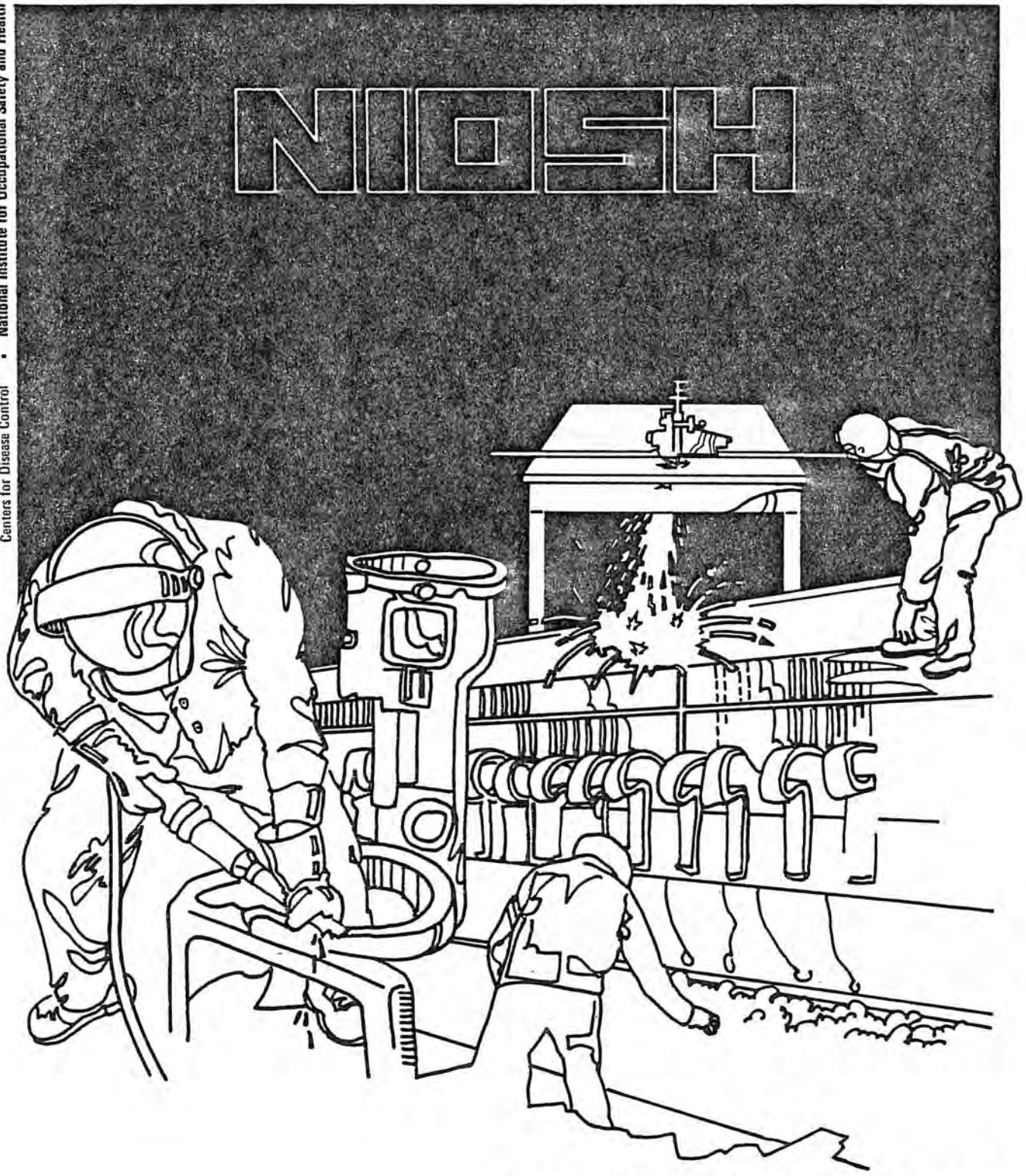
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

79-88-768

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 699(a)(6), which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HE 79-88-768
November 1980
U.S. Steel Tubing Specialities Center
Gary, Indiana

NIOSH INVESTIGATORS:
Paul Johnson I.H.
James Melius, M.D.

I. SUMMARY

In April, 1979 NIOSH received a request from the United Steelworkers of America, Local 2697 to evaluate a high rate of cardiovascular disease among maintenance workers at the U.S. Steel Tubing Specialities Center in Gary, Indiana. Environmental samples were collected by both general area and personal sampling techniques in May, 1979 and January 1980 to determine workplace exposure(s). In addition, a medical survey was conducted in September, 1979 among 47 current and former maintenance workers. The September survey included a cardio-respiratory disease questionnaire, blood pressure measurements, and blood samples for lead, free erythrocyte protoporphyrin, and carboxyhemoglobin.

Analysis of the environmental samples was performed by various standard analytical methods. Substances and respective concentrations were determined as follows: Total chromium - 0.02 mg/M^3 (permissible exposure level (PEL) 1.0 mg/M^3); hexavalent chromium - 0.006 mg/M^3 (PEL 1.0 mg/M^3); iron oxide range 0.1 to 2.9 mg/M^3 (PEL 10 mg/M^3); particulate fluoride - 0.003 mg/M^3 (PEL 2.5 mg/M^3); manganese - range 0.004 to 0.19 mg/M^3 (PEL 5.0 mg/M^3); lead range 0.01 to 0.57 mg/M^3 (PEL 0.05 mg/M^3); and total welding fumes range 0.59 to 9.6 mg/M^3 (PEL 5.0 mg/M^3). Analysis for gaseous fluorides, nickel, molybdenum and vanadium resulted in non-detectable levels. Carbon monoxide levels, analyzed by direct reading instruments, ranged from less than 2 to 73.8 ppm (PEL 50 ppm).

