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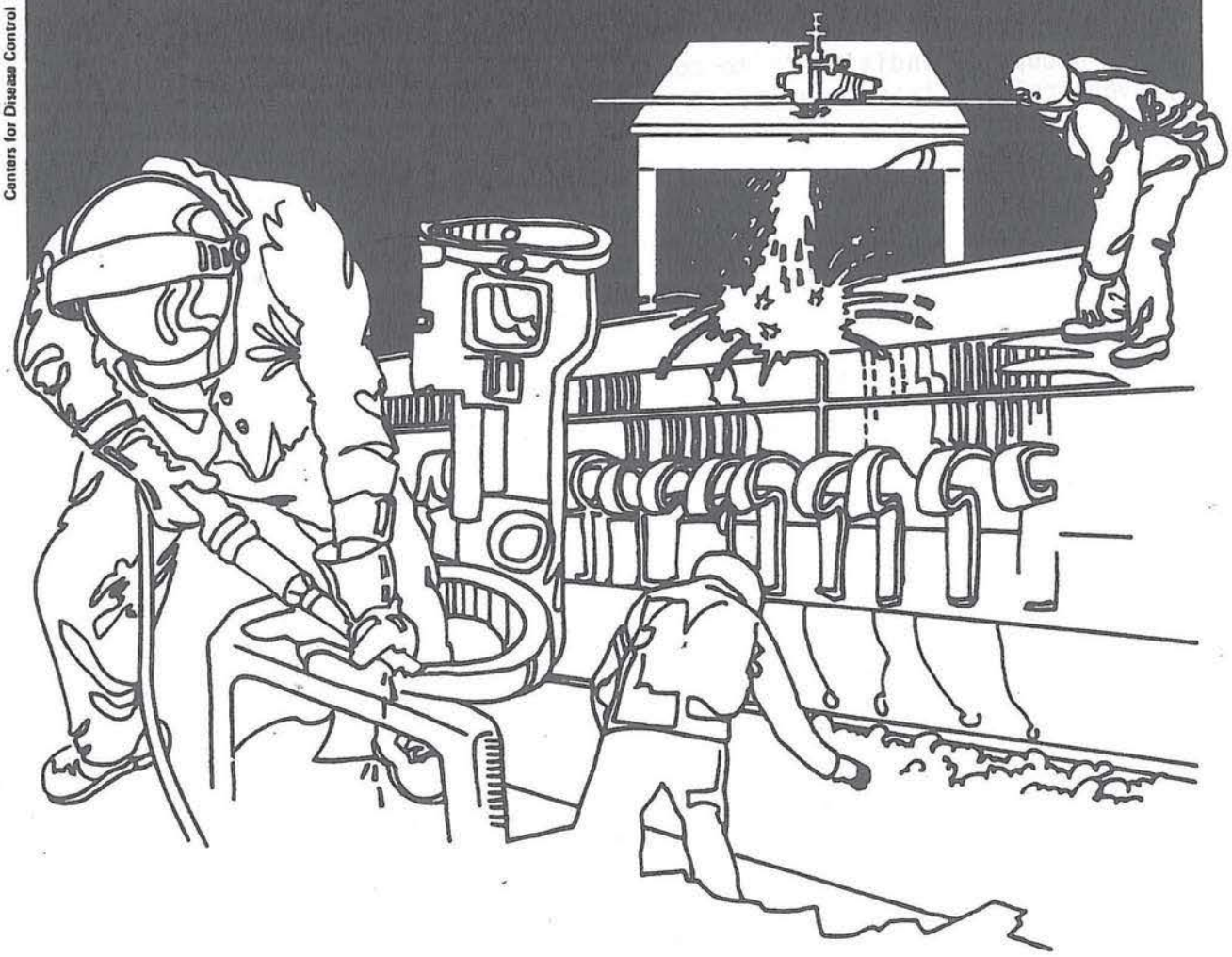

Health Hazard Evaluation Report

HETA 84-302-1542
C.F. & I. STEEL
PUEBLO, COLORADO

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. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 84-302-1542
DECEMBER, 1984
C.F. & I. STEEL
PUEBLO, COLORADO

NIOSH INVESTIGATORS:
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I. SUMMARY

In June, 1984 the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate occupational exposures to metal fumes during the operation of an electric arc furnace at C.F. & I Steel, Pueblo, Colorado.

