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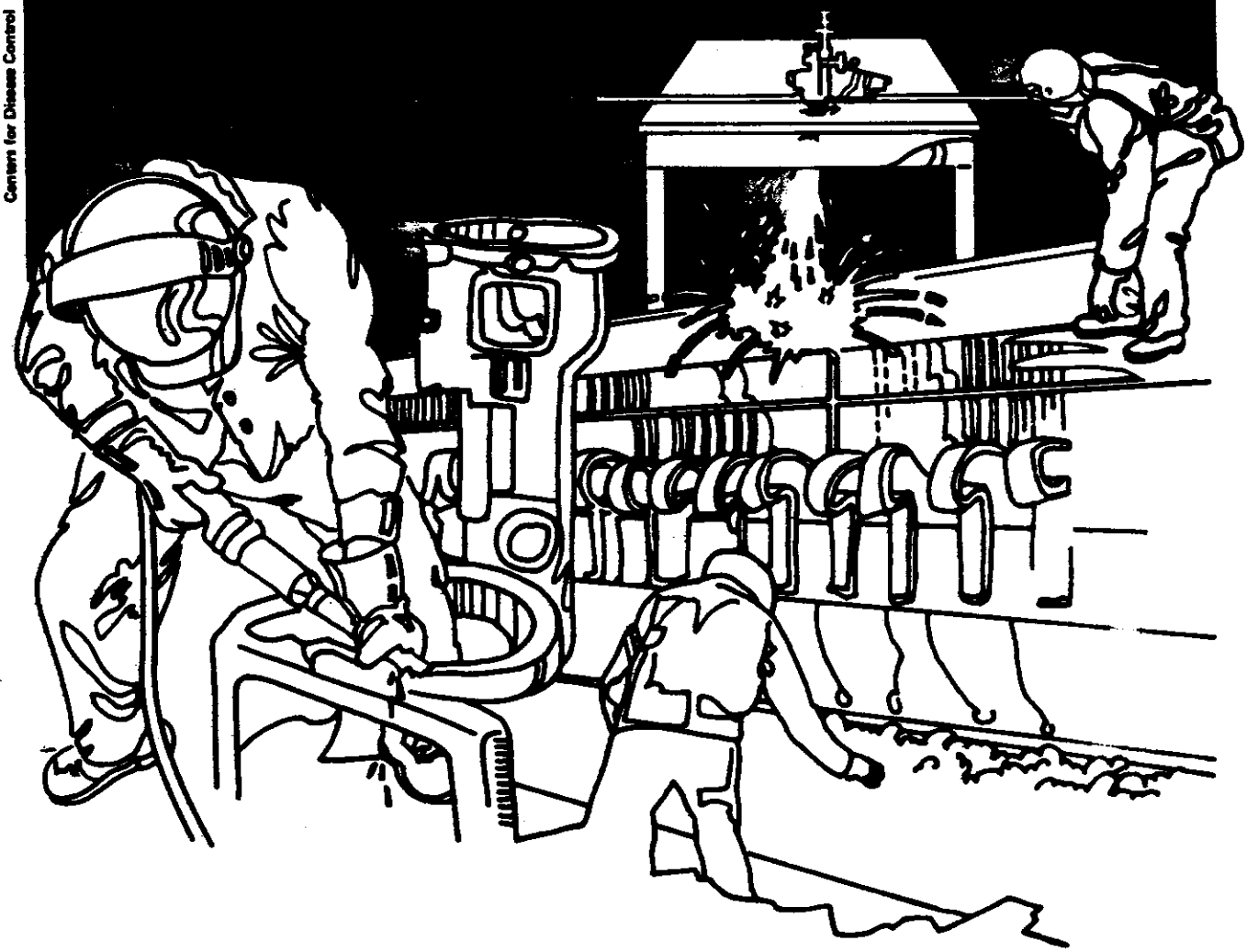

Health Hazard Evaluation Report

HETA 88-127-1903
C F & I STEEL CORPORATION
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 88-127-1903
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C F & I STEEL CORPORATION
PUEBLO, COLORADO

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I. SUMMARY

In January 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from management to evaluate occupational exposures to metals, silica, sulfur dioxide, and unknown chemicals that were causing employee complaints in several areas of the electric arc furnaces at C F and I Steel, Pueblo, Colorado.

