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

HEALTH HAZARD EVALUATION REPORT
HE 80-50-722

CF&I STEEL CORPORATION
PUEBLO, COLORADO

JULY 1980

I. SUMMARY

In February 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from United Steelworkers of America Local Union 2102, Pueblo, Colorado, to evaluate exposures to carbon monoxide and other toxic substances (none specified) at the D, E, and F blast furnaces at CF&I Steel Corporation, Pueblo, Colorado (Standard Industrial Classification Code [SIC] 3310). In order to evaluate the blast furnaces, a medical and industrial hygiene evaluation was performed. Breathing zone and general room air samples were taken on workers for determination of exposures to carbon monoxide (CO), quartz and cristobalite (crystalline silica), total respirable particulate, lead, iron, benzo(a)pyrene (BaP), and coal tar pitch volatiles (CTPV). Medical evaluation consisted of a medical questionnaire and pre-shift and post-shift carboxyhemoglobin.

Atmospheric general room air concentrations of carbon monoxide taken during this evaluation were intermittent samples taken periodically throughout work shift. High levels of carbon monoxide were consistently found throughout this evaluation. The direct reading carbon monoxide analyzer went off scale (in excess of 100 parts per million) on the D, E, and F Furnaces. None of the breathing zone air samples taken for crystalline silica exceeded the NIOSH recommended standard of 0.05 mg/M^3. Seventeen percent (17%) of the breathing zone air samples taken for total particulate exceeded the 1979 ACGIH Threshold Limit Value. None of the lead and iron breathing zone air samples exceeded the Occupational Safety and Health Administration (OSHA) standards of 0.05 mg/M^3 and 5.0 mg/M^3 respectively. Low levels of CTPV and BaP were found.

Pre-shift and post-shift carboxyhemoglobin (COHb) illustrated that COHb did increase while the men were working around the blast furnaces. The greatest difference was noted in F Furnace workers.

On the basis of the environmental and medical data, NIOSH concluded that a health hazard existed from overexposure to carbon monoxide and total particulate at CF&I Steel Corporation. Recommendations on ventilation, work practices, and medical surveillance procedures necessary to control these hazards are included on page 7.

II. INTRODUCTION

NIOSH received a request from United Steelworkers of America Local Union 2102 in Pueblo, Colorado, to determine if there was a health hazard to exposure to carbon monoxide and other toxic substances in the D, E, and F blast furnaces at CF&I Steel Corporation in Pueblo, Colorado.[1] An environmental evaluation was conducted on February 13, 1980, and April 9-10, 1980. The medical evaluation was performed on April 9-10, 1980.

III. BACKGROUND

The blast furnaces receive high grade iron ore. This ore is fed into the furnace along with coke, lime and sometimes a silica compound. Oxygen is added to the furnace. During these operations large amounts of carbon monoxide are routinely emitted by the furnace. Blast furnace gas may run as high as 27-30% of carbon monoxide.

IV. METHODS AND MATERIALS

A. Environmental

Carbon monoxide was measured by using a direct reading carbon monoxide instrument. Crystalline silica samples were collected on 37 mm FWS-B filters and analyzed according to NIOSH Method P&CAM No. 109 using x-ray diffraction. Total respirable particulate samples were collected on 37 mm filters and calculated by weight difference. Lead and iron air samples were collected on 37 mm AA filters using vacuum pumps operated at 1.5 liters per minute and analyzed by NIOSH Method P&CAM No. 173. BaP and CTPV samples were collected on 37 mm silver membrane filters and analyzed by reverse -phase high pressure liquid chromatography.

B. Medical

Grab sampling for carbon monoxide levels in several areas of the F Furnace had demonstrated excessive carbon monoxide exposure. Informal questioning elicited complaints of headaches, dizziness, and fatigue from some of the furnace workers, and it was decided to do biological testing for carboxyhemoglobin levels in potentially affected workers from Furnaces D, E, and F.

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[1]Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 19 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative to employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

On April 9-10, 1980, testing was conducted on all three shifts of workers. All Furnace F workers and approximately two workers from Furnaces D and E on each shift were tested, for a total of 37 workers.

