion of the filters. The lower limits of detection as reported in milligrams (mg) per sample for the analysis were as follows: (1) iron 0.003-0.005; (2) copper, 0.002-0.003; (3) manganese, 0.002-0.004; (4) nickel, 0.003-0.008; (5) chromium, 0.002-0.005; (6) vanadium, 0.020-0.025; (7) zinc 0.001; (8) magnesium, 0.0003; and (9) aluminum, 0.03.

b. Chromium (VI):

Samples were collected on 5.0u PVC filters mounted in 3 piece closed face cassettes; air was drawn through the samplers at a flow rate of 1.5 lpm. Chromium (VI) particulates collected on the filters were extracted with sulfuric acid. Diphenylcarbazide solution was added to the extract to form a colored complex which was analyzed colorimetrically. The lower limit of detection using the specific diphenylcarbozide method for chromium (VI) was 0.0002 milligrams.

c. Fluorides:

Samples were collected for fluorides on 0.8u mixed cellulose ester membrane filters pre-treated with a solution of 50% ethanol-10% sodium formate. The filters were encased in 3 piece cassettes, in which air was drawn through at a flow rate of 1.5 lpm. After sampling, the filters were fused in sodium hydroxide, neutralized, and analyzed for fluorides by a specific ion electrode. The lower limit of detection for total fluorides was 0.01 milligrams.

d. Ozone:

The rubber-cracking method was used to quantitate the levels of ozone generated during welding and plasma arc burning. The procedure consisted of exposing a standarized strip of unvulcanized stretched rubber (1.5 inches by 0.25 inch) to ozone. The strip of rubber was folded in the middle with the ends secured together to create reproducible tension. The concentration of ozone was derived through optical examination of the strip to determine the number and depth of cracks in a given area. The lower limit of detection for ozone ranged from 0.01 to 0.03 parts per million (ppm), depending upon the duration of the sampling period.

e. Carbon Monoxide and Carbon Dioxide:

Employee exposures to carbon monoxide (CO) and carbon dioxide (CO_2) were measured using direct reading instrumentation. In order to evaluate exposures during welding, the employees were individually equipped with aluminum coated mylar bags to store air collected over given intervals.

Air was drawn from inside the welding helmet at a constant flow rate then discharged into the bag for subsequent analysis for CO and CO_2. The carbon monoxide concentrations were measured with an Ecolyzer, whereas the carbon dioxide concentrations were determined with NIOSH certified indicator tubes. Monitoring was generally confined to intervals when welding inside the tanks, to evaluate peak periods of exposure, with additional samples collected when welding outside the tanks. (Instantaneous measurements were also taken for CO and CO_2 as described in sub part "f".)

The extent of exposure of welders to carbon monoxide was further evaluated with an expired air analysis method using a breath-hold technique.[1] The concentration of CO in the expired air provided an index of the percent of hemoglobin (Hb) bound as carboxyhemoglobin (COHb) in the blood. In this procedure, the subject exhaled completely, filled his lungs rapidly and held for 20 seconds while being timed, then exhaled a small portion (several hundred milliliters) into the ambient air, and blew the remainder into an evacuated bag. The former maneuver was necessary since the expired air contained unequilibrated gas from the pulmonary dead space. The CO level in the exhaled air was measured in parts of CO per million parts of air by volume with an Ecolyzer. The COHb level in percent saturation was calculated using Ringold's equation:[1]

$$\text{COHb\%} = \frac{0.5+\text{CO in ppm}}{5}$$

Pre- and post-shift breath analysis samples were collected from the welders. The smoking habits of the employees were recorded.

f. Carbon Monoxide, Carbon Dioxide, Sulfur Dioxide, and Nitrous Fumes:

Instantaneous measurements using Drager indicator tubes for carbon monoxide, carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and nitrous gases ($NO+NO_2$) were collected in the welding plume near the welder's helmet, and at the crane operator's breathing zone. All Drager indicator tubes, except for nitrous fumes, were NIOSH certified to have an accuracy of ±35% at ½ the exposure limit and ±25% at 1 to 5 times the limit.

g. Formaldehyde and Carbon Monoxide:

Area samples were collected for carbon monoxide and formaldehyde at various locations throughout the Plant 3 Annealing Furnace and the F&D Annealing Furnace. Measurements were taken using Drager indicator tubes; the tubes used for formaldehyde were not NIOSH certified.

h. Fibrous Glass:

Personal samples were collected for fibrous glass (Plant 1-Dept. 114) using 0.8u mixed cellulose ester membrane filters. The filters were encased in 3 piece cassettes with the face cap removed and the filter completely exposed; air was drawn through the filter at a flow rate of 1.5 lpm with a vacuum pump. The samples were analyzed by first cleaning the membrane filter to make it optically transparent followed by fiber counts at 400 to 500 X magnification by phase contrast optical microscopy. The lower limit of detection for the method was 0.05 fibers of fibrous glass per cubic centimeter of air.

i. Methylene Bisphenyl Isocyanate and Polymethylene Polyphenylisocyanate:

Area and personal samples were collected for methylene bisphenyl isocyanate (MDI) and polymethylene polyphenylisocyanate (PAPI) with midget impingers containing 10 milliliters (ml) of nitro reagent. Air was bubbled through the sampling media at a flow rate of 1.0 lpm. The media was analyzed by the high speed liquid chromatographic (HSLC) method which had a lower limit of detection for MDI, and PAPI of 0.00003 and 0.00008 milligrams per sample, respectively.

2. Medical

On April 5, 6, and 7, 1977, the NIOSH medical investigator interviewed and examined 85 employees selected at random from the production personnel roster. The interviews consisted of having the employees sign a consent form, after which a brief questionnaire was administered to obtain personal identification data on occupational history, and past and present medical history. The examination involved inspection of the exposed surface of the body, and of the eyes, nose, and throat, taking of blood pressure, pulse, auscultation of the lungs, palpation of the kidneys, and urinalysis for protein using Bili-Labstix. A spot check of the employees' company health records was also made.

E. Evaluation Study Criteria

1. Toxicological Effects

The following is a summary of the adverse effects resulting from excessive exposure to each of the substances of concern. Only those substances in which the airborne concentrations approached or exceeded one-fourth (25%) of the applied exposure limits will be discussed.

a. Welding Fumes:

Inhalation of excessive amounts of welding fumes may result in metal fume fever. Whereas iron oxide, tin oxide, and aluminum are considered relatively inert, such metals as copper, nickel, manganese, and zinc are capable of producing the condition. The symptoms are similar to those of influenza and usually occur a few hours after exposure. The symptoms include a metallic taste in the mouth, dryness of the nose and throat, weakness, fatigue, muscle and joint pain, fever, chills, and nausea. These symptoms usually last less than 24 hours and a temporary tolerance follows. As a result, welders are more susceptible to this condition on Monday or on workdays following a holiday than on other workdays.[3]

b. Iron Oxide Fume:

Excessive exposure to iron oxide fume may result in siderosis, a benign condition that takes 6-10 years of exposure to develop.[2] Siderosis appears as dense areas in chest X-rays resulting from discrete pigmentation caused by the iron oxide fume. The spots (pigmentation) are not considered harmful themselves, however they may mask the presence of existing lung disorders and cause the disorders to go undetected in the early stages. Other symptoms include a shortness of breath and a tendency towards coughing. Shortness of breath or coughing tendencies do not always accompany positive X-ray findings. The condition often eases after excessive exposure is discontinued.[4]

c. Manganese:

Manganese itself has little effect on the body, but compounds of manganese such as the oxides of manganese are toxic.[5] Chronic manganese poisoning is primarily a disease of the central nervous system. Early symptoms include a sluggish feeling, sleepiness, and weakness in the legs. A masklike appearance of the face, emotional disturbances such as uncontrollable laughter, and spastic gait with tendency to fall when walking may occur in more advanced cases. In addition, a high incidence of pneumonia has been reported in workers exposed to the dust or fume of some manganese compounds.[6]

d. Vanadium (V_2O_5) as V fume:

The local effects are irritation to mucous membranes of eyes, nose, throat, and upper respiratory tract. Greenish discoloration of the tongue is common, but is of no known toxicologic significance. The systemic effects include pulmonary irritation and possibly pneumonitis; no specific chronic lung lesions have been described[2,7].

e. Copper:

Industrial exposure to copper occurs chiefly from fumes generated in welding copper-containing metals. The fumes and dust cause irritation of the upper respiratory tract, metallic taste in the mouth, nausea, metal fume fever, and in some instances discoloration of the skin and hair. Inhalation of dusts, fumes, and mists of copper salts may cause congestion of the nasal mucous membranes, and on occasions, ulceration with perforation of the nasal septum.[8,9]

f. Aluminum:

The effects caused by the inhalation of aluminum dust and fumes are not known with certainty at this time. Present data suggest that pneumoconiosis (a disease of the lungs) might be a possible outcome. In the majority of cases investigated, however, it was found that exposure was not to aluminum dust alone, but to a mixture of aluminum, silica, iron dusts, and other materials.[8]

g. Chromium:

The known health hazards from excessive exposure to chromium welding fumes are dermatitis, ulceration and perforation of the nasal septum, irritation of the mucous membranes of the larynx, pharynx, conjunctivia, and chronic asthmatic bronchitis. It should be noted that while some forms of chromium (VI) are suspected carcinogens (cancer producing agents), the type of chromium (VI) formed during welding is believed to be CrO_3 (chromic acid anhydride) which is presently considered noncarcinogenic.[10]

h. Nickel:

There is evidence that elemental nickel and nickel salts are carcinogenic, producing an increased incidence of cancer of the lungs and nasal passages. Nickel and its compounds also causes skin sensitization (this often results in chronic eczema "Nickel itch"), and are irritants to the conjunctiva of the eye and the mucous membranes of the upper respiratory tract.[8]

i. Fluoride:

Exposure to toxic concentrations of fluorides in air initially causes a sudden onset of chills, followed by a period of labored breathing, fever, and cough. There is also irritation to the respiratory tract which may result in nosebleed and sinus trouble. Prolonged exposure to fluoride particulates may cause changes in bone structure. Workers may suffer from nausea, loss of appetite, and other digestive problems.[11]

j. Formaldehyde:

Irritation to the eyes, nose, mouth, and throat are the most common effects from inhalation of formaldehyde. Formaldehyde has a pungent odor which is detectable at levels less than 1 ppm; discomfort with a tingling sensation in eyes, nose, and throat noted at 2-3 ppm, and difficulty in breathing at 10-20 ppm.[12] Considerable variation with individual sensitivity to formaldehyde is noticeable.[13] Some people are able to develop a physical tolerance to the irritant effects of formaldehyde, while others may become more sensitive. Dermatitis may result from contact with either liquid solutions, solid materials, or resins containing free formaldehyde.[14]

k. Carbon Dioxide:

Inhalation of carbon dioxide at elevated concentrations may produce mild narcotic effects, metabolic stress, and asphyxiation, depending on the concentration present and the duration of exposure. The gas is weakly narcotic at 30,000 ppm giving decreasing acuity of hearing and increasing blood pressure and pulse. Seventy-thousand (70,000) to 100,000 ppm of carbon dioxide will result in unconsciousness.[6]

l. Carbon Monoxide:

Inhalation of carbon monoxide causes asphyxiation by combining with hemoglobin to form carboxyhemoglobin, thereby interfering with the oxygen carrying capacity of the blood.[15] The effects of CO exposure are increased by duration of exposure, high environmental temperatures, and work effort (oxygen demand). Symptoms such as headache, nausea, fatigue, and dizziness appear in healthy workers engaged in light labor near sea level when about 10 percent of the Hb is combined with CO. Such a degree of saturation could be achieved by continually breathing air containing 50 ppm of CO for about 6 to 8 hours. Disturbance of coordination, judgment, psychomotor tasks, and visual acuity appear at about 2 percent COHb but do not become significant until about 5 percent COHb saturation is reached.

The medical criteria used to evaluate the breath analysis data was 5 percent COHb as recommended by NIOSH.[15] The 5 percent COHb criteria applies only to occupational exposure and does not take smoking into account. The blood of cigarette smokers may contain between 3 and 10 percent COHb depending on the number of cigarettes smoked and the manner of smoking, inhaling or not inhaling.[16] The COHb of non-smokers is approximately 0.5-0.8 percent.

m. Isocyanates[17] i.e., Polymethylene Polyphenylisocyanate (PAPI), Methylene Bisphenyl Isocyanate (MDI), and Toluene Diisocyanate (TDI):

The greatest practical hazard in the use of isocyanates arises from inhalation of their vapors. Inhalation of isocyanate vapors can produce severe irritation of the mucous membranes in the respiratory tract (nose, throat, lungs, etc.). Short exposure to concentrations of isocyanate vapor at or near the ceiling value of 0.02 ppm has caused a progressive disabling illness characterized by breathlessness, chest discomfort and reduced pulmonary function. Massive exposure to high concentrations has caused, within minutes, irritation of the trachea and larynx and severe coughing spasms. Massive exposure may also lead to bronchitis, bronchial spasm and/or pulmonary edema.