The environmental evaluation was performed on February 22, 23, and 24, 1988. During this evaluation breathing-zone and general room air samples were collected for sulfur dioxide (SO_2), arsenic, cadmium, lead, total particulate, and crystalline silica (quartz, cristobalite). Identification of chemicals that could be released from mortars used when replacing furnace brick was performed by gas chromatographic/mass spectographic analyses of two charcoal tube samples. Formaldehyde samples were also collected during the relining of the electric arc furnaces.

The respiratory protection program was evaluated; this included the cleaning, assembly, distribution, and collection of used respirators. Quantitative fit test data were also reviewed. Current biological monitoring data of workers without identifiers were made available.

One personal and seven general room air samples were collected for SO_2. General area concentrations ranged from 0.2 to 1.7 milligrams per cubic meter (mg/M^3) with a mean of 1.2 mg/M^3. The NIOSH recommended exposure limit for a 10-hour TWA is 1.3 mg/M^3, and the Occupational Safety and Health Administration's (OSHA) permissible exposure limit is 13 mg/M^3. The one breathing-zone air sample contained 0.78 mg/M^3.

Eleven breathing-zone air samples for arsenic, cadmium, and lead were collected from workers in all areas of the electric arc furnace. Arsenic was found in one sample at a concentration of 0.02 mg/M^3; the evaluation criterion is 0.002 mg/M^3. Cadmium was also found in one of the eleven samples at a concentration of 0.006 mg/M^3; the OSHA PEL is 0.2 mg/M^3, NIOSH recommends reducing exposures to the lowest feasible limit. Lead was found in all eleven samples, with values ranging from 0.004 to 0.3 mg/M^3. The average lead concentration was 0.04 mg/M^3. The (NIOSH/OSHA) evaluation criterion for lead is 0.05 mg/M^3. Four personal air samples (two respirable and two total) were collected for particulate and free silica (quartz and cristobalite). Two total particulate samples exceeded the evaluation criterion; concentrations were 14 and 12 mg/M^3; the (ACGIH) evaluation criterion for total particulate is 10mg/M^3. The respirable dust samples contained 1.5 and 1.4 mg/M^3 and the evaluation criterion is 5 mg/M^3. Two free silica (quartz) samples exceeded the evaluation criterion of 0.05 mg/M^3. Concentrations were 0.5 and 0.2 mg/M^3. The GC/MS scan of the two charcoal tubes showed only traces of toluene. The analysis of the two Orbo-23 tubes for formaldehyde showed concentrations on both samples of 0.03 mg/M^3. NIOSH recommends that formaldehyde exposure be reduced to the lowest feasible level (LFL).

The respiratory protection program and the biological monitoring program were in compliance with the OSHA standards (1910.34) at the time of the NIOSH investigation.

On the basis of the environmental data, it was concluded that a potential health hazard existed from exposures to arsenic, cadmium, lead, and crystalline silica (quartz). Recommendations for improved respiratory protection were provided in order to reduce potential hazards.

Keywords: Sic 3313, Electrometallurgical products, steel mill, electric arc furnace, silica, lead, arsenic, cadmium, formaldehyde

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), received a request in January 1988 from management of C F and I Steel, Pueblo, Colorado, to evaluate exposures in the electric arc furnace that was causing complaints among workers. These complaints included irritating odors, bad taste in mouth, and upper respiratory irritation. Since sulfur containing compounds are added to the molten steel to improve its quality, it was postulated that the production of SO_2 may account for some of the irritation and odors. When the arc furnaces are relined with brick, dust and odors are produced, especially when the mortarizing compound is placed on the brick and hot furnace walls. All other work stations in the electric arc furnace area were monitored so that additional questions could be answered concerning this evaluation.

III. BACKGROUND

C F & I Steel, Pueblo, Colorado, produces steel in electric arc furnaces. The areas that this request covered include the electric arc furnaces and the overhead cranes that are used to fill the arc furnace with scrap metal. Sulfur compounds such as pyrite, are occasionally added to the molten steel. Several electricians that were working on an overhead crane during the addition of sulfur compounds to the steel became ill and were treated by a physician. It was assumed that sulfur dioxide was the causative agent. C F & I Steel monitored the area for sulfur dioxide and asked for NIOSH assistance in doing more extensive SO_2 monitoring. In the process of monitoring for SO_2, other areas of the arc furnace were also monitored.

