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

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 77-106 -469

FOUNTAIN FOUNDRY, INC.
PUEBLO, COLORADO

FEBRUARY 1978

I. TOXICITY DETERMINATION

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at the Fountain Foundry, Inc., Pueblo, Colorado, on August 18 and 29, 1977. At the time of this evaluation, breathing zone air samples were taken for lead, free silica, and total particulate. A medical evaluation of 19 workers was also conducted. This evaluation included a medical history and physical examination with blood and urine biological tests.

The case definition for lead toxicity consisted of either a blood lead level of at least 60 micrograms per deciliter (ug/dl), a urinary lead of at least 100 ug/dl, or a free erythrocyte protoporphyrin (FEP) value of at least 620 ug/dl red blood cells (RBC) associated with three objective signs and/or subjective symptoms. Two persons met this case definition. Neither of these workers had sufficient lead levels to require any treatment.

Breathing zone air samples for lead exceeded NIOSH recommended exposure criteria. Considerable exposure to total particulate containing free silica was also detected.

It has been determined on the basis of medical and environmental evidence that a potential health hazard existed to workers exposed to lead and possibly free silica at Fountain Foundry during this evaluation.

II. DISTRIBUTION AND AVAILABILITY

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Services, Information 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. Fountain Foundry, Inc.
2. U.S. Department of Labor/OSHA - Region VIII
3. NIOSH - Region VIII

For the purpose of informing approximately 20 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.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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.

NIOSH received such a request from Fountain Foundry, Inc., Pueblo, Colorado, to evaluate the potential exposures to lead, free silica, and total particulate during the operation of a grey iron foundry.

IV. HEALTH HAZARD EVALUATION

A. Process Evaluated

This plant is a grey iron foundry that takes scrap metal (usually a mixture of cast iron and various other metal parts) and produces a molten metal from a furnace charged with coke and limestone. The molten metal is then poured into various types of sand molds, where products such as manhole covers are formed. All areas of the foundry were monitored for lead, free silica, and total particulate. No other potentially toxic substances were being used in this operation to a degree to warrant additional investigation.

B. Environmental Design and Methods

Breathing zone air samples were taken on all workers throughout the foundry. Samples for lead were collected on AA filters using vacuum pumps operated at 1.5 liters per minute and analyzed by atomic absorption spectroscopy. Free silica samples were collected on 37 milliliter filters using vacuum pumps operated at 1.5 liters per minute and analyzed colorimetrically. Total particulate samples were analyzed by weight difference to an accuracy of 0.01 milligrams (mg).

C. Medical Design and Methods

The NIOSH physician and physician's assistant evaluated 19 workers and one office worker with full history, physical, evaluation, and biological sample testing. Three other non-Fountain Foundry employee persons volunteered biological samples for control results.

The medical history questionnaires were conducted by the physician and physician's assistant. The history included medical symptoms, work history, and questions of personal hygiene and other potential lead exposures. The symptoms were read in layman's terms, and the workers were asked if they experienced any of these complaints. The list of symptoms is shown in Table 1.

The physical exams were administered by the NIOSH physician and physician's assistant. Reflexes and strength were tested to evaluate peripheral nerve activity. The reflexes studied were the biceps, brachioradialis, knee jerk, and ankle jerk--all bilaterally. The reflexes were recorded between 0 to 4,

with 0 as an absent reflex and 4 as clonus. The strengths evaluated were wrist strength and ankle strength. Since the extensor aspect of frequently used muscle groups is the most commonly found weakness abnormality, the workers were asked to hyperextend their wrists against the investigator's applied resistance. The workers were also asked to walk on their heels. Other evaluations of the peripheral nervous system were evaluation of extra-ocular muscle strengths and tremor of the outstretched hands; finger-nose coordination was also tested.

Blood samples were obtained to evaluate lead levels, blood urea nitrogen (BUN), serum creatinine, blood FEP, hemoglobin, and hematocrit. Urine specimens were obtained for lead determinations.