A small percentage of the population can become sensitized to isocyanates. In these sensitized individuals, exposures to minute concentrations of isocyanates may lead to asthmatic attacks and respiratory distress.

Since vapor concentrations at any given temperature are a direct function of the vapor pressure of the substance in question, TDI presents a greater potential hazard as compared to MDI and PAPI. The vapor pressure of TDI at 77^{o}F is reported to be 0.07 millimeters of mercury (mmHg), while that of MDI and PAPI are 0.00014 and 0.00006 mmHg, respectively. This would indicate that liquid TDI at room temperature will generate approximately 438 times as much isocyanate vapor as liquid PAPI at the same temperature.

2. Environmental Evaluation Criteria

Airborne exposure levels intended to protect the health of workers have been recommended or promulgated by several sources. These limits represent conditions under which it is believed that nearly all workers may be repeatedly exposed to a substance for an 8-hour or up to a 10-hour workday, 40-hour per week basis without adverse effect. For this investigation, the criteria used to assess the degree of health hazards to workers were selected from three sources: (1) airborne exposure limits which NIOSH has recommended to OSHA for occupational health standards, (2) Threshold Limit Values (TLVs) for 1977 and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), and (3) Occupational Health Standards as promulgated by the U.S. Department of Labor (Federal Register, 29CFR1910, pp. 506-509, January 1, 1976).

The NIOSH Recommended Standards and the TLVs presented in the following tabulation are given prominence in this evaluation since they represent the most current health criteria. The OSHA Standards are provided only as a reference to determine the state of compliance or non-compliance with Federal Regulations. The federal standards are legal standards and enforcement is a responsibility of the U.S. Department of Labor, OSHA.

Table A

Exposure Limits Presented in mg/M^3*

Substance	NIOSH	TLV	OSHA
Aluminum		5 (for total welding fume)	
Chromium (VI)	0.025		
Chromium (as Cr)		0.5	1
Copper Fume		0.2	0.1
Copper, Dust and Mist		1.0	1.0
Inorganic Fluoride	2.5	2.5	2.5
Iron Oxide Fume		5	10
Magnesium Oxide Fume		10	15
Manganese (as Mn)		5 (C)**	5(C)
Methylene Bisphenyl Isocyanate		0.2 (C)	0.2 (C)
Nickel	0.015	1	1
Nitrous Fume ($NO+NO_2$)***			
Polymethylene Polyphenyl Isocyanate***			
Total Particulate		10	15
Vanadium Fume	0.05 (C)	0.05 (C)	0.1 (C)
Vanadium Dust	0.05 (C)	0.5	0.5 (C)
Zinc Oxide	5	5	5
Fibrous Glass	3.0 fibers/cc****		

*mg/M^3 - denotes milligrams of substance per cubic meter of air.

**(C) - denotes a ceiling value which should not be exceeded (determined for intervals of 30 minutes or less). All other values presented in the table are permissible exposure levels based on either an 8 or 10-hour time weighted average.

***No exposure limits have been adopted.

****Fibers per cubic centimeter of air. Note: A fiber is defined as a particle with a length-to-diameter ratio of 3 to 1 or greater.

Table B

Exposure Limits Presented in ppm*

Substance	NIOSH	TLV	OSHA
Carbon Dioxide	10,000	5,000	5.000
Carbon Monoxide	35 (200)**	50	50
Formaldehyde	1 (C)***	2 (C)	5 (C)
Nitrogen Dioxide	1 (C)	5 (C)	5
Nitric Oxide		25	25
Ozone		0.1	0.1
Sulfur Dioxide	0.5	5	5

*ppm - parts of contaminant per million parts of air by volume.
**NIOSH has proposed a ceiling value of 200 ppm for carbon monoxide.
***(C) - denotes a ceiling value which should not be exceeded (determined for intervals of 30 minutes or less). All other values presented in the table are permissible exposure limits based on either an 8 or 10-hour time weighted average.

F. Evaluation Results and Discussion

1. Production Activities

The processes observed during the environmental investigation appeared representative of normal conditions. Most of the welding performed in Plants 1, 2, and 3 involved carbon steel materials with occasional welding of stainless steel in Plants 1 and 3, and of aluminum in Plant 1. No aluminum or stainless steel tank cars were fabricated during the survey, however, this was not considered atypical based upon review of production data for October 1976 through March 1977.

2. Environmental

Air sampling was conducted April 5-7, 1977, to evaluate emissions from plasma arc cutting, welding, air arc repairing, chipping, gouging, tank cleaning, and grinding. The operators of the respective processes, along with cranemen in the vicinity were monitored for various substances including iron oxide fume, aluminum, manganese, copper fume and dust, nickel, chromium metal, chromium (VI), vanadium fume and dust, magnesium oxide fume, zinc oxide fume, fluorides, ozone, sulfur dioxide, nitrogen dioxide, nitric oxide + nitrogen dioxide, carbon dioxide, and carbon monoxide. Additional sampling was conducted June 7-8, 1977, to further evaluate welding exposures to carbon monoxide and carbon dioxide.

Other operations monitored included: (1) Exposures to PAPI and MDI during application of urethane foam (April 7, 1977); (2) exposures to fibrous glass during application of rolled fibrous materials (April 7 and June 8, 1977); and (3) exposures to formaldehyde and carbon monoxide from the annealing furnaces (June 8-9, 1977).

a. Results of Personal Air Monitoring Conducted on Welders, Plasma Arc Burners, Chippers and Gougers, Tank Cleaners, Air Arc Repairmen, Grinders and Cranemen

1. Fluorides, Total Particulate, and Metals

Fifty two (52) employees were monitored to evaluate their exposure to fluorides, total particulate, and various metals. Of these employees, 24 were determined to have been exposed to airborne contaminant level(s) which exceeded the applied health criteria. Eleven (11) of the 24 employees were excessively exposed to a single substance, and 13 employees to a multiple of substances (from 2 to 5 substances). Those employees found to have excessive exposures included: (1) air arc repairmen, (2) grinders, (3) chippers and gougers, (4) tank cleaner, and (5) welders - - flux core arc, gas metal arc, shielded metal arc, and submerged arc welders. Presented below is a tabulation of contaminants and respective processes which exceeded the applied criteria. The table provides data on the type of processes monitored, the number of employees sampled, the range of concentrations exceeding the criteria, and the number of samples exceeding the criteria. For more detailed information refer to Tables 2, 3, 4, and 5.

Substance	Operation	Number of Employees Sampled	Range of Concen. Exceeding Criteria mg/M^3	Number of Samples Exceeding Criteria	
Iron Oxide Fume	Welder	31	5.12-17.3	12	(2)*
	Air Arc Repair	4	7.01-17.1	4	
	Chipper/Gouger	2	6.53-6.70	2	
	Tank Cleaner	1	11.4	1	
	Grinder	3	6.20-7.14	2	
Copper Fume	Air Arc Repair	4	0.28	1	
Nickel	Welder	30	0.018-0.647	5	(1)
	Air Arc Repair	4	0.021-0.146	3	
	Chipper/Gouger	2	0.017	1	
	Tank Cleaner	1	0.038	1	
	Grinder	3	0.021-0.199	2	(1)
Chromium (Cr)	Welder	31	0.62-1.60	2	(1)
Chromium (VI)	Welder	6	0.115	1	
Vanadium	Welder	5	0.060 (Fume)	1	
	Chipper/Gouger	2	0.070 (Dust)	1	
	Tank Cleaner	1	0.101 (Dust)	1	
Fluoride	Welder	20	3.20	1	(1)
Total Particulate	Welder	5	10.9-30.2	5	(2)
	Air Arc Repair	2	15.1-16.2	2	
	Chipper/Gouger	1	11.7	1	
	Tank Cleaner	1	20.0	1	
	Grinder	1	14.3	1	

*Number of samples taken over a sampling period of less than 4 hours.

Sampling results for aluminum, zinc oxide fume, magnesium oxide fume, and manganese were within acceptable limits. The highest exposure levels recorded for these substances were as follows: (1) aluminum, 2.27 mg/M^3; (2) zinc oxide fume, 0.02 mg/M^3; (3) magnesium oxide fume, 0.32 mg/M^3; and (4) manganese, 4.56 mg/M^3. Also, of the 7 job classifications monitored, only the plasma arc burners and cranemen were found not to be over-exposed to any contaminants.

2. Carbon Monoxide

Based on environmental and biological monitoring, it was determined that excessive concentrations of carbon monoxide were present during various welding operations (Tables 1, 7, and 8). The highest concentrations occurred when welding on the interior of the tanks using an electric arc shielded with carbon dioxide gas. Instantaneous measurements up to 355 ppm of carbon monoxide were recorded in the smoke plume (measurements taken near the employees' breathing zone outside the welding helmet) and average concentrations up to 170 ppm inside the helmet. Although it was not possible to take instantaneous measurements inside the helmet to define the peak CO concentrations, the CO excursion levels most likely exceeded the NIOSH recommended ceiling limit of 200 ppm. This is based on the fact that bag samples were taken over extended intervals (12 to 35 minutes), thus integrating the high and low excursion levels.

Biological monitoring was used to determine the extent of exposure to CO throughout the workday. Results of the post-shift carboxyhemogloblin determinations (Table 8) were consistent with the environmental findings. Forty percent (4 out of 10) of the welders were exposed to sufficient concentrations of carbon monoxide to produce carboxyhemogloblin (COHb) values in excess of the NIOSH recommended criteria of 5 percent. The amount of CO absorbed by the non-smokers resulted in COHb levels of 2.1 to 9.1 percent. (The range for all employees exceeding the criteria was 5.9 to 9.1 percent COHb.) Although the COHb levels which exceeded the criteria are not considered to be in a hazardous range, they do indicate appreciable absorption of CO.

Since the contributions of CO from the work environment and smoking habits cannot be readily discerned, only data on the non-smokers were used to evaluate CO exposures. The levels of COHb for the two smokers were 5.5 and 10.5 percent.

3. Carbon Monoxide, Carbon Dioxide, Ozone, Sulfur Dioxide, Nitrogen Dioxide, and Nitric Oxide + Nitrogen Dioxide

Personal air monitoring was conducted for carbon monoxide and carbon dioxide on the welders and the cranemen, and for ozone on the welders, the plasma arc burners, and the chippers and gougers. Whereas the carbon monoxide concentrations at various welding locations were excessive (as previously discussed) the carbon monoxide, carbon dioxide, and ozone concentrations at all other locations were within acceptable limits (Table 6 and 7).

Detector tube measurements were also taken in the plume of welding emissions and inside the overhead crane cabs for carbon dioxide, sulfur dioxide, nitrogen dioxide, and nitric oxide + nitrogen dioxide. Results of the sampling indicated insignificant concentrations of these substances (Tables 1 and 7).

b. Results of Air Sampling Conducted at the Annealing Furnaces

1. Formaldehyde

During the evaluation it was alleged that the annealing process emanated an unknown substance which produced intense tissue irritation. A review of the process immediately indicated that formaldehyde vapor was being evolved during the annealing cycle. Upon entry into the Burner Room, the NIOSH investigator began to experience symptomatology consistent with formaldehyde exposure. The symptoms included irritation to the mucous membranes of the upper respiratory tract and eyes.

Instantaneous measurements were taken for formaldehyde at various locations around the Plant 3 Annealing Furnace and the F&D Annealing Furnace. While the area measurements collected in the Panel Rooms did not detect significant concentrations of formaldehyde, the measurements taken near the furnace doors and throughout the Burner Rooms did reveal a potential problem. Concentrations of formaldehyde measured in these areas exceeded the ceiling limit of 2ppm, with levels greater than 10 ppm measured adjacent to the doors of the furnaces (refer to Table 11).

When investigating the source of contaminant generation, it was observed that fibrous glass insulation was used to seal the furnace doors. The doors were re-sealed with new insulation upon completion of each heating cycle. Since phenol-formaldehyde resins are frequently used in the curing of insulation, it is believed that the formaldehyde vapors are generated from resin decomposition. This does appear to be substantiated by the peak contaminant levels found at the annealing furnace doors.

2. Carbon Monoxide

Area measurements taken for carbon monoxide at the Plant 3 Anneal Furnace were within acceptable criteria. The highest concentration of CO recorded during the annealing process was 10 ppm (Table 11).

c. Results of Air Sampling for Polymethylene Polyphenyl Isocyanate and Methylene Bisphenyl Isocyanate During Foam Application

Personal and area samples were collected in the Paint and Foam Shop to determine the airborne concentrations of PAPI and MDI during applications of urethane foam. Since there had been an extended absence of work orders for foam products, a mock operation was performed to simulate actual work conditions. This process was conducted over a 15 minute period in which PAPI was poured into barrier molds. The Foam Operator assigned to the process was monitored during this interval.