The medical survey revealed both a significant excess prevalence of cardiovascular disease and a significant increased prevalence of some respiratory symptoms (e.g. productive cough) among the workers. Blood lead and FEP results were generally normal.

On the basis of the environmental and medical survey, it is concluded that a health hazard due to occasional overexposures to lead, carbon monoxide and welding fumes, and an excess prevalence of cardiovascular disease and respiratory symptoms exists for these workers. Recommendations to correct this hazard are found on page 10 of this report.

KEYWORDS: SIC 3312 Steel Tubing Fabrication, Welders, Welding fumes, Carboxyhemoglobin levels, Carbon monoxide, Lead, Cardiovascular disease, Respiratory symptoms.

II. INTRODUCTION

Under the Occupational Safety and Health Act* of 1970, NIOSH investigates the toxic effects of substances found in the workplace. In April, 1979, NIOSH received a request from the United Steelworkers of America, Local 12697, for a health hazard evaluation at the U.S. Steel Tubing Specialties Center in Gary, Indiana. The request alleged that maintenance workers at the plant were being exposed to substances that were causing a high rate of cardiovascular disease (heart attack, etc.) in the workers. An initial environmental survey was conducted on May 23-25. This was followed by a medical survey on September 26-28, 1979 and a second environmental survey on January 30 to February 1, 1980. Results of the first two surveys were sent to both labor and management as interim reports or letters.

III. BACKGROUND

U.S. Steel Tubing Specialities Center, a subsidiary of U.S. Steel Corporation, is located on a multi-acre site in Gary, Indiana.

The Maintenance Weld Shop was started in 1967. The total work force in this shop consisted of approximately 34 welders (32 craft and 2 apprentice). These workers were assigned electric arc, gas and oxy-acetylene welding and burning tasks in locations throughout the plant (rotary furnaces, selas lines, hot mills, etc.). Most welding and cutting were performed on mild steel materials using low hydrogen, cast iron and mild steel welding rods.

The only means of ventilation noted in the 36 x 81 foot welding area were four overhead window fans. Workers stated they did not wish to use local exhaust equipment because of its noise emission(s).

Personal protective equipment provided to the welders/burners included flame retardant clothing, welder's gloves and helmets, burner's goggles, hard hats, eye protection, metatarsal foot protection and welding flash screens.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Breathing zone (BZ) samples collected inside the welders' helmets and general area (GA) samples collected in the welding area(s) were obtained to determine exposure concentrations of airborne contaminants. Potential fume emissions were obtained for analysis by using cellulose membrane filters connected via tygon tubing to sampling pumps calibrated at 1.5 liters per minute (l/m). Personal sampling pumps operating at 20 cubic centimeters per minute connected via tygon tubing to detector tubes were used to determine concentrations of carbon monoxide. Direct reading instruments attached to recorders were also used to monitor carbon monoxide exposures. In addition, bulk samples of cutting fluids were obtained for qualitative analysis.

Analysis of the membrane filters were performed by following NIOSH Method P&CAM 173 for total chromium, iron, manganese, molybdenum, nickel, lead, and vanadium and Method No. P&CAM 169 for hexavalent chromium. In addition, NIOSH Method No. 3-176 was utilized in analyzing gaseous and particulate fluorides. All carbon monoxide samples were analyzed by direct observation of the sample tube or the recorder attached to the sampler.

A qualitative infrared scan was run on the bulk cutting fluids in an attempt to identify various esters. Bulk samples were analyzed for nitrosamines.

B. Medical

The medical study was designed to determine if an increased risk of cardiovascular disease existed among the welders at the facility, and if the possible increased risk was due to any specific occupational exposure. The group of welders was studied by interview questionnaire and medical records review (company and personal physician records) to determine the prevalence of cardiovascular disease, cardiovascular disease risk factors, and workplace exposures. The medical records review focused on confirming reported cardiovascular disease and detecting unreported disease (particularly hypertension). Blood pressure measurements were obtained on each worker, and blood was drawn for lead, free erythrocyte protoporphyrin (FEP), and carboxyhemoglobin levels.

A control group of nonwelding maintenance workers was studied in a similar manner. The data obtained on the welders could then be compared to that on the nonwelders and to medical data on outside comparison groups to help determine if the cardiovascular disease rate was higher among the welders. Two outside sources of medical data were used for comparison. One was data from the Chicago Heart Disease Detection Project, a large recent survey of over 20,000 workers in the Chicago area screened for cardiovascular disease and coronary heart disease risk factors.[1] The other comparison group was obtained from the Health and Nutrition Examination Survey, a national cross-sectional study which included data on over 1000 white male blue collar workers currently employed at the time of the survey.[2] Comparisons with these reference groups were based on the responses to questionnaire items.

V. EVALUATION CRITERIA

A. Environmental Criteria

To assess the concentrations of air contaminants found in the place of employment, three primary sources of criteria are used: (1) NIOSH criteria for recommended standards for occupational exposure to substances (Criteria Documents), (2) ACGIH recommended and proposed Threshold Limit Values (TLV); and (3) Occupational Health and Safety Standards as promulgated by the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor (29 CRF 1910.1000 & 1025).

Whenever possible, the NIOSH recommended standards will be the environmental criteria applied since these usually represent the most recent knowledge concerning toxic occupational exposures. If such a standard does not exist or is outdated, the TLV or OSHA legal standard, whichever is more stringent, will be used.

Substances in mg/M^3	NIOSH	ACGIH	OSHA
Welding Fumes (NOC)	-	5.0	-
Total Chromium	-	0.05	1.0
Iron Oxide fume	-	5.0	10.0
Manganese	-	5.0	5.0
Molybdenium	-	10.0	15.0
Nickel	0.015	1.0	1.0
Lead	0.10	0.15	0.05 (SO_4)
Vanadium	-	0.05	0.10
Hexavalent Chromium	0.025	0.05	1.0
Fluoride (Gaseous)	-	2.0 (1 ppm)	0.2 (0.1 ppm)
Fluoride (Particulate)	2.5	2.5	2.5
Welding fumes	-	5.0	-
Carbon Monoxide	63 (35 ppm)	90 (50 ppm)	90 ppm (50 ppm)
N-nitrosamine	-	-	-

The above criteria in mg/M^3 are based on 8-hour time-weighted average exposures (TWA).

