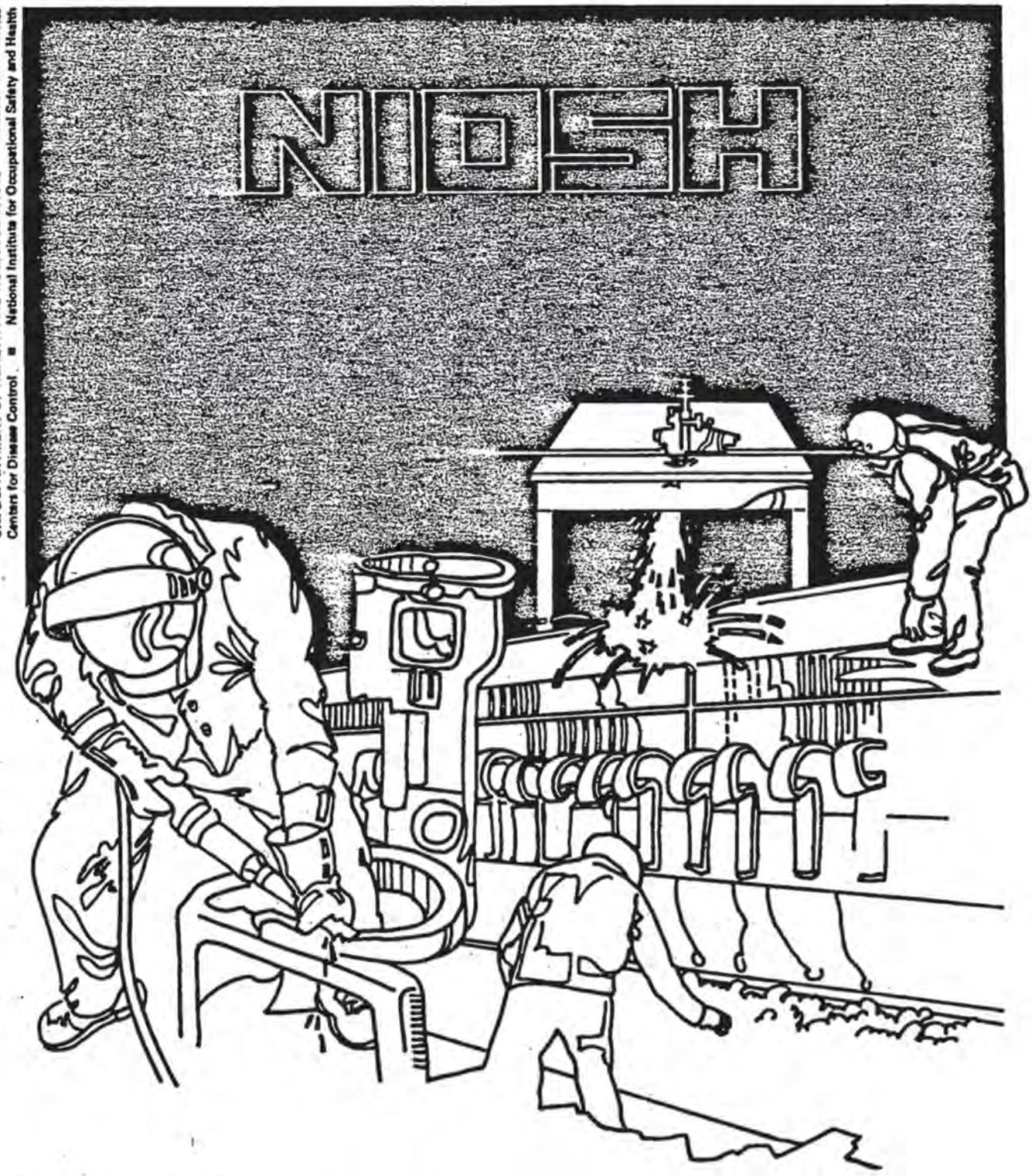
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-450-1378
INLAND STEEL COMPANY
EAST CHICAGO, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 81-450-1378
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INLAND STEEL COMPANY
EAST CHICAGO, INDIANA

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I. SUMMARY

On September 31, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate employee complaints of dry nose, dry mouth, and eye irritations associated with a clay-like substance (Narcarb 85P®) being used during the rebuilding of continuous casting troughs at the #7 blast furnace of the Inland Steel Company, East Chicago, Indiana.

