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. 77-20-411

INLAND STEEL CORPORATION
EAST CHICAGO, INDIANA

AUGUST 1977

I. TOXICITY DETERMINATION

A survey team from the National Institute for Occupational Safety and Health (NIOSH) performed a health hazard evaluation in Plant #1 (Slab Yard) at Inland Steel Corporation, East Chicago, Indiana. The following determinations are based on environmental measurements of airborne concentration contaminants, non-directive medical questionnaires, a review of pertinent literature, observations of employees' work practices and engineering controls.

Airborne concentrations of respirable crystalline silica and total respirable particulate matter were collected in the workers breathing zone and in the general work area. The airborne contaminants' concentrations were measured to be within the accepted limits of exposure.

Sulfur dioxide (SO_2) gas levels were monitored in the slab yard using certified gas detector tubes. Seven of the eight SO_2 measurements exceeded the NIOSH recommended health standard, and four of the eight measurements exceeded the Occupational Safety and Health Administration Standard (OSHA).

Airborne concentrations of metallic fumes and dusts (lead, iron oxide, manganese and copper) were monitored in the workers breathing zone and the general work area. The airborne metallic dusts concentrations were measured to be within the acceptable limits of exposure.

A review of the non-directive questionnaire indicates that employees experienced difficulty in breathing, and tightness of chest whenever a high carbon steel (greater than 0.33 percent) is scarfed. Additionally, the crane operators and the NIOSH investigators experienced upper respiratory irritation once they climbed to the upper levels to board the cranes.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

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:

a) Inland Steel Corporation, East Chicago, Indiana
b) Authorized representatives of Local 1010, United Steelworkers of America
c) U.S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately 25 "affected employees" the employer shall promptly "post", for a period of thirty calendar days, this 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. Code 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.

The National Institute for Occupational Safety and Health received such a request from an authorized representative of Local 1010, United Steelworkers of America. The request alleges that the scarfers, cranemen, chargers and inspectors who work in Plant #1 (Slab Yard) may be exposed to lead. Furthermore, the request alleges that fumes evolving from the slabs being scarfed are malodorous, and that employees are coughing up black particles.

Due to the nature of the slab yard operation, sampling was not limited to monitoring for lead alone. An evaluation of airborne concentrations for crystalline silica, several metallic fumes and dusts, nuisance particulate, and various gases were included in this survey. More specifically, screening for a number of gases was accomplished using gas detector tubes. The detector tube results are listed in Table V; however, a discussion of the toxicological effects for each gas sampled has been excluded because it would serve no purpose in clarifying the nature of the problem.

IV. HEALTH HAZARD EVALUATION

A. Process Description

The slab yard employs eight workers per shift, three shifts per day, and includes the following personnel: one inventory clerk, three crane operators for two crane cabs (one craneman is a relief man), two scarfers, one recorder stocker and one recorder helper. The slabs are produced and

transported from another part of the plant to the slab yard via stake cars. Upon receipt of the slabs, the inventory clerk inspects the slabs for their size, length, thickness, heat number and slab number prior to unloading of the stake cars. The slab thickness ranges in size from 3-9 inches. Inventory of the slabs is an extremely important function because not all of the slabs are scarfed and rolled. Those slabs which are not scarfed are lead alloy slabs and "hazardous" steel slabs. Hazardous steel slabs are characterized as having greater than 0.33 percent carbon and 1.2 percent manganese content. Hazardous steel is termed as such because it can inadvertently explode given proper environmental conditions; consequently, hazardous steel slabs are specially transported to the slab yard in gondolas.

Upon completion of the inventory, one of the two cranemen unloads the slabs from the stake cars, placing them either on the scarfing dock (conditioning dock) or in the slab storage yard. The scarfers then inspect the slabs for surface defects which they repair using a high pressure oxygen-acetylene torch. The recorder stockers and recorder helpers coordinate which slab will be utilized during their respective shifts. As the slabs are needed, a second crane operator transports slabs from either the conditioning dock or the slab storage yard to the furnace charging table. Two skid pipes run the entire length of the furnace; ergo, two slabs may be pushed through the furnace at one time.