Biological laboratory samples were evaluated by Medical Diagnostic Services Laboratory (MDS). The urines were kept in the original containers. The blood lead level specimens were placed in anticoagulate, then centrifuged to separate serum and cells. All specimens were then refrigerated until given to MDS on August 19, 1977.

Blood and urine lead levels were analyzed by Delves cup atomic absorption technique. Internal control measures conducted by MDS to ensure accuracy consisted of four evaluations of high and low blood lead control supplied by the A. R. Smith Company. All of these control evaluations were found to be within the MDS acceptable range.

The urine lead values were reported as ug/dl. These values were corrected to a specific gravity of 1.024 by NIOSH and reported as ug lead/dl corrected. Two urine specimens were considered too dilute to make this correction factor valid.[1]

FEP was measured by fluorometric ethyl acetate-hydrochloric acid extraction method using a zinc protoporphyrin standard. The results are presented as ug FEP/dl RBC.

Serum creatinine and BUN samples were performed by centrifugal analyzer specific methodology. Both are reported as mg/dl.

D. Criteria for Assessing Workroom Concentrations of Air Contaminants

The three sources of criteria used to assess workroom concentrations of air contaminants were: (1) recommended threshold limit values (TLV's) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1977; (2) Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910), January 1976; and (3) NIOSH criteria for recommended standards for free silica (1974), and for lead (March 1977 testimony).

Substances	TLV	Permissible Exposures 8-Hour Time-Weighted Exposure Basis (mg/M^3) OSHA Standard	NIOSH Criteria For Recommended Standard
Lead	0.15	0.2	0.1
Free Silica (resp.)	0.05	10.0/% SiO_2+2	0.05
Total Particulate	10.0	15.0	----

OSHA proposed standard for lead is 0.1 mg/M^3
mg/M^3 = approximate milligrams of substance per cubic meter of air

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.

E. Toxicology

1. Lead

Lead is a highly toxic metal, but long experience in industry has shown that good engineering controls in the workplace and good personal hygiene among employees can make lead a safe material with which to work.

There is a very large amount of information available on the toxic properties of lead. Any person who works with lead should be aware of the following facts:

a. Lead is a solid at room temperature. Chunks of lead at room temperature are not usually a hazard to health; but when lead is melted and heated to high temperature, lead fume comes off the molten lead. This fume can easily be breathed deep into the lungs, where the lead can be readily absorbed into the bloodstream.

b. Lead can also be absorbed from the intestines after it is swallowed. Because of this, persons working with lead should be very careful to wash their hands carefully before picking up anything to put in their mouths. There should be no eating or drinking in a work area where lead is used.

c. Lead is not absorbed through the skin to any significant extent. It is very important, however, to shower and change clothes before going home in order to prevent contaminating the home with lead dust. There have been cases of lead workers' wives being poisoned by lead dust while laundering lead-contaminated work clothes. Young children who crawl on the floor and put things in their mouths are especially likely to be poisoned by lead dust which has been carried home by workmen.

d. Lead is a naturally-occurring material that is normally present in small quantities everywhere in our environment. There have always been small quantities of lead present in our air, water, and food. Lead has no known normal function in the human body; it is not essential for human growth.

(Many metals such as iron, copper, and zinc are necessary for the proper functioning of the human body.)

All normal people have a small amount of lead in their bodies, and there is no known health problem caused by these "normal" levels of lead. The normal human body has ways of handling these small amounts of lead. Most of the lead eventually comes out in the urine, although small amounts can come out in feces, sweat, and saliva. Lead has a tendency to be deposited in the bones. Large amounts of lead can accumulate in the bones, where it tends to stay for a long time. For this reason, a long period of time away from a lead exposure area may be needed for a person to eliminate most of the lead from his body.

e. Lead has many effects on the human body. When a lot of lead is absorbed into the body over a short period of time, the symptoms of "acute" lead poisoning occur. When lead is absorbed over a long period of time, "chronic" lead poisoning may occur. The symptoms of lead poisoning include: constipation, headache, loss of appetite, general weakness and fatigue, inability to sleep, abdominal pains, aches and pains in muscles and joints, and weakness or shakiness in the arms or legs.

