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
HE 77-97-482

INLAND STEEL COMPANY
INDIANA HARBOR WORKS
EAST CHICAGO, INDIANA

APRIL 1978

I. TOXICITY DETERMINATION

Based on environmental air samples, medical examinations, review of medical records, evaluation of the ventilation system and work practices, and available toxicity information collected or conducted during December 5-8, 1977, it has been determined that a potential hazard to the health of the workers exposed to lead dust and fumes exists at Inland Steel Company, #2 BOF.

Ten of thirteen personal samples for inorganic lead exceeded the proposed Occupational Safety and Health Administration (OSHA) lead standard of 100 micrograms of lead per cubic meter of air (ug/M^3), which NIOSH now supports. Eight personal samples exceeded the current OSHA lead standard of 200 ug/M^3. These concentrations ranged from 25 - 2600 ug/M^3 of lead (Table I).

Of the 16 blood lead analyses, three were in excess of 60 micrograms lead per 100 milliliters of whole blood (60 ug/100 ml), five were in the range of 40-60 ug/100 ml, and eight were less than 40 ug/100ml. NIOSH recommends that a blood lead level of 60 ug/100 ml or less be allowed as a safe concentration (Table IV).

Recommendations are included in this determination report which are designed to insure a safe and healthful working environment. These include the need for improved local ventilation and better medical monitoring.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, 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:

a) Inland Steel Company, E. Chicago, Indiana
b) Authorized Representative of Employees - United Steelworkers of America, Local 1010, E. Chicago, Indiana
c) U.S. Department of Labor - Region V
d) NIOSH - Region V
e) United Steelworkers of America, Pittsburgh, Pennsylvania
f) Indiana Division of Labor, Indianapolis, Indiana

For the purpose of informing the approximately 40 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

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 an 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of United Steelworkers of America, Local 1010, regarding employee exposures to inorganic lead in the #2 Basic Oxygen Furnace (BOF) at the #2 (North) Pouring Stand. An interim report (Shefs I) was sent to the Company on August 17, 1977, following the initial visit.

IV. HEALTH HAZARD EVALUATION

A. Conditions of Use

The area of concern was in the #2 (North) pouring stand of the "Pit" section of the #2 Basic Oxygen Furnace (BOF) Shop. Leaded steel is produced at the stand to produce precision products of good machinability. From the BOF, a steel ladle is transported via a crane to the stand where approximately 25-29 ingot molds (each weighing eight tons) are arranged in a series. During each "teeming" (adding molten steel to ingots) approximately 210 tons of molten steel are fed equally into all molds combined.

On the average, approximately 50 pounds of lead shot are added to each ingot when it is one-third to two-thirds full. Lead is shot into the steel stream with a "lead gun", comprised of a rubber hose and long steel pipe with a nozzle. A teeming takes about 30-35 minutes, and approximately 1100-1400 total pounds of lead are added. No more than three heats per shift are poured. Two heats were poured each day of this evaluation.

The lead pouring crew usually numbers six employees: one craneman, one steel pourer, three pitmen, and one metallurgical observer. Another metallurgical observer alternates each lead heat with a colleague. There is also a foreman who may be present during the heat.

The craneman positions the ladle over each mold, while the steel pourer operates the hydraulic lines of the ladle, allowing each mold to be filled properly. The pitmen may do one of three jobs, which are rotated among them in successive heats: one will operate the lead gun, standing six to eight feet from the nozzle, the second will throw a topping on each ingot which helps the mold from losing heat, and the third will obtain a steel sample for future quality control analysis. The metallurgist judges the quality of the leaded steel being produced. Except for the craneman, the other crew members all stand near each other. During one heat observed, tellurium metal, in 8-pound bags, was also added as another steel improving agent.

The stand crew must wear aluminized coats and face shields to reduce serious injury from molten steel. Employees do not wear respiratory protection.

Ventilation

The lead pouring stand has a built-in local exhaust ventilation system. Adjacent to each ingot mold, there is a lateral exhaust hood with dimensions of approximately 26 inches by 11 inches. Each hood is designed to exhaust approximately 6,000 cubic feet of air per minute (cfm).