A walk-through survey, followed by an environmental evaluation, was conducted on June 6 & 7, 1984. During the environmental survey, breathing zone air samples were taken for measurement of occupational exposure to arsenic, lead, copper, chromium, iron, and total airborne particulates. Detector tube samples were collected for measurement of sulfur dioxide, oxides of nitrogen, carbon monoxide and ammonia.

Breathing zone concentrations of arsenic, copper, chromium, and iron were below the evaluation criteria. Concentrations of lead exceeded the evaluation criteria (50 ug/m^3) in 25% of the air samples; values ranged from below the detection limits of 5 ug/sample to 60 ug/m^3. The average air lead concentration was 30 ug/M^3. Concentrations of airborne particulate ranged from 2 to 40 mg/M^3 (average 10.7 mg/M^3); two of six air samples collected exceeded the evaluation criteria. Detection concentrations of sulfur dioxide (SO_2) and carbon monoxide (CO) were found only on top of the arc furnaces. Levels for SO_2 were 1-2 parts per million. The highest CO level observed was 30ppm.

The respirator program for workers in all areas of the electric arc furnace was reviewed and found to be deficient.

On the basis of the environmental data, personal interviews, and the inadequate respirator program, NIOSH concluded that a health hazard from exposure to lead and total particulate existed at C.F.& I. Steel at the time of this survey. Recommendations on decreasing these hazards may be found in Section VIII of this report.

KEYWORDS: SIC 3313 (Electrometallurgical products), steel mill, electric arc furnace, arsenic, lead, sulfur dioxide, total particulate

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), received a request in May, 1984 from a representative of C.F. & I. Steel Pueblo, Colorado. The request was to determine if the workers were overexposed to carbon monoxide, iron oxide, and lead in the area of the electric arc furnaces. The environmental survey was conducted on June 6 and 7, 1984. Approximately 60% of the workers in this area were also interviewed.

III. BACKGROUND

C.F. & I. Steel, Pueblo, Colorado is in the business of steel production. The area this request covered concerned only the electric arc furnaces. This department produces steel ingots from scrap iron, and other metals. A variety of metals are melted and vaporized in the process creating the possibility of metal exposures, exposures to sulfur dioxide and carbon monoxide, and an excess of airborne particulate.

IV. ENVIRONMENTAL DESIGN AND METHODS

All job categories in the electric arc furnaces were evaluated by collecting breathing zone air samples.

Lead, copper, chromium and iron samples were collected on 37 mm AA filters using vacuum pumps operated at 1.5 liters per minute. Samples were analyzed by NIOSH procedure 7300.

Arsenic samples were collected in the same manner as the above samples but were analyzed by NIOSH method No. 7901.

Total particulate samples were collected on preweighed FWSB 37 mm filters. Analyses included pre and post exposure weight difference in filters.

Sulfur dioxide and carbon monoxide air samples were collected on direct reading detector tubes.

Interviews were conducted with approximately 30 workers to determine if they were experiencing symptoms compatible with overexposures to lead, arsenic, carbon dioxide, and sulfur dioxide.

V. EVALUATION CRITERIA

A. Environmental

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experi-

ence adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

	Permissible Exposure Limits mg/M^3 8-Hour Time-Weighted Exposure Basis	
	NIOSH	OSHA
Lead	0.05	0.05
Copper	1.0	1.0
Chromium	1.0	1.0
Iron Oxide	5.0	5.0
Arsenic	0.01	0.01
Sulfur Dioxide	1.3	1.3
Carbon Monoxide	35.0	55.0
Total Particulate	10.0 ACGIH	15.0

mg/M^3 = milligrams of substance per cubic meter of air.

B. Toxicological

Lead--Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter whole blood are considered to be normal levels which may result from daily environmental exposure. The Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/m^3 calculated as an 8-hour time-weighted average for daily exposure.[1] The standard also dictates that workers with blood lead levels greater than 60 ug/deciliter must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 60 ug/deciliter must also be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 110g whole blood. They can then return to lead exposure areas.

Copper Mist, Dust, and Fume--Inhalation of dusts and mists of copper and copper salts results in irritation of the upper respiratory tract and, occasionally, ulceration and perforation of the nasal septum. Metal fume fever, a 24-28 hour illness characterized by chills, fever, aching muscles, dryness in the mouth and throat, and headache, may occur due to exposure to metal oxide fume rather than copper dust.