Large amounts of lead can damage several organs in the body. Nerves can be damaged, especially those in the arms and legs. This results in muscle weakness, usually first noticed in the hands and feet. Another result can be a tremor, or shakiness, that usually starts in the hands. The brain is rarely affected in adults exposed to lead. The kidneys can be damaged by lead. This may result in abnormalities of blood tests used to check on kidney function, such as serum blood urea nitrogen or serum creatinine. Gout can be a complication of damage to kidneys by lead but is usually only seen in people who drink lead-contaminated moonshine liquor. Lead can also cause anemia, or low blood count, by impairing the ability of the bone marrow to make new red blood cells. This anemia usually improves rapidly after the lead is removed from the body.[2]

Lead is not known to cause cancer in humans. Lead may be dangerous to unborn children, so pregnant women should not be exposed to lead.

f. There are large differences in the ability of individual human bodies to handle lead. Some people absorb lead better than others; some people get rid of lead in the urine better than others; and some people show symptoms of lead poisoning at lower blood lead levels than others. These differences among individuals depend on age, sex, general health and nutrition, kidney function, and many other factors that are not well understood.

g. The federal government has established limits for the amounts of lead that can be present in the blood of a person who works with lead.

In the past, NIOSH has recommended that 80 ug of lead per 100 ml of whole blood should be the maximum allowable level. This was based on evidence showing that normal persons are not harmed by levels up to 80 ug/100 ml blood. More recent evidence indicates that a maximum level of 60 ug/100 ml blood may give a more adequate margin of safety. OSHA has been conducting hearings in recent months to determine if the maximum permissible level of lead in the blood should be lowered.

h. The recommended treatment of lead intoxication has been changing in recent years. The currently accepted practice is as follows:

> Any person with substantial exposure to lead should have a periodic lead determination.
>
> If a worker's blood lead level reaches a level of 60 ug/100 ml or greater, the blood lead level should be rechecked if there is any reason to suspect lab error. If the lead level is correct, the worker should be removed from lead exposures. He should not return to lead exposure until a repeat blood lead determination is at least below 60 ug/100 ml and preferably below 40 ug/100 ml.
>
> There should be no chelation agents used to treat a high blood lead level unless:
>
> 1) The lead level is very high. (Exactly how high is a matter of medical judgment. There are no written standards for this.)
>
> 2) The worker has symptoms suggestive of lead poisoning.
>
> 3) The blood lead level has failed to drop after a prolonged period away from lead exposure. (This is also a matter of medical judgment. There are no written standards for this.)

Chelating agents should not be used on a worker who continues to work in an area of high lead exposure. There is some evidence that oral chelating agents can enhance the absorption of lead which has been swallowed; this could make lead intoxication worse.

i. Chelating agents have been used for many years to treat lead intoxication: Calcium Versenate (ethylene-diamine tetraacetic acid or EDTA) is the compound most commonly used to help remove lead from the body. This compound binds lead very tightly and then helps the lead to pass into the urine and out of the body. Versenate is not absorbed very well after being swallowed, which makes it relatively ineffective when given as a pill. For this reason, Versenate is usually given directly into a vein for maximum effectiveness. This can be done under medical supervision in a properly equipped plant medical facility, but now it is usually done in a hospital.