Results of the environmental sampling for PAPI and MDI have been presented in Table 9. The concentrations of MDI were determined to be less than 0.000006 mg/M^3, which were within acceptable criteria. The concentrations of PAPI for the personal and area samples were 0.03 mg/M^3 and 0.35 mg/M^3, respectively. Since no exposure limits have been adopted for PAPI, it was not possible to base a toxicity determination on a comparison of environmental data to exposure criteria. However, a potential for exposure is indicated based upon: (1) the presence of PAPI in the atmosphere during foam application, and (2) the fact that PAPI is an isocyanate and should therefore be considered a hazardous material. Until more is known on the relative toxicity of PAPI, the material should be handled as if highly toxic and with all necessary precautions afforded to other isocyanates.

Employee exposure to the isocyanates was controlled through use of personal protective equipment. Each worker was provided with an air purifying type respirator certified for protection against either organic vapors (NIOSH Approval No. TC-23C-40) or against dust, fumes, and mists (NIOSH Approval No. TC-21C-178). During spray application the employee also wore a face shield, rubber gloves, and long sleeve shirt. While the above equipment would provide limited protection against isocyanate exposure, a more inclusive personal protective equipment program should be considered. Since isocyanate break-through is not easily ascertained with air purifying respirators, it would be advisable to use air supplied respirators. Also, where there is a likelihood of skin contact with the isocyanates the employees should wear clothing which is impervious to the material. This should include such articles as face protection (i.e., impervious hood), pants, gloves, shirts, and footwear. After use, the equipment should be properly cleaned and stored.

Methylene chloride is used in the Foam Shop as a cleaning solvent. While methylene chloride is a good solvent for removing urethane foam, it is undesirable for use on the skin. The mechanical action of harsh scrubbing along with the effects of the solvent may prompt the formation of a dermatitis. When skin has come into contact with isocyanate, removal of the contaminant should be done quickly, with thorough cleansing using soap and water.

d. Results of Air Sampling for Evaluation of Personal Exposures to Fibrous Glass

Personal samples were collected to evaluate employee exposures to fibrous glass during the application of rolled insulated materials. The airborne concentrations of fibrous glass (including total fiber count of all fibrous material present) were less than 0.05 fibers per cubic centimeters of air, which were within acceptable criteria.

When analyzing the samples it was observed that a fibrous material resembling asbestos was present. Regardless of the composition of the fibrous material, the concentrations measured were also within the proposed standard for asbestos (0.5 fibers/cc of air).

e. Other Potential Problems Observed or Alleged During the Survey

1. During interior painting of the tank cars, the spray painter was observed using inadequate personal protective equipment. The hood used for the airline respirator was not equipped with eye protection, nor was the respirator NIOSH or Bureau of Mines approved. The respirator contained paint residue and appeared to be in poor working condition.

2. It was observed that a railroad tank car brought onto the premises for repair was leaking an unknown chemical (white vapor) from the manway. Since the tank car was positioned near the Repair Shop Building in Plant 1, a potential for contaminant exposure did exist. Employees were observed to be working within approximately 100 yards of the tank car.

3. A potential exposure problem to decomposition products of various types of insulation has been reported during the repair of railroad tank cars. Several employees indicated that considerable smoke was evolved when cutting or welding on cars insulated with polyurethane and fibrous glass. It was also stated that local ventilation was infrequently used during the repair process.

3. Medical

The plant's medical facilities included a first aid station staffed by two registered nurses: one assigned to first shift, and one assigned to second shift. There is also a consulting physician who maintains his practice in North Hermitage, Pennsylvania. All pre-employment and rehire physicals are performed by the physician in his office.

Minor injuries and illnesses are treated in the first aid station by the attending nurse. Any serious health problems are referred to local hospitals for treatment.

New employees are given a complete physical examination (including a chest X-ray). Any employee who has been off work for an extended period of time is given a complete physical examination before returning to work. Also, periodic physicals are given to Sand Blast Operators, Shot Blast Operators, Maintenance Personnel, Motor Equipment Operators, Cranemen, and Painters.

In the first aid station, three separate medical files are maintained on each employee. The first file contains the employees' pre-employment and re-hire employment physical examination results. The second file contains data on job related injuries and illnesses. The third file consists of a courtesy book which is used to record employee visits (for treatment) to the first aid station during working hours. This book is maintained on a daily basis. No entry is made in the employees' health records from this book regarding visits to the first aid station.

A total of 83 males and 2 females (refer to Table 12) were interviewed and examined. During the interview all the employees stated that they had a chest X-ray in the past three years and that the report received from the radiologist was negative. Company sponsored chest X-rays are periodically given only to sand blast and shot blast operators. Available radiology reports on these employees were reviewed and found to be negative. Also, during the interview two employees related past symptomatology consistent with "metal fume fever". The results of the inspection of the exposed surfaces of the body of the employees revealed no abnormalities other than abrasions, and burns associated with welding and handling of heavy metal. The physical examination revealed that 24 employees had elevated blood pressure or pulse. Ten could be correlated with a past history of hypertension. Those employees with no history of hypertension were referred to the company nurse for disposition. None of the employees had suffered myocardial infarction or cerebrovascular accidents. Auscultation of the lungs revealed several employees with bi-lateral wheezing or rhonchi, which were possibly from heavy smoking or having a cold at the time of the examination. The bili-labstix examination of urine for protein revealed several employees with trace readings. Employees with a 1+ or greater reading were re-tested later in the day and found to be negative. Palpation of the kidneys revealed no abnormalities. Three employees did report having passed renal stones in the past, but no association was determined between this and plant exposure. Four workers complained of symptoms of muscle aches or fatigue which they felt were not work related.

The ENT examination proved to be negative. Several employees complained of irritation of the eyes, nose and throat (ENT) which they attributed to poor ventilation in the plant. A review of the employees' company health records revealed that nearly all of the employees who were examined had been treated more than once for flash burns. This is a common industrial injury found among welders.

One employee, who was on sick leave and being treated by his private physician for acute cardiac insufficiency and pneumoconiosis, was interviewed and examined by the NIOSH medical investigator. During the interview, this employee indicated that he worked as a welder for 28 1/2 years at GATX, welding various types of metal. On examination, the only abnormalities noted were that the employee was obese and experienced some forced inspiration.

There was one death at GATX in March of 1977. The deceased was a 39 year old male Caucasian who was employed at GATX 13 years. At the time of his death, he held the position of a Coiler Finisher, a position he held for three years. The local coroner ruled death was due to acute coronary occlusion. No post-mortem examination was performed. A review of the deceased's company health record revealed no abnormalities.

A review of medical reports received from the private physicians of several employees revealed no abnormalities in their electrocardiogram or chest X-ray.

G. Conclusions

1. Environmental

Based on environmental sampling, it was concluded that excessive contaminant emissions were produced from welding, air arc repairing, chipping and gouging, tank cleaning, and grinding. Twenty-four (24) of the 52 employees monitored were over exposed to various contaminants including iron oxide fume, copper fume, nickel, chromium metal, chromium (VI), vanadium, fluoride, and/or total particulate. While 11 of the 24 employees were excessively exposed to a single substance, 13 were excessively exposed to a multiple of substances (from 2 to 5 substances).

Other processes in which potential health problems were identified included: (1) carbon monoxide exposures from welding, (2) formaldehyde exposures from the annealing process, and (3) polymethylene polyphenyl isocyanate exposures from application of urethane foam. Also, it should be noted that the fibrous glass material used for tank car insulation contained a substance resembling asbestos.

2. Medical

The company is providing good medical care for its employees. Results of the physical examinations revealed no abnormalities other than abrasions and burns associated with welding and handling of heavy metal. Also data collected from review of employees' company health records, chest X-rays, and medical reports (from private physicians) did not disclose any job related health problems.

V. RECOMMENDATIONS

A. Environmental

1. Local ventilation should be instituted to control excessive emissions from welding, chipping and gouging, tank cleaning, air arc repairing, and grinding. Presented in Figures 1 through 8 are system designs applicable to various welding processes (Figures 1 to 6) and to portable grinding processes (Figures 7 and 8) used at GATX. When designing control procedures for welding, particular attention should be given to Figures 1 and 2, as they demonstrate techniques better adapted to processes requiring considerable mobility. For additional information on ventilation controls for welding and grinding, and for data on air arc repairing and gouging the following NIOSH publications should be consulted: (1) Recommended Industrial Ventilation Guidelines - HEW (NIOSH) Publication No. 76-162, (2) Engineering Control of Welding Fumes - HEW (NIOSH) Publication No. 75-115, and (3) Ventilation Requirements for Grinding, Buffing, and Polishing Operations - HEW (NIOSH) Publication No. 75-107.

2. Three objectives should be achieved when considering or designing ventilation controls:

   a. Processes in which toxic materials are used should be adequately ventilated (i.e.; welding of stainless steel).

   b. When designing local ventilation it is important that sufficient capture velocities are maintained at the points of contaminant generation.

   c. While respiratory protection should be used until effective engineering controls are implemented, respirators should not be used as the final means of contaminant control.

3. In view that respirators are extensively used at GATX, it is imperative that a high level of expertise be established and maintained in the art of respiratory protection. A formal respirator program, as outlined in the Occupational Safety and Health Standards 29 CFR 1910.134, must be maintained and enforced. Also, NIOSH certified respirators should be used.

A provision listed in 29 CFR 1910.134 (d) which should be afforded particular attention is the use of compressors for supplying air to airline respirators. GATX should insure that the proper type of compressors are used and are adequately equipped with necessary safety devices (i.e., filters, alarms, etc.).

4. Fibrous glass insulation treated with resin materials should not be used to seal the annealing furnace doors. A material which would not evolve potentially toxic substances should be substituted.

5. When handling urethane foams, care must be taken to avoid undue exposure to isocyanates. Proper protection should be provided through the use of ventilation controls, protective clothing, and respiratory protection. When respiratory protection is employed, it is recommended that an air supplied respirator be used. Also, all protective clothing should be impervious to the material, and should be cleaned after daily use.

6. GATX should conduct additional environmental sampling in the Foam Shop. Extensive sampling should be conducted under actual work conditions to evaluate employee exposure to isocyanates during the filling of barrier molds and the spraying of bolsters and sills with urethane foam.

7. Since decomposition products of polyurethane and resin treated fibrous glass are toxic, local ventilation should be used when heating these materials to high temperatures; this is particularly true when working in confined spaces such as the interior of the tank cars.

8. The company should insure that all necessary corrections or precautions are immediately taken to prevent toxic exposures with any tank cars leaking contaminants.

9. Good hygiene practices must be followed when repairing tank cars which have contained toxic materials. Whenever possible, a history of the car should be obtained in order to ensure proper handling. All necessary precautions (i.e., proper cleaning procedures, ventilation controls, and personal protective equipment) should be taken when working with the cars.

10. An environmental survey should be conducted of the spray painting processes (i.e., interior and exterior painting of tank cars) to evaluate employee exposure to organic solvents and other possible contaminants.

11. It is recommended that GATX maintain continuous surveillance of all radiography equipment used in the non-destructive testing of welds. The surveillance program should include monitoring of employee exposure, of the environment, and of the equipment.

B. Medical

1. All hourly employees should be given an annual physical examination to include a 14" x 17" chest roentgenogram every five years.

2. Only one (1) health record should be maintained on each employee, and such record should be kept for at least 30 years after the termination of employment.

3. The company should ensure that employees working with equipment such as welding arcs, plasma torches, and carbon arcs which are sources of high intensity ultraviolet radiation should use strict precautions against exposure of the eyes and skin. Eyes should be protected by the use of suitable goggles, face shields or mask. Protective clothing of densely woven flannelette poplin of synthetic fabric will provide adequate skin protection. (In operations where a fire hazard exists, flame-resistant clothing should be worn.) Gloves should be worn to protect the hands. Face shields and barrier creams may be used as supplementary skin protection.

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VII. REFERENCES

1. Ringold, A., et. al., Estimating Recent Carbon Monoxide Exposures - A Rapid Method. Archives of Environmental Health, 5:308, (1962).

2. Documentation of Threshold Limit Values, American Conference of Governmental Industrial Hygienists, Committee on Threshold Limit Values, Cincinnati, Ohio, 1975.

3. Welding Safety, DHEW (NIOSH) Publication No. 77-131, 1977.

4. Commonwealth of Pennsylvania Department of Health Division of Occupational Health. Hygiene Information Guide, No. 35, June, 1967.

5. Ibid, No. 29.

6. Documentation of Threshold Limit Values, American Conference of Governmental Industrial Hygienists, Committee on Threshold Limit Values, 3rd Edition, Cincinnati, Ohio, 1971.

7. Lewis, C.E. The Biological Effects of Vanadium. 2, The Signs and Symptoms of Occupational Vanadium Exposure. A.M.A. Arch, Indust. Health, Vol. 19:497, 1959.

8. Occupational Diseases, A Guide to Their Recognition, Revised Edition, June 1977, DHEW (NIOSH) Publication No. 77-181.

9. The Welding Environment, American Welding Society, 1973, Library of Congress Catalog Card Number: 72-95119.

10. Criteria for a Recommended Standard...Occupational Exposure to Chromium (VI), HEW Publication No. (NIOSH) 76-129.

11. Commonwealth of Pennsylvania Department of Health Division of Occupational Health. Hygiene Information Guide, No. 38, April, 1971.