Chrome (metal)--The most toxic route of entry is by inhalation--followed by percutaneous (through the skin). Chrome (metal) is very corrosive and is a strong sensitizer. Perforation of nasal septum may occur after high exposure. Adequate ventilation and frequent monitoring of the work environment is necessary to prevent overexposures. No eating or smoking should be allowed in the work area. Workers sensitized should be removed from exposure.[2]

Iron Oxide--Iron oxide is relatively non-toxic. Chronic exposures to high concentrations do cause a disease called siderosis. The main complication of this disease is that it prevents getting a good X-ray of the lungs in case another lung disease occurs. Siderosis does not decrease pulmonary function or cause any other metabolic disturbances.

Arsenic--NIOSH has recommended that airborne concentrations of inorganic arsenic be controlled to prevent exposures in excess of 0.002 mg/M^3. For the purposes of the recommended standard, arsenic is defined as elemental arsenic and all of its inorganic compounds. To determine the extent of worker exposures, a 15 minute sampling period is advised for concentrations (not to be confused with the traditional "ceiling" designation occasionally assigned to some of the more toxic chemicals which require 15 minute exposure

determinations). The recommended standard was designed to protect workers from the possible development of lymphatic and respiratory arsenic-related cancer. This relationship has been suggested by numerous studies of working populations.

The OSHA standard for inorganic arsenic is .01 mg/M^3, as averaged over an 8 hour work shift.

Studies of arsenic exposure related to copper smelting have focused on concerns over lung cancer. Excess mortality from lung cancer has been described in several populations of copper smelter workers exposed to arsenic trioxide.[3,4,5,6,7,8] Exposures in smelters are multiple raising the issue of whether arsenic alone is a lung carcinogen or whether concomitant exposure to sulfur dioxide or other dusts is necessary for the subsequent development of lung cancer. However, studies of arsenic-exposed pesticide workers in the U.S. and abroad, with no sulphur dioxide exposure, have consistently demonstrated excess lung cancer mortality. Increasing exposure to arsenic-containing materials with increasing duration of employment has been shown to correlate directly with an increasing trend of excess lung cancer.

Chronic excess exposure to arsenic in drinking water is reputed to produce peripheral vascular disease, with the most severe exposures leading to gangrene of the extremities. There is no evidence at present to indicate that arsenic exposure is a risk factor in the development of cardiovascular disease.

Arsenic is widely distributed in nature, and everyone is exposed to this metal. Human exposures occur via seafood ingestion, contact with arsenical pesticides, and inhalation of arsenic-containing particulates. Inhalation of arsenic-contaminated dust ;is the primary route of occupational exposure. Ingestion of seafood is the principal source of background population exposure to arsenic. Major occupational exposure occurs at smelting operations. Once assimilated, arsenic is distributed throughout the body. Arsenic seems to accumulate in muscle tissue. Arsenic in blood is evenly distributed between the plasma and erythrocytes. Ninety percent of assimilated arsenic will be excreted via the kidney within six days. Urine arsenic concentration appears to be the best indicator of recent exposure with the biologic half-life of arsenic trioxide being 1-2 days. While 24-hour collections of urine are optimal for determining arsenic exposure, random spot-urine collections, as were done here, give adequate indication of arsenic absorption. Arsenic III, one of the most toxic forms of arsenic, has a biologic half-life of 1-2 days.[9,10,11]

Given the strong dose-related association between exposure to arsenic and lung cancer, it is difficult to determine a level of exposure that is absolutely safe. Ingestion of 200 mg of arsenic is considered a lethal dose.[12] Humans exposed to arsenic concentrations of 500 ug/m^3 will eventually have a urine concentration of 1000 ug/L.[13] Exposure to 50 ug/m^3 will produce urine arsenic

levels of 170 ug/L.8 (KR) Ingestion of seafood may raise the arsenic levels to 200-1700 ug/L within four hours. 9(KR) Urine arsenic levels of 10-300 ug/L are reported for unexposed mg arsenic per gram of creatinine in the urine[14] has been suggested as an indicator of "safe" exposure to occupational arsenic.