The furnace has two charging doors which are elevated each time a new slab is introduced into the heating zone. It should be noted that as one slab is introduced into the furnace, one slab is normally ejected at the opposite end of the furnace. The slabs, when pushed into the furnace first enters the heating zone (soak zone) where approximately 70-80 percent of the total slab heating occurs. The fuel source for the heating zone (soak zone) is #6 crude oil* with a median sulfur content of 1.5 percent. Dependent upon slab thickness, the surface temperature of each slab may reach up to 2600° F. Once the slab has been heated for the proper time and temperature, the slab is pushed to the final heating area of the furnace called the hearth zone. The fuel source for the hearth area is natural gas. The final 20 percent of slab heating is accomplished in the hearth zone after which the red hot slab is ejected and directed to the next area where the slab is rolled to the desired thickness.

B. Evaluation Design and Methods

1. Environmental

On January 17-19, 1977, a health hazard evaluation was performed to determine airborne concentration for crystalline silica dust, total particulate, lead, iron oxide, manganese, copper and various gases. Sampling logistics included personal breathing zone sampling, general work area sampling and use of gas detector tubes. The collection and laboratory analyses for these substances are discussed below.

*It should be heeded that #6 crude oil may contain Benzene in varying percentages.

a) Crystalline Silica: All the day shift employees were instrumented with a personal sampling train. The sampling train consisted of a Mine Safety Appliance (MSA) vacuum pump whose flow rate was 1.7 liters per minute (lpm), a two stage, 10 millimeter (mm) nylon cyclone size selective sampler and a two piece, 37-mm cassette which housed a 5.0 micrometer (um) 37-mm FWSB filter which is a low ashing type of polyvinyl chloride (PVC) filter. In addition, high volume respirable dust samples were collected using a nonpulsating flow pump (GAST PUMP), a one-half inch metal cyclone, a critical orifice to restrict airflow to 9.0 lpm, and a three piece cassette with a 5.0 um pore size FWSB filter. The filters were gravimetrically analyzed to determine total dust. Afterwards, the filters were evaluated via one of two analytical methods: 1) x-ray diffraction analysis, the most desirable evaluation technique, was performed whenever possible in order to identify the various polymorphs of free silica. The limits of detection for each polymorph, quartz and cristobalite, was 40 micrograms. 2) The colorimetric analysis was performed whenever the filters were too heavy to be analyzed by x-ray diffraction. The colorimetric method simply determines the total amount of free silica present on the filter. The limits of detection for total free silica was 40 micrograms.

b) Inorganic Metals (Lead, Iron Oxide, Manganese and Copper): Personal samples for all of these metals were concurrently collected from all of the day shift employees except the crane operators. General work area samples were collected in each of the two crane cabs. The sampling train consisted of a MSA pump operating at 1.5 lpm, and a three piece 37 mm closed face cassette which housed a 37 mm diameter tared polyvinyl chloride (PVC) filter. The metals were analyzed by digesting and solubilizing the filter in a nitric acid solution and finally aspirating the analyte into an atomic absortption spectrophotometer to determine the type and concentration of the constituents. The lower limits of analytical detection using the atomic absorption technique for lead, iron oxide, manganese and copper were 0.002, 0.005, 0.002, and 0.001 milligrams (mg) per sample respectively.

c) Sulfur Dioxide: The direct reading NIOSH certified (certification No. TC-84-030) gas detector tubes were used to evaluate the employees' exposure. In order for a gas detector tube to be certified, it must have ±35 percent accuracy at one-half the exposure limit and ±25 percent accuracy at 1-5 times the exposure limit. Further explanation of the regulations regarding gas detector tubes appear in the Code of Federal Regulations (CFR) as Title 42 CFR Part 84 under the authority of the Occupational Safety and Health Act of 1970.