IV. METHODS

Environmental air monitoring consisted of general room and personal breathing-zone air samples. Sulfur dioxide samples were collected on cellulose-ester membrane filters pretreated with potassium hydroxide, using vacuum pumps operated at 2 liters per minute. The SO_2 samples were analyzed according to NIOSH method 6004 using ion chromatography. Arsenic, cadmium, and lead samples were collected on AA filters using vacuum pumps operated at 1.5 to 2.0 liters per minute. Metal analyses were performed by atomic absorption spectroscopy. Total particulate, free silica (quartz, cristobalite) samples were collected on preweighed FWSB filters using vacuum pumps operated at 1.7 and 2 liters per minute. Total particulate was determined by weight difference and crystalline silica was analyzed by x-ray diffraction according to NIOSH method 7500. Charcoal tubes and vacuum pumps operated at 100 cc/minute were used to collect samples for GC/MS qualitative identification of organic vapors. Orbo-23 sampling tubes with vacuum pumps operated at 50 cc/minute were used for collection of formaldehyde. The qualitative analysis of the orbo-23 tubes was also conducted by GC/MS. The operation of the electric arc furnaces was discussed with workers and health complaints were also addressed.

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

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled 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 exposure limits (RELs), by contrast, are based primarily 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 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.

Workplace exposure limits for the substances studied in this evaluation are as follows:

8-Hour Time-Weighted Average in mg/M^3

	NIOSH REL	OSHA PEL	ACGIH TLV
Arsenic	0.002 15-min. ceiling	0.010	0.2
Cadmium	LFL	0.20	0.05 C
Lead	0.05	0.05	0.15
Sulfur Dioxide	1.3	13	5.0
Formaldehyde	LFL	1.2	1.2
Silica (Crystalline)	0.05	$10/mg/M^3/\%SiO+2$	0.05

B. TOXICOLOGICAL

CADMIUM--The NIOSH Current Intelligence report #42, September 27, 1984 states that a recent epidemiological study has demonstrated a statistically significant excess of lung cancer mortality among workers exposed to cadmium oxide. A chronic inhalation exposure study with rats provides toxicological evidence that exposure to cadmium chloride aerosol can cause a dose-dependent incidence of malignant lung tumors. Based primarily on this data, the National Institute for Occupational Safety and Health (NIOSH) recommends that cadmium and its compounds be regarded as potential carcinogens and that appropriate controls be used to reduce worker exposure.

Additional toxicological information on cadmium shows that it is a severe pulmonary irritant. Inhalation overexposure also may result in renal calculi and irreversible renal tubular injury. This is accompanied by abnormal lung function, renal tubular damage, and urinary excretion of a specific low molecular weight protein. Signs and symptoms include delayed onset of pulmonary edema, dyspnea, cough, feeling of chest constriction, substernal pain; headache; chills, muscle aches; nausea, vomiting, diarrhea; prolonged exposure may result in emphysema, proteinuria, anosmia, and mild anemia.

ARSENIC--Arsenic and arsenic compounds are irritating to the skin, mucous membranes, and eyes. Arsenical dermatoses and epidermal carcinoma are reported risks of exposure to arsenic compounds, as are other forms of cancer. NIOSH criteria for a recommended standard for Occupational Exposure to Inorganic Arsenic in 1975 recommended an exposure level of less than 0.002 mg/M^3 to prevent lung cancer. NIOSH presently recommends the lowest feasible level for occupational carcinogens.[1]

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 interferes with red blood cell production and may affect the kidneys, peripheral and central nervous systems, the blood forming organs (bone marrow), and the reproductive system.

Blood lead levels below 25 micrograms/deciliter (ug/dl) whole blood are considered to be levels which may result from daily environmental exposure. Individual PbB's between 25-40 ug/dl are in excess of the national averages, but are not associated with adverse health effects in non-prenant adults. Identifiable signs or symptoms. Lead levels between 40-60 ug/dl in lead-exposed workers indicate excessive adsorption of lead and may result in more readily identifiable adverse health effects. Levels of 60-100 ug/dl represent unacceptable elevations which may cause serious adverse health effects. Blood lead levels over 100 ug/dl are considered to be extremely dangerous and often these workers require hospitalization and medical treatment.