Versenate can have some side effects. When given orally, it can cause diarrhea and abdominal upset. When injected into a muscle, it causes considerable pain. It can cause itching and allergic reactions in some individuals. There is some recent evidence that it might cause kidney damage when given in large doses over a long period of time. There is also some evidence that it can bind other necessary metals from the blood, thus causing a deficiency of these essential trace metals in the body. This would only be a problem when Versenate was used in large amounts.[3]

For these reasons, there has been a trend away from using Versenate in recent years. In 1976, NIOSH recommended that chelation should no longer be routinely used in asymptomatic workers who had a blood lead level over 80 ug/100 ml. Removal from lead exposure without chelation should be the first choice of therapy. Chelation should not be done while a worker is still exposed to significant amounts of lead and should not be repeated very often. Intravenous chelation should generally be used in preference to oral chelation.[4]

2. Free Silica

Chronic free 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.[5]

3. Total Particulate

This is a term that is applied to the total dust in the air. It is very non-specific. However, at levels that exceed 10 mg/M^3, work conditions are very dusty and uncomfortable and can lead to coughing, sneezing, and respiratory irritation.

F. Environmental Results and Discussion

Results of environmental sampling showed that workers were overexposed to lead, free silica, and total particulate. Seven out of 15 air samples taken for lead exceeded the evaluation criteria. All of the samples taken for free silica exceeded the evaluation criteria, and one out of five of the total particulate samples exceeded the evaluation criteria. For a detailed description of all environmental samples, please refer to tables 6 and 7.

The ventilation in this foundry was totally inadequate. This conclusion was based on visual observation during the charging of the furnace and shake-out operations. This was also verified by the high dust concentrations found on workers. There was an electrostatic precipitator in the attic of the building, which did not appear to be working at the time of the evaluation. Such a system is not recommended for foundries.

G. Medical Results and Discussion

There are multiple lab values and clinical indicators present in the work environment that suggest a potential hazard may exist. These values are displayed in Tables 1-5.

All but two workers had some symptomatic complaints which could be attributable to lead toxicity. The major complaints were muscle cramps, metallic taste, joint pains, tiredness, and headache (Table 1).

Objective signs were rare, with the most frequent abnormalities being two workers with an abnormal knee jerk reflex and two workers having a noted tremor. One worker complained of occasional abdominal cramps, but no one noted a history of abdominal colic. No workers had gingival lead lines.

The results of the laboratory samples showed the mean blood lead as 47 ug/dl in the workers as compared to 18 ug/dl in the controls. The mean FEP value was 392 ug FEP/dl RBC in the workers as compared to 58 ug FEP/dl RBC in the controls (Table 5).

Despite these wide differences between the exposed group and the controls, only five individual workers had elevated values of blood lead, urinary lead, or FEP. There were two workers with blood lead levels greater than 60 ug/dl (Table 3, numbers 4 and 8). Although the case definition includes a blood lead greater than 60 ug/dl, this allows a margin of safety. The zone of 60-80 ug/dl of whole blood is an "at risk" zone. Those workers should be carefully evaluated on a regular basis. In accordance with potential toxic effects of chelating agents, treatment should not be initiated at that level. This is especially true, since neither of these workers satisfied clinical criteria of lead toxicity.

There was one worker with an FEP level of 920 (Table 3, number 15). This worker did not have an elevated blood lead and did not show evidence of lead toxicity.

There were two workers who met the case definition (Table 3, number 12 and 13). Worker number 12 had mildly elevated urinary lead levels of 108 ug/dl urine, with normal less than 100 ug/dl. He did not have a significant blood lead or FEP level; however, they were close to abnormal levels. Clinical evidence of toxicity was based on five of the symptomatic complaints listed in Table 1. Worker number 13 had an elevated urinary lead level as well as an elevated FEP. His blood lead level was high "normal," and he had two symptomatic complaints (Table 1) and one objective sign (Table 2). The abnormal values are not high enough to justify chelation therapy.