Since allowing each hood to be open during the entire teeming operation would put a strain on the fan system, they are opened according to a sequence. Whenever a particular mold is being filled, the exhaust hoods for that mold, the two preceding ones, and the next one are opened by operating the dampers. Each hood exhausts mold emissions for about four minutes. Lead captured by the hoods is conveyed to collecting hoppers nearby. The lead is shaken into bins lined with polyethylene-lined bags. The bins are then removed as necessary. When replacing bins, employees are required to wear dust/fume respirators.

B. Evaluation Methods

1. Environmental

Atmospheric samples for lead were collected on Millipore filters Type AA* (mixed cellulose ester) with 0.8 micron (u) pore size. The filters were encased in a three-piece plastic field monitor cassette with the face cap removed and filter completely exposed. Personal samples were taken at the employee's breathing zone using a battery powered vacuum pump. The pumps were operated at a flow rate of 1.5 liters per minute (lpm), and were worn by the employees. Area samples were collected with the same equipment along the pouring stand.

*Mention of commercial products does not constitute endorsement by NIOSH

Ventilation measurements were taken with a Sierra Air Velocity Meter, Model 441.

2. Medical

The medical evaluation included interviews, physical examinations, and biological testing. The NIOSH medical investigator interviewed and examined sixteen (16) employees (Ref. Tables III-IV). The interviews consisted of having the employees sign a consent form, after which a brief questionnaire was administered to obtain data on occupational as well as past and present medical histories. The physical examination consisted of rating skin and conjunctival color changes, examining gums for lead lines, assessing tremors, biceps tendon reflexes, wrist and ankle strengths. The biological testing included blood sampling for BUN, creatinine, free erythrocyte protoporphyrin (FEP), hematocrit, hemoglobin, and lead determinations.

The blood lead levels were determined by a Delves Cup atomic absorption method; FEPs by an ethyl acetate/HCl extraction method using zinc protoporphyrin as a primary standard.

C. Evaluation Criteria

1. Toxic Effects

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 to work with.

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:

1. 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 lung, where the lead can be readily absorbed into the bloodstream.

2. 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 before picking up anything to put in their mouths. There should be no eating, drinking, or smoking in a work area where lead is used.

3. Lead is not absorbed through the skin to any significant extent. It is very important, however, to shower and change clothes before going home 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.

4. 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.

5. 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. Severe symptoms due to very large amounts of lead in the body are rarely seen today because of better engineering controls and medical monitoring.

Large amounts of lead can damage several organs in 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 kidney 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 (BUN) 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.

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.

6. 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.

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.

2. Environmental Criteria

Airborne exposure limits for inorganic lead have been recommended or promulgated by several sources. For this study the criteria used to assess the degree of health hazards were collected from three sources:

1) NIOSH: Criteria for a Recommended Standard...Occupational Exposure to Inorganic Lead, 1972, and revised recommendations - 1977.

2) Threshold Limit Values (TLV): Guidelines for Chemical Substances and Physical Agents recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for 1977.

3) OSHA Standard: The air contaminant standard for inorganic lead enforced by the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor and found in the Federal Register - CFR 1910.1000(b) (Table Z-2), and 1975 proposal.

Source	8-Hour Time Weighted Average Concentration (TWA)[1]	Acceptable Ceiling Concentration[2]
NIOSH Criteria Document - 1972 (now outdated)	150 ug/M^3 [3]	-----
OSHA Standard -	200 ug/M^3	-----
OSHA Standard - Proposed - 1975[4]	100 ug/M^3	-----
1977 TLV	150	450 ug/M^3

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1 USDOL employee exposure standards are based on a computed time-weighted average exposure during any 8-hour work shift or a 40-hour work week. The standard represents conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effects.

2 This value should never be exceeded during a commonly used 15-minute sampling period.

3 ug/M^3 = micrograms of lead per cubic meter of air (1 ug = 0.001 milligrams).

4 NIOSH supports the proposed environmental standard, as presented at the OSHA hearing in March 1977.

In 1975[1], NIOSH recommended reducing the maximum permissible blood level to 60 micrograms of lead per 100 milliliters of whole blood (ug/100 ml) and that level was proposed by OSHA also.