2. Medical Evaluation Methods

A confidential non-directive medical questionnaire was administered to ten employees during the period of this survey. The employees interviewed were the same workers who were instrumented with sampling devices. The non-directive questionnaire is designed to review the employees work history, and includes information such as the workers' medical history and symptomatology with regard to the work environment.

C. Evaluation Criteria

1. Environmental Assesment

There are several criteria used to evaluate the toxic air contaminants of an employees work environment: (1) NIOSH Criteria Documents for a Recommended Occupational Health Standard, (2) Proposed and Recommended Threshold Limit Values (TLV's), as suggested by the American Conference of Governmental Industrial Hygienists (ACGIH), 1976. (3) The OSHA standard. These values are based upon the current state of knowledge concerning toxicity of these substances. The values for each contaminant is designed to allow an occupational exposure for an 8-hour work day up to a 10-hour work day, 40-hour work week Time Weighted Average (TWA) over a normal lifetime without the worker experiencing discomfort. In some instances, a few employees may experience discomfort at or below the criteria. There are some airborne contaminants for which this TWA is inappropriate, consequently, the substance may be proceeded by the letter "C", which indicates a ceiling value for an interval of 30 minutes or less.

The best health criteria (in this author's opinion) has been tabulated, footnoted and compared to the OSHA standard listed in the Code of Federal Regulations (CFR), (1976) Title 29, Part 1910, subpart Z, Section .1000. The OSHA standard has been cited in order that the reader may see which of the standards have been exceeded. However, no discussion of the OSHA standard with respect to measured airborne levels will be presented.

Substance	Time Weighted Average (TWA) 8-Hour	10-Hour	Ceiling Value	Max. Exposure Minutes
Silica				
Free Silica (Respirable)[1]		.05 mg/M^3		
Quartz (Total Dust)[2]		30.0 mg/M^3 / % Quartz +2		
Lead & its inorganics[3]	0.10 mg/M^3			
Iron Oxide Fume[4]	5.0 mg/M^3			
Manganese[5]	5.0 mg/M^3		5.0 mg/M^3	15
Copper Dust & Mists[6]	1.0 mg/M^3			
Sulfur Dioxide[7]	2.0 ppm			

1) NIOSH Criteria Document (1974). The OSHA Standard for respirable silica is calculated by dividing 10 mg/M^3 by the % quartz + 2.

2) The ACGIH TLV Document (1976) and the OSHA Standard (1976) both utilize this formula.

3) OSHA proposed and NIOSH supported standard for lead is 0.10 mg/M^3 (1977).

4) The ACGIH TLV Document (1976). The OSHA Standard (1976) is 10.0 mg/M^3.

5) The ACGIH TLV Document (1976). The OSHA Standard (1976) is 5.0 mg/M^3.

6) The ACGIH TLV Document (1976). The OSHA Standard (1976) is 1.0 mg/M^3.

7) NIOSH Criteria Document (1974). The OSHA Standard (1976) is 5 ppm.

2. Toxicological Effects

a. Crystalline Silica: The primary health effects associated with inhalation of free silica is a form of pneumoconiosis (dusty lung) termed silicosis. Onset of this malady may vary from several years to twenty years or more. The percent of free silica present in the environment generally determines the course of this disease. As the silicon dioxide is deposited into the lungs, the silica stimulates production of fibrotic nodules. The nodules in turn compress the alveoli (air sacs) thereby decreasing the lung function and producing restrictive type pulmonary disease.

Early silicosis termed "simple silicosis" is normally diagnosed by chest x-ray examination. Individuals with this disease are usually asymptomatic, and lung function impairment is non-existent. As the severity of silicosis increases, the symptoms become prevalent and these are marked by intolerance to exertion, episodes of coughing, and production of a thick sputum. Silicosis of this severity is diagnosed as "conglomerate silicosis" which is irreversible. Conglomerate silicosis incapacitates the affected worker regardless of termination of exposure.

b. Lead: Lead intoxication (plumbism) may occur via inhalation, ingestion, and/or absorption through the skin; however, the latter method of exposure is rare. Once lead has entered the body, the blood transports the lead to the various body organs as well as depositing the lead in the skeletal system.