The laboratory tests of most concern were the elevations of BUN and creatinine over the control group. Since only two workers gave any history of any chelation therapy, this would probably not explain the decreased renal function. Workers number 4 and 10 received one dose of penicillamine as a diagnostic test by a private physician, and neither of these two workers had elevations in renal function tests. Chronic lead exposure may cause renal damage. One may speculate that long-term lead exposure may be causing the elevations found. However, most values at the time of this study indicate "safe" levels, and those persons with the higher BUN and creatinine levels are not the persons with the higher lead monitoring tests. Also, there seems to be no correlation between length of work exposure and the BUN or creatinine values.

Conclusions

The available data supports a conclusion that there is an exposure to lead in the work environment at Fountain Foundry, Inc., Pueblo, Colorado. This exposure is causing elevations in lead concentrations of blood and urine, but these elevations are not at the toxic level. They also do not justify chelation treatment at this time. Since lead exists in the environment, measures for its control are certainly necessary to prevent a future medical hazard.

RECOMMENDATIONS

1. Prior to this time Fountain Foundry, Inc., has had no medical surveillance program to evaluate potential lead toxicity. Medically, the most essential part of such a surveillance program is frequent monitoring of workers.

2. The medical program should include a pre-employment examination. This has two purposes. The first is to establish a baseline level for future evaluations. The second is to identify workers who would have excessive sensitivity to lead exposure. It should include monitors for lead toxicity: a) medical history exposing other potential or past exposures; b) a physical examination; c) blood count; d) urine analysis; e) renal function studies; and f) those biological tests that will be performed in the ongoing surveillance program.

3. In determining what tests to monitor in the surveillance program, the blood lead, urinary lead, urinary coproporphyrin, urinary delta amino levulinic acid, and some FEP are the most common. Certainly all are not necessary. The choice should be based on reliability, cost, accessibility, and the monitoring physician's experience with these tests. The frequency in monitoring depends on the degree of risk. Carl Zenz, M.D., in his text, Occupational Medicine, recommends approximately every month when 50% or more of the test group are abnormally high and bimonthly when 20-50% of the group are elevated. Since 5 of 19 workers, or 26%, had elevated monitor test values, bimonthly monitors may be an appropriate time frequency to begin testing. Should it be determined that more workers have elevated values or workers become clinically toxic, more frequent testing would be necessary. If few high values are found, less frequent monitoring may be sufficient to protect the health of the workers. Positive results on screening tests merit a further evaluation, with each case considered individually.

The workers show signs of lead exposure, but few show levels that require close monitoring; none are acutely toxic. Although an acute problem does not exist, the potential for subsequent hazards exists. NIOSH recommends a program of continuing medical surveillance be established to monitor workers' lead levels.

4. Attention to personal hygiene is an important aspect in lowering lead absorption. Extra time and effort should be taken to educate workers to the hazards and effects of lead toxicity. Make sure they understand that the potential problem occurs in their jobs. Eleven of the 19 workers admitted smoking on the job; however, none washed their hands prior to touching the cigarettes prior to placing in their mouths. Although shower facilities were provided, their use was optional. Cleanliness, including clean work clothes, shower, and clean clothes after work, and prevention of carrying dirt home should be stressed.

5. No eating facility was provided at the job which was free of dust and designated an eating area only. This is also necessary to prevent consumption of lead-containing dust.

6. The ventilation system should be improved, especially near the blast furnace. Improving the ventilation system in this area would effectively remove the dust and fumes during the charging and tapping process.

7. The ventilation system that exists at the shakeout area should be evaluated and improved in order to eliminate the high dust exposures to workers performing the shakeout duties.

8. Since total particulate and free silica were found during this survey, it would be advisable for all workers to have pulmonary function studies performed as well as chest x-rays to determine if any biological damage is being done to the lungs.