Carbon monoxide was monitored throughout the survey with a portable direct-reading CO analyzer equipped with recorders. Breath samples were taken by having the workers blow an inhalation held for 20 seconds into the carboximeter. The CO concentration of the samples was determined on the carboximeter. The amount of CO in the sample was converted to percent COHb in the workers' blood by Peterson's formula, and this value is the value used for biological results reported here. On the swing and graveyard shifts, both pre- and post-shift levels were taken, and smokers were asked not to smoke for the last three hours before coming off shift. On the day shift, only post-shift readings were taken, and these are separately reported.

V. EVALUATION CRITERIA

A. Environmental

Three sources of criteria were used to assess workroom concentrations of air contaminants: (1) NIOSH criteria for recommended standards; (2) recommended threshold limit values (TLVs) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1979; (3) Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910), January 1978.

	Permissible Exposure Limits 8-Hour Time-Weighted Exposure Basis (mg/M^3)	
Carbon monoxide	35.0 ppm (NIOSH)	50.0 ppm (OSHA)
Iron	5.0 (TLV)	10.0 (OSHA)
Lead	0.05 (OSHA)	0.05 (OSHA)
Benzo(a)pyrene	* (NIOSH)	0.2 (OSHA)
Coal tar pitch volatiles	* (NIOSH)	0.2 (OSHA)
Total respirable particulate	5.0 (TLV)	5.0 (OSHA)
Total particulate	10.0 (NIOSH)	15.0 (OSHA)
Quartz	0.05 (NIOSH)	$\frac{10\ mg/M^3}{\%\ SiO_2 + 2}$ (OSHA)
Cristoblate	0.05 (NIOSH)	$\frac{5\ mg/M^3}{\%\ SiO_2 + 2}$ (OSHA)

* = no safe level since it is a potential carcinogen; 1977 TLV = 0.2 mg/M^3 as total benzene solubles.

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

ppm = parts of vapor or gas per million parts of contaminanted air by volume.

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

B. Toxicological

Carbon Monoxide -- The signs and symptoms of carbon monoxide poisoning may include headache, nausea, vomiting, dizziness, drowsiness, and collapse. In the bloodstream, carbon monoxide rapidly binds to the oxygen-carrying molecule hemoglobin, forming "carboxyhemoglobin" (COHb). When carbon monoxide binds with hemoglobin to form COHb, it reduces the oxygen-carrying capacity of the blood. The more COHb is formed, the more significant the symptoms are. Heart disease may be made worse in workers who have coronary heart disease and are exposed to carbon monoxide concentrations high enough to produce a COHb level greater than 5%. There is also important evidence that exposure to lower carbon monoxide concentrations, producing COHb levels below 5%, affects the nervous system and causes changes in visual alertness, response time, and fine judgment.

Non-smoking, non-exposed persons have an average COHb level of 1%. Cigarette smokers usually have an average COHb level of 2 to 10%. Non-smokers exposed to 50 ppm (50 parts per million of carbon monoxide, the OSHA standard) for six to eight hours have COHb levels of 8 to 10%. Symptoms such as headache and nausea may be seen above 15%, but usually not at lower levels. At 25%, there may be electrocardiographic evidence of heart effects, and 40% usually results in collapse.

The current OSHA standard for carbon monoxide is 50 ppm. Exposure at this level for 90 minutes may cause chest pain for persons with angina (chest pain related to heart disease); exposure for 2 hours may make leg cramps worse for persons who have leg cramping associated with vascular disease. The effects of carbon monoxide exposure, including the more common symptoms of headache, dizziness, and nausea, are made worse by heavy labor and a high temperature in the work area.

In 1972, after considering all of these factors, NIOSH recommended an exposure limit of 35 ppm for an 8-hour time-weighted average, and a ceiling limit of 200 ppm. This recommendation is based on the concentration necessary to produce a COHb level of not more than 5%. The recommendation does not consider the smoking habits of workers since the COHb levels in smokers has generally been found to be in the 4 to 5% range, but may run as high as 10 to 15% in heavy smokers. Therefore, smokers who already have a blood level of 5%, and then are exposed in a work place with an average concentration of 35 ppm will have a total COHb of about 10%.