Diagnosis of lead intoxication is difficult due to the lack of a specific sign or symptom. Symptomology of plumbism may include metallic taste in the mouth, loss of appetite, insomnia, nervousness, constipation or diarrhea, muscle tremors, weakening of the muscles, colic and loss of kidney function which may be irreversible.

c. Manganese: Inhalation of manganese dust is considered the primary method for exposure. Manganese compounds may be irritating to the upper respiratory tract; however, the workers vary in their susceptibility to the manganese compounds. Symptomology is primarily related to neurologic dysfunction manifested by sleepiness and apathy, low monotonous voice, muscular twitching in varying degree and walking with a peculiar slapping gait. Manganese produces no life shortening degeneration, but seriously poisoned individuals become neurologic cripples.

d. Copper: Inhalation of copper dust and mists of copper salts may produce congestion of the nasal mucous membranes, pharynx, and on occasion, ulceration with perforation of the nasal septum. If copper salts reach the gastrointestinal tract, they act as irritants producing nausea, vomiting, gastric pain, and diarrhea. Skin contact with copper salts may produce an itching eczema.

e. Sulfur Dioxide: Inhalation of this colorless irritant gas which has a characteristic taste and smell produces mucous membrane irritation. Symptoms of exposure may include throat irritation which may produce a cough. Additionally, exposure to SO_2 may cause eye irritation which might produce a burning sensation or lacrimation.

D. Results and Discussion

The results of personal samples for crystalline silica determinations are presented in Table I. The lowest limit of detection, for these samples, based upon x-ray diffraction analytical technique was forty micrograms per cubic meter. The silicon dioxide concentrations were measured to be less than the lowest limit of detection. Consequently, the acronym N.D. (non-detectable) was annotated for each concentration value. General work area sample results in which the filters were analyzed colorimetrically are presented in Table II. Although the analytical method detected free silica in concentrations ranging from less than 0.01 milligrams per cubic meter (mg/M^3) to 0.02 mg/M^3, the levels measured during the period of this survey were below the recommended standard.

It should be heeded that there is no recommended silica standard for area samples; however, area samples are a good indication of general environmental conditions in addition to the evaluation of environmental engineering controls.

Personal and area samples were analyzed for inorganic metals (lead, iron oxide, manganese and copper) and for total nuisance dust. The results are presented in Table III and Table IV. All of these heavy metals were analyzed via atomic absorption analytical method; however, the metallic environmental concentrations monitored during the dates of this survey did not exceed the recommended standards.

Sampling for various gases was accomplished using gas detector tubes. The results of this survey are presented in Table V. NIOSH certified gas detector tubes identified sulfur dioxide levels which ranged from 2.5 parts of contaminant per million parts of air by volume (ppm) to 10. ppm. Sampling for SO_2 was primarily performed in crane cab #2. As previously mentioned, crane #2 is basically used to transport slabs to the furnace charging table. The greatest SO_2 exposure was found to occur when the crane was situated directly above the furnace charging area. The majority of slabs which the NIOSH survey team observed to be used ranged in thickness from 5 inches to 7 inches. The NIOSH investigators rode in both crane cabs in order to determine worker exposure to gases. As the NIOSH investigators climbed the ladder to the crane, both investigators began to experience a tightness in the chest area. Once crane #2 started to transport the slabs from the slab yard or conditioning dock to the furnace charging table, the investigators experienced several or all of the following symptoms: irritation to the throat which produced a coughing response, a burning sensation to the eyes, and a fluid discharge from the nose. All of these symptoms ceased once the investigators left the crane cab level.