B. Medical Criteria

Blood Pressures: Blood pressures were evaluated with a diastolic of 90 mm Hg or greater being indicative of possible hypertension. All workers with such readings were advised to consult their physicians.

Heart Disease: A worker was considered to have heart disease if he gave a history of any known manifestation of arteriosclerotic heart disease, including angina or myocardial infarction, and if this finding could be confirmed from his medical records.

Carboxyhemglobin Levels: These were considered abnormal if higher than 5% in a nonsmoker, or 10% in a smoker. Those with elevated levels were advised that this finding may be due to cigarette smoking or other environmental exposure.

Blood Leads: These were considered abnormal if greater than 40 ug/dl, while those in the range 30 ug/dl to 40 ug/dl were considered indicative of possible excess exposure. Blood FEP's greater than 100 ug/dl were considered abnormal. The blood FEP's were interpreted in light of the blood lead levels. Those workers with an elevated FEP, but normal lead level, were advised to see their physician regarding other sources of elevated FEP (e.g., iron deficiency).

C. Toxicology

1. Lead

Inhalation of lead dust and fumes is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion of lead dust contamination on food, cigarettes, or other objects. Once absorbed lead is excreted from the body very slowly. The absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/100ml whole blood are considered to be normal levels which may result from daily environmental exposure. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/100ml. Lead levels between 40-60 ug/100ml in lead exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60 to 100 ug/100ml represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/100ml are considered dangerous and often require hospitalization and medical treatment.

The present standard for lead in air is 50 ug/M^3 on an eight hour time-weighted average for daily exposure. The standard also dictates that in four years workers with blood lead levels greater than 50 ug/100ml must be immediately removed from further lead exposure and in some circumstances workers with lead levels less than 50ug/100ml must also be removed. At present medical removal of workers is necessary at blood lead levels of 70 ug/100ml or greater. Removed workers have protection for wage, benefits, and seniority for up to eighteen months until their blood levels adequately decline and they can return to lead exposure areas.

2. Welding Fumes

Welders are known to be at increased risk for several medical problems including respiratory diseases such as bronchitis and siderosis,[3,4,5] skin diseases including cancer, and eye injuries.[6] An increased incidence of lung cancer has been suggested by one recent NIOSH study.[7] Increased risk for cardiovascular disease has been mentioned in the medical literature about welders, but very few studies have actually looked for or found any increased cardiovascular disease risk.[6] A recent Russian study did find an increased prevalence of hypertension among welders.[8] Another recent study of welders in Italy found an increased prevalence of abnormal electrocardiograms in the welders studied.[9] A large study of mortality in steelworkers also found increased death rates due to heart disease in general laborers, mechanical maintenance workers, and janitors.[10] The appropriateness of any of these job classifications to the workers examined in this study is uncertain, but it does suggest increased cardiovascular disease risk among similar groups in the steel industry.

Several welding exposures are conceivably capable of increasing the risk of cardiovascular disease. These exposures include carbon monoxide, ozone, nitrous oxides, and cobalt, cadmium, and lead fumes. The increased prevalence of respiratory disease among welders also might increase the risk for cardiovascular disease.[11,12] Thus, while very few studies demonstrate increased cardiovascular disease risk among welders, many welding exposures could potentially be linked to the development of such disease.

3. Carbon Monoxide

The signs and symptoms of acute carbon monoxide poisoning may include headache, nausea, vomiting, dizziness, drowsiness, and collapse. Carbon monoxide exerts its harmful effect by reducing the oxygen-carrying capacity of the blood through the formation of carboxyhemoglobin. The intensity of the symptoms is related to the carboxyhemoglobin levels achieved. Deleterious effects to the heart may be initiated or enhanced in individuals with coronary heart disease who are exposed to carbon monoxide concentrations sufficient to produce a carboxyhemoglobin level greater than 5 percent. The role of cigarette smoking also must be considered since cigarette smoking causes increased exposure to carbon monoxide and there is an undeniable relationship between chronic cigarette smoking and increased risk of coronary heart disease. Important evidence also exists which indicates that subtle aberrations may occur in the central nervous system during exposure to low levels of carbon monoxide.[13] Upon weighing all these factors, NIOSH, in its 1972 criteria document, recommended an 8-hour time-weighted average exposure of 35 ppm and a ceiling limit of 200 ppm. The recommended time-weighted average standard of 35 ppm is based on the concentration of carbon monoxide sufficient to produce a carboxyhemoglobin level not exceeding 5 percent. The ceiling concentration of 200 ppm represents an excursion above the 35 ppm level which is not expected to significantly alter the employees carboxyhemoglobin level. This recommended standard does not consider the smoking habits of workers since the levels of carboxyhemoglobin in chronic cigarette smokers has generally been found to be in the 4 to 5 per cent range before exposure to carbon monoxide, but may run as high as 10 to 15 percent in heavy smokers.[15]

The current permissible OSHA limit for an 8-hour time-weighted average exposure to carbon monoxide is 50 ppm. This value also is recommended by the ACGIH as its 1979 threshold limit values.

VI. RESULTS

A. Environmental

The major objective of the health hazard evaluation was to identify exposure potentials responsible for cardiovascular problems.

Lead fumes ranged from 0.01 to 0.57 mg/M^3. One personal sample exceeded the present legal (OSHA 0.05 mg/M^3) standard. This sample was found on a floater who assumed various welding responsibilities throughout the hot-mill area.