On April 29, 1982, NIOSH investigators conducted an initial survey visit during which a walk-through inspection of the facility was conducted. On July 27 and July 30, 1982, follow-up environmental surveys of the facility were conducted during which general area and personal breathing zone air samples were collected for formaldehyde, phenol, and crystalline silica. Air samples collected for formaldehyde were all below the average blank value of 5.03 micrograms formaldehyde per sample, the limit of detection was 3.60 micrograms formaldehyde per sample. Personal sampling for phenol collected near the workers' breathing zone showed an eight-hour time weighted average (TWA) concentration of 0.02 parts per million (ppm) on July 27, and an eight-hour TWA concentration of 0.26 ppm on July 30, 1982. A general area sample collected on July 30, showed an eight-hour TWA concentration of 0.07 ppm of phenol. The current Occupational Safety and Health Admininistration (OSHA) standard for phenol is 5 ppm averaged over an eight-hour work shift. This may also be expressed as 19 milligrams phenol per cubic meter of air (mg/M^3). NIOSH has recommended that the permissible exposure limit be changed to 20 mg/M^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/M^3 averaged over a 15-minute period.

Samples collected for crystalline silica showed no detectable quantities of either quartz or cristobalite therefore, results are compared to the nuisance dust particulate standard. The current OSHA standard for nuisance dust particulates is 15 mg/M^3 (total dust), and 5 mg/M^3 (respirable dust) as an eight-hour TWA. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 10 mg/M^3 for total dust. Personal breathing zone air sampling revealed an eight-hour TWA respirable dust concentration of 1.09 mg/M^3 and 0.31 mg/M^3. A high volume general area sample showed a concentration of 0.86 mg/M^3 over a half shift [4-hour TWA - 0.66 mg/M^3].

On the basis of the data collected in this study, NIOSH has concluded that a health hazard did not exist at this plant due to exposure to airborne formaldehye, phenol, or crystalline silica during the rebuilding of the continuous casting troughs at the #7 blast furnace. Recommendations are contained in the full body of this report.

KEYWORDS: SIC 3312 [Blast Furnace (Including Coke Ovens), Steel Works, and Rolling Mills], continuous casting, formaldehyde, phenol, silica.

II. INTRODUCTION

On September 31, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation at the Inland Steel Company, East Chicago, Indiana. The request noted employee complaints of dry nose, dry mouth, and eye irritations, during the relining and curing of continuous casting troughs of the #7 blast furnace.

Following receipt of the request, information about the product being used in the lining of the troughs was obtained from the manufacturer. On April 29, 1982, NIOSH investigators conducted an initial visit which consisted of an opening conference and a walk-through inspection of the cast house of the #7 blast furnace. On July 27, and July 30, 1982, a follow-up environmental survey was conducted during which environmental sampling was conducted to determine employee exposures to formaldehyde, phenol, and crystalline silica.

III. BACKGROUND

A. Plant Production

This facility is engaged in the iron and steel making industry. The essential feature in the production of iron is the blast furnace where iron ore is melted (reduced) to produce pig iron. The furnace is charged from the top with iron ore, coke and limestone; hot air is blown in from the bottom, and the carbon monoxide produced from the coke transforms the iron ore into pig iron containing carbon (the limestone acts as a flux). At a temperature of about 1600° centigrade the pig iron melts and collects at the bottom of the furnace and the limestone combines with impurities to form slag. The furnace is tapped regularly and the pig iron may then be poured into pigs for later use, e.g. in foundries, or into ladles where it is transferred, still molten, to the steelmaking plant.