A summary of the employees non-directive medical questionnaires indicate that eight of nine employees experienced some type of physical irritation. About six of the nine employees interviewed indicated that they exhibited one or more of the following symptoms upon exposure to dusts which include: cough, expectoration of dusts daily, sinus difficulty, and dry mouth. Approximately six of the nine employees plus the two NIOSH investigators experienced one or more of the listed symptoms when exposed to sulfur dioxide, and these symptoms are as follows: throat irritation, cough, burning sensation of the eyes, and fluid discharge from the nose.

V. RECOMMENDATIONS

Whenever possible, engineering controls are the preferred method for decreasing environmental exposure to toxic substances for the protection of the employees health. The recommendations cited below are of the temporary type which may be implemented immediately until such time that engineering controls can be provided. These recommendations are contained in the NIOSH criteria document[2] relative to sulfur dioxide exposure.

A. Medical

1. Comprehensive preplacement and annual medical examinations should be provided for employees exposed to sulfur dioxide. Examination should evaluate eye and cardiopulmonary system; special attention should be directed towards complaints of mucous membrane irritation and cough.

2. Initial examination for workers shall be offered within 6 months of the promulgation of a standard.

3. Medical records shall be maintained for employees working one or more years in environments involving exposure to sulfur dioxide. X-rays for the 5 years preceeding termination of employment plus all other medical records shall be maintained 20 years after a workers' employment is terminated.

4. A medical evaluation should be performed on employees assigned duties using respirators in order to insure compatibility.

B. Respirator Use

1. The employer shall measure the atmospheric concentration of SO_2 in order to determine the type of respirator necessary.

2. The employer shall initiate a respirator protection program meeting the requirements described in the Occupational Safety and Health Administration Standard, Title 29 of the Code of Federal Regulations, Part 1910, Section .134. (See Table VI extracted from the sulfur dioxide criteria document date 1974.)

3. Respirators approved under provisions of 30 CFR 11 and published in the Federal Register, volume 37, page 6244 dated March 25, 1972, are the only type to be used.

4. Employees shall be instructed how to use respirators assigned to them, clean respirators, and leak test respirators.

C. It is recommended that the company industrial hygiene section monitors the crane cabs sulfur dioxide levels. More specifically, SO_2 levels should be measured and compared to the various thickness of slabs that are pushed through the furnace. On the dates of this survey, the 5-7 inch thick slabs were the only slabs observed.

D. It is recommended that several louvers be installed along the entire south wall of the slab yard operation. This will help alleviate dust and sulfur dioxide gas generated at the scarfing dock. Additionally, the sulfur dioxide gas generated at the furnace will be vented outside.

E. It was reported that high carbon steel slabs generate more yellow smoke than low carbon steel slabs. Ergo, it is recommended that the company industrial hygiene section monitor this operation.

F. The #6 crude oil should be monitored periodically for the presence of Benzene.

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VII. REFERENCES

1. Criteria for a Recommended Standard ... Occupational Exposure to Crystalline Silica, (1974), HEW Publication No. (NIOSH) 75-120.

2. Criteria for a Recommended Standard ... Occupational Exposure to Sulfur Dioxide (1974), NIOSH, CDC, PHS, DHEW.

3. P&CA Method No. 173, NIOSH Manual of Analytical Methods, HEW Publication No. (NIOSH) 75-121, (1974).

4. P&CA Method No. 106, NIOSH Manual of Analytical Methods, HEW Publication No. (NIOSH) 75-121, (1974).

5. P&CA Method No. 109, NIOSH Manual of Analytical Methods, HEW Publication No. (NIOSH), 75-121.

6. Documentation of Threshold Limit Values, ACGIH, 3rd Ed., Cinti. Ohio, 1971.

7. Patty, F.A. Industrial Hygiene and Toxicology, Second Revised Ed., Vol. II, Interscience Publishers, New York, 1967.

8. Encyclopedia of Occupational Health and Safety, International Labor Office, McGraw-Hill Book Co., New York, 1971.

TABLE I
Summary of Personnel Silica Concentration Data
Inland Steel Corporation
East Chicago, Indiana
January 18 and 19, 1977