Total welding fumes ranged from 0.59 to 9.6 mg/M^3 (Table I). Four of the above fume samples exceeded the current 5.0 mg/M^3 TLV standard. The increased concentrations were found on 2 shop welders (5.4 and 7.1 mg/M^3), a floater (9.6 mg/M^3) and a welder worker in the Hot Mill Gator Bar Area (8.9 mg/M^3). Other welding fumes detected during welding operations included: Total chromium (0.02 mg/M^3); hexavalent chromium 0.006 mg/M^3 (iron may have interfered with sample analysis); iron (ranged from 0.1 to 2.9 mg/M^3); particulate fluoride (0.003 mg/M^3); and manganese (ranged from 0.004 to 0.19 mg/M^3). It should be noted that all personal samples were collected under the welding helmet in the breathing zone of the welder.

Carbon Monoxide BZ and direct reading samples, with one exception, were within the present legal (50 ppm) exposure criteria (Table II). The sample that did exceed the standard (73.8 ppm) was obtained from a floater (pipefitter) working inside a heat treated furnace during most of his 8-hour shift. It should be noted that this sample as well as two additional personal samples (each 38 ppm), from floaters, exceeded the NIOSH 35 ppm recommended standard. Direct-reading instruments, equipped with 96-hour recorders were placed in 2 areas in and/or near the weld-fabrication shop and allowed to record exposures for 3 day and 2 night shifts. As noted in Table III the CO levels increased as the welder(s) assumed various welding responsibilities throughout the plant (e.g. the hot mills, garage and pipe shop areas). CO levels during the night shifts decreased which is likely due to the decrease in number of employees and overall work loads. As mentioned above, the NIOSH recommended 35 ppm CO standard was exceeded in 3, personal samples.

The bulk cutting fluid sample was found to be composed primarily of water. There were small amounts of aliphatic hydrocarbons, and an organic phosphate ester and an N-nitrosamine were also present in the sample. Since the phosphate and nitrosamine could not be specifically identified no further evaluation of the sample could be conducted.

B. Medical

Forty-seven workers were interviewed. These included 27 welders presently working, 4 disabled or retired welders, 15 nonwelders presently working, and 1 retired nonwelder. The participation rate among welders was 100%, while among the other eligible workers it was much less. The latter low rate probably reflects their less direct involvement in the health hazard and the last minute refusal of the company to pay the workers while they participated in the study.

Table IV presents basic demographic information on the participating workers. This includes the work history information. The two groups are reasonably comparable in age and work histories.

Table V presents some of the reported workplace exposures. Due to the nature of maintenance work, the exposures are quite varied and hence difficult to easily characterize. A large proportion of the workers described the overall quality of workplace ventilation as poor ("there are dust and fumes present most of the time.") This evaluation is especially strong among the welders.

Table VI presents the medical histories of the participating workers. The prevalence of confirmed heart disease (angina, myocardial infarction, and/or coronary artery bypass) among the welders was 22%. This seems quite excessive. The small number of participating workers makes statistical comparisons difficult. The use of a large outside group comparably surveyed helps confirm this excess. Table VII compares the prevalence of cardiovascular disease in the welders to the findings of the Chicago Heart Disease Detection Data. A statistically significant excess of heart disease is seen in the welder group even if the disabled welders are excluded from the comparison. For confirmed hypertension, no excess is seen.

Table VIII presents the prevalence of coronary heart disease risk factors. While a higher proportion of the welders are current cigarette smokers as a group, they average fewer pack years of smoking. This high prevalence of smoking is expected in an industrial working group. The excess reporting of elevated cholesterol levels in the welders is probably attributable to increased awareness in those workers with heart disease.

Table IX presents the prevalence of respiratory and cardiac symptoms. The welders show an excess of several symptoms, especially those concerning productive cough and chest pain. The latter may be explained by the increased prevalence of confirmed heart disease in the welding group. The excess of productive cough symptoms probably relates to welding fume exposures, as evidenced by the increased prevalence of bronchitis among welders. This excess is confirmed by comparison with the Health Examination Survey results as shown in Table X. An increased prevalence of reported wheezing, shortness of breath, morning phlegm production, and three week periods of increased phlegm production is found in the currently working welders (i.e. disabled welders excluded) even after controlling for the frequency of smoking.

Table XI presents the results of the laboratory testing. The blood lead and FEP testing showed generally normal results. Only one worker had a blood lead above 30 ug/dL. Another worker had an elevated FEP, but a normal blood lead. The elevated FEP may be due to another medical problem (e.g. anemia). The carboxyhemoglobin results were discarded due to methodological problems.

VII. CONCLUSIONS

A. An excess of heart disease was confirmed in the welders at this facility. This excess was on the order of ten times what would be expected in a similar working group. No excess of hypertension was

found, nor was there a demonstrated excess of other coronary heart disease risk factors (smoking, family history, cholesterol) which would account for the large excess of coronary heart disease in the welders.

B. An excess of respiratory symptoms, especially productive cough, was found among the welders even after controlling for smoking histories. This increase in respiratory symptoms probably results from exposure to welding fumes. Increased respiratory disease could account for some of the increased risk for heart disease.

C. Elevated carbon monoxide levels were found for only one confined space work situation. No general pattern of carbon monoxide overexposure was seen which could account for the excess of cardiovascular disease found.

D. Another possible contributing factor to elevated cardiovascular disease risk is workplace stress. The long hours worked by the welders (48.9 hours/week) and the often stressful nature of the work (repairs to maintain production schedules) could contribute to excess heart disease risk.

E. No evidence of lead intoxication was found. However, one environmental lead sample was elevated.

F. The number of nonwelders studied was too small to determine if they share in the elevated risk of heart disease. Many of their occupational exposures are similar, and some did have heart disease. However, firm conclusions concerning their risk cannot be made.

