U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
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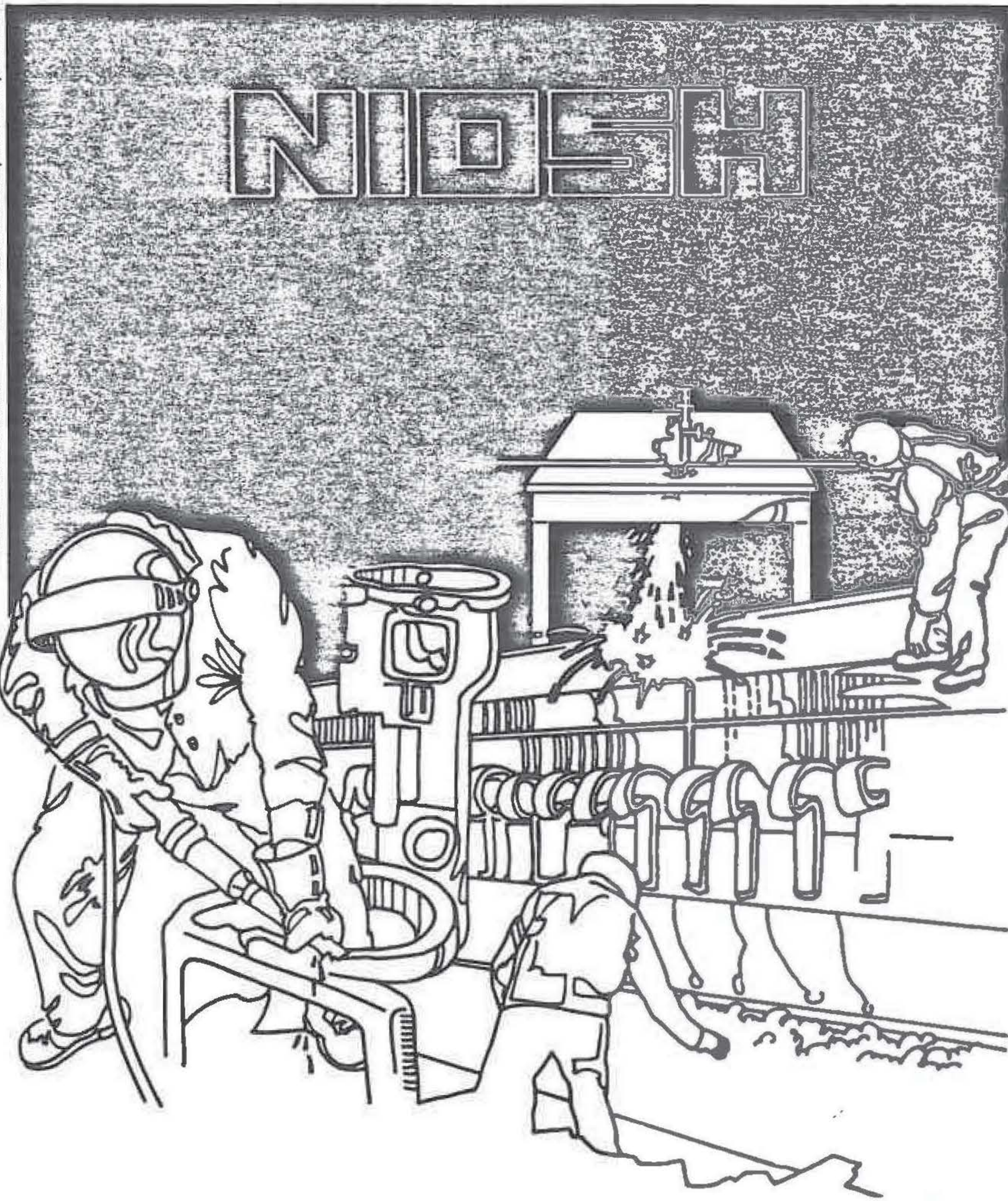

Health Hazard Evaluation Report

HETA 80-115-1401
U.S. STEEL, LORAIN-CUYAHOGA WORKS
LORAIN, OHIO

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 80-115-1401
JANUARY 1984
U.S. STEEL, LORAIN-CUYAHOGA WORKS
LORAIN, OHIO

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I. SUMMARY

In response to a May 1980 request by Local 1044 of the United Steel Workers of America, NIOSH conducted a health hazard evaluation of the Basic Oxygen Process (BOP), the C&D (mold reconditioning) area, and pouring areas of the U.S. Steel plant in Lorain, Ohio.