12. Patty, Fa. A., Industrial Hygiene and Toxicology, Vol. II, Interscience Publishers, New York, N.Y., pp. 1971-72, (1967).

13. Elkins, H. The Chemistry of Industrial Toxicology. Wiley and Sons, New York, N.Y. pp. 116 and 231, (1950).

14. Kominsky, J.R. and Thoburn, T.W., Health Hazard Evaluation Determination Report H.H.E. 76-43 A-F-429, Hersey Products Company, Inc., Gilbertville, Massachusetts, NIOSH, Cincinnati, Ohio.

15. Criteria for a Recommended Standard...Occupational Exposure to Carbon Monoxide, 1972. HEW Publication (NIOSH) HSM 73-11000.

16. Hutchison, M.D., A Guide to Work-Relatedness of Diseases. HEW Publication No. (NIOSH) 77-123.

17. Precautions for the Proper Usage of Polyurethanes, Polyisocyanates and Related Materials, Upjohn Chemical Division, Technical Bulletin 107, (1973).

Table 2
Environmental Samples Collected for Various Metals
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Type of Welding	Shielding Gas	Contaminant (mg/M³) Copper Fume (Cu)	Iron Oxide Fume (Fe_2O_3)	Manganese (Mn)	Nickel (Ni)	Chromium (Cr)	Chromium (VI) (CrVI)	Vanadium Fume/Dust (V)	Total Particulate
4-5-77	Plant 2-Dept. 182 (Bay 2)	Outside Coil Welder	P[2]	0705-1455	Submerged Arc		0.02	1.32	0.12	N.D.[3]	N.D.			
	Plant 2-Dept. 181 (Bay 1)	Welder	P	1135-1700	Flux Core E70T-1	CO_2	0.01	10.22	0.22	N.D.	N.D.			
	Plant 2-Sub Assembly	Small Parts Welder	P	0715-1440	Stick E7018 Stick E7014		<0.02	2.06	0.16	N.D.	N.D.			
	Plant 2-Sub Assembly	Welding	A[4]	0755-1435	Stick E7014 Flux Core E70T-1	CO_2	N.D.	1.00	0.09	N.D.	N.D.			
	Plant 2-Dept. 183 (Bay 3)	Plasma Arc Cutting	P	0740-1445			0.03	1.82	0.08	N.D.	N.D.			
	Plant 2-Sub Assembly	Welder-Fit and Tack Parts	P	0705-1435	Flux Core E70T-1	CO_2	<0.02	2.49	0.27	N.D.	N.D.			
	Plant 2-Column between Bays 1 & 2	Welding	A	0850-1530	Flux Core E70T-1	CO_2	N.D.	0.60	0.03	N.D.	N.D.			
	Plant 2-Dept. 182 (Bay 2)	Fitter Welder	P	0825-1453	Stick E6012		N.D.	2.36	0.12	N.D.	N.D.			
	Plant 2-Dept. 183 (Fab Shop)	Plasma Arc Cutting	A	0804-1445			N.D.	0.69	0.02	N.D.	N.D.			
	Plant 2-Dept. 102 (Bay 2)	Welds Bolsters	P	1520-2215	Stick E7014 Flux Core E70T-1	CO_2	N.D.	5.12	0.84	N.D.	N.D.			
	Plant 2-Dept. 182 (Bay 2)	Welds Bolsters	P	1520-2215	Flux Core E70T-1	CO_2	N.D.	>0.83[5]	>0.13[5]	N.D.	N.D.			
	Plant 3-Dept. 142	Welder-Tandem System (Shell Fixture Operation)	P	1530-2245	Submerged Arc		0.01	4.82	0.15	N.D.	N.D.			
	Plant 3-Dept. 143-(Heavy Weld Bay)	Welds Manways & Inside of Tank	P	1510-2245	Gas Shield E309-16 E70T-1	CO_2	<0.02	2.20	0.19	0.255	0.62	0.115		
	Plant 3-Fabrication Bay	Plasma Arc Cutting	P	1510-2245			0.02	3.04	0.18	N.D.	N.D.			
	Plant 3-Dept. 142	Welder-Car Tank Fitter Welds Inside/Outside of Tank	P	1535-2245	Tack Welding With Stick E7018		0.01	1.24	0.05	N.D.	N.D.			
	Plant 2-Dept. 183 (Fab Shop)	Plasma Arc Cutting	P	0740-1442			0.01	0.98	0.02	0.005	<0.01		N.D.	1.61
	Plant 2-Dept. 82 (Bay 2)	Welds Pipe Fixtures & Repairs Cooling Coil Defects	P[6]	0725-1045	Flux Core E70T-1	CO_2	0.01	5.33	0.73	N.D.	0.02		N.D.	10.87
	Plant 2-Dept. 181 (Bay 1)	Crane Operator-Over Plasma Arc Cutting Table	P[7]	0800-1450			0.01	0.80	0.02	N.D.	<0.01		N.D.	1.35
	Plant 2-Dept. 181	Welder	P[5]	0720-1440	Flux Core E70T-1	CO_2	>0.02	>5.66	>0.88	>0.008	>0.02		N.D.	>12.31
4-6-77	Plant 2-Dept 181 (Bay 1)	Crane Operator-Over Plasma Arc Cutting Table	P	0840-1450			0.01	1.34	0.05	N.D.	0.01	0.001	N.D.	2.11
	Plant 3-Heavy Welding	Combination Welder	P[8]	1245-1425	Flux Core ER-309	CO_2	0.02	7.33	2.60	0.647	1.60		N.D.	28.47
	Plant 3-Heavy Welding (OSW-3)	Combination Welder	P	0725-1420	Flux Core E70T-1 Stick E7018 Stick E7014	CO_2	0.02	9.31	1.59	0.018	0.05		N.D.	20.61
	Plant 3-Heavy Welding (ISW-3/OSW-4)	Combination Welder	P	0750-1420	Flux Core E70T-1	CO_2	0.03	15.53	2.05	0.027	0.06		0.060 (fume)	30.16
	Plant 3-Dept 142	Chipper/Gouger	P[9]	0705-1130			0.05 (dust)	6.53	0.16	0.015	0.03		0.070 (dust)	11.68
	Plant 3-Dept. 142	Air Arc Repair-Approximately 80% of Time Outside Tank	P	0800-1430	Stick E8018-C3		0.02	7.09	0.48	0.022	0.03		N.D.	15.09
	Plant 3-Dept. 142	Air Arc Repair-Inside/Outside of Tank	P	0740-1430	Stick E8018-C3		0.04	7.01	0.55	0.021	0.03		N.D.	16.22
	Plant 3-Dept. 142	Air Arc Repair-Inside/Outside of Tank	P	0730-1430	Stick E8018-C3		0.28	17.14	1.81	0.146	0.07			
	Plant 3-Dept. 142	Inside Union Melt	P[10]	0715-0955	Submerged Arc		0.05	1.67	0.05	N.D.	N.D.			
	Plant 3-Dept. 142	Chipper/Gouger	P[11]	0730-1130			0.04 (dust)	6.70	0.15	0.017	N.D.			
	Plant 3-Dept. 142	Air Arc Repair/Tacking-Inside & Outside of Tank	P	0750-1430	Stick E8018-C3		0.10	12.07	0.11	N.D.	N.D.			
	Plant 3-Heavy Welding (OSW-1)	Combination Welder	P[12]	0820-1030	Flux Core E70T-1	CO_2	0.02	2.27	0.19	N.D.	N.D.			
	Plant 3-Heavy Welding (ISW-3/OSW-4)	Combination Welder	P	0805-1425	Flux Core E70T-1	CO_2	0.04	12.30	0.21	N.D.	N.D.			
	Plant 3-Heavy Welding (OSW-3)	Combination Welder	P	0725-1420	Flux Core E70T-1 E7018 E7014	CO_2	0.01	17.30	0.26	N.D.	0.01			

Table 2 (Continued)

Date	Location	Operation	Sample Type	Sample Period	Type of Welding	Shielding Gas	Copper Fume (Cu)	Iron Oxide Fume (Fe_2O_3)	Manganese (Mn)	Nickel (Ni)	Chromium (Cr)	Chromium (VI) (CrVI)	Vanadium Fume/Dust (V)	Total Particula
							Contaminant (mg/M[3])							
4-6-77	Plant 3-Heavy Welding (OSW-1&2)	Combination Welder	P	0840-1440	Flux Core E70T-1 Stick E7018 Stick E7014	CO_2	0.02	14.25	0.41	N.D.	N.D.			
	Plant 2-Dept. 184 (Sub Assembly)	Grinder	P9	0755-1130			0.02 (dust)	2.70	0.08	0.199	0.06			
	Plant 3-Dept. 142	Inside Union Melt	P	1500-2215	Submerged Arc		0.03	6.40	0.28	0.011	N.D.			
	Plant 3 (Bay 2)	Crane Operator	P	1540-2225			N.D.	8.20	0.06	N.D.	N.D.			
	Plant 3-Dept. 143	Crane Operator	P	1535-2235			N.D.	1.06	0.06	N.D.	N.D.			
	Plant 3-Bay 1 (Middle Crane)	Crane Operator	P	1510-2225			N.D.	0.83	0.05	N.D.	N.D.			
	Plant 3-Dept. 143 (Bay 1)	Grinder	P	1525-2200			0.02 (dust)	6.20	0.13	0.012	N.D.			
	Plant 3-Dept. 143 (Bay 1)	Grinder-Inside/Outside of Tank	P	1515-2200			0.03 (dust)	7.14	0.14	0.021	0.03		N.D.	14.34
4-7-77	Plant 1-Dept. 1475	Combination Welder-Inside & Outside of Tank	P13	0945-1310	Stick 308L-16 Stick E6012 Stick E6012		0.03	4.10	0.23	0.052	0.09	0.023		
	Plant 1-Dept. 1475 (Build Line)	Welds Outside Fittings	P	0725-1440	Gas Shield E70S-3	Argon	0.02	2.76	0.13	N.D.	N.D.	0.001		
	Plant 1-Dept. 170 (Repair Shop)	Crane Operator	P	0730-1210			N.D.	0.71	0.02	N.D.	N.D.			
	Plant 1-Dept. 170 (Repair Shop)	Heavy Welder-Inside/Outside of Tank	P	0725-1315	Stick E7018 308L-16		0.05	15.11	0.41	N.D.	N.D.	0.013		
	Plant 1-Dept. 114 (Jacket Welding Area)	Welds Flashing & Jacket to Head	P	0723-1430	Gas Shield E70S-3	98% Argon 2% CO_2	0.02	3.14	0.10	N.D.	N.D.			
	Plant 1-Dept. 1475 (Build Line)	Tank Cleaner	P	0740-1430			0.04 (dust)	11.36	0.20	0.038	0.08		0.101 (dust)	19.98
	Plant 1-Dept. 170 (Repair Shop)	Crane Operator	P	0730-1210			0.01	0.74	0.02	0.007	N.D.		N.D.	3.81
	Plant 1-Dept. 1517	Welds Bonnets	P	0735-1430	Stick E7014 Stick E6012 Gas Shield LINDE5554HQ	Argon						0.005		
	Plant 1-Aluminum Tank Works)	Welded Inside Aluminum Tank	P	0735-1330	Gas Shield ER4043	Argon						0.001		

1. mg/M[3]-milligrams of substance per cubic meter of air
2. P-Personal sample collected in breathing zone of employee
3. N.D.-None detected
4. A-Area sample
5. Part of sample lost
6. Sample period less than 4 hours
7. Plasma arc cutting table was not used in Bay 1 on 4-5-77.
8. Sample collected when welding stainless steel.
9. Sample terminated at 11:30 a.m. due to employee leaving work.
10. Union melt process in operation for 4 hours (0700-1100) on 4-6-77.
11. Process was down due to crane repairs (Operator left work at 11:30 a.m.).
12. Sample terminated at 10:30 a.m. due to employee leaving work.
13. Employee discontinued welding at approximately 1:00 p.m.

	Limits of Detection for Total Metal (mg per sample)	8-Hour Time Weighted Average Exposure Limits (mg/M[3]) NIOSH	TLV	OSHA
Copper Fume (Cu)	0.002-0.003		0.2 (Fume) 1.0 (Dust)	0.1 (Fume) 1.0 (Dust)
Iron Oxide Fume (Fe_2O_3)	0.003-0.005		5	10
Manganese (Mn)	0.002-0.003		5*	5*
Nickel (Ni)	0.003-0.005	0.015	1	1
Total Chromium (Cr)	0.002-0.005		0.5	1
Chromium VI (CrVI)	.0002	0.025		
Vanadium (V)**	0.020-0.025	0.05*	0.05 (Fume)* 0.5 (Dust)	0.1 (Fume)* 0.5 (Dust)*
Total Particulate	-		10	15

*Ceiling value
**OSHA standard is for vanadium pentoxide (V_2O_5).