This continuous casting operation utilizes four tapholes which are located around the perimeter of the base of the blast furnace. The four tapholes and trough systems are rotated so that at least two are operational at any time. Iron and slag flow through the tapholes down the trough system to a skimmer box where the slag is separated from the iron, iron flows down one trough system where it is poured into railcars for transport to other steel making processes. The slag flows down a separate trough to the outside of the building where it cools and is then hauled away.

B. Relining of troughs

A clay plug is placed via remote controlled equipment into one of the four tapholes to seal the taphole so that the trough systems can be repaired after several days of cooling. Steel coverings over the

trough systems are removed by use of remote controlled overhead cranes, employees are also required to help guide the coverings. Approximately six employees are engaged in the stripping and relining of the trough system and rotate among the various jobs of stripping the old refractory liner, filling the troughs with new sacks of Narcarb®, and pounding the refractory (Narcarb®) filler.

The old refractory lining is stripped away using pneumatic chipping equipment, both hand held and mobile, exposing the brick lining of the trough. Eighty pound sacks of Narcarb® are emptied into the trough and evenly spread over the bottom and pounded. A steel mold is then placed in the trough, sacks of Narcarb® are emptied into the space between the sides of the trough and the mold and pounded with a hand helded pneumatic hammer. The steel molds are removed and the trough lining (Narcarb®) is heated and cured for 2 to 4 days. During the heating and curing process the repairmen are assigned to work in other areas of the blast furnace, stripping and relining one of the other four troughs. After the curing time, the troughs are ready for use and are usable for a period of approximately 10 to 12 days before the relining process is again necessary.

IV. EVALUATION DESIGN AND METHODS

During the initial survey visit of April 29, 1982, an opening conference was held. Detailed discussions focused on process description, engineering controls, medical surveillance monitoring, person protective equipment, work practices, and environmental monitoring to be conducted in the cast house of the #7 blast furnace.

The environmental evaluation conducted on July 27, 1982, consisted of general area and personal breathing zone air sampling for crystalline silica to assess employee exposures during the stripping of the old refractory lining from the trough system and general area and personal breathing zone air sampling to assess employee exposures to formaldehyde and phenol during the relining of the trough system. The environmental evaluation of July 30, 1982, consisted of general area and personal breathing zone air sampling for formaldehyde and phenol to assess the effect of heat upon the decomposition and release of formaldehyde and phenol from the organic binder in the refractory compound (Narcarb®).

Air sampling for formaldehyde was conducted using solid sorbent tubes (Supelco Inc., XAD-2 Resin Formaldehyde Tubes®) attached via TYGON® tubing to battery powered sampling pumps operating at approximately 50 cubic centimeters per minute (ccpm). Personal exposures were obtained by placing the sampling media near the workers' breathing zone. The samples were analyzed using gas chromatography in accordance with NIOSH P&CAM No. 354 (modified).[1] The duration, location, and other information pertinent to sample collection are presented in Table 1.

Air samples for phenol were collected using midget bubblers attached to battery powered pumps operating at a flow rate of 1.0 liter per minute

(lpm). The collecting media was 15 millimeters of 0.1 N sodium hydroxide solution. The samples were analyzed using gas chromatography in accordance with NIOSH Analytical Method No. S330.[2]

Respirable dust sampling for crystalline silica was performed near the worker's breathing zone on FWSB filters (37 millimeter, low ashing, polyvinyl chloride filters with a 5.0 micron pore size) using a battery powered pump operating at 1.7 lpm, attached via TYGON® tubing to a two stage, 10 millimeter nylon cyclone. The samples were analyzed in accordance with NIOSH P&CAM 259 (modified). [3]

One high volume respirable dust sample was collected from the employees' work area. This sample was collected via a 1/2 inch metal cyclone connected to a filter holder cassette containing a PVC filter (37 mm, low ashing, polyvinyl chloride, with a 5.0 micron pore size) attached to a nonpulsating flow pump operating at 9 liters per minute for a period of approximately 4 hours (1/2 shift).