Date	Sample Number	Job Classification	Period	Volume (m^3)[1]	Respirable Particulate (mgs)[2]	Quartz (mg/M^3)[3]	Cristobalite (mg/M^3)
1/18/77	PV 918	Scarfer	0750-1435	0.69	0.25	N.D.[4]	N.D.
1/18/77	PV 913	Scarfer	0755-1440	0.69	0.05	N.D.	N.D.
1/18/77	PV 1005	Craneman	0757-1450	0.65	1.00	N.D.	N.D.
1/18/77	PV 909	Craneman	0800-1350	0.59	0.62	N.D.	N.D.
1/18/77	PV 912	Craneman	0815-1305	0.49	0.45	N.D.	N.D.
1/18/77	PV 919	Stocker Recorder	0815-1337	0.55	0.19	N.D.	N.D.
1/18/77	PV 902	Recorder, Inspector, Helper	0740-1439	0.71	0.13	N.D.	N.D.
1/18/77	PV 910	Inventory Clerk	0744-1407	0.65	0.20	N.D.	N.D.
1/19/77	PV 900	Scarfer	0735-1510	0.77	0.52	N.D.	N.D.
1/19/77	PV 907	Scarfer	0730-1510	0.78	0.52	N.D.	N.D.
1/19/77	PV 916	Craneman	0745-1456	0.73	0.09	N.D.	N.D.
1/19/77	PV 899	Craneman	0715-1400	0.69	0.18	N.D.	N.D.
1/19/77	PV 903	Craneman	0729-1400	0.66	0.61	N.D.	N.D.
1/19/77	PV 908	Stocker, Recorder	0745-1345	0.61	0.15	N.D.	N.D.
1/19/77	PV 905	Recorder, Inspector, Helper	0730-1440	0.73	0.28	N.D.	N.D.
1/19/77	PV 906	Inventory Clerk	0850-1436	0.59	0.23	N.D.	N.D.
1/19/77	PV 904	Blank	Ø	0.00	Ø	-----	---
1/19/77	PV 915	Blank	Ø	0.00	Ø	-----	

1) m^3 - volume of air sampled is expressed in cubic meters.
2) mgs - Weight of contaminant is expressed in units of milligrams.
3) mg/M^3 - milligrams of contaminant per cubic meter of air
4) N.D. - none detected. The lowest limit of detection for Quartz and Cristobalite is 40 micrograms per cubic meter (40 ug/M^3)

TABLE II
Summary of Work Area Silica Concentration Data
Inland Steel Corp.
East Chicago, Indiana
January 18 & 19, 1977

Date	Sample Number	Location	Period	Volume (m^3)[1]	Total Particulate (mgs)[2]	SiO_2[3] (mgs)	SiO_2 (mg/M^3)[4]
1/18/77	PV 489	Area Sample of Scarfing Operation (Total Dust)	0948-1453	2.70	7.29	0.06	0.02
1/18/77	PV 502	Area Sample of Scarfing Operation (Respirable Dust)	0900-1453	3.20	3.50	N.D.[5]	N.D.
1/19/77	PV 473	Area Sample of Scarfing Operation (Total Dust)	0715-1500	4.14	24.77	0.10	0.02
1/19/77	PV 527	Area Sample of Scarfing Operation (Respirable Dust)	0715-1500	4.23	6.56	N.D.	N.D.

1) m^3 - volume of air sampled is expressed in terms of cubic meter.
2) mgs - weight of contaminant is expressed in units of milligrams.
3) SiO_2 - this acronym is used to identify free silica.
4) mg/M^3 - units are expressed as milligrams of particulate per cubic meter of air.
5) N.D. - none detected

TABLE III
Metallic Particulate Concentration Measured in the Breathing Zone
Inland Steel Corp.
East Chicago, Indiana
January 18 & 19, 1977