Table 3
Environmental Samples Collected for Various Metals
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Type of Welding	Shielding Gas	Contaminant (mg/M^3)[1] Iron Oxide Fume (Fe_2O_3)	Manganese (Mn)	Magnesium Oxide Fume (MgO)	Zinc Oxide Fume (ZnO)	Aluminum (Al_2O_3)	Chromium (Cr)	Copper Fume (Cu)	Nickel (Ni)
4-5-77	Plant 3-Fabrication Bay	Crane Operator-Over Plasma Arc Cutting Table	P[2]	1515-2245			1.16	0.06	0.03	N.D.[3]	N.D.	N.D.	N.D.	N.D.
4-6-77	Plant 2-Dept. 181 (Bay 1)	Crane Operator-Over Plasma Arc Cutting Table	P	0840-1447			1.22	0.04	0.03	N.D.	N.D.	N.D.	N.D.	N.D.
	Plant 2-Dept. 182 (Bay 1)	Plasma Arc Cutting	P	0706-1442			0.71	0.03	0.02	<0.01	N.D.	0.006	N.D.	N.D.
4-7-77	Plant 1-Dept. 1517	Bonnet Area-Welder	P	0735-1430	Gas Shield ER5554 Stick E6012 Stick E7014	Argon	4.29	0.19	0.32	0.02	1.12	0.007	N.D.	N.D.
	Plant 1-Aluminum Tank Works	Welded Inside Aluminum Tank	P	0735-1330	Gas Shield ER4043	Argon	0.19	N.D.	0.02	0.01	2.27	N.D.	N.D.	N.D.

1. mg/M^3-milligrams of substance per cubic meter of air.
2. P-Personal sample collected in breathing zone of employee.
3. N.D.-None detected

	Limits of Detection for Total Metal (mg per sample)	8-Hour Time Weighted Average Exposure Limits (mg/M^3) NIOSH	TLV	OSHA
Iron Oxide (Fe_2O_3)	0.005		5	10
Manganese (Mn)	0.004		5 (c)*	5 (c)
Magnesium Oxide (MgO)	0.0003		10	15
Zinc Oxide (ZnO)	0.001	5	5 (for Welding Fumes)	5
Aluminum (As Al_2O_3)	0.030		10	
Total Chromium (Cr)	0.004		0.5	1
Copper Fume (Cu)	0.003		0.2 (Fume) 1.0 (Dust)	0.1 (Fume) 1.0 (Dust)
Nickel (Ni)	0.008	0.015	1	1

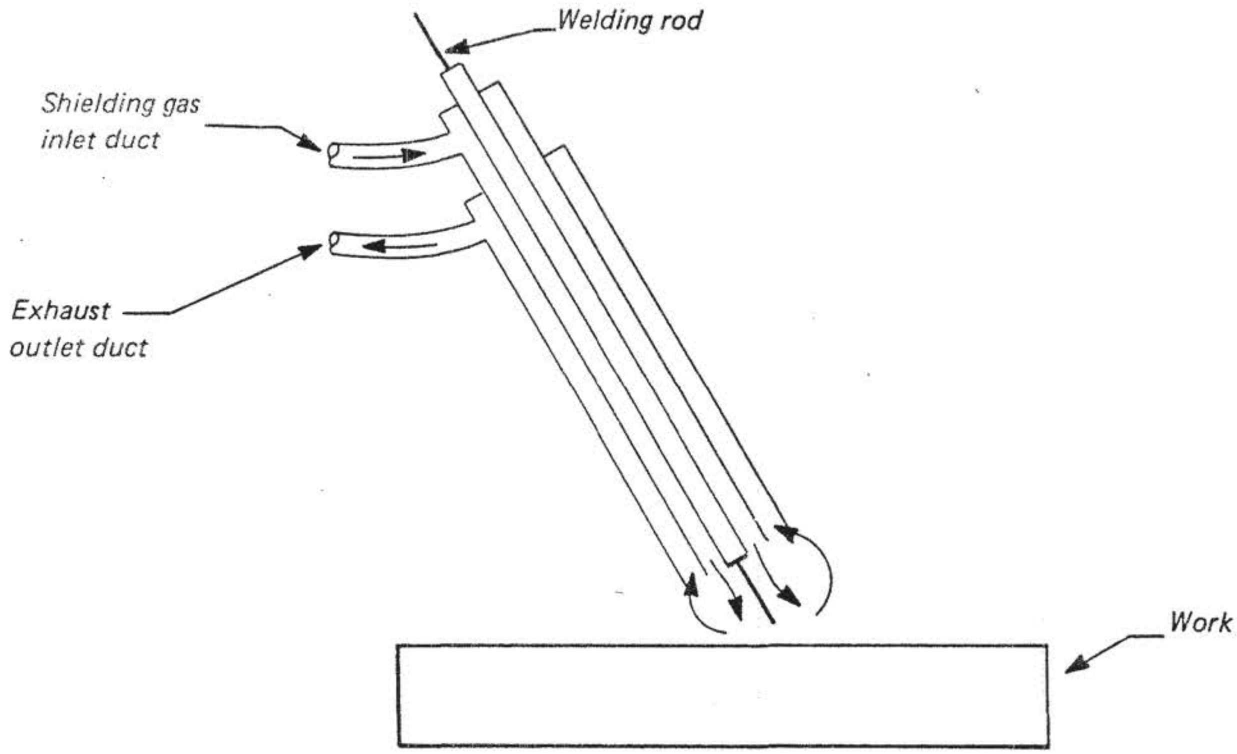
*(c) Ceiling value

Table 12

List of Workers Interviewed
by Job Title and Sex

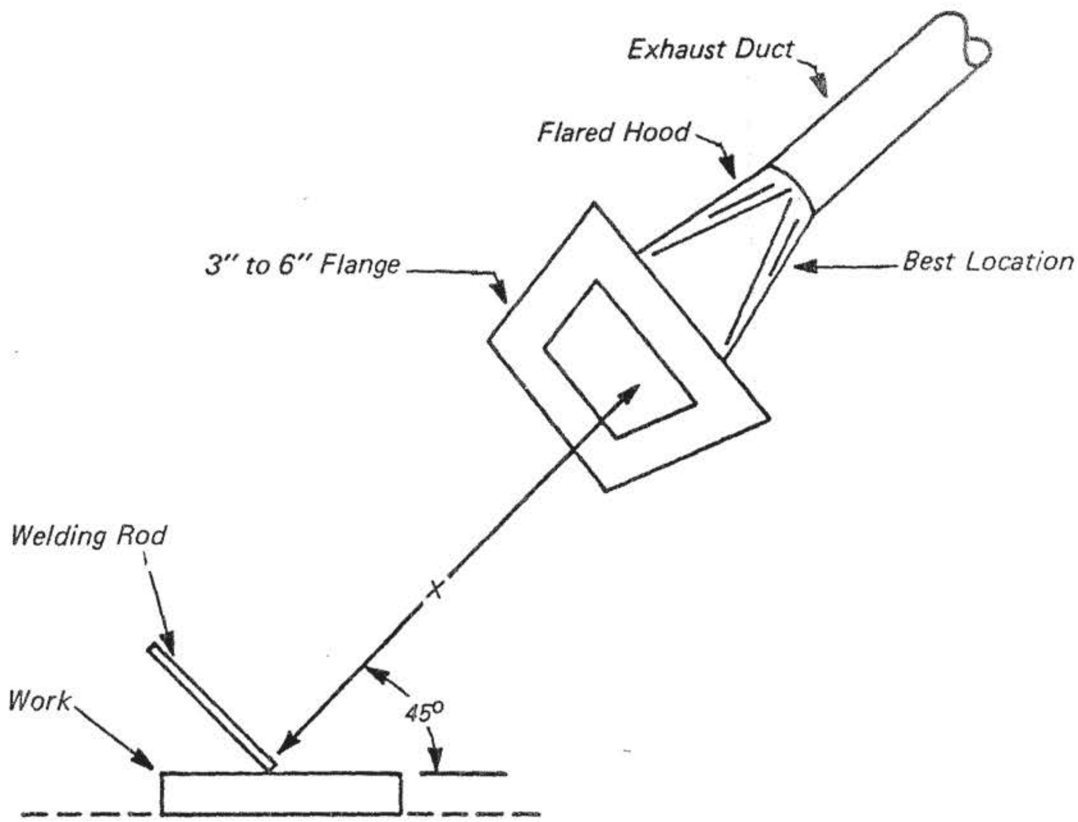
General American Transportation Corporation
· Masury, Ohio

Job Title	Number Interviewed	
	Male	Female
Stenciller/Painter	2	0
Trailer Finisher	2	0
Repairman	2	0
Tester	1	0
Shear Helper	1	0
Machinist	1	0
Chipper	1	0
Slag Cleaner	1	0
Air Arc Repairman	1	0
Coiler Finisher	2	0
Sub Fitter	4	0
Arc Welder	3	0
Burner	3	0
Crane Operator	3	0
Driver	2	0
Sand Blaster	1	0
Cranemen	1	0
Shot Blast	1	0
Grinder	7	0
Fitter	5	0
Sein Auto Welder	5	0
Laborer	5	2
Welder	30	0



Exhaust flow requirements must be determined for each welding operation and welding gun configuration by experimental testing with air contaminant sampling and analysis.

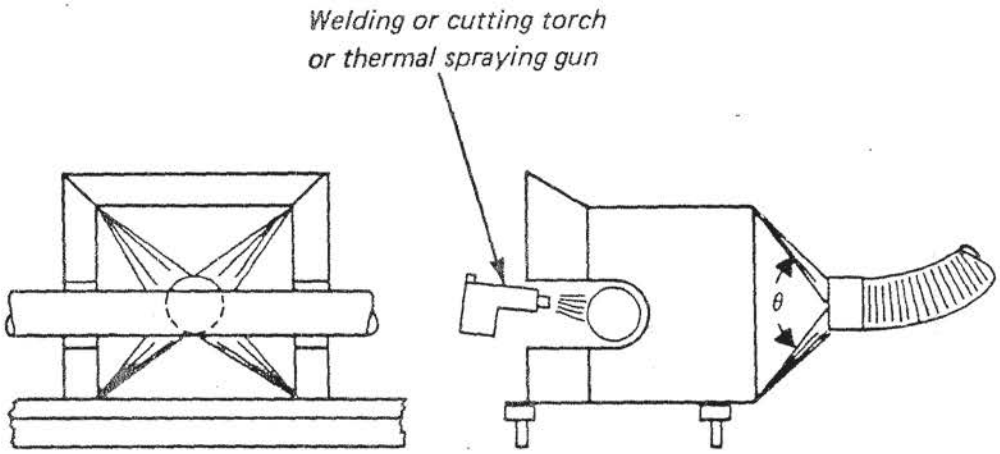
FIGURE 1 WELDING GUN-MOUNTED EXHAUST HOOD



$$Q = K(10\,x^2 + A)V_x$$

Q = exhaust volume, cfm
X = distance from center of hood face to farthest point of contaminant release, ft
A = hood face area (not including flange), sq ft
V_x = minimum capture velocity, fpm
K = 1.0 for unflanged hood; 0.75 for flanged hood
Entry loss = entry loss factor for tapered hood X duct VP
Duct velocity = 2000 fpm minimum