Sulfur Dioxide--Sulphur dioxide (SO_2) is a gas which produces eye and respiratory irritation. Bronchoconstruction is observed probably as a result of an irritant-induced stimulation of the airway walls. Asthmatics may be particularly sensitive to bronchoconstriction from SO_2 exposure. Acute decrements in forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) have been observed in smelter workers after an 8-hour shift following exposure to SO_2. Whether chronic loss of lung function following long-term SO_2 exposure occurs is controversial. The current OSHA standard establishes a permissible exposure limit (PEL) of 5 ppm over an 8-hour time-weighted average (TWA). In 1980, the American Conference of Governmental Hygienists recommended lowering the PEL to 2 ppm because it can cause bronchoconstriction and a temporary decrease in pulmonary function. ACGIH also recommends a 15-minute short-term exposure limit of 5 ppm. NIOSH recommends a 10-hour TWA exposure limit of 0.5 ppm based on studies indicating chronic respiratory disease among workers exposed to 1-4 ppm. of sulfur dioxide.

There are no reports in the medical literature describing an association between the potential exposures in the smelting industry and retroperitoneal fibrosis. Most cases of this condition arise without a known cause, with certain medications containing methysergide derivatives (Sansert) for relief of migraine headaches having been implicated as an etiologic factor.

Carbon Monoxide--Carbon monoxide combines with hemoglobin in the blood reducing the oxygen carrying capacity of the blood. Symptoms of CO poisoning are headache, dizziness, drowsiness, nausea, vomiting, collapse, coma, and death. Long term low level exposure to CO can increase the risk of heart attack for some people.[15]

Respirable Particulate--Exposures to total particulate may cause unpleasant deposits in the eyes and nasal passages. Some respirable problems due to deposition in the lungs may also occur.

VI. ENVIRONMENTAL RESULTS AND DISCUSSION

Twelve breathing zone air samples were collected for arsenic, lead, copper, chromium, iron, and total particulate. Lead levels exceeded the evaluation criteria in 25 percent of these samples. Levels ranged from less than the detection level of 0.005 mg/sample to 0.06 mg/M^3. The NIOSH and recommended level in the current OSHA Standard is less than 0.05 mg/M^3.

Six breathing zone air samples were collected for total particulate. Two of these samples exceeded the evaluation criteria. The values ranged from 2 to 40 mg/M^3. The levels of copper, chromium, iron,

arsenic, carbon monoxide and sulfur dioxide did not pose a health hazard during this evaluation. The respiratory protection program was deficient in numerous areas namely: 1.) many of the workers had excessive facial hair 2.) respirators were dirty and not adequately maintained 3.) workers are very casual about wearing the respirator and often leave it hanging from their necks instead of wearing it.

VII. CONCLUSIONS

Based on the environmental data, a health hazard existed from excessive exposure to lead and total particulate during this evaluation. A hazard also existed from an inadequate respirator program which could result in a worker receiving an overexposure. All other chemicals measured were well below the most recent evaluation criteria.

VIII. RECOMMENDATIONS

1. A respiratory program that complies with OSHA regulations outlined in 1910.134 should be initiated and enforced.

2. A complete industrial hygiene survey of all areas should be performed at least annually.

3. Improved exhaust ventilation over the arc furnaces would help eliminate airborne exposure over the electric arc furnace area.

XI. REFERENCES

1. Occupational Safety & Health Administration. Occupational exposure to lead--final standard. Federal Register, 1978 Nov. 14: 53007.

2. Plunkett, E.R. Handbook of Industrial Toxicology, Chemical Publishing Company, New York, 1976, pp. 188-190.

3. Lee, AM, and Fraumeni, JF, Jr. Arsenic and Respiratory Cancer in Man: An Occupational Study. J Natl Cancer Inst 42:1045-1052, 1969.

4. Milham S., Jr., and Strong T. Human Arsenic Exposure in Relation to a Copper Smelter. Environ Res 7:176-182, 1974.

5. Kuratsune M., Tokudome S, Shirakusa T, Yoshida M, Tokumitsu Y, Hayano T, and Seita M. Occupational Lung Cancer Among Smelters. Int J Cancer 13:552-558, 1974.

6. Axelson O., Dahlgren E, Jansson CD, and Rehnlund SO. Arsenic exposure and mortality: a case referent study from a Swedish copper smelter. Brit J of Ind Med 35:8-15, 1978.