D. Evaluation Results and Discussion

1. Environmental

Results of atmospheric sampling are contained in Table I. Of 13 personal samples collected on December 6 and 7, 1977, ten exceeded the proposed OSHA lead standard, which NIOSH supports, of 100 ug/M^3 for an 8-hour work-day. Eight personal samples exceeded the OSHA lead standard of 200 ug/M^3. The pitmen were exposed to lead concentrations ranging from 140-240 ug/M^3 on December 6, and from 660-2600 ug/M^3 on December 7. Mechanical difficulties with the hydraulic lines of the steel ladle allowed much molten steel to pour on the ground instead of in the ingot molds on December 7, thus causing the release of emissions not at all controllable by the existing ventilation system. Poor work practices in the way the lead was added and the mechanical problems probably accounted for the higher lead exposures on December 7. Additional personal samples which exceeded 100 ug/M^3 were collected on the pit foreman (December 6), both metallurgists (December 7), and the steel pourer (December 7).

Area samples collected along the pouring stand ranged from 70-350 ug/M^3 of lead. Area samples collected in the locomotive repair area (nearby the lead collecting hoppers) and inside the crane cab were below 100 ug/M^3.

Ventilation measurements are illustrated in Table 2. Each hood velocity was measured with the same adjacent dampers open as during the actual pouring. There were approximately seven-eight hoods which were not measured. Average face velocities ranged from approximately 600-1600 feet per minute (fpm). Calculated air volumes into the hoods ranged from approximately 1300-3200 cubic feet per minute (cfm). The design air volume was said to have been 6,000 cfm.

2. Medical

The plant's medical facilities include a complete hospital, designed to handle any type of emergency that may occur at the plant. The facilities are manned by a staff of physicians, registered nurses and technicians during all shifts. All employees are given a pre-employment physical. Subsequently, workers are required to participate in the lead screening program if they are exposed to lead dust or fumes. The company draws blood leads on these employees every six months. The blood is analyzed by the Analytical Section, Kettering Laboratory, Cincinnati, Ohio. A review of the results of the blood leads drawn in November 1977 reveal none of the results were above 30 ug/100 ml whole blood (ug/100 ml).

It is the policy of the company medical director that if any employee's blood lead is above normal, to treat the employee until his blood lead level returns to normal. When NIOSH requested to review the procedure for treatment of employees with elevated blood lead levels, it was denied by the company for legal reasons.

None of the 16 employees interviewed and examined had definite signs or symptoms of classical plumbism at the time of the NIOSH visit. Of the 16 blood lead analyses, eight were less than 40 ug/100 ml, five were in the 40-60 ug/100 ml range and three were in excess of 60 ug/100 ml.

The FEP determinations are shown in Table IV as micrograms of FEP per 100 milliliters of erythrocytes (ug FEP/100 ml RBCs). A plot of log FEP versus blood lead levels is shown in Figure I. A regression analysis yields the following:

$$\log \text{FEP} = 1.306 + 0.012 \text{ (blood lead)}$$
$$r = 0.633$$

A blood lead level of 40 ug/100 ml (for this data) corresponds to a FEP value of 61 ug/100 ml RBCs (Figure II). An FEP of 62-189 ug/100 ml RBCs indicates some degree of increased lead absorption or anemia; while an FEP > 189 ug/100 ml RBCs indicates potentially severe lead intoxication and can be present in other rare blood disorders. Of the 16 blood samples, nine had an FEP value greater than 61 ug/100 ml RBCs. The FEP values do not always correlate with blood levels because the FEPs represent the effects of chronic lead exposure upon the red blood cells while the blood lead levels represent the effects of more acute lead exposure. It should also be noted that there are four individuals with elevated creatinine and one individual with a low hemoglobin (reader is referred to Table IV). However, it is not felt that these are clinically significant.

The medical laboratory results indicate that a potential lead toxicity problem does currently exist. The company does not have a lead screening program that is comprehensive enough to deal with lead exposures in the #2 BOF area. Specific procedures for this recommended by NIOSH will be given in the next section.