Lead -- Inhalation of lead dust and fumes is the major route of lead exposure in industry. A secondary source of exposure may be from 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 new OSHA standard for lead in air in most workplaces is 50 ug/M^3 on an eight-hour time-weighted average for daily exposure. For this particular industry the current standard is 50 ug/M^3. The new 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 50 ug/100ml must also be removed. At present medical removal is necessary at blood lead levels of 70 ug/100 grams of whole blood or greater. Removed workers have protection for wage, benefits, and seniority until they can return to lead exposure areas.

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. However, the irritative effects of iron oxide and the other welding fumes may cause other lung diseases, e.g. bronchitis.

Coal Tar Pitch Volatiles (CTPV) -- CTPV refers to the volatile matter emitted when coal tar or coal tar pitch is heated. CTPV contain thousands of organic substances, including BaP and other polynuclear aromatic hydrocarbons (PNAs).

CTPV may be hazardous both by inhalation or skin contact.

CTPV have caused cutaneous photosensitization and irritation of the eyes. Exposure to coal tar and coal tar pitch has caused phototoxic skin reactions. The skin reaction is characterized as an exaggerated sunburn on areas exposed to sun or ultraviolet light--usually the face and hands. Erythema and swelling subside after removed from exposure; hypermelanosis is commonly observed. Coal tar and coal tar oils also produce acne.

Skin carcinomas have been observed in occupations where there is contact with CTPV. The high incidence of lung and skin cancer among workers exposed to CTPV is probably due to the high content of polynuclear aromatics present in CTPVs.

There is no safe exposure to CTPV. Signs and symptoms of CTPV exposure include photosensitization, dermatitis, and irritation of eyes. (Reference 1)

Benzo(a)pyrene -- Benzo(a)pyrene, a chemical carcinogen frequently used for the experimental induction of cancer, was identified as a carcinogen following its isolation by investigators seeking to identify coal tar's carcinogenic constituents. Another commonly used experimental chemical carcinogen found in coal tar is beta-naphthylamine, which has been demonstrated to be a potent bladder carcinogen in a variety of species, including the dog and the monkey. (Reference 2)

Total Respirable Particulate -- Overexposures to any particulate may produce damage to the total respiratory system especially if the particulate contains disease producing substances. The particulate sampled during this evaluation did not contain silica or heavy metals. However, maintaining worker exposures below 5 mg/M^3 should offer adequate protection.

Quartz and Cristobalite (crystalline silica) -- Exposures at levels above the recommended criteria can produce a fibrotic condition of the lungs (silicosis). This is a disabling disease that can lead to permanent disability and death. Maintaining a worker's exposure below 0.05 mg/M^3 should prevent any occupational disease.

VI. RESULTS

A. Environmental Results

Excessive levels of carbon monoxide were found throughout D, E, and F Furnaces. Levels ranged from 5 parts per million (ppm) to greater than 100 ppm. Overexposures were also observed in 2 of 5 air samples taken for total respirable particulates. The results may be reviewed in Table 1-4.

B. Medical Results

Table 5 lists the results of breath analyses for carboxyhemoglobin determinations on the workers in Furnaces D, E, and F. The values for 8 workers were discarded because of machine failure during some of the testing on workers coming off shift at the end of swing shift; these were 7 workers from F Furnace and 1 from E Furnace. Many of these F Furnace workers were smokers who were instructed not to smoke for three hours before coming off shift. The values that had to be discarded because of machine failure would have shown results that included smokers who had refrained from smoking for three hours before testing. The results, therefore, do not include many smokers who had not smoked for three hours before the testing.

Pre-shift levels for workers in all three furnaces were substantially the same, when grouped by smoking habits. Post-shift levels for Furnaces E and D were also substantially the same, showing an average post-shift differential in COHb of 2.5%.

It is interesting to note that although we would expect non-smoking, non-exposed workers to have a level of only 1%, most of the non-smokers had pre-shift levels of approximately 4% COHb, indicating that they are receiving a significant amount of carbon monoxide exposure causing COHb levels similar to those of non-exposed smokers. This results in a post-shift level of approximately 8%, well above the level which may affect workers with underlying coronary heart disease.

Post-shift levels for Furnace F showed an average post-shift differential of 7.8%, or three times that for Furnaces D and E. This is consistent with the environmental monitoring in these three furnaces, which showed a marked increase in carbon monoxide concentrations in some areas of Furnace F.