FIGURE 2 FREELY-SUSPENDED OPEN HOOD



$$Q = A\,V_f$$

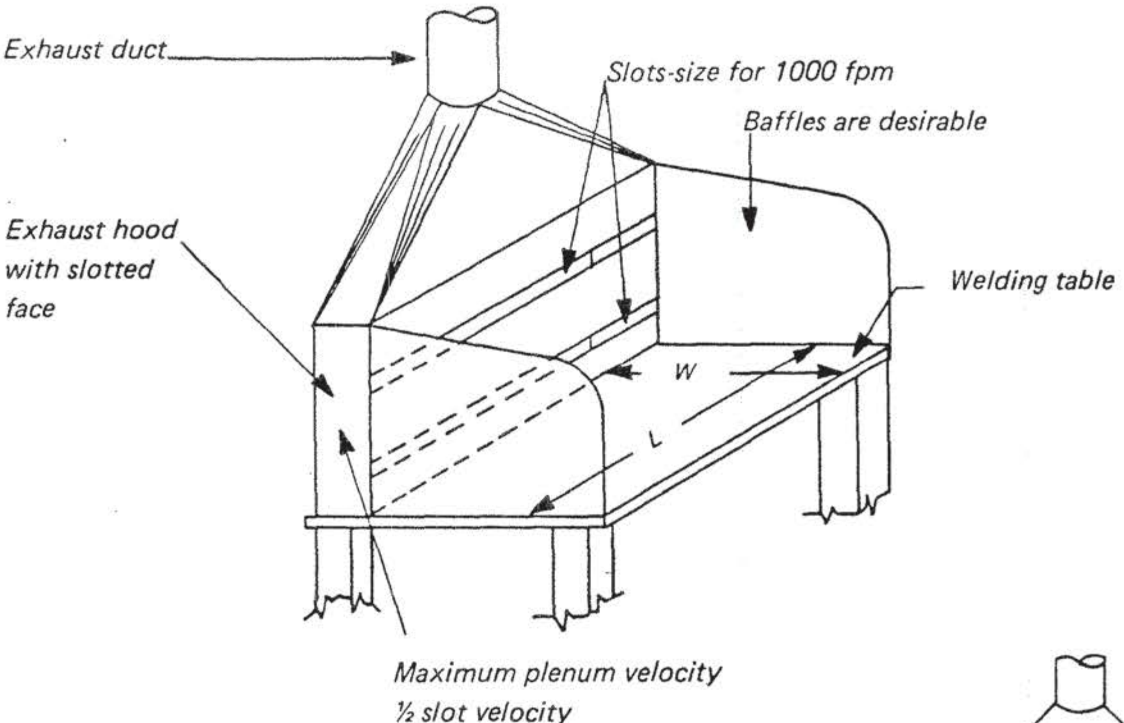
Q = exhaust volume, cfm

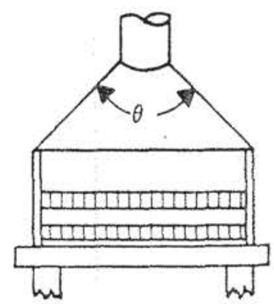
A = hood face area, sq ft

V_f = minimum face velocity, fpm

Entry loss = entry loss factor for tapered hood x duct VP

FIGURE 3 OPEN HOOD WITH WELDING OPERATION AT FACE

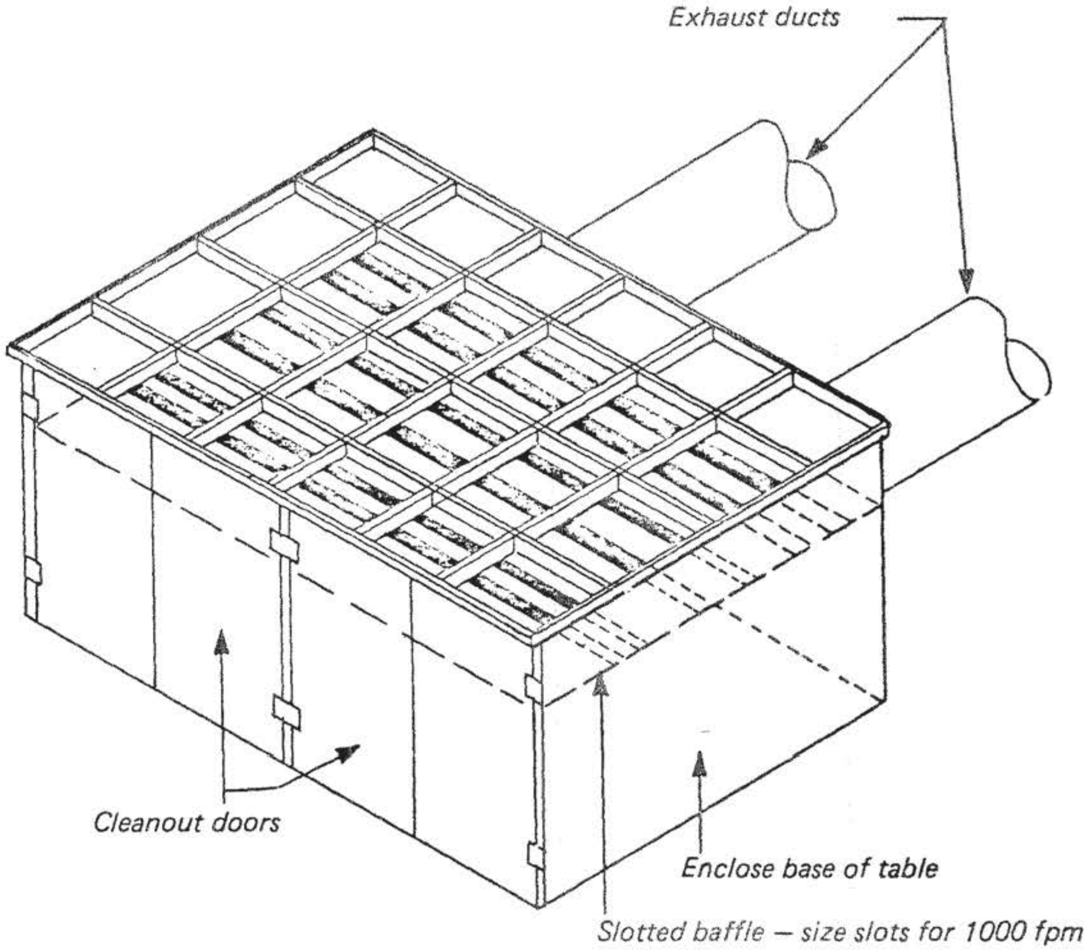




$$Q = KLWV_x$$

Q = exhaust volume, cfm
W = table width, ft (not to exceed 4 ft)
L = table length, ft
V_x = minimum capture velocity, fpm
K = 2.4 with baffles; 2.8 without baffles
Entry loss = 1.78 slot VP plus entry loss factor for tapered hood x duct VP
Duct velocity = 2000 fpm minimum

FIGURE 4 CROSSDRAFT TABLE



$$Q = A\ V_f$$

Q = exhaust volume, cfm
A = table top area, sq ft
V_f = minimum face velocity, fpm
Entry loss = 1.78 slot VP plus entry loss factor for tapered hood x duct VP
Duct velocity = 2000 fpm minimum

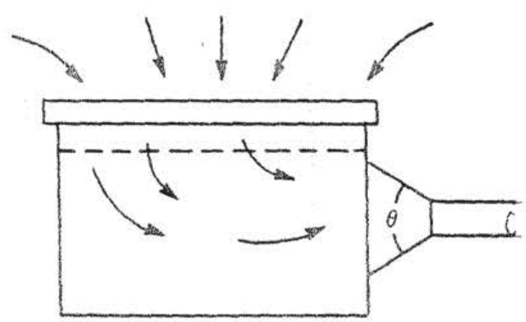
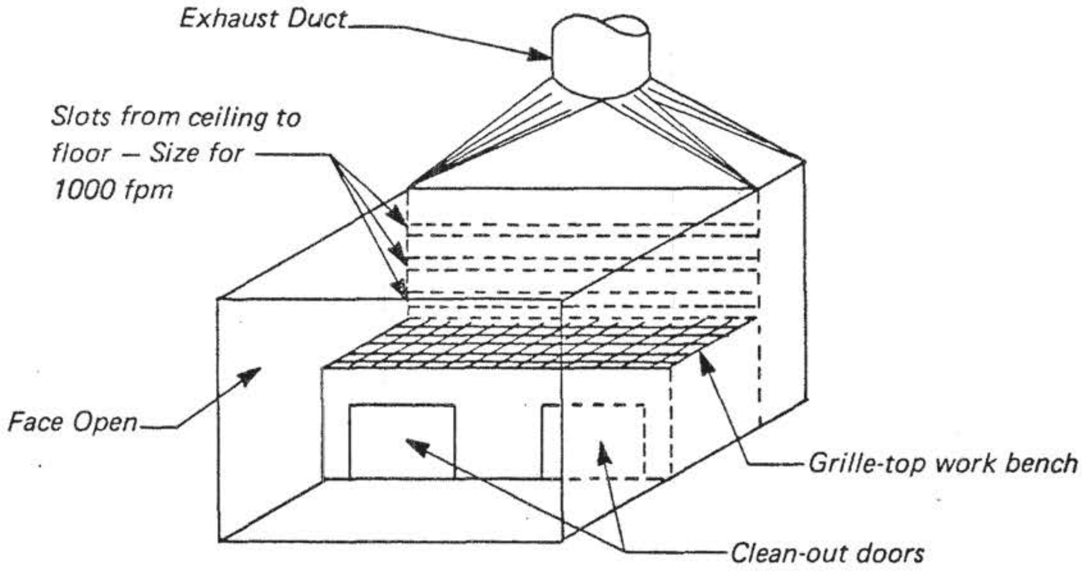


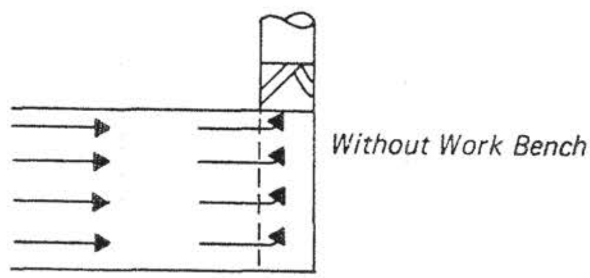
FIGURE 5 DOWNDRAFT TABLE

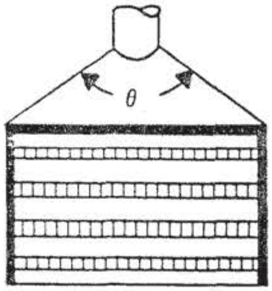


Work bench required for thermal spraying; optional for other welding operations.

$$Q = A\ V_f$$

Q = exhaust volume, cfm
A = hood face area, sq ft
V_f = minimum face velocity, fpm
Entry loss = 1.78 slot VP plus entry loss factor for tapered hood x duct VP
Duct velocity = 3000 fpm minimum