Date	Sample Number	Job Classification	Sampling Period	Sampling Volume(m^3) [1]	Airborne Concentration - (mg/M^3) [2] Total Particulate	Iron Oxide	Lead	Manganese	Copper
1/18/77	V 2345	Scarfer	0750-1435	0.61	1.6	0.8	0.004	0.008	0.005
1/18/77	V 2327	Scarfer	0755-1440	0.61	2.2	1.2	0.003	0.012	0.007
1/18/77	V 2346	Stocker, Recorder	0815-1338	0.49	1.6	0.7	0.005	0.006	0.004
1/18/77	V 2325	Recorder, Inspector, Helper	0740-1439	0.63	1.7	0.8	0.004	0.006	0.004
1/18/77	V 2317	Inventory Clerk	0744-1407	0.56	1.3	0.5	0.004	0.004	0.003
1/19/77	V 2339	Scarfer	0735-1510	0.68	2.6	1.6	0.004	0.011	0.007
1/19/77	V 2310	Scarfer	0730-1510	0.69	2.2	0.9	0.006	0.005	0.005
1/19/77	V 2341	Stocker, Recorder	0745-1456	0.64	0.5	0.1	0.004	0.003	0.002
1/19/77	V 2354	Recorder, Inspector, Helper	0730-1440	0.64	1.5	0.7	0.004	0.005	0.002
1/19/77	V 2323	Inventory Clerk	0850-1436	0.52	2.0	0.8	0.005	0.005	0.004

Limits of Detection:
Iron Oxide - $0.005_3 mg/M^3$
Lead - 0.0025 mg/M^3
Manganese - 0.002 mg/M^3
Copper - 0.0015 mg/M^3

1) m^3 - volume of air is expressed in cubic meters.
2) mg/M^3 - milligrams of contaminant per cubic meter of air.

TABLE IV
Metallic Particulate Concentration Measured in Work - Area
Inland Steel Corporation
East Chicago, Indiana
January 18 and 19, 1977

Date	Sample Number	Location	Sampling Period	Sampling Volume (M^3)[1]	Airborne Concentration (mg/M^3)[2] Total Particulate	Iron Oxide	Lead	Manganese	Copper
1/18/77	V 2932	Charging Area Near Furnance (Total Dust)	1006-1457	2.59	2.1	1.0	0.002	0.009	0.006
1/18/77	PV 498	Charging Area Near Furnance (Respirable Dust)	1006-1457	2.62	1.2	0.5	0.002	0.005	0.005
1/19/77	PV 482	Charging Area Near Furnance (Total Dust)	0715-1515	4.27	1.9	0.8	0.004	0.006	0.004
1/19/77	PV 548	Charging Area Near Furnance (Respirable Dust)	0715-1515	4.32	1.2	0.5	0.004	0.004	0.004
1/19/77	V 2335	Crane Cab # 1	0835-1505	0.58	2.8	1.1	0.004	0.004	0.006
1/19/77	V 2353	Crane Cab # 2	0830-1505	0.59	2.7	1.2	0.004	0.006	0.007
1/19/77	V 2351	Blank	Ø	Ø	0.03	N.D.[3]	N.D.	N.D.	N.D.
1/19/77	V 2318	Blank	Ø	Ø	0.03	N.D.	N.D.	N.D.	N.D.

1) M^3 - volume of air is expressed in cubic meters.
2) mg/M^3 - milligrams of contaminant per cubic meter of air by volume.
3) N.D. - none detected

TABLE V

Summary of Data Collected Using Chemical Indicator Tubes
Inland Steel Corporation
East Chicago, Indiana
January 18 and 19, 1977