The OSHA standard for lead in air is 50 ug/M^3 calculated as an 8-hour time weighted average for daily exposure. According to the standard, blood lead and protoporphyrin levels must be monitored at least every 6 months for workers exposed to air lead levels above 30 ug/M^3 for more than 30 days per year, and at least every 2 months if the worker's last lead was at or exceeded 40 ug/100 g whole blood. The standard also dictates that workers with blood lead levels greater than 60 ug/100 g whole blood must be immediately removed from further lead exposure if these levels are confirmed by a follow-up test. Workers with average lead levels of 50 ug/100 g or greater must be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months or until they can safely return to lead exposure areas.

FORMALDEHYDE--Acute exposure to formaldehyde causes burning, tearing eyes and irritation of the nose and throat. These symptoms can occur at concentrations as low as 0.1 ppm. Exposure to formaldehyde vapor, solutions or resins can also cause dermatitis. Formaldehyde has induced a rare form of nasal cancer in inhalation studies of mice and rats. Formaldehyde has also demonstrated mutagenic activity in several test systems. NIOSH investigators recently conducted a proportionate mortality study of garmet industry workers exposed to formaldehyde levels ranging from 0.1 to 1.0 ppm. Statistically significant excesses in mortality were observed for cancers of the mouth, biliary passages and liver, and other lymphatic and blood-forming sites. The authors concluded that these observed excesses in cancer mortality could be related to occupational formaldehyde exposure. NIOSH recommends that occupational exposure to formaldehyde be reduced to the lowest feasible level.

SULFUR DIOXIDE--SO_2 is a severe irritant of the eyes, mucous membranes, and skin. The most toxic route of entry is inhalation. The irritant effects of SO_2 are caused by the rapidity with which sulfurous acid forms on contact with moist membranes. Approximately 90 percent of the inhaled SO_2 is absorbed in the upper respiratory passages. The upper respiratory system is where the damage usually occurs, however, SO_2 may cause pulmonary edema. Workers do adapt to SO_2 exposures but about 10 to 20 percent of the healthy young adults are hypersusceptible to the effects of sulfur dioxide.[2]

VI. RESULTS

Seven general area sample measurements for SO_2 ranged from 0.2 to 1.7 mg/M^3 with a mean of 1.2 mg/M^3. One breathing-zone sample had a concentration of 0.78 mg/M^3. Eleven breathing-zone air samples were collected among workers in all areas of the arc furnace department for arsenic, cadmium and lead. Arsenic was found in one of the samples; the level was 0.02 mg/M^3. Cadmium was found in one of eleven samples; the concentration was 0.006 mg/M^3. Lead was found in all eleven samples; values ranged from 0.004 to 0.3 mg/M^3 with a mean of 0.04 mg/M^3. Two total dust sample measurements were 14 and 12 mg/M^3; crystalline silica was not found in these samples. Two respirable dust samples contained 1.5 and 1.4 mg/M^3. These samples also had 0.5 and 0.2 mg/M^3 crystalline silica, respectively. The charcoal tubes that were analyzed qualitatively by GC/MS contained a trace amount of toluene. The Orbo-23 tubes that were analyzed qualitatively and quantitatively by GC-MSD contained only formaldehyde (0.03 mg/M^3).

VII. DISCUSSION

Environmental data may be reviewed in Tables 1, 2, and 3 included in this report. Overexposures were found for cadmium, lead, total particulate, and crystalline silica (quartz). C F & I has an effective respirator program. The blood lead program also indicates that this program is effective by demonstrating low blood lead levels among workers in the electric arc furnace department. Workers were not overexposed during this evaluation to SO_2; however, it would be prudent for workers in the vicinity of the overhead cranes to wear respiratory protection for exposure to SO_2 and metal fumes.

VIII. RECOMMENDATIONS

1. Continued enforcement of the respirator program in the electric arc furnace department should assist in preventing hazardous exposure.

2. When working on the overhead cranes workers should wear half-facepiece respirators fitted with combination acid gas cartridges and high efficiency particulate filters.