V. RECOMMENDATIONS

The ventilation system for the lead teeming operation should be improved. Figures III and IV illustrate designs of pouring stations and foundry shakeout mold ventilation systems[2]. In both cases, the local exhaust hoods are approximately one and one-half times as wide as the ingot mold with flanges or baffles to more effectively capture fumes and dust. Since the hoods used now are only as wide as the molds, flanges and side baffles may be useful in the capturing of lead laden air. Currently there is a potential for capturing air not containing lead, thus reducing the effectiveness of the local exhaust system.

In Reference 3, a similar local exhaust system for leaded steel is described. Under design features, the average hood face velocity was approximately 8,000 fpm and the air volume flow rate 8,000 cfm. Whereas Inland Steel kept four hoods open during the teeming, in this design five were kept open - the hood for the mold being filled and the two hoods on each side of this mold. Care was taken to keep only the necessary hoods open in order to prevent a decrease in the air flow rate through each.

For Inland Steel's system, the design air volume flow rate per hood was 6,000 cfm but calculated volumes ranged from 1300-3200 cfm with measured face velocities ranging from 600-1600 fpm. An increase to those values of Reference 3 should be considered. A lower air volume may be acceptable if coupled with the addition of baffles or flanges.

The ventilation system can also be aided by good employee work practices. Toppings should not be carelessly heaved into the molds, but pushed in gently to avoid spattering of the mold contents. The evolution of fume and dust quantities not controllable by the exhaust system can be minimized through proper maintenance of equipment, such as the ladle hydraulic lines. Until lead levels can be reduced, NIOSH-certified respirators should be worn by employees.

Medical recommendations would include the following:

1. Biologic monitoring of employees who are exposed to lead dust or fumes should occur every three months. 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 the lead-exposed area. He should not return to a lead-exposed area until a repeat blood lead determination is below 60 ug/100 ml.

2. There should be no chelation agents used to treat a high blood lead level unless:

a) The lead level is very high. (Exactly how high is a matter of medical judgment. There are no written standards for this).

b) The worker has symptoms suggestive of lead poisoning.

c) 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).

3. 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.

4. Chelating agents have been used for many years to treat lead intoxication: Calcium Versenate (EDTA, ethylene-diamine-tetraacetic acid) 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.

5. 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 some 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 usually only be a problem when Versenate was used in large amounts.

6. 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; chelation should not be repeated very often; intravenous chelation should generally be used in preference to oral chelation.

VI. REFERENCES

1. Statement of Edward J. Baier, Deputy Director NIOSH, before the Department of Labor, OSHA Public Hearing on the Occupational Health Standard, March 1977.

2. Industrial Ventilation - A Manual of Recommended Practice. American Conference of Governmental Industrial Hygienists, 13th ed., Lansing, Mich., 1974.

3. Ruhf, R.: Lead Exposure Control in the Production of Leaded Steel. Amer. Ind. Hyg. Assoc. J. 24:63-67, 1963.

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Table I

Results of Air Sampling for Inorganic Lead
#2 (North) Pouring Station
#2 BOF

Inland Steel Company
E. Chicago, Indiana

December 6-7, 1977

Date	Job Title	Type Sample[1]	Sampling Period (hrs./min.)	Concentration (ug/M^3)[2]
12/6	Pit foreman	P	7/35	150
12/6	#2 Ladle crane	A	7/05	40
12/7	#2 Ladle crane	A	7/18	50
12/6	Metallurgist 1	P	6/40	25
12/6	Metallurgist 2	P	6/40	50
12/7	Metallurgist 1	P	7/0	370
12/7	Metallurgist 2	P	7/0	365
12/6	Steel pourer	P	7/0	85
12/6	Pitman	P	7/20	240
12/6	Pitman	P	7/0	220
12/6	Pitman	P	6/40	140
12/7	Steel pourer	P	6/48	500
12/7	Pitman	P	7/10	660
12/7	Pitman	P	7/09	670
12/7	Pitman	P	7/08	2600
12/6	Locomotive repair Lunch table	A	7/05	12
12/6	On lead gun unit	A	6/50	850
12/7	North Stand-across from 6th ventilation hood	A	7/14	190
12/7	North stand-across from 16th hood	A	7/16	350
12/7	North stand-across from 28th hood	A	7/16	70