On five separate occasions, NIOSH personnel visited the facility in order to collect environmental data, interview workers, and conduct medical testing.

Personal air sampling data exceeding exposure levels recommended in this report are:

- 18% (5/28) of employees sampled for respirable free silica were exposed in excess of the NIOSH recommended standard of 50 ug/m^3 (range: 50-810 ug/m^3). In addition, 4% (1/28) exceeded the calculated OSHA PEL of 280 ug/m^3 (810 ug/m^3).
- 10% (4/42) of employees sampled for lead were exposed in excess of the NIOSH and OSHA standard of 50 ug/m^3 (range: 58-79 ug/m^3).
- 5% (2/42) of employees sampled for manganese were exposed in excess of the ACGIH TLV of 1000 ug/m^3 (range: 1140-1183 ug/m^3). The OSHA standard is 5000 ug/m^3, not to be exceeded at any time (ceiling).
- 12% (5/42) of employees sampled for calcium oxide were exposed in excess of the ACGIH TLV of 2000 ug/m^2 (range: 2024-5096 ug/m^3). Two percent (1/42) exceeded the OSHA standard of 5000 ug/m^3(5096 ug/m^3).
- 2% (1/42) of employees sampled for iron oxide exceeded the ACGIH TLV of 5000 ug/m^3 (value: 7400 ug/m^3). The OSHA standard is 10,000 ug/m^3.
- 54% (15/28) of employees sampled for coal tar pitch volatiles (benzene soluble fraction) were exposed in excess of the NIOSH recommended standard of 100 ug/m^3 (range: 119-276 ug/m^3). 11% (3/28) exceeded the OSHA standard of 200 ug/m^3.
- All 28 employees sampled for polynuclear aromatic hydrocarbons (PNA) were exposed to one or more of the following PNAs: benzo(a)pyrene, chrysene, pyrene, benz(a)anthracene, and fluoranthrene. The range of values were from non-detectable to 243, 945, 4100, 310, and 566 ug/m^3, respectively.

NIOSH reviewed company medical records of 163 BOP and C&D employees and performed pulmonary function tests (PFT's) on 119 workers. Blood lead concentrations among BOP personnel ranged from 1 to 32.5 ug/dL, with means of 15 in the pouring crews and 8 in the maintenance workers. (OSHA requires removal from lead exposure at blood lead concentrations >50 and permits return at <40.) One of 161 chest X-rays had findings suggestive of pneumoconiosis, and another had findings suggestive of asbestos exposure. NIOSH PFT's found 17 (14%) of 119 workers with a forced vital capacity (FVC) <80% of predicted and 24 (20%) with a one-second forced expiratory volume (FEV_1)/FVC ratio <0.7. Regression analyses revealed no significant association between years of reported silica exposure and either FEV_1/FVC or percent predicted FVC.

There is an apparently high prevalence of impaired pulmonary function in this workforce. Although we could not epidemiologically attribute this decrement to silica exposure, we were able to document silica and other dust exposures in excess of recommended exposure limits. Silica exposure data obtained from the company support this. We conclude that a health hazard from lung disease-producing dusts exists in the steel plant. Recommendations for medical monitoring and reduction of dust exposure are presented in Section V of this report.

KEYWORDS: SIC 3310 (Blast Furnaces, Steel Works, and Rolling and Finishing Mills), foundries, silica, PNAs, metal fume, coal tar pitch volatiles

II. INTRODUCTION

On May 1, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from Local Union No. 1044 of the United Steel Workers of America to evaluate possible hazards to workers health in the Basic Oxygen Process (BOP) shop, the "C&D" (mold reconditioning) area, and the pouring area at the U.S. Steel plant in Lorain, Ohio.

NIOSH has distributed four interim reports on this investigation. The purpose of this report is to present a summary of findings resulting from extensive industrial hygiene sampling, review of company medical records, and questionnaire and pulmonary function test data. Data not included herein have been explained in previous interim reports (Attachments A, B, C, and D).

The dates, purpose, and content of the four interim reports are listed below.

A. July 1980. This report contains a description of the process and areas visited during the initial walk-through survey conducted May 28-29, 1980.

B. January 1981. This report partially details the follow-up environmental survey conducted November 17-21, 1980. Personal and general area air samples were collected during the morning and afternoon shift for polynuclear aromatic compounds (PNAs), metals, total and respirable dust, respirable silica, fluorides, carbon monoxide, hydrogen sulfide, and nitrogen dioxide. Several short-term noise measurements were made also. Results of analyses of bulk samples collected during the initial walk-through survey are presented.