3. All workers who wear respirators should be clean shaven.

4. Workers should be notified when the sulfur compounds are added to the hot molten steel. This may not be possible all of the time, however, such an effort may help decrease the number of complaints.

5. Workers were provided respirators that provided protection for silica, lead, cadmium, SO_2, and all other possible chemical exposures.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic arsenic (revised). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975, (DHEW publication no. (NIOSH) 75-149).

2. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to sulfer dioxide. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1974 (DHEW publication no. (NIOSH) 74-111).

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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 Corp., Pueblo, Colorado
2. United Steelworkers of America
3. U.S Dept. of Labor/OSHA, Region VIII
4. NIOSH - Denver Region
5. Colorado Department of Health

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 1

Breathing Zone and General Room Air Concentrations
of Sulfer Dioxide at
the Electric Arc Furnace Area of
C F & I Steel
Pueblo, Colorado
February 24, 1988

Sample #	Location	Gen. Area/Personal	Sampling Time	Mg/M^3 SO_2
SO 1	South Crane	Personal (Electrician)	7:30 - 2:25	0.78
SO 2	Top of S. Crane	Area	8:20 - 12:20	1.5
SO 3	Top of S. Crane	Area	8:20 - 12:20	1.7
SO 4	Top of S. Crane	Area	8:30 - 12:30	1.4
SO 5	Top of S. Crane	Area	8:30 - 12:30	1.2
SO 6	Top of S. Crane	Area	12:30 - 4:30	1.2
SO 7	Top of S. Crane	Area	12:30 - 4:30	0.2
SO 8	Top of S. Crane	Area	12:30 - 4:30	1.3

Evaluation Criteria 13
Laboratory Limit of Detection 1 microgram of Sulfate ion/Filter

Table 2

Breathing Zone and General Room Air Concentrations
of Arsenic, Lead, and Cadmium at
the Electric Arc Furnace Area of
C F & I Steel
Pueblo, Colorado
February 24, 1988

Sample #	Location	Sampling Time	Mg/M^3 Arsenic	Cadmium	Lead
01	#4 Furnace Operator	7:00 - 2:00	*	*	0.004
02	#4 Furnace 3rd Helper	7:00 - 2:10	*	*	0.008
03	#4 Furnace 1st Helper	7:00 - 2:08	*	0.006	0.3
04	Crane Charger	7:20 - 2:00	*	*	0.01
05	#3 Furnace/Mason	11:50 - 1:40	0.02	*	0.01
06	Ladle Treatment Oper.	7:05 - 2:20	*	*	0.005
100	All areas/Utility	7:10 - 2:22	*	*	0.008
03302	#3 Furnace/1st Helper	7:20 - 2:22	*	*	0.005
03314	Ladle Treatment	7:05 - 2:20	*	*	0.013
03328	All areas/Electrician	7:30 - 2:25	*	*	0.02
03340	#4 Furnace/Helper	7:07 - 2:10	*	*	0.006
Evaluation Criteria			0.002(A)	LFL(A)	0.05

Laboratory Limit of Quantitation 0.001 mg/Sample

(A) = NIOSH Occupational Carcinogen
LFL = Lowest Feasible Limit

Table 3

Breathing Zone and General Room Air Concentrations
of Crystalline Silica (Quartz, Cristobalite) and Particulate
on Brick Masons in
the Electric Arc Furnace Area of
C F & I Steel
Pueblo, Colorado
February 22, 1988

Sample #	Location	Sampling Time	Particulate	Mg/M^3 Quartz	Cristo.
9712	Brick Mason/Arc Furn.	12:00 - 1:40	T 14	*	*
9715	Brick Mason/Arc Furn.	12:00 - 1:40	T 12	*	*
9716	Brick Mason/Arc Furn.	12:00 - 1:40	R 1.5	0.5	*
9718	Brick Mason/Arc Furn.	12:00 - 1:40	R 1.4	0.2	*
Evaluation Criteria			10-T 5-R	0.05	0.05
Laboratory Limit of Detection		0.08 mg/filter Quartz 0.015 mg/filter Cristobalite			

T = Total Particulate
R = Respirable Particulate
Cristo. = Cristobalite