In addition, the average post-shift COHb level for workers in Furnace F was 14.9%. This is well above the levels at which minor visual and judgment deficiencies have been noted, and is the level at which symptoms such as headache, dizziness, and nausea may commonly be found in persons carrying out normal activities. In the conditions of furnace work, however, with heavy labor and intense heat levels, we would expect these symptoms to appear at even lower concentrations of carbon monoxide.

Nine workers were briefly interviewed regarding symptoms of carbon monoxide poisoning, with the following results: 2 workers reported no symptoms, 7 workers reported fatigue and occasional weakness, 4 workers reported frequent headaches associated with periods of lots of "gas" in the work area, 2 workers reported dizziness, and one worker reported dizziness with a sensation of flushing and heat. This brief survey produced results consistent with the periodic high carbon monoxide exposures found on environmental sampling.

VII. CONCLUSIONS

A health hazard existed at the time of this evaluation. This conclusion is based upon excessive exposures to carbon monoxide and total particulates. Medical evaluation confirms these overexposures by the excessive post-shift COHb accompanied by headaches, nausea, and dizziness which are consistent with overexposures to carbon monoxide.

VII. RECOMMENDATIONS

1. No workers should be exposed to CO levels above the 35 ppm standard recommended by NIOSH.

2. Workers should be informed of the additive effects of cigarette smoke and occupational sources of CO.

3. An alarm system should be installed in all blast furnaces that would go off when carbon monoxide levels exceeded 50 ppm.

4. Additional ventilation should be installed on the casting floor at the F furnace since carbon monoxide levels found could be either immediately dangerous to health or fatal.

5. No eating, drinking, smoking, or snuff usage should be allowed in the work area.

VIII. REFERENCES

1. Proctor, N.H. Chemical Hazards of the Workplace, J. P. Lippincott Company, 1978, p. 178.

2. Criteria for a Recommended Standard....Occupational Exposure to Coke Oven Emissions, NIOSH Publication No. 73-11016, p. III-12.

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X. DISTRIBUTION AND AVAILABILITY

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Copies of this report have been sent to:

1. CF&I Steel Corporation.
2. United Steelworkers of America.
3. United Steelworkers of America Local Union 2102.
4. U.S. Department of Labor/OSHA - Region VIII.
5. NIOSH - Region VIII.
6. Colorado Department of Health
7. State Designated Agency

For the purpose of informing all 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

Carbon Monoxide Levels at Various Locations on D, E, and F Furnaces

CF&I Steel Corporation
Pueblo, Colorado

February 13, 1980
April 9-10, 1980

Location	Area	ppm Carbon Monoxide
D Furnace	Rigger Shack	40
D Furnace	Top of Stairs	15
D Furnace	East of Runner	> 100
D Furnace	At Runner	> 100
D Furnace	East of Runner	> 100
D Furnace	Blower Shack Office	> 100
D Furnace	Blower Shack Wash House	100
D Furnace	South End of Furnace	85
D Furnace	West End of Furnace	50
D Furnace	Walk Up to High Line	60
D Furnace	Stairway to High Line	10
Between D and F	High Line	15
E Furnace	Stairway Down from High Line	15
E Furnace	North End	10
E Furnace	East End	10
E Furnace	Stove Area	10
F Furnace	North End	5
F Furnace	Northeast End	> 100
F Furnace	East End	> 100
F Furnace	Southeast End	> 100
F Furnace	South End	> 100
F Furnace	Below Shack	15
	EVALUATION CRITERIA	35

The carbon monoxide analyzer will only go to 100 ppm.

TABLE 2

Breathing Zone Air Concentrations of
Coal Tar Pitch Volatiles (CTPV) and Benzo(a)pyrene (BaP)
at the Blast Furnaces

CF&I Steel Corporation
Pueblo, Colorado

February 13, 1980

Sample Number	Job Classification	Sampling Time	mg/M3 CTPV	mg/M3 BaP
AG7	Millwright	7:09 AM - 1:47 PM	0.13	0.003
AG01	Blower Foreman	5:58 AM - 1:25 PM	0.07	0.002
AG9	Foreman	7:16 AM - 1:28 PM	*	*
AG00	Stove Man	5:50 AM - 1:26 PM	*	0.0003
AG8	Pipefitter	7:14 AM - 1:40 PM	*	*
AG6	High Line Dumper	6:58 AM - 1:25 PM	*	*
	EVALUATION CRITERIA		**	**
	LABORATORY LIMIT OF DETECTION mg/sample		0.02	0.00006

* = below laboratory limit of detection
** = suspect carcinogen--any detectable level could be hazardous to worker's health.