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) occupational health standards. Often, the NIOSH recommendation and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may

be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

A. Formaldehyde

The current OSHA standard for formaldehyde is 3 parts formaldehyde per million parts air (ppm) averaged over an eight-hour work shift.[4] The ACGIH recommends that exposure to formaldehyde be limited to 1 ppm as a ceiling limit.[5]

Since recent studies have found that formaldehyde is carcinogenic in rodents, NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen and that it is prudent to reduce exposures to the lowest feasible levels.[6] Formaldehyde is an irritating substance that can cause respiratory, mucous membrane, and skin irritation, as well as sensitization dermatitis. Safe levels of carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure; therefore, it is prudent to reduce exposures to the lowest feasible limit.[6]

B. Phenol

The current OSHA standard for phenol is 5 ppm averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of phenol per cubic meter of air (mg/M^3). NIOSH has recommended an exposure limit of 20 mg/M^3, averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/M^3 averaged over a 15-minute period.[7] The ACGIH recommends that exposure to phenol be limited to 5 ppm as an eight-hour TWA and a short term exposure limit (STEL) of 10 ppm, the ACGIH also notes the potential to overall exposure by the cutaneous route, including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substance.[5]

Phenol can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. Systemic effects may occur from any route of exposure, especially after skin contact. Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark unine, mental disturbances, and possibly a skin rash. Liver

damage and discoloration of the skin may occur. Phenol in the vapor form is an irritant to the eyes, mucous membranes, and skin; systemic absorption causes central nervous system effects as well as liver and kidney damage. Sudden collaspe is characteristic of gross overexposure. Reports of the odor threshold for phenol have varied from 0.3 ppm to 5 ppm.[7]

C. Nuisance Dust Particulates

In contrast to fibrogenic dusts which cause scar tissue to be formed in the lungs when inhaled in excessive amounts, so-called "nuisance" dusts are stated to have little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. The nuisance dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lung when inhaled in sufficient amount. However, the lung-tissue reaction caused by inhalation of nuisance dusts has the following characteristics: (1) The architecture of the air spaces remains intact; (2) Collagen (scar tissue) is not formed to a significant extent; and (3) The tissue reaction is potentially reversible.

Excessive concentrations of nuisance dusts in workroom air may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears and nasal passages, or cause injury to the skin or mucous membranes by chemical or mechanical action, per se, or by the rigorous skin cleansing procedures necessary for their removal. The American Conference of Governmental Industrial Hygienists recommends a threshold limit value (TLV) of 10 milligrams per cubic meter of air (mg/M^3) for an 8-hr TWA for total dust[8]. The OSHA standard is 15 mg/M^3 for an 8-hr TWA[5].

VI. RESULTS AND CONCLUSION

Results of both general area and personal samples collected near the breathing zones of the repairmen showed formaldehyde levels below the average blank values of 5.03 micrograms (ug) of formaldehyde per sample. The detection limit for these analyses was 3.60 ug formaldehyde/sample. The sample results have been corrected of the average blank value. The results of the analysis are given in Table I.

Results of general area sampling for phenol showed a concentration of 0.09 ppm for the time sampled and an 8-hour TWA of 0.07 ppm. Personal samples collected near the breathing zone of the repairmen showed concentrations of 0.08 ppm (8-hour TWA - 0.02 ppm) and 0.43 ppm (8-hour TWA - 0.26 ppm). The personal sample showing the highest concentration was collected on the second day of sampling (7/30/82) during the repair of the section of trough nearest the blast furnace, indicating that the effect of heat upon the refractory lining (Narcarb®) was to increase the amount of phenol released. The material safety data sheet supplied by the company notes that phenol may be detected in trace quantities when the Narcarb® is subjected to heat.