Date	Time	Location	Contaminant	Type Sample	Concentration (ppm)[4]
1/18/77	11:05	Crane Cab #2 (CC#2) Above Charging Area	Carbon Monoxide	B.Z.[1]	7.0
1/18/77	11:05	" " " " " " "	Carbon Monoxide	B.Z.	10.0
1/18/77	11:15	" " " " " " "	Ammonia	B.Z.	N.D.[5]
1/18/77	11:15	" " " " " " "	Ammonia	B.Z.	N.D.
1/18/77	11:20	" " " " " " "	Ozone	B.Z.	N.D.
1/18/77	11:20	" " " " " " "	Ozone	B.Z.	N.D.
1/18/77	11:30	" " " " " " "	Formaldehyde	B.Z.	N.D.
1/18/77	11:30	" " " " " " "	Formaldehyde	B.Z.	N.D.
1/18/77	11:35	" " " " " " "	Phenol	B.Z.	N.D.
1/18/77	11:35	" " " " " " "	Phenol	B.Z.	N.D.
1/18/77	11:45	" " " " " " "	Hydrogen Cyanide	B.Z.	N.D.
1/18/77	11:45	" " " " " " "	Hydrogen Cyanide	B.Z.	N.D.
1/19/77	12:45	CC#2 Over Scarfing Area	Sulfur Dioxide	B.Z.	2.5
1/19/77	13:00	CC#2 Moving From Slab Area to Furnace	Sulfur Dioxide	B.Z.	3.0
1/19/77	13:10	CC#2 Above Furnace	Sulfur Dioxide	B.Z.	7.0
1/19/77	13:20	" " "	Sulfur Dioxide	B.Z.	10.0
1/19/77	13:30	" " "	Sulfur Dioxide	B.Z.	8.0
1/19/77	13:40	Platform Overlooking Scarfing Area	Sulfur Dioxide	A[2]	0.5
1/19/77	13:50	CC#2 as it moves along length of Slab Yard	Sulfur Dioxide	A.I.[3]	4.0
1/19/77	14:00	" " " " " " " " "	Sulfur Dioxide	B.Z.	5.0
1/19/77	12:45	CC#2 Over Scarfing Area	Nitrogen Dioxide	A.I.	0.25
1/19/77	13:00	" " " "	Nitrogen Dioxide	A.I.	0.25
1/19/77	13:10	CC#2 Over Furnace Area	Nitrogen Dioxide	A.I.	0.25
1/19/77	13:20	" " " "	Nitrogen Dioxide	A.I.	0.50
1/19/77	13:25	" " " "	Hydrogen Chloride	A.I.	N.D.
1/19/77	13:30	" " " "	Hydrogen Chloride	A.I.	N.D.

Limits of Sensitivity

Contaminant	Lower Range of Measurement
Carbon Monoxide	5.0 ppm
Ammonia	5.0 ppm
Ozone	0.05 ppm
Formaldehyde	0.5 ppm
Phenol	5.0 ppm
Hydrogen Cyanide	2.0 ppm
Sulfur Dioxide	1.0 ppm
Nitrogen Dioxide	5.0 ppm
Hydrogen Chloride	1.0 ppm

1) B.Z. - breathing zone sample of worker
2) A - area sample
3) A.I. - area sample collected by Inland Steel Corporation Industrial Hygienist
4) ppm - parts of a contaminant per million parts of air by volume
5) N.D. - not detected

TABLE VI

REQUIREMENTS FOR RESPIRATOR USAGE

Multiples of TWA Limit	Respirator Type
Less than or equal to 10x	(1) Chemical cartridge respirator for sulfur dioxide with quarter, half, or full facepiece.
	(2) Type C supplied air respirator, demand type (negative pressure), with quarter or half mask facepiece.
Less than or equal to 100x	(1) Gas mask with chin style canister for acid gases.
	(2) Gas mask with front or back mounted chest type canister for acid gases.
	(3) Type C supplied air respirator, demand (negative pressure); pressure-demand; or continuous flow type with full facepiece.
	(4) Self-contained breathing apparatus in demand mode (negative pressure) with full facepiece.
Greater than 100x	(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure).
	(2) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply.
Emergency (No concentration limit)	(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure).
	(2) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply.
Evacuation or escape (No concentration limit)	(1) Self-contained breathing apparatus in demand or pressure-demand mode (negative or positive pressure).
	(2) Gas mask with acid gas chest canister, and mouthpiece respirator.