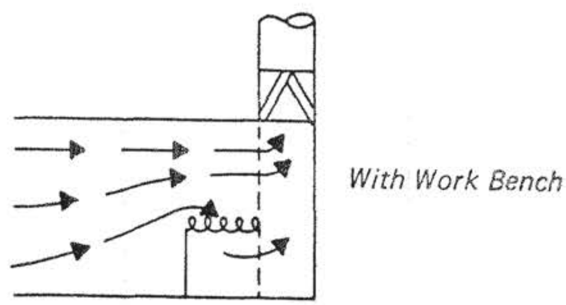


FIGURE 6 ENCLOSING HOOD

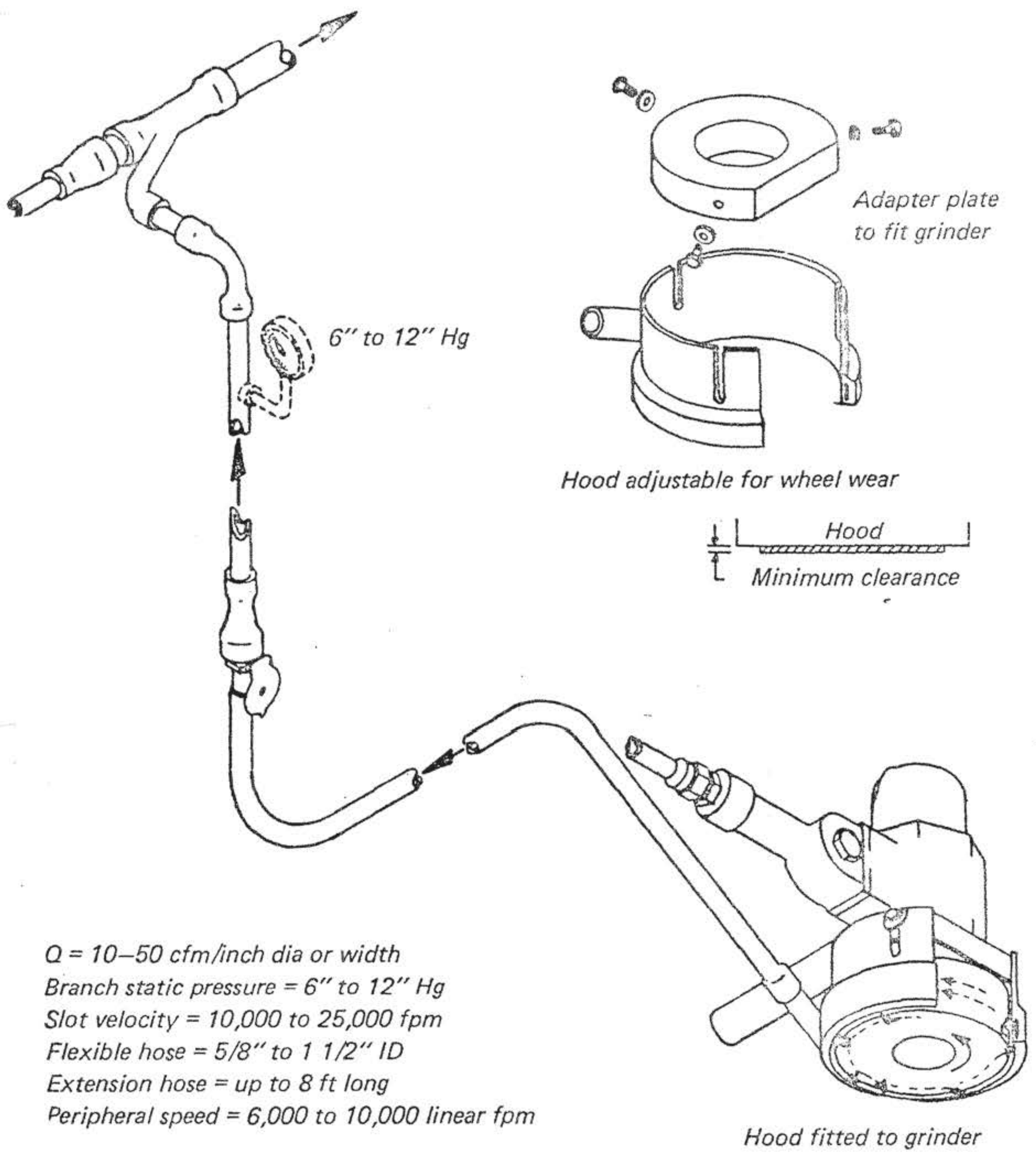


FIGURE 7 PORTABLE GRINDER WITH SHAPED HOOD

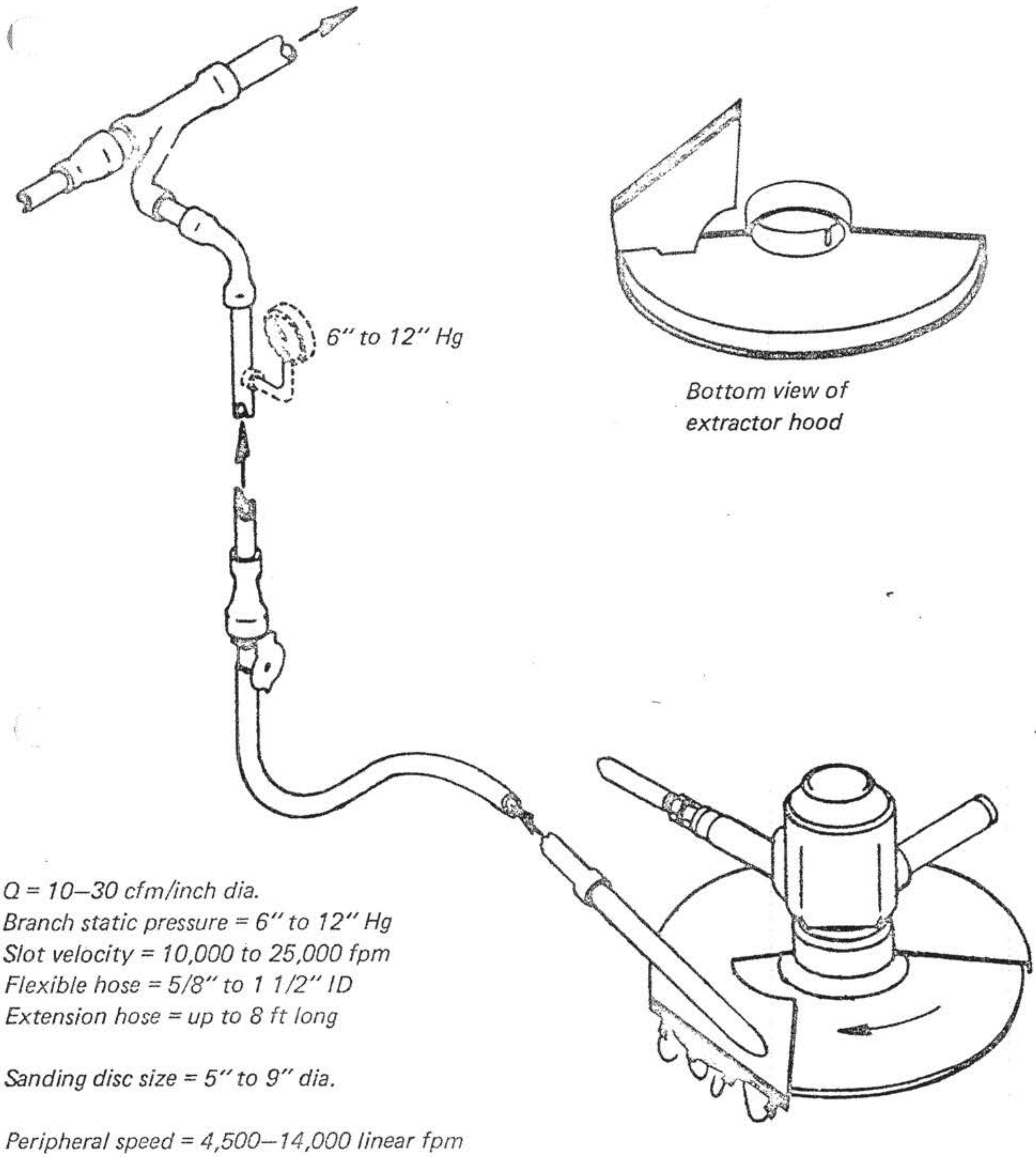


FIGURE 8 DISC POLISHER WITH LOW-VOLUME-HIGH-VELOCITY HOOD

Table I
Environmental Samples Collected for Various
Chemical Substances with Drager Indicator Tubes
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Time of Day	Type of Welding	Shielding Gas	Contaminant	Tube Reading (ppm)[1]
4/5/77	Plant 2 Bay 1	Crane[2] Operator	P[3]	1230			Carbon Monoxide(CO)	Trace(<5ppm)
							Carbon Dioxide(CO_2)	<1000
							Sulfur Dioxide(SO_2)	None
							Nitric Oxide(NO)+ Nitrogen Dioxide(NO_2)	.5
				1310			CO	5
							CO_2	<1000
							SO_2	None
							NO+NO_2	.5
	Plant 2 Bay 3			1415			NO+NO_2	.5
							CO	<10
							SO_2	None
				1430			CO	10
							CO_2	<1000
	Plant 2 Dept. 181	Welder	SP[4]	0845	Flux Core E70T-1	Carbon Dioxide	NO+NO_2	<.5
							NO_2	None
							CO	>50
	Plant 2 Dept. 181	Welder	SP	0930	Flux Core	Carbon Dioxide	NO+NO_2	<1
							CO	50
							NO_2	None
	Plant 2 Dept. 82	Welder	SP	0945	Flux Core E70T-1	Carbon Dioxide	NO+NO_2	.5
							NO_2	None
							CO	130
	Plant 2 Dept. 182	Welder	SP	1015	Submerged Arc		NO+NO_2	Trace(<.5)
							NO_2	None
							CO	10
							[5]CO	110
				1030			CO	10
	Plant 2 Sub-Assembly	Welder	SP		Stick E7014		NO+NO_2	<.5
							NO_2	None
	Plant 2 Dept. 182	Welder	SP	1400	Stick E6012		NO_2	None
							NO+NO_2	.5
	Plant 3 Dept. 142	Welder	SP	2015	Stick E7018		NO+NO_2	Trace(<.5)
				2100			NO_2	None
4/6/77	Plant 3 Heavy Weld	Welder (Welding Inside Tank)	SP	1400	Flux Core E70T-1	Carbon Dioxide	CO	110
				1410			CO_2	6000
				1412			NO+NO_2	.5
				1415			CO	375
				1418			CO_2	5000
4/6/77	Plant 3 Heavy Weld	Welding (Welding Inside Tank)	SP	1330	Flux Core E70T-1	Carbon Dioxide	CO	160
							CO_2	7500
							NO_2	None
							NO+NO_2	.5
	Plant 2 Bay 1	Crane Operator[6]	SP	0920			CO	<10
				0925			CO_2	<1000
				0935			NO+NO_2	<.5
				0945			NO_2	None
				1113			CO	<10
				1120			CO_2	<1000
				1128			NO+NO_2	.7
				[illegible]			NO_2	.5

Table 11
Environmental Samples Collected for
Formaldehyde and Carbon Monoxide Using Drager Indicator Tubes
General American Transportation Corporation
Masury, Ohio

Date	Location	Sample Type	Sample Period	Contaminant Concentration (ppm)[1] Formaldehyde	Carbon Monoxide
6-8-77	Plant 3 - Annealing Furnace[2]				
	Panel Room	A[3]	13:17		N.D.[4]
	West Burner Room	A	13:30		10
	West Burner Room - Near door leading into Panel Room	A	13:40	>10	
	West Burner Room - Near door leading into Panel Room	A	13:45	2	
	Panel Room	A	13:50	<0.5	
	West Burner Room - Near door leading into Panel Room	A	14:25	0.5	
	East Burner Room	A	14:35		5
	West Burner Room	A	14:45		5
	West Burner Room - Near door leading into Panel Room	A	15:05	0.5	
6-9-77	F & D Annealing Furnace[5]				
	West Burner Room	A	10:55	0.5 - 0.7	
	West Burner Room	A	11:05	2	
	South Door - Around seal of south door of furnace	A	11:10	2 - 4	
	North Door - Around seal of north door of furnace	A	11:18	N.D.	
	Panel Room	A	11:20	N.D.	
	South Door - Around seal of south door of furnace	A	11:30	>10	

1. ppm - parts of contaminant per million parts of air by volume
2. Heating cycle started at approximately 12:50 pm
3. A - Area Sample
4. N.D. - None Detected
5. Heating cycle started at 10:45 am

Note: A fibrous glass insulation material (apparently containing a formaldehyde resin) was used to seal the doors of the furnace. This material was replaced after each heating cycle.

	Eight Hour Time Weighted Average Exposure Limits (ppm) NIOSH	TLV	OSHA	Range of Measurement For Indicator Tube (ppm)
Formaldehyde	1 (Ceiling Limit)	2 (Ceiling Limit)	3	0.5 to 10
Carbon Monoxide	35	50	50	5 to 700

Table 10
Environmental Samples Collected for Fibrous Glass
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Fibers Per Cubic Centimeter (cc) of Air[1]
4-7-77	Plant 1 - Dept. 114 (Medium Weld)	Insulator - Top Man	P[2]	0820-1425	< 0.05
	Plant 1 - Dept. 114 (Medium Weld)	Insulator - Bottom Man	P	0820-1317	< 0.05
6-8-77	Plant 1 - Dept. 114 (Medium Weld)	Insulator - Bottom Man	P	0735-1500	< 0.05
	Plant 1 - Dept. 114 (Medium Weld)	Insulator - Bottom Man	P	0735-1500	< 0.05

1. NIOSH evaluation criteria is 3.0 fibers of fibrous glass per cubic centimeter of air (3.0 fibers/cc). No OSHA standard or TLV has been adopted for fibrous glass.

2. Personal sample collected in breathing zone of employee.

Note: All samples contained fibrous material resembling asbestos.

Table 9
Environmental Samples Collected for Methylene Bisphenyl
Isocyanate (MDI) and Polymethylene Polyphenyl Isocyanate (PAPI)
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Concentration (mg/M^3) MDI	PAPI
4-7-77	Plant 1 - Finishing Dept. (Interior Foam and Paint Shop)	Foam Operator - Pouring Foam Insulation into Molds	P[2]	0905-1010	N.D.[4]	0.03
	Plant 1 - Finishing Dept. (Interior Foam and Paint Shop)	On Catwalk Near Foam Spray Unit	A[3]	0955-1007	N.D.	0.35

1. The TLV and OSHA exposure limit for MDI is a ceiling value of 0.2 milligrams of contaminant per cubic meter of air (0.2 mg/M^3). An exposure limit for PAPI has not been adopted.

2. Personal sample collected in breathing zone of employee.

3. Area sample.

4. N.D. - None detected. The lower limit of detection for MDI is 0.00003 mg per sample. The collecting media volumes analyzed ranged from 4 to 7 milliliters.

Note: The foam pouring process was simulated due to the extended absence of work orders for foam products.

Table 8
Expired Air Carbon Monoxide (CO) and Carboxyhemoglobin (COHb) Levels
General American Transportation Corporation
Masury, Ohio

		Pre-Exposure			Post-Exposure			Approx. Number of Cigarettes Smoked		
Date	Location/Operation[1]	Approx. Time	Expired Air CO Level (ppm)[1]	% COHb	Approx. Time	Expired Air CO Level (ppm)	% COHb	Smoker	Pre-Exposure	During Exposure
6-7-77	Plant 3 - Dept. 143 (Heavy Welding)									
	Welded Outside of Tank	0700	27	5.9	1430	25	5.5	Yes	4	5
	Welded Inside & Outside of Tank	0700	10	2.5	1430	30	6.5	No		
	Welded Outside of Tank	0700	52	10.9	1430	50	10.5	Yes	5	8
	Welded Inside & Outside of Tank	0700	10	2.5	1430	16	3.7	No		
	Welded Inside & Outside of Tank	0700	6	1.7	1430	8	2.1	No		
	Welded Outside of Tank	0700	8	2.1	1430	13	3.1	No		
6-8-77	Plant 3 - Dept. 143 (Heavy Welding)									
	Welded Outside of Tank	0700	7	1.9	1430	14	3.3	No		
	Welded Inside & Outside of Tank	0700	11	2.7	1430	35	7.5	No		
	Welded Inside & Outside of Tank	0700	6	1.7	1430	9	2.3	No		
	Welded Inside & Outside of Tank	0700	8	2.1	1430	27	5.9	No		
		0700	9	2.3	1430	17	3.9	No		
		0700	9	2.3	1430	43	9.1	No		
	NIOSH Environmental Criteria						5% COHb			

1. All employees monitored were classified as Combination Welders. The process consisted of flux core welding using wire E70T-1 shielded with CO_2 gas.

2. ppm - parts of carbon monoxide per million parts of air by volume.