Results of one high volume general area sample and two personal samples collected showed no detectable quantities of either quartz or cristobalite therefore, the results were compared to the OSHA standard for nuisance dust particulates (respirable) and the ACGIH-TLV for nuisance dust particulates. Personal samples collected near the workers' breathing zone showed total respirable dust concentrations of 0.38 mg/M^3 (8-hour TWA - 0.31 mg/M^3) and 1.31 mg/M^3 (8-hour TWA - 1.09 mg/M^3). One high volume general area sample was collected over a period of 4 hours (1/2 shift) and showed a concentration of 0.86 mg/M^3 (4-hour TWA - 0.66mg/M^3).

On the basis of the data collected in this study it has been concluded that a health hazard due to airborne formaldehyde, phenol, or crystalline silica did not exist at the time of this study. The repairmen involved in the operation (relining of the continuous casting troughs) were not exposed in excess of the OSHA permissible exposure limit, the NIOSH recommended standard, or the ACGIH Threshold Limit Values; however, this does not preclude the possibilty of increased exposures under conditions (e.g. increased-trough temperature, longer duration of exposure, etc.) other than those present during the evaluation.

Although personnel are not present in the area during the heating and curing of the refractory compound there is the potential for the production and release of coal tar pitch volatiles (some of which have been demonstrated to be carcinogenic) any time organic materials are being burned at high temperatures. Therefore, this potential problem should be investigated by the company.

VII. RECOMMENDATIONS

1. Empty sacks of Narcarb® should be properly disposed of and not placed in operational troughs to burn as was observed, to prevent the release of any decomposition products.

2. The continuous casting troughs should be allowed to adequately cool prior to the stripping and relining process to prevent personal exposures to any decompostion products of the refactory lining (Narcarb®).

3. The company should continue to periodically monitor the area for carbon monoxide.

4. Eating, drinking, and smoking should be prohibited in the area and should be allowed only at designated lunch and break areas.

VIII. REFERENCES

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4. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

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IX. AUTHORSHIP

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1. Inland Steel Company
2. North American Refractories Corporation
3. Requestor
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5. HETAB File
6. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table I

General Area and Personal Breathing Zone Air Concentrations of Formaldehyde

Inland Steel Company
East Chicago, Indiana

July 27 & 30, 1982

Sample Date	Sample Location	Sampling Time (Minutes)	Formaldehyde Conc. (micrograms)
7/27/82	Repairman #1	237	< avg. blank
"	"	139	< avg. blank
"	"	Total 376 min.	Total Conc. < avg. blank
"	Blank	-0-	5.03*
7/30/82	Area	369	< avg. blank
"	Repairman #2	351	< avg. blank
"	Blank	-0-	5.03*

* An average blank value of 5.03 micrograms of formaldehyde per sample was found on the blank tubes submitted for analysis. The results of the analysis of each blank tube is given. The sample results have been corrected for the average blank value.

Table II

General Area and Personal Breathing Zone Air Concentrations of Phenol

Inland Steel Company
East Chicago, Indiana

July 27 & 30, 1982

Sample Date	Sample Location	Sample Time (Minutes)	Phenol Concentration† (parts per million)	Phenol Conc. (8-hour TWA)
7/27/82	Blank	-0-	<0.01 ppm	---
"	Repairman #1	138	0.08 ppm	0.02 ppm
7/30/82*	Area	385	0.09 ppm	0.07 ppm
"	Repairman #2	289	0.43 ppm	0.26 ppm
"	Blank	-0-	<0.01 ppm	----

* Samples taken nearer to blast furnace and heat
† Concentration given is for the total sample time.

Table III

General Area and Personal Breathing Zone Air Concentrations
Nuisance Dust Particulates (respirable)

Inland Steel Company
East Chicago, Indiana

July 27, 1982

Location	Sample Time (Minutes)	Nuisance Dust Conc.† (respirable)	Nuisance Dust Conc. (8-hour TWA)
Area (trough)	183 min.	0.86 mg/M^3	0.66 mg/M^3*
Repairman #1	398 min.	0.38 mg/M^3	0.31 mg/M^3
Repairman #2	400 min.	1.31 mg/M^3	1.09 mg/M^3

† Concentration given is for total sample time
* 4 hour TWA, sample collected for less than 1/2 shift