[1] P = personal   A = area

[2] ug/M^3 = micrograms of lead per cubic meter of air

EVALUATION CRITERIA (in ug/M^3)

OSHA Standard	1975 Proposed OSHA Standard (NIOSH supported)	1977 TLV
200	100	150

Table II

Ventilation Measurements
Exhaust Hoods*
North Pouring Stand
#2 BOF

Inland Steel Company
E. Chicago, Indiana

December 7, 1977

	Hood	Average Measured FPM[1]	Calculated CFM[2]
(North End)	1	750	1500
	2	775	1550
	3	650	1300
	4	1100	2200
	5	900	1800
	6	725	1450
	7	1400	2800
	8	1000	2000
	9	1025	2050
	10	1050	2100
	11	1375	2750
	12	1000	2000
	13	1275	2550
	14	1250	2500
	15	1075	2150
	16	1375	2750
	17	1250	2500
	18	1375	2750
	19	1550	3100
(South End)	20	1625	3250

[1] FPM = linear feet of air per minute

[2] CFM = cubic feet of air per minute

* Hood face dimensions: 26 inches X 11 inches

Table III

Inland Steel Company
East Chicago, Indiana
December 5-8, 1977

Summary of Demographic Data

Job Category	Number Assigned	Number of Volunteers	Percent	Age of Volunteers			Years at Current Position		
				Range	Median	Mean	Range	Median	Mean
Ladlecrane Men Service	8	2	25	53-61	-	57	4-38	-	21
Service Aisle Cranemen	8	4	50	24-58	44.5	42	3-35	17	18
Standmen	20	7	35	25-60	49	45	1-37	4	12
Steel Pourer	8	-	-	-	-	-	-	-	-
Ladlemen	4	-	-	-	-	-	-	-	-
Maintenance	44	-	-	-	-	-	-	-	-
Metallurgical	8	2	25	26-31	-	28.5	5-6	-	5-5
TOTAL	100	15	5	24-61	49	43	1-38	4	12

Table IV

Inland Steel Company
East Chicago, Indiana
December 5-8, 1977

Results of Biological Analyses

Subject	Blood Lead Level (ug/100 ml rbc)	Hemoglobin Level (gm/100 ml)	Hematocrit (Vol. %)	Free Erythrocyte Protoporphyrin (ug/100 ml rbc's)	BUN (mg/100 ml)	Creatinine Level (mg/100 ml)
201	30	16.9	50.1	22	12	1.3
202	24	14.6	45.8	163	16	1.2
203	63	14.8	45.6	123	15	1.1
204	42	17.3	52.4	31	17	1.0
205	60	13.9	43.6	358	14	1.2
206	54	15.4	46.4	189	13	1.0
207	27	16.2	48.7	45	20	1.5
208	88	16.3	48.5	142	16	1.4
209	30	17.5	52.5	14	15	1.1
210	20	14.4	43.3	29	10	0.9
211	33	15.2	46.0	74	16	1.2
212	35	14.4	43.7	115	12	1.4
213	46	15.7	48.5	91	12	1.1
214	41	15.1	45.5	56	16	1.2
215	18	16.0	48.1	19	16	1.3
216	82	15.5	47.7	148	18	1.4
Normals	40	14-18	42-52	60	5-26	0.5-1.3

Figure I

Log FEP vs Blood Lead Levels
Inland Steel Company
East Chicago, Indiana
December 5-8, 1977