C. December 1981. This report describes a visit by medical personnel July 14-16, 1981. Medical records were microfilmed for detailed examination. Results of the records review and rationale for further medical evaluation of workers were presented. In addition, in a letter dated June 1, 1982, and addressed to the General Supervisor of Environmental Health, U.S. Steel, pulmonary function test data results and conclusions were presented. This information resulted from a follow-up medical visit on May 17-20, 1982.

D. August 1982. This report presents the methodology and results of the environmental sampling conducted during the follow-up visit in November, 1980. This report contains a detailed explanation of the results of all samples collected. The data presented herein has been exerpted from this August 1982 report.

III. EVALUATION CRITERIA

A. General

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 (OSHA) occupational health standards. Often, the NIOSH recommendations 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.

B. Specific Substances

1. Silica[1]

Silicosis is a form of diffuse interstitial pulmonary fibrosis resulting from the deposition of respirable crystalline silica in the lung. Conditions of exposure may affect both the occurrence and severity of silicosis. Although it usually occurs after 15 or more years of exposure, some forms with latent periods of only a few years are well recognized and are associated with intense exposures to respirable dust high in free silica. Early, simple silicosis usually produces no symptoms. However, both acute and complicated silicosis (progressive massive fibrosis) are associated with shortness of breath, intolerance for exercise, and a marked reduction in measured pulmonary function. Diagnosis is most often based on a history of occupational exposure to free silica and the characteristic appearance of chest radiograph. Respiratory failure and premature death may occur in advanced forms of the disease. Individuals with silicosis are also at increased risk of contracting tuberculosis. No specific treatment is available, and the disease may progress even after a worker is no longer exposed to silica.

NIOSH recommends that exposure to respirable free silica be controlled to levels below 50 ug/m^3 10 hour TWA regardless of the crystalline form. OSHA, on the other hand, bases its exposure standard on the crystalline form and the percent contained in the silica source. The formula for determining the exposure limit for respirable free quartz is $\frac{10\ mg/m^3}{\%\ quartz + 2}$. The formula for either cristobalite or tridymite is $1/2\ \frac{10\ mg/m^3}{\% + 2}$.

2. Lead[2]

a. Toxicological

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter whole blood are currently considered to be acceptable for occupationally exposed, non-pregnant adults. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/deciliter. Lead levels between 40-60 ug/deciliter in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-100 ug/deciliter represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/deciliter are considered dangerous and often require hospitalization and medical treatment.

The new Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/m^3 calculated as an 8-hour time-weighted average for daily exposure. The standard also dictates that workers with blood lead levels greater than 50 ug/deciliter must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 50 ug/deciliter must also be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 ug/deciliter and they can return to lead exposure areas.

3. Manganese[2]

Severe intoxication by manganese causes languor, sleepiness, weakness in the legs, emotional disturbances, and spastic gait. Dust or fume exposure can cause pneumonia. These effects were documented at levels well above the TLV. Exposure should be maintained below the TLV of 1000 ug/m^3 (8-hour TWA) and should never exceed 3000 ug/m^3 (ceiling) to prevent the occurrence of symptoms. The OSHA standard is 5000 ug/m^3 (ceiling).

4. Chromium[3] (trivalent)

Chromium compounds have been reported to cause dermatitis, ulceration of the skin, perforation of the nasal septum, eye irritation, and cancer of the lung. The 1973 NIOSH Criteria Document recommends that exposures to chromic acid be limited to a 100 ug/m^3 ceiling and a 50 ug/m^3 8-hour TWA, while the TLV for metallic and insoluble chromium compounds is 1 mg/m^3 (8-hour TWA). Metallic chromium exposure has been suggested by some investigators to cause pulmonary disease. Since the type of chromium likely to be encountered at U.S. Steel is metallic or insoluble chromium, and in the absence of data on the presence or levels of hexavalent chromium, this report will recommend adherence to the TLV of 1000 ug/m^3. The OSHA standard is also 1000 ug/m^3 (8-hour TWA).

5. Calcium Oxide[3]

Exposure to calcium oxide (lime) may cause skin and eye irritation and can be dehydrating to the skin. Since it reacts rapidly with CO_2 and H_2O to form relatively harmless calcium carbonate, it is not expected to cause health effects other than irritation. The TLV is 2000 ug/m^3 (8-hour TWA), while the OSHA standard is 5000 ug/m^3 (8-hour TWA).