Table 7 (Continued)

1. Except as noted, the operation consisted of flux core welding using wire E 70T-1 shielded with CO_2 gas.
2. ppm - Parts of contaminant per million parts of air by volume.
3. OT - Outside tank
4. P - Personal sample collected in breathing zone of the employee
5. IT - Inside tank
6. SP - Air sample collected in the smoke plume of the welding operation near the employees' breathing zone
7. Gas shielded arc using McKay 309L-0 wire shielded with CO_2
8. Welded with stick E 7014

Note: Instantaneous measurements of existing contaminant concentrations were taken near the employees' breathing zone (outside of the welding helmet) using Drager Indicator Tubes. Air samples taken over longer sampling periods were collected in bags and subsequently analyzed for CO with an Ecolyzer and CO_2 with Drager Tubes. The bags were filled with air collected from inside the welding helmet.

	Eight Hour Time Weighted Average Exposure (ppm)			Range of Measurement for Indicator Tube (ppm)
	NIOSH	TLV	OSHA	
Carbon Monoxide	35	50	50	5-700
Carbon Dioxide	10,000	5,000	5,000	1,000-60,000

Table 7 (Continued)

Date	Location	Operation[1]	Welding Site	Sample Period	Sample Type	Contaminant Concentration (ppm)[2] Carbon Monoxide	Carbon Dioxide
6-7-77	Plant 3 - Dept. 143 (Heavy Welding)	Combination Welder	IT	1637-1654	P	128	5000
			IT	1638	SP	100	
			IT	1641	SP		5000
			IT	1643	SP	100	
			IT	1657	SP		5000
		Combination Welder	IT	1637-1704	P	170	4500
			IT	1638	SP	100	
			IT	1645	SP	150	
			IT	1650	SP	200	
			IT	1700	SP	200	
6-8-77		Combination Welder[7]	IT	0802-0815	P	30	1000
			IT	0807	SP	50	
			IT	0814	SP	< 100	
		Combination Welder[8]	IT	0936-0956	P	6	1000
		Combination Welder	IT	1237-1258	P	107	3000
			IT	1244	SP	100	
			IT	1245	SP	100	
			IT	1250	SP	200	
		Combination Welder	IT	1239-1301	P	148	4500
			IT	1236	SP	10	
			IT	1247	SP	150	
			IT	1254	SP	200	
			IT	1300	SP	300	
		Combination Welder	IT	1051-1118	P	150	5000
			IT	1058	SP	150	
			IT	1107	SP	280	
			IT	1115	SP	≥ 300	

Table 7
Environmental Samples Collected for Carbon Monoxide and Carbon Dioxide Using Drager Indicator Tubes and the Ecolyzer
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation[1]	Welding Site	Sample Period	Sample Type	Contaminant Concentration (ppm)[2] Carbon Monoxide	Carbon Dioxide
6-7-77	Plant 3 - Dept. 143 (Heavy Welding)	Combination Welder	OT[3]	0740-0825	P[4]	5	< 1000
			OT	0915-0930	P	4	< 1000
			IT[5]	1255-1307	P	97	3000
			IT	1300	SP[6]	160	
			IT	1305	SP	110	
		Combination Welder	OT	0735-1000	P	12	2000
			IT	1254-1306	P	97	5000
			IT	1302	SP	100	
			IT	1308	SP	100	
		Combination Welder	OT	0730-0800	P	5	< 5000
			OT	1110-1155	P	6	
		Combination Welder	OT	0730-1000	P	7	
			IT	1030-1105	P	198	8000
			IT	1045	SP	150	
			IT	1050	SP	200	
			IT	1055	SP	225	
			IT	1100	SP	300	
		Combination Welder	OT	0740-0810	P	7	< 1000
			OT	0914-0934	P	4	1000
			OT	1335-1344	P	4	
		Combination Welder	OT	0740-0805	P	4	< 1000
			OT	0914-0918	P	5	< 1000

Table 6
Determination of Ozone Concentrations
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Type of Welding	Shielding Gas	Concentration of Ozone (mg/M^3)[1]
4-5-77	Plant 2 - Dept. 183 (Bay 3)	Plasma Arc Cutting	P[2]	0745-1445			< 0.03
	Plant 2 - Dept. 183 (Fab Shop)	Plasma Arc Cutting	P	0735-1442			< 0.02
	Plant 3 - Fabrication Bay	Plasma Arc Cutting	P	1520-2240			< 0.01
4-6-77	Plant 2 - Dept. 182 (Bay 1)	Plasma Arc Cutting	P	0725-1441			< 0.01
	Plant 2 - Dept. 182	Plasma Arc Cutting	P	1000-1435			< 0.02
	Plant 3 - Heavy Welding (OSW-1)	Combination Welder[3]	P	0820-1030	Flux Core E70T-1	CO_2	< 0.03
	Plant 3 - Heavy Welding (ISW-3/ OSW-4)	Combination Welder	P	0905-1425	Flux Core E70T-1	CO_2	< 0.02
	Plant 3 - Heavy Welding (OSW-3)	Combination Welder	P	0900-1420	Flux Core E70T-1 Stick E7018 Stick E7014	CO_2	< 0.02
	Plant 3 - Dept. 142	Chipper/Gouger[4]	P	0700-1130			< 0.02
4-7-77	Plant 1 - Dept. 1517	Bonnet Area	P	0735-1430	Gas Shield ER5554 Stick E6012 Stick E7014	Argon	Sample Lost
	Plant 1 - Dept. 1475 (Build Line)	Welds Outside Fittings	P	0750-1440	Gas Shield E70S-3	Argon	< 0.01
	Plant 1 - Dept. 170 (Repair Shop)	Heavy Welder - Inside and Outside of Tank	P		Stick E7018 308L-16		< 0.01
	Plant 1 - Aluminum Tank Works	Welded Inside Aluminum Tank	P	0730-1055	Gas Shield ER4043	Argon	< 0.02

1. The TLV and OSHA exposure limit for ozone is 0.1 parts of contaminant per million parts of air by volume (0.1 ppm).
2. Personal sample collected within breathing zone of employee.
3. Sample terminated at 10:30 am due to employee leaving work.
4. Sample terminated at 11:30 am due to employee leaving work.

Table 5 (Continued)

Date	Location	Operation	Sample Type	Sample Period	Type of Welding		Shielding Gas	Concentration of Fluoride (mg/M³)[1]
4-6-77	Plant 3 - Heavy Welding (OSW-3)	Combination Welder	P	0725-1420	Flux Core Stick Stick	E70T-1 E7018 E7014	CO_2	2.28
	Plant 3 - Dept. 142	Air Arc Repair - Inside and outside of tank	P	0730-1430	Stick	E8018-C3		1.13
	Plant 3 - Dept. 142	Inside Union Melt[7]	P	0715-0955	Submerged Arc			0.28
	Plant 3 - Dept. 142	Air Arc Repair - Inside/ outside of tank	P	0740-1430	Stick Stick	E7018 E8018-C3		0.99
	Plant 3 - Dept. 143 (Bay 1)	Grinder	P	1525-2200				0.13
	Plant 3 - Dept. 142	Inside Union Melt	P	1500-2215	Submerged Arc			0.21
	Plant 3 - Dept. 143 (Bay 1)	Grinder - Inside and Outside of tank	P	1515-2200				0.14

1. The NIOSH, OSHA and TLV exposure limit for fluoride is 2.5 milligrams of contaminant per cubic meter of air (2.5 mg/M^3).
2. Personal sample collected in breathing zone of employee.
3. N.D. - None detected. The lower limit of detection for fluoride is 0.01 mg per sample.
4. Part of sample lost.
5. Sample collected when welding stainless steel.
6. Sample terminated at 10:30 am due to employee leaving work.
7. Union Melt process in operation for 4 hours (0700-1100) on 4-6-77.

Table 5
Determination of Fluoride Concentrations
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Type of Welding		Shielding Gas	Concentration of Fluoride (mg/M^3)[1]
4-5-77	Plant 2 - Dept. 182 (Bay 2)	Fitter Welder	P[2]	0825-1453	Stick	E6012		N.D.[3]
	Plant 2 - Sub Assembly	Small Parts Welder	P	1005-1440	Stick	E7014		0.04
	Plant 2 - Sub Assembly	Welder - Fit and Tack Parts	P	0705-1435	Flux Core	E70T-1	CO_2	0.13
	Plant 2 - Dept. 82 (Bay 2)	Welds Pipe Fixtures and Repairs Cooling Coil Defects	P	0725-1045	Flux Core	E70T-1	CO_2	0.60
	Plant 2 - Dept. 182 (Bay 2)	Outside Coil Welder	P	0705-1455	Submerged Arc			0.31
	Plant 2 - Dept. 181 (Bay 1)	Welder	P	1135-1700	Flux Core Stick	E70T-1 E7018	CO_2	1.27
	Plant 2 - Dept. 181	Welder[4]	P	0720-1440	Flux Core	E70T-1	CO_2	>0.61
	Plant 2 - Dept. 182 (Bay 2)	Welds Bolsters	P	1520-2215	Stick Flux Core	E7014 E70T-1	CO_2	0.69
	Plant 2 - Dept. 182 (Bay 2)	Welds Bolsters	P	1520-2215	Flux Core	E70T-1	CO_2	0.32
	Plant 3 - Dept. 142	Welder - Tandem System (Shell Fixture Operation)	P	1530-2245	Submerged Arc			0.16
	Plant 3 - Dept. 142	Welder - Car Tank Fitter-Welds Inside/Outside of Tank	P	1535-2245	Tack Welding With Stick	E7018		0.04
4-6-77	Plant 3 - Heavy Welding (OSW-1 & 2)	Combination Welder	P	0840-1440	Flux Core Stick Stick	E70T-1 E7018 E7014	CO_2	1.10
	Plant 3 - Heavy Welding (OSW-3)	Combination Welder	P	0725-1420	Flux Core Stick Stick	E70T-1 E7018 E7014	CO_2	1.06
	Plant 3 - Heavy Welding	Combination Welder - Welded in Tank for 15 minutes[5]	P	1245-1425	Flux Core	ER-309	CO_2	3.20
	Plant 3 - Heavy Welding (OSW-1)	Combination Welder[6]	P	0820-1030	Flux Core	E70T-1	CO_2	0.15
	Plant 3 - Heavy Welding (ISW-3/OSW-4)	Combination Welder	P	0750-1420	Flux Core	E70T-1	CO_2	1.52
	Plant 3 - Heavy Welding (ISW-3/OSW-4)	Combination Welder	P	0805-1425	Flux Core	E70T-1	CO_2	1.53

Table 4
Determination of Manganese Ceiling Concentration
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Sample Period	Type of Welding		Shielding Gas	Concentration of Manganese (mg/M^3)[1]
4-7-77	Plant 1 - Dept. 1475 (Build Line)	Welds Outside Fittings	P[2]	1221-1236 1237-1252 1345-1400	Gas Shield	E70S-3	Argon	0.18 0.14 0.23
	Plant 1 - Repair Shop	Heavy Welder - Repairing X-ray Flaws Inside of Tank	P	0810-0825	Stick	E7018		2.18
	Plant 1 - Repair Shop	Heavy Welder - End Weld On Top of Tank	P	0953-1007 1247-1302 1304-1315	Stick	E7018		1.82 4.14 4.56

1. The OSHA and TLV exposure limit for manganese is 5 milligrams of contaminant per cubic meter of air (5 mg/M^3). The exposure limit represents a ceiling value which should not be exceeded even instantaneously.

2. P - Personal sample collected in breathing zone of employee.

Table 1 (continued)
Environmental Samples Collected for Various
Chemical Substances with Drager Indicator Tubes at
General American Transportation Corporation
Masury, Ohio

Date	Location	Operation	Sample Type	Time of Day	Type of Welding	Shielding Gas	Contaminant	Tube Reading (ppm)
	Plant 3 Dept. 142	Welder (Welding Inside Tank)	P	1800	Union Melt (Submerged Arc)		CO	50
				1810			CO	50
				1825			CO	70
	Plant 3 Heavy Weld	Welder (Welding Inside Tank)	SP	2050	Flux Core E70T-1	Carbon Dioxide	CO	<10
				2055			CO	30
				2100			CO_2	1000
				2106			CO	130
				2109			$NO+NO_2$	.6
				2111			CO	200

1. ppm - Parts of contaminant per million parts of air by volume.
2. Plasma arc table located in Bay 1 not in use.
3. P - Personal sample collected in breathing zone of the employee.
4. SP - Air sample collected in smoke plume of welding operation (outside of welding helmet) near the employees' breathing zone.
5. Sample collected 12 inches below breathing zone (plume measurement).
6. Plasma arc table in Bay 1 in use.

Contaminant	Eight Hour Time Weighted Average Exposure (ppm) NIOSH	TLV	OSHA	Range of Measurement for Indicator Tube (ppm)
Carbon Monoxide	35	50	50	5-700
Sulfur Dioxide	0.5	5	5	1-25
Carbon Dioxide	10,000	5,000	5,000	1,000-60,000
Nitric Oxide + Nitrogen Dioxide	-	-	-	0.5-10
Nitric Oxide	-	25	25	-
Nitrogen Dioxide	1(C)*	5(C)	5	0.5-25

*(C) Denotes a ceiling value which should not be exceeded.