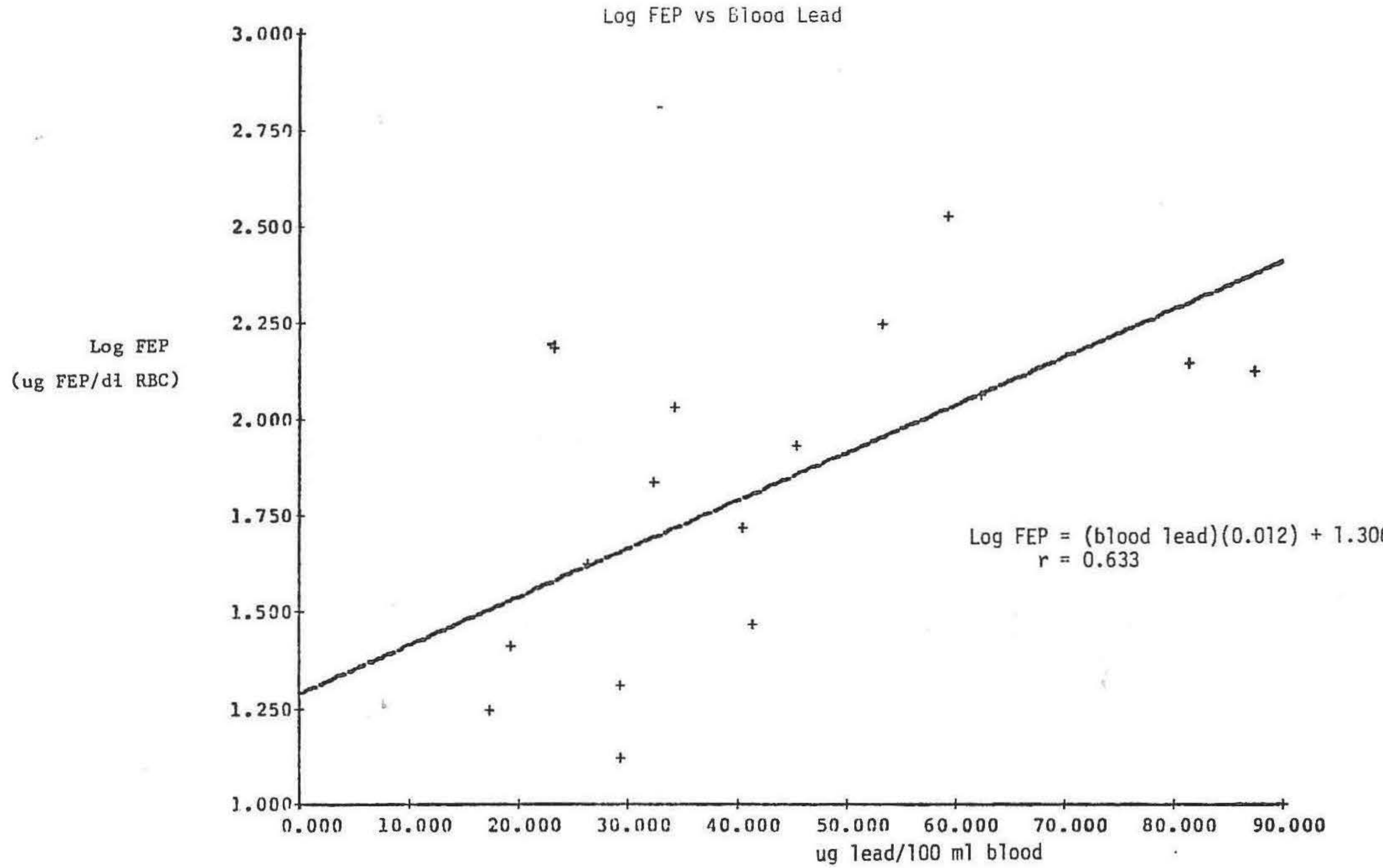


Figure II

Summary of Log FEP
Inland Steel Company
East Chicago, Indiana

December 5-8, 1977

Log FEP = 1.306 + 0.012 (blood lead)

r = 0.663

Blood Lead (ug/dl)	FEP (ug/dl red blood cells)
20	35 ug/dl rbc
30	46
40	61
50	80
60	115
80	184