G. While no definite association between a specific occupational exposure and the excess heart disease can be established, NIOSH is currently investigating several other groups of metal workers with possible excess risk of heart disease. For this reason, as well as respiratory considerations, it would be prudent to reduce workplace exposures to welding fumes.

VIII. RECOMMENDATIONS

1. All parts should be degreased and steamed cleaned prior to welding. Oil and grease in the presence of oxygen may burn with explosive force if ignited. As noted during the study, grease and grit were melted and blown from the part by acetylene torches.

2. Due to the potential for fires, explosions and health hazards cutting and welding should not be permitted near vapor degreasing operations, or spray booths. Degreasing solvents, such as trichlorethylene, can decompose under ultraviolet radiation and cause serious fume problems.

3. Acetylene fuels which are most commonly used for gas welding, cutting, and brazing, are capable of displacing oxygen from the atmosphere. Such displacement can reduce oxygen to levels below that required by the body. Another major hazard associated with acetylene is its explosion potential. Accordingly, acetylene becomes unstable at excessive pressures and it should not be pressurized above 15 psi gauge (30 psi absolute).

4. It is recommended that personal protection (welder's helmets or glasses and protective clothing) be supplied to, and worn by weld shop employees. It should be noted that ultraviolet radiation (UV) is generated by the electric arc in the welding process. Skin exposure to UV can result in severe burns, in many cases without prior warning. UV radiation can also damage the cornea of the eye. Many arc welders are aware of the condition known as "arc-eye", a sensation of sand in the eyes. This condition is caused by excessive eye exposure of UV. Ultraviolet rays also increase the skin effects of some chemicals such as coal tar and cresol compounds.

5. The nature and location of the welding process may make local exhaust ventilation difficult to use. Or, the welding processes may produce extremely toxic substance (cadmium or chromium). Therefore, it is recommended that respiratory protection be supplied and used. Common respirators are not suitable for welding. The welder's helmet and welding position interfere with the fit of the respirator. However, several companies have developed "modified" welding helmets with build-in respirators, or helmets which allow respirators to fit beneath.

6. The need for respiratory protection should be determined and administered by a qualified safety person based on conditions and test results from the confined space and/or work activities being performed by the weld shop.

7. When welding below ground or in a confined space continuous ventilation should be part of the welding procedure. It should be noted that a toxic atmosphere may develop due to the nature of the confined space, as in the case of desorption from walls, evaporation of residual chemicals or decomposition of grease by the welding or cutting operations. General ventilation is an effective procedure for exhausting contaminants (low level) from generation points (welding) throughout the work space, to obtain maximum dilution.

8. Local exhaust ventilation is another effective means of control for airborne contaminants produced by welding or cutting. Such exhaust means can be provided by freely movable hoods, fixed enclosures (booths), downdraft benches, and extractor nozzles.

9. A cardiovascular screening program for the welders should be initiated. This should include periodic EKG's, symptom review and examination for other cardiovascular disease risk factors.

IX. AUTHORSHIP/ACKNOWLEDGEMENTS

Report Prepared By:

Paul Johnson
Industrial Hygienist
Industrial Hygiene Section

James Melius
Chief
Hazard Evaluations and
Technical Assistance Branch

Originating Office:

Hazard Evaluations and
Technical Assistance Branch
Division of Surveillance, Hazard
Evaluations and Field Studies
Cincinnati, Ohio

Report Typed By:

Linda Morris
Clerk-Typist
Industrial Hygiene Section

X. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. Safety Department, U.S. Steel Tubing Specialities Center

2. Employee Relations, U.S. Steel Tubing Specialities Center

3. Local #2697, U.S. Steelworkers of America

4. Region V, OSHA

5. Region V, NIOSH

For the purpose of informing the "affected employees," the employer shall promptly "post" the determination report for a period of 30 days in a prominent place near where exposed work.