7. Cordier S, Theriault G, and Iturra H. Mortality Patterns in a Population Living near a Copper Smelter. Environ Res 31:311-322, 1983.

8. Pershagen, G. The Carcinogenicity of Arsenic. Environ Health Perspectives 40:93-100, 1981.

9. Landrigan P. Arsenic-State of the Art, Am J of Ind Méd, 2:5-14, 1981.

10. Lauwerys RR. Industrial Chemical Exposure Guidelines for Biological Monitoring, pp. 29, Biomedical Publications, Davis CA, 1983.

11. Baselt RC. Biological Monitoring Methods for Industrial Chemicals, pp. 29-35, 159, Biomedical Publications, Davis, CA, 1980.

12. Baselt RC. Biological Monitoring Methods for Industrial Chemicals, pp. 29-35, 159, Biomedical Publications, Davis, CA, 1980.

13. Baselt RC. Biological Monitoring Methods for Industrial Chemicals, pp. 29-35, 159, Biomedical Publications, Davis, CA, 1980.

14. Lauwerys RR. Industrial Chemical Exposure Guidelines for Biological Monitoring, pp. 29, Biomedical Publications, Davis CA, 1983.

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

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 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:

1. C.F. & I. Steel.
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH - Region VIII.
4. Colorado State Health Department.

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

Table I

Breathing Zone Air Concentrations of
Lead, Copper, Chromium, and Iron at the Electric Arc Furnace

C.F.& I. Steel
Pueblo, Colorado

June 6-7, 1984

Sample Number	Location	Job	Sampling Time	Concentration - mg/m^3 Lead	Copper	Chromium	Iron
1	#3 Furnace	Furnace operator	6:45-2:05	.04	.01	*	.35
2	#3 Furnace	1st Helper	6:50-2:05	.05	.01	*	.83
4	All areas	Utility Man	7:00-1:55	.05	.01	*	.58
6		Groundman	7:04-1:40	*	*	*	.09
7		Unloader	7:08-2:05	.01	*	*	.22
21	#3 Furnace	Operator	6:50-1:55	.01	*	*	.34
22	#4 Furnace	Operator	7:03-2:05	.06	.01	.03	.04
26		Utility Man I	7:16-2:08	*	*	*	.38
24		Utility Man II	7:23-1:55	.03	*	*	.37
23	Ladle	Treatment Operator	7:03-2:02	.01	*	*	.22
25	Electrical	Electrician 2	7:34-2:12	.02	*	*	.26
31	Electrical	Electrician 3	7:35-2:11	.02	*	*	.37
Evaluation Criteria - mg/m^3				0.05	1.0	1.0	5.0
Laboratory limit of Detection mg/sample					0.005	0.0020	0.005

TABLE II

Breathing Zone Air Concentrations of Arsenic
at the Electric Furnace

C.F.& I. Steel
Pueblo, Colorado

June 6-7, 1984

Sample #	Location	Job	Sampling Time	mg/M3 Arsenic
3	Charging Crane	Operator	6:55-2:58	0.0003
5	Ladle Treatment	Treater	7:03-2:38	0.0003
8	Furnace	Helper	7:20-9:50	*
9	All Areas	Mobile Eq. Op.	7:26-2:34	*
10	Crane	Crane Operator	7:30-2:40	0.0002
11	Furnace	Helper	9:50-2:55	0.0003
30	All Areas	Electrician #1	7:32-2:11	0.0003
20	Furnace	1st Helper	6:39-1:55	0.0003
Evaluation Criteria				0.010
Laboratory limit of Detection in mg/sample				0.0001

TABLE III

Breathing Zone air Concentrations of Total Particulate
at the Electric Furnace

Sample #	Location	Job	Sampling Time	mg/M3 Total Particulate
FB 1005	Furnace	Helper	7:05-10:10	10.0
FB 1003	Furnace	Helper	7:06-2:05	40.0
FB 1002	Furnace	Helper	7:15-2:02	4.0
FB 697	Furnace	Helper	7:17-2:36	2.0
FB 688	Furnace	Helper	7:18-2:36	6.0
FB 703	Furnace	Helper	7:19-2:36	2.0
Evaluation Criteria				10.0
Laboratory limit of Detection				0.01 mg