Figure III

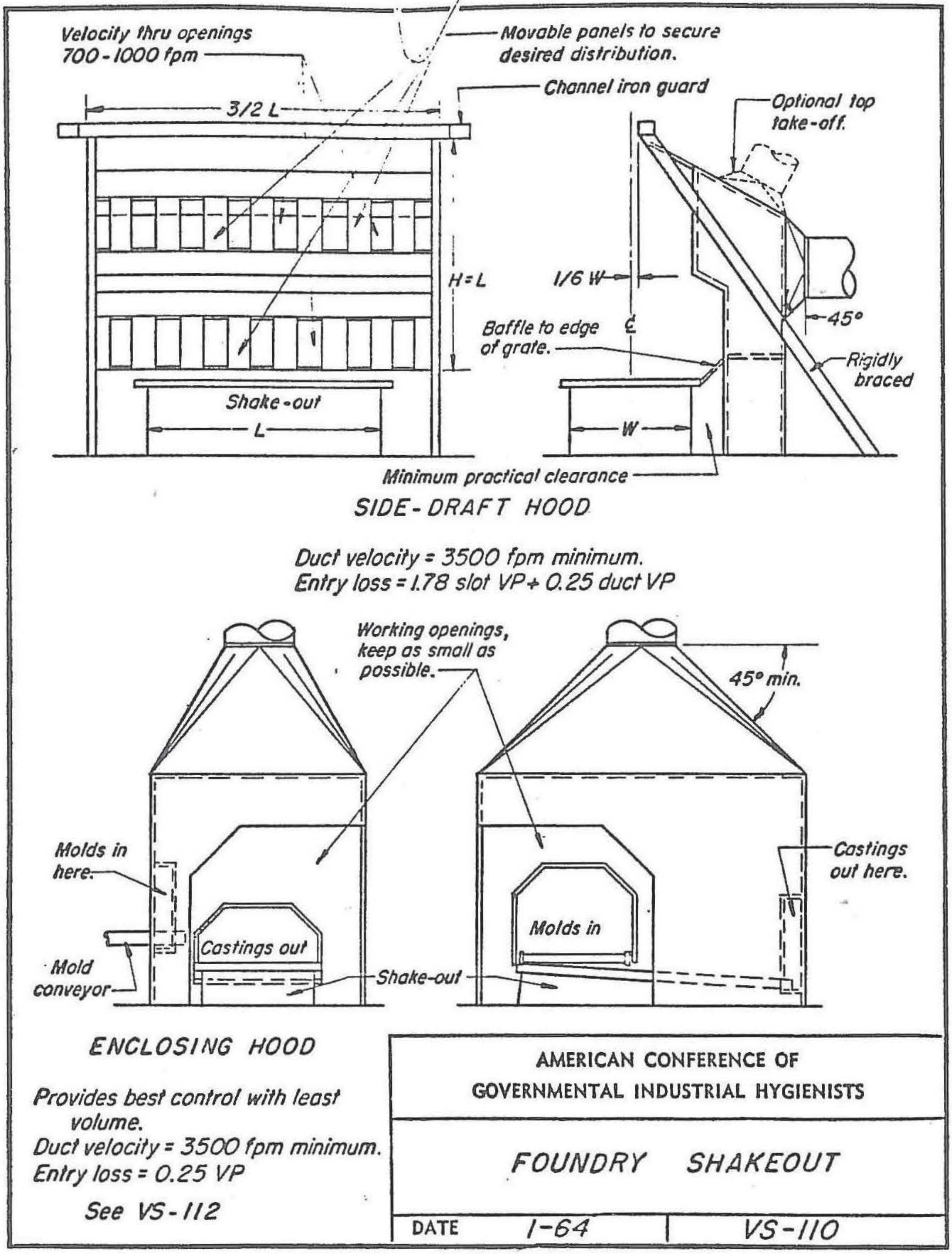
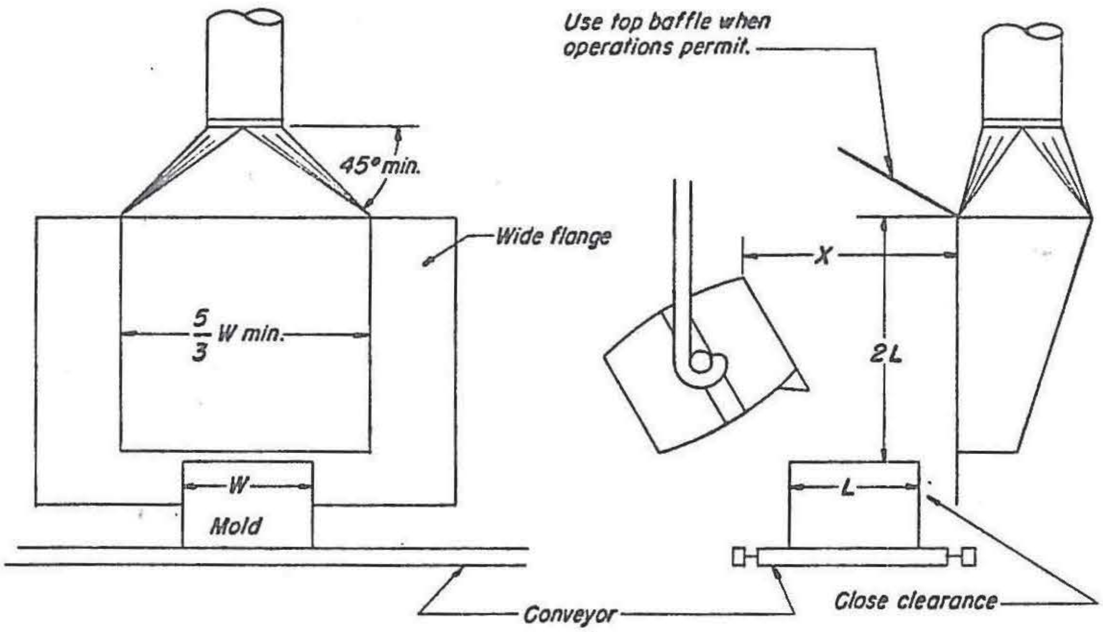