Table I

Results of Air Sampling for Airborne Particulates, Metals, and Fluorides

U.S. Steel Tubing Specialties Center
Gary, Indiana
May 23-24, 1979
HE 79-88

Environmental Conditions: Indoors, Temp. 59-73°F, R.H. - 45-62%

Sample Number	Time	Description	Results (mg/M³)*										
			Cr[1]	CrVI[2]	Fe[3]	Fg[4]	Fp[5]	Mn[6]	Mo[7]	Ni[8]	Pb[9]	V[10]	TW[11]
AA-1	1518-2232	General (G.A.) Weld Shop Cabinet #6	-	-	-	N.D.**	0.003	-	-	-	-	-	-
AA-2	1535-2230	G.A. Crane Cab	-	-	-	N.D.	N.D.	-	-	-	-	-	-
D82527	1525-2227	Personal Sample (P.S.) Welder - Shop	-	N.D.	-	-	-	-	-	-	-	-	1.3
D82515	1505-2228	P.S. Welder - Shop	-	.006***	-	-	-	-	-	-	-	-	5.4
D82516	0731-1435	P.S. Welder - Shop	-	N.D.	-	-	-	-	-	-	-	-	1.3
D82566	1535-2230	G.A. Crane Cab	N.D.	-	0.12	-	-	N.D.	N.D.	N.D.	N.D.	N.D.	0.59
D82521	1531-2228	P.S. Welder - Shop	N.D.	-	1.2	-	-	0.08	N.D.	N.D.	N.D.	N.D.	3.5
D82522	1525-2225	P.S. Welder - Floater - #3 Piecer, #2 Hot Mill Reeler	N.D.	-	2.9	-	-	0.12	N.D.	N.D.	0.01	N.D.	9.6
D82509	1522-2210	P.S. Welder - Floater - #3 Hot Mill Cold Saw, Big Straightener	N.D.	-	0.29	-	-	0.01	N.D.	N.D.	N.D.	N.D.	1.0
D82526	1518-2231	G.A. Weld Shop Cabinet #6	N.D.	-	0.15	-	-	0.005	N.D.	N.D.	N.D.	N.D.	0.85
D82520	1515-2231	P.S. Weld Shop Vising Foreman	N.D.	-	0.86	-	-	0.09	N.D.	N.D.	N.D.	N.D.	2.8
D82525	0726-1447	P.S. Relief Foreman	N.D.	-	0.14	-	-	0.004	N.D.	N.D.	N.D.	N.D.	0.68
D82510	0727-1453	P.S. Welder - Pipe Shop used a 31015 Stainless Steel Rod	N.D.	-	0.12	-	-	N.D.	N.D.	N.D.	N.D.	N.D.	0.73
D82507	0729-1445	P.S. Welder - #2 Hot Mill - used (3) 7018 1/8" Rods	N.D.	-	0.37	-	-	0.003	N.D.	N.D.	N.D.	N.D.	1.3
D82519	0730-1415	P.S. Welder - Pipe Shop	N.D.	-	0.54	-	-	0.007	N.D.	N.D.	0.01	N.D.	1.9
D82512	0732-1447	P.S. Welder - Floater	N.D.	-	0.48	-	-	0.01	N.D.	N.D.	N.D.	N.D.	1.4
D82523	0733-1443	P.S. Welder - Shop	0.02	-	3.3	-	-	0.03	N.D.	N.D.	0.009	N.D.	7.1
D82511	0734-1415	P.S. Welder - Floater	N.D.	-	0.63	-	-	0.02	N.D.	N.D.	0.57	N.D.	3.3
D82504	0735-1431	P.S. Welder - Garage	N.D.	-	0.29	-	-	0.08	N.D.	N.D.	0.02	N.D.	1.2
D82524	0737-1425	P.S. Welder - Shop - Tack Weld 2 Nuts #3 Hot Mill 8 Stands	N.D.	-	1.5	-	-	0.12	N.D.	N.D.	N.D.	N.D.	4.3
D82505	0738-1439	P.S. Welder - #3 Hot Mill Gator Bar Repair	N.D.	-	1.4	-	-	0.19	N.D.	N.D.	N.D.	N.D.	8.9
D82508	0740-1257	P.S. Welder - Machine Shop	N.D.	-	0.65	-	-	0.05	N.D.	N.D.	0.01	N.D.	2.5
D82517	0741-1445	P.S. Welder - Shop	N.D.	-	0.8	-	-	0.07	N.D.	N.D.	N.D.	N.D.	3.1
D82506	0741-1440	P.S. Welder - Shop	N.D.	-	0.35	-	-	0.02	N.D.	N.D.	N.D.	N.D.	1.5
D82514	0745-1450	G.A. Crane Cab	N.D.	-	0.1	-	-	N.D.	N.D.	N.D.	N.D.	N.D.	0.67

*Approximate milligrams of substance per cubic meter air.
**Not Detected: The limit of detection for these samples was: .004 .002 .002 .002 .002 .002 .015 .003 .005 .02 .01
***There may have been a positive interference due to the iron present.

Environmental Criteria

NIOSH	-	0.025	-	-	2.5	-	-	-	0.1	-	-
OSHA	1.0	1.0	10.	0.2	2.5	5.0	15.0	1.0	0.05	0.10	
TLV	.05	.05	5.0	2.0	2.5	5.0	10.0	1.0	0.15	0.05	5.0

1. Total Chromium
2. Hexavalent Chromium
3. Iron Oxide
4. Gaseous Fluorides
5. Particulate Fluorides
6. Manganese
7. Molybdenum
8. Nickel
9. Lead
10. Vanadium
11. Total Welding fume

Table II

Results of Carbon Monoxide Samples Collected at
U.S. Steel Specialty Tubing Center
Gary, Indiana