VI. REFERENCES

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VII. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:

Bobby J. Gunter, Ph.D.
Regional Industrial Hygienist
NIOSH - Region VIII - Denver, Colorado

Jeffrey Lybarger, M.D.
Medical Section
Hazard Evaluation and Technical Assistance Branch
NIOSH - Cincinnati, Ohio

Originating Office:

Jerome P. Flesch, Acting Chief
Hazard Evaluation and Technical Assistance Branch
NIOSH - Cincinnati, Ohio

Acknowledgments

Biological Sample Collection and Physical Examinations:

Bonita Nelson
Physician's Assistant, Medical Section
Hazard Evaluation and Technical Assistance Branch
NIOSH - Cincinnati, Ohio

Report Typed By:

Mary Margaret Fehrman
NIOSH - Region VIII - Denver, Colorado

Table 1

Fountain Foundry Company
Pueblo, Colorado

HE 77-106
August 18, 1977

Frequency of Medical History Symptomatology

	Number of Workers Interviewed	Symptomatology	Percent
trouble sleeping	20	0	0
unusually tired	20	6	30
dizziness	20	3	15
irritability	20	4	20
poor memory	20	1	5
headache	20	5	25
muscle weakness	20	1	5
muscle cramps	20	8	40
tremors	20	2	10
joint pains	20	7	35
poor appetite	20	0	0
weight loss	20	3	15
abdominal cramps	20	1	5
nausea	20	1	5
emesis	20	2	10
diarrhea	20	0	0
constipation	20	1	5
metallic taste	20	8	40

Table 2

Fountain Foundry Company
Pueblo, Colorado

HE 77-106
August 18, 1977

Frequency of Physical Signs

	Number of Workers Studied	Number Abnormal	Percent Abnormal
Bicepts reflex	20	1	5
Brachioradialis reflex	20	0	0
Knee jerk	20	2	10
Ankle jerk	17	1	6
Wrist strength	20	0	0
Toewalk	20	0	0
Lead lines	20	0	0
Extraoccular muscle weakness	20	0	0
Finger-nose coordination	20	1	5
Tremor	20	2	10
Gingival lead lines	21	0	0

Table 3

Fountain Foundry Company
Pueblo, Colorado

HE 77-106
August 18, 1977

Signs, Symptoms, FEP, and blood and Urine Leads

#	Subjective complaints	Objective signs	Urine Lead corrected for spgr (ug/dl urine)	Blood lead (ug/dl whole blood)	FEP (ug/dl RBC)
Normal workers			100	60	620
1	2	0	**	5	83
2	5	0	**	26	57
3	1	4	47	52	365
4	2	0	71	64	423
5	6	1	64	60	148
6	1	0	32	23	31
7	0	0	86	49	576
8	1	0	**	66	725
9	3	0	**	54	582
10	5	0	**	48	241
11	4	0	**	42	217
12	5	0	108	59	589
13	2	1	64	57	892
14	0	0	90	42	352
15	1	0	**	53	921
16	1	0	6	30	125
17	2	1	79	51	468
18	5	0	89	*	*
19	3	4	43	48	264
Mean			75	47	392
S.D.			27	14	276
Control (office worker and non-employee controls)					
20			None Detc.	16	37
21			***	29	122
22			5	13	41
23			7	12	34
Mean				18	58
S.D.				8	42