Velocity thru openings
700-1000 fpm
Movable panels to secure desired distribution.
Channel iron guard
3/2 L
Optional top take-off.
H=L
1/6 W
45°
Baffle to edge of grate.
℄
Rigidly braced
Shake-out
L
W
Minimum practical clearance
SIDE-DRAFT HOOD
Duct velocity = 3500 fpm minimum.
Entry loss = 1.78 slot VP + 0.25 duct VP
Working openings, keep as small as possible.
45° min.
Molds in here.
Castings out
Mold conveyor
Shake-out
Molds in
Castings out here.
ENCLOSING HOOD
Provides best control with least volume.
Duct velocity = 3500 fpm minimum.
Entry loss = 0.25 VP
See VS-112
AMERICAN CONFERENCE OF
GOVERNMENTAL INDUSTRIAL HYGIENISTS
FOUNDRY SHAKEOUT
DATE 1-64
VS-110

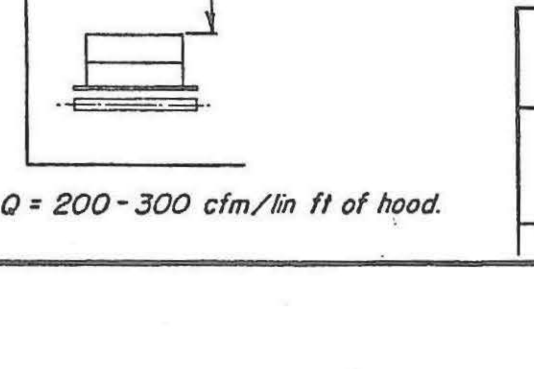
Figure IV



SMALL MOLDS

Unflanged hood: Q = 200 (10 X^2 + hood area).
Flanged hood, reduce Q 25%
Duct velocity = 2000 fpm
Entry loss = 0.25 VP (For slots, 1.78 slot VP + 0.25 duct VP).

PARTIAL SIDE ENCLOSURE



Q = 200 - 300 cfm/lin ft of hood.

NOTE:
For large molds and ladles provide large side-draft hood similar to shakeout.
Q = 400 cfm/sq ft working area.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

POURING STATION

DATE 1-64	VS-109