January 30 - February 1, 1980

Date	Shift	Sample No.	Time	Volume (liters)	Job Description/Location	Concentration in parts per million parts/air (ppm) Time Weighted Averages (TWA)
01/30/80	2nd	C-17	1015-1601	3.4	Weld Shop (personal)	8.9 ppm
01/30/80	2nd	C-19	1017-1600	6.4	Weld Shop (personal)	7.9 ppm
01/30/80	2nd	C-18	1016-1546	5.6	Weld Shop (personal)	8.9 ppm
01/30/80	2nd	C-16	1019-1548	3.2	Weld Shop (personal)	7.9 ppm
01/30/80	2nd	C-12	1014-1604	3.0	Fitting Floor Machine Shop	6.8 ppm
01/30/80	2nd	C-14	1013-1543	5.6	Weld Shop (personal)	9.8 ppm
01/30/80	2nd	C-15	1021-1605	4.4	Weld Shop (personal)	9.2 ppm
01/30/80	2nd	C-13	1022-1600	6.2	Weld Shop (personal)	12.8 ppm
01/30/80	2nd	C-11	1023-1455	4.9	Welder Worked in garage	10.1 ppm
01/30/80	2nd	C-20	1013-1600	6.9	Weld Shop (personal)	8.0 ppm
01/30/80	2nd	C-21	1015-1604	5.4	Weld Shop (personal)	11.0 ppm
01/30/80	2nd	C-22	1049-1500	4.3	Floater (personal)	16.2 ppm
01/30/80	2nd	C-24	1025-1600	5.2	Welder-garage	8.7 ppm
01/30/80	2nd	C-26	1027-1600	5.6	Pipefitter - welding inside heat treating furnace	73.8 ppm
01/30/80	2nd	C-28	1035-1540	6.2	#2 Hot Mill (personal)	4.0 ppm
01/30/80	2nd	C-27	1052-1425	4.6	Floater (personal)	22.0 ppm
01/30/80	2nd	C-23	1045-1551	5.0	Floater (personal)	8.0 ppm
01/30/80	2nd	-	1040-1600	-	Area - direct reading (Weld Shop)	15.4 ppm
01/30/80	3rd & 1st	-	1600-0700		Area - direct reading (Weld Shop)	8.0 ppm
01/31/80	2nd	C-30	0730-1505	7.5	Weld Shop (personal)	13.1 ppm
01/31/80	2nd	C-31	0730-1500	6.4	Weld Shop (personal)	7.8 ppm
01/31/80	2nd	C-32	0730-1423	5.7	Weld Shop (personal)	7.8 ppm
01/31/80	2nd	C-35	0731-1500	9.0	Hot Mill #2 (personal)	7.2 ppm
01/31/80	2nd	C-36	0735-1514	6.0	Floater (personal)	15.7 ppm
01/31/80	2nd	C-37	0732-1500	5.5	Boiler House (personal)	4.5 ppm
01/31/80	2nd	C-39	0732-1505	8.2	Weld Shop (personal)	9.2 ppm
01/31/80	2nd	C-40	0731-1505	8.2	Weld Shop (personal)	6.3 ppm
01/31/80	2nd	C-41	0730-1400	3.4	Welder-garage	13.7 ppm
01/31/80	2nd	C-42	0739-1500	6.0	Weld Shop (personal)	8.3 ppm
01/31/80	2nd	C-43	0734-1500	2.2	#3 Floater Hot Bar Repair	21.6 ppm
01/31/80	2nd	C-44	0740-1500	8.1	Weld Shop (personal)	9.2 ppm
01/31/80	2nd	C-45	0734-1435	3.8	#3 & 4 Furnaces (Floater)	38.1 ppm
01/31/80	2nd	C-46	0745-1500	3.3	Crane Operator	8.0 ppm
01/31/80	2nd	C-47	0734-1400	3.1	Weld Shop (personal)	8.0 ppm
01/31/80	2nd	C-49	0746-1500	7.9	Weld Shop (personal)	7.6 ppm
01/31/80	2nd	-	0700-1545	-	Area - Weld Shop Direct Reading	15.0 ppm
01/31/80	3rd & 1st	-	1545-0715	-	Area - Weld Shop Direct Reading	8.0 ppm
01/31/80	2nd	-	1045-1545	-	Area - Fitting Shop	13.0 ppm
02/01/80	2nd	C-50	0710-0900	0.6	Fitting Floor (personal	16.6 ppm
02/01/80	2nd	C-51	0910-1340	3.8	Fitting Floor (C-50 cont.)	6.5 ppm
02/01/80	2nd	C-52	0710-1340	3.5	Floater - Mill Area	33.37 ppm
02/01/80	2nd	C-53	0725-1505	6.1	Garage (personal)	10.0 ppm
02/01/80	2nd	C-54	0725-1505	7.6	Pipe Shop (pipe fitter)	< 2.0 ppm
02/01/80	2nd	C-55	0730-1505	2.6	Crane Operator	< 2.0 ppm
02/01/80	2nd	C-56	1100-1340	2.6	Weld Shop (personal)	5.7 ppm
02/01/80	2nd	C-58	0718-1335	7.1	Floater & Weld Shop (personal)	38.5 ppm
02/01/80	2nd	C-57	0710-1340	1.3	Weld Shop (personal)	< 3.0 ppm
02/01/80	2nd	C-59	0720-1505	7.2	#2 Hot Mill (personal)	9.7 ppm
02/01/80	2nd	C-60	1100-1355	2.5	Weld Shop (personal)	9.8 ppm
02/01/80	2nd	C-61	0708-1415	3.4	Floater (personal)	14.9 ppm
02/01/80	2nd	C-63	0725-	2.9	Weld Shop (personal)	8.7 ppm
02/01/80	2nd	C-64	0725-1055	4.1	Weld Shop (personal)	10.9 ppm
02/01/80	2nd	C-65	0730-1340	10.5	Weld Shop (personal)	< 5.0 ppm
02/01/80	2nd	C-66	0845-1420	5.9	Floater & Shop	9.4 ppm
02/01/80	2nd	C-67	0725-1452	7.0	Draw Benches - Floater	20.6 ppm
02/01/80	2nd	C-68	0730-1055	2.7	Weld Shop (personal)	12.9 ppm
02/01/80	2nd	C-69	0730-1500	0.4	Bar Repair #3 Hot Mill (Floater)	< 25.0 ppm
02/01/80	2nd	-	0715-1445	-	Area - Direct Reading Weld Shop	11.0 ppm
02/01/80	2nd	-	0930-1430		Area - Fitting Area	9.0 ppm

Table III

Distribution of Carbon Monoxide Exposures Among Welders
At U.S. Steel Specialty Tubing Center
Gary, Indiana

January 30 - February 1, 1980

Categories/location	Frequency Number of Welders			Mean			Long Term Samples Area - Weld Shop		
	Day I	Day II	Day III	Day I	Day II	Day III	Day I	Day II	Day III
Weld Shop - Area	10	10	9	8.2 ppm	7.6 ppm	7.7 ppm	15.4 ppm	14 ppm	10 ppm
Hot Mill Area/Furnace (Floaters)	4	4	7	12.6 ppm	20.7 ppm	21.5 ppm			
Garage Area	2	2	1	9.4 ppm	13.7 ppm	10 ppm	Night I	Night II	
Pipe Shop Area	1	0	3	73.8 ppm	0	<2 ppm	8.0 ppm	8.0 ppm	