* - no sample
** - not able to conduct sample
*** - urine too dilute to correct

Table 4

Fountain Foundry Company
Pueblo, Colorado

HE 77-106
August 18, 1977

BUN, Creatinine, Hgb and Hct

*	BUN (mg/dl)	Creatinine mg/dl	Hgb (gm/dl blood)	Hct (percent)
Normal	5-26	0.5-1.3		
1	34	1.6	15.7	46.4
2	22	1.3	15.8	46.4
3	14	1.4	15.3	47.5
4	19	1.4	15.4	46.2
5	24	1.2	16.2	47.9
6	25	1.4	16.2	47.5
7	29	1.4	14.8	44.7
8	26	1.7	15.4	47.6
9	36	1.3	16.9	50.9
10	20	1.2	16.4	49.2
11	26	1.4	16.2	49.1
12	23	1.4	15.8	47.7
13	27	1.6	**	**
14	19	1.2	15.2	46.1
15	16	1.4	14.0	42.8
16	18	1.4	16.6	49.6
17	28	1.4	15.6	49.1
18	*	*	*	*
19	30	1.5	11.5	48.8
Mean	24.2	1.4		
S.D.	6.0	.14		
	Controls (office worker and non-employee control)			
20	17	0.9	14.6	44.0
21	21	1.1	*	*
22	11	0.6	16.6	48.5
23	20	0.9	14.5	43.2
Mean	17.3	0.8		
S.D.	4.5	.17		

BUN = blood urea nitrogen
Hgb = hemoglobin
Hct = hemotacrit

Table 5

Fountain Foundry Company
Pueblo, Colorado

HE 77-106
August 18, 1977

Mean values of controls vs exposed workers

Test	Exposed Workers	Control
Blood lead (ug/dl whole blood)	47 ± 14	18 ± 8
Urinary lead (corrected) (ug/dl urine)	75 ± 27	-
FEP (ug/dl RBC)	392 ± 276	58 ± 42
BUN (mg/dl)	24.2 ± 6.0	17.3 ± 4.5
Creatinine (mg/dl)	1.4 ± .14	0.8 ± .17
Number in Group	19	4

Table 6

ATMOSPHERIC CONCENTRATIONS OF LEAD

Fountain Foundry
Pueblo, Colorado

August 18, 1977

Sample Number	Location	Time of Sample	Lead (mg/M^3)	Type of Sample
11	Core Room	7:56 AM - 3:44 PM	.09	BZ
10	Mold Room	8:08 AM - 3:35 PM	.11	BZ
15	Furnace Area	8:35 AM - 3:42 PM	.22	BZ
9	Mold Room	8:40 AM - 3:45 PM	.14	BZ
1	Pattern Shop	8:30 AM - 3:37 PM	.002	BZ
3	Core Room	8:44 AM - 3:33 PM	.08	BZ
2	Finishing Room	8:39 AM - 3:35 PM	.02	BZ
12	Mold Room	8:00 AM - 3:45 PM	.09	BZ
5	Mold Room	8:21 AM - 3:43 PM	.14	BZ
16	All Areas	8:48 AM - 3:18 PM	.03	BZ
14	All Areas	7:48 AM - 3:42 PM	.05	BZ
8	Core Room	9:04 AM - 3:44 PM	.10	BZ
7	Mold Room	8:12 AM - 3:33 PM	.14	BZ
6	Mold Room	8:36 AM - 3:46 PM	.20	BZ
13	All Areas	9:10 AM - 3:48 PM	.02	BZ
		EVALUATION CRITERIA	0.10	
		NIOSH LIMIT OF DETECTION	5.0 µg/sample	

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

BZ = breathing zone

ug/sample = micrograms per sample

Table 7

ATMOSPHERIC CONCENTRATIONS OF FREE SILICA AND TOTAL PARTICULATE

Fountain Foundry
Pueblo, Colorado

August 29, 1977

Sample Number	Location	Job Classification	Time of Sample	Free Silica (mg/M^3)	Total Particulate (mg/M^3)	Type of Sample
1284	Foundry	Shakeout	10:10 PM- 6:50 AM	.10	1.2	BZ
1282	Foundry	All Areas	7:30 AM-12:00 noon	.10	3.1	BZ
1297	Foundry	Mixer	10:20 PM- 6:50 AM	.78	6.5	BZ
1293	Foundry	Facing	7:33 AM-12:00 noon	.60	13.0	BZ
)	Foundry	Grinding	7:40 AM-12:00 noon	.46	2.6	BZ
			EVALUATION CRITERIA		10.0	
			NIOSH LIMIT OF DETECTION	.04 mg/sample	.04 mg/sample	

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

BZ = breathing zone

mg/sample = milligrams per sample