TABLE 3

Breathing Zone Air Concentrations of
Quartz and Cristobalite (Crystalline Silica) and Total Respirable Particulate Weight

CF&I Steel Corporation
Pueblo, Colorado

February 13, 1980

Sample Number	Job Classification	Sampling Time	mg/M^3 Quartz	Cristobalite	Total Particulate
5797	Scale Car Operator	5:54 AM - 1:38 PM	*	*	*
5769	High Line Crane Helper	6:53 AM - 1:53 PM	*	*	0.35
5791	Laborer	6:02 AM - 1:30 PM	*	*	0.06
5781	Pipefitter	7:07 AM - 1:38 PM	*	*	1.03
5786	High Line Car Dumper	6:55 AM - 1:25 PM	*	*	11.5
5774	Furnace Keeper	6:15 AM - 1:26 PM	*	*	8.6
	EVALUATION CRITERIA		0.05	0.05	5.0
	LABORATORY LIMIT OF DETECTION mg/sample		0.03	0.03	0.01

* = below laboratory limit of detection

TABLE 4

Breathing Zone Air Concentrations of Iron and Lead
at the Blast Furnaces

CF&I Steel Corporation
Pueblo, Colorado

February 13, 1980

Sample Number	Job Classification	Sampling Time	mg/M3 Iron	mg/M3 Lead
AA-1	Fall Man	5:50 AM - 1:30 PM	0.45	*
AA-2	Car Man	5:50 AM - 1:59 PM	0.13	*
AA-60	2nd Helper	6:05 AM - 1:30 PM	0.64	0.004
AA-90	1st Helper	6:08 AM - 1:30 PM	0.97	*
AA-88	Millwright	7:12 AM - 1:48 PM	0.07	*
	EVALUATION CRITERIA		5.0	0.05
	LABORATORY LIMIT OF DETECTION mg/sample		0.003	0.003

* = below laboratory limit of detection

TABLE 5

Percent Carboxyhemoglobin of Blast Furnace Workers

CF&I Steel Corporation
Pueblo, Colorado

April 9-10, 1980

Furnace E	Pre-Shift	Post-Shift	Differential
Smokers	10.8%	11.0%	0.2%
	8.5	11.6	3.1
	10.8	14.0	3.2
	8.0	10.2	2.2
	3.8	7.8	4.0
Non-Smokers	3.4	6.8	3.4

Average Post-Shift Differential = 2.6%

Furnace D			
Smokers	9.2%	10.0%	0.8%
	8.2	10.0	1.8
	11.0	10.8	-0.2
Non-Smokers	4.0	8.4	4.4
	7.8	11.2	3.4
	4.4	8.6	4.2

Average Post-Shift Differential = 2.4%

Furnace F			
Smokers	11.8%	16.0%	4.2%
	11.4	17.0	5.6
	8.2	10.0	1.8
	5.4	10.8	5.4
	11.6	23.0	11.4
	6.8	22.0	15.2
	9.2	20.0	10.8
Non-Smokers	1.6	6.8	5.2
	3.2	8.6	5.4
	3.6	19.0	15.4
	5.5	11.0	5.5

Average Post-Shift Differential = 7.8%
Average Post-Shift Level = 14.9%

TABLE 5 (continued)

Post-Shift Only Available	% Carboxyhemoglobin	Last Cigarette
Furnace F	11.2	1 hour before
	10.6	Non-Smoker
Furnace D	8.6	Non-Smoker
	10.2	2 hours before
	12.0	2 hours before
Furnace E	6.0	1 hour before

Machine failure led to unreliable readings on Post-Shift, Swing Shift, for:
- 7 workers from F Furnace
- 1 worker from E Furnace