Current OSHA Standard 50 ppm

Current NIOSH REcommended Standard 35 ppm

TABLE IV - DEMOGRAPHIC AND WORK HISTORY INFORMATION

	Welders	Non Welders	Total
Total Participating	31	16	47
Race: White	26	16	42
Black	4	0	4
Oriental	1	0	1
Average Age (yrs)	42.0	45.9	43.3
Average Years Working at U.S. Steel	10.9	12.6	11.5
Average Years in Maint. at U.S. Steel	10.0	10.7	10.4
Average Years as Welder at U.S. Steel	10.0		
Average Years Working as Welder	16.8		
Estimated Average Hours Worked/week	48.9	44.3	47.4

TABLE V - WORKPLACE EXPOSURES REPORTED BY MAINTENANCE WORKERS AT U.S. STEEL (% WORKERS REPORTING)

Exposure	Welders	Non Welders	Total
Lead	65%	44%	57%
Asbestos	71%	56%	66%
Chrome	29%	25%	28%
Nickel	68%	19%	51%
Coke Oven Emissions	94%	88%	91%
Methylene Chloride	3%	6%	4%
Manganese	26%	6%	17%
Aluminum	77%	50%	68%
Beryllium	3%	6%	4%
Trichlorethylene	6%	25%	13%
Cadmium	10%	0%	6%
Tungsten	32%	19%	28%
Silica	16%	0%	11%
Workplace Ventilation:			
Poor	84%	50%	72%
Fair	16%	38%	23%
Adequate		12%	4%

TABLE VI - MEDICAL HISTORIES

	Welders		Non-Welders		Total	
	No.	%	No.	%	No.	%
History of Hospitalization	23	49%	11	69%	34	72%
for Heart Disease	6	19%	2	12%	8	17%
for Lung Disease	1	3%	1	6%	2	4%
History of:						
Myocardial Infarction	3	10%	3	19%	6	13%
Angina	8	26%	2	13%	10	21%
Coronary Bypass Surgery	6	19%	1	6%	7	15%
Confirmed Heart Disease	7	22%	2	13%	9	19%
Heart Murmur	2	6%	1	6%	3	6%
Rheumatic Fever	1	3%	0	0%	1	2%
Hypertension Under Treatment	5	16%	3	19%	8	17%
Cancer	1	3%	0	0%	1	2%
Pneumonia	8	26%	4	25%	12	26%
Bronchitis	6	19%	1	6%	7	15%
Emphysema	1	3%	2	13%	3	6%
Asthma	3	10%	0	0%	3	6%
Gout	1	3%	0	0%	1	2%
Diabetes	0	0%	1	6%	1	2%

TABLE VII PREVALENCE OF CARDIOVASCULAR DISEASE IN WELDERS COMPARED TO CHICAGO HEART DISEASE DETECTION DATA[1]

	White Welders No.	%	CHDD No.	%	Relative Risk
Confirmed Heart Disease	7	27%	312[2]	2%	14.9[3]

	White Working Welders No.	%	CHDD No.	%	Relative Risk
Confirmed Heart Disease	3	14%	266[2]	2%	8.9[3]
Confirmed Hypertension	4	18%	3803[2]	21%	.9

1 See Appendix B.
2 Age adjusted.
3. For corrected Chi-square or Fischer exact p value less than .01.

TABLE VII: PREVALENCE OF SMOKING AND OTHER RISK FACTORS

	Welders		Non-Welders		Total	
	No.	%	No.	%	No.	%
Ever Smoked	29	94%	14	88%	43	91%
Currently Cigarette Smoking	21	68%	8	50%	29	62%
Average Pack Years Smoked	24.2		30.4		26.2	
Reported Elevated Cholesterol	6	19%	0	0%	6	13%
Family History of Heart Attacks	16	52%	8	50%	24	51%
Family History of Angina	7	22%	4	25%	11	23%

TABLE IX - PREVALENCE OF RESPIRATORY AND CARDIAC SYMPTOMS

	Welders No.	%	Non-Welders No.	%	Total No.	%
Dyspnea when hurrying on the level or walking up a slight hill (Q26)	12	39%	5	31%	17	36%
Dyspnea at ordinary pace (Q27)	5	16%	0	0%	5	11%
Morning courgh (Q35)	4	13%	3	19%	7	15%
Morning Phlegm Production (Q41)	12	39%	3	19%	15	32%
Phlegm 3 months each year (Q43)	9	29%	2	13%	11	23%
Three week period of increase phlegm production (Q45)	8	26%	1	6%	9	19%
Time off work due to chest illnesses (Q46)	6	19%	2	13%	8	17%
Wheezing (Q47)	9	29%	4	25%	13	28%
Sudden Dyspnea with wheezing (Q52)	6	20%	0	0%	6	13%
Chest pains (Q57)	14	45%	4	25%	18	38%
Pleuritic Chest Pain (Q57a)	6	19%	2	13%	8	17%
Exertional Chest Pain (Q57b)	8	26%	0	0%	8	17%
Irregular Heart Beat (Q58)	12	39%	4	25%	16	34%

TABLE X - PREVALENCE OF RESPIRATORY SYMPTOMS IN WELDERS COMPARED TO HEALTH EXAMINATION SURVEY RESULTS IN BLUE COLLAR WORKERS[1]

	White Working Welders		HES		Relative
	No.	%	No.	%	Risk
Dyspnea when hurrying on the level or walking up a slight hill (Q26)	7	32%	241[2]	24%	1.3
Morning Phlegm Production (Q41)	9	41%	215[2]	22%	1.9[3]
Three Week Period of increased Phlegm Production (Q45)	4	18%	61[2]	6%	3.0[4]
Episodes of Wheezing (Q47)	6	27%	147[2]	15%	1.8

1 See Appendix B.
2 Adjusted for age and smoking.
3 P value for corrected Chi-square less than .06.
4 P value for corrected Chi-square less than .07.

TABLE XI - LABORATORY TEST RESULTS

	Welders	Non-Welders	Total
Mean Blood Lead (µg/dL)	13.4	11.4	12.7
Mean FEP (µg/dL)	6.9	22.2	12.2

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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