6. Iron Oxide[3]

Iron oxide exposure may result in X-ray changes in the lungs after long-term exposure, a condition called siderosis, which does not progress to fibrosis. However, iron oxide exposure should not be considered harmless. Accordingly, the TLV is 5000 ug/m^3 (8-hour TWA), a level intended to prevent accumulations in the lungs. The OSHA standard is the same as the TLV.

7. Coal Tar Pitch Volatiles[3] (CTPV) and Polynuclear Aromatic Hydrocarbons (PAHs)

CTPVs generally contain large quantities of PAHs, which have been shown in both the laboratory and in industrial situations to cause lung cancer in exposed subjects. There is no known safe exposure limit for carcinogens; therefore, NIOSH recommends that exposure be limited to the extent feasible by engineering or administrative control and personal protective clothing and equipment. One way to reduce PAH exposure is to maintain CTPV exposures below 100 ug/m^3 (10-hour TWA) (NIOSH recommendation). The OSHA standard for CTPV is 200 ug/m^3 (8-hour TWA).

IV. RESULTS

A. Environmental

The environmental sampling data (i.e., that indicating overexposure) from the November 1980 industrial hygiene survey are presented here, categorized by the substance sampled.

1. Bulk sample silica polymorphs. X-ray diffraction analysis of the respirable fraction of three of five hot top preparation compounds showed 2.1 to 3.6% quartz. A sieved fiberboard sample was analyzed similarly and found to contain 75% quartz.

2. Respirable silica personal breathing zone (BZ) samples. A total of 28 respirable particulate samples were collected. Five breathing zone samples for respirable silica exceeded the NIOSH recommended exposure limit of 50 ug/m^3 (range: 50-810 ug/m^3). Three of these overexposures occurred in Pouring Area #5 and two in the C&D area. On November 24, 1982, U.S. Steel provided NIOSH (Attachment E) with further silica exposure data for BOP and C&D. These data indicated that 50% (8/16) of those employees monitored for free silica were exposed in excess of the NIOSH recommended standard (range: 51-566 ug/m^3).

3. Total and respirable particulate personal BZ samples. A total of 28 respirable and 19 total particulate samples were collected. None exceeded the ACGIH TLV of 5 mg/m^3 respirable or 10 mg/m^3 total particulate.

4. Metals and metal oxides. Forty-two personal BZ samples were collected for metal and metal oxides.

   a. Manganese. Two samples (1140 and 1083 ug/m^3) exceeded the TLV of 1000 ug/m^3. Both were collected on maintenance workers.

   b. Lead. Four samples (flux operator, 58 ug/m^3; trim station operator, 79 ug/m^3; 2 pourers, pouring area #5, 58 ug/m^3 each) exceeded the OSHA standard of 50 ug/m^3.

   c. Calcium oxide. Two samples in the flux area (flux operators, 2024 ug/m^3 and 2428 ug/m^3) and three from maintenance workers (3712, 5096, and 3892 ug/m^3) exceeded the TLV of 2000 ug/m^3.

   d. Iron oxide. One sample (maintenance worker, 7400 ug/m^3) exceeded the TLV of 5000 ug/m^3.

   Analysis for carcinogenic (Cr^{+6}) chromium was not performed.

5. Total benzene solubles and PNAs. Total benzene solubles and PNAs were found in all areas except the Trim Station, which was not evaluated. Fourteen samples (range: 138-276 ug/m^3) exceeded the NIOSH exposure criterion of 100 ug/m^3 for coal tar pitch volatiles (benzene solubles). These were located in the Pouring Floor #5 (5), Pouring Floor #1 and #2 (1), maintenance (1), operating floor (1), and mixing and skimming area (6).

   Individual PNA values (benzo(a)pyrene, benz(a)anthracene, chrysene, pyrene, and fluoranthene) ranged from nondectable up to approximately 243, 310, 945, 4100, and 566 nanograms/m^3, respectively.

B. Medical

1. Review of medical records. NIOSH reviewed company medical records of 93 (65%) of 142 workers from the BOP shop and 70 (96%) of 73 from the C&D area, for a total of 163 records.

   a. Blood lead data. Blood lead data were available for 35 (88%) of 40 members of the BOP pouring crews and 44 (90%) of 49 BOP maintenance personnel. Blood lead levels in both groups were within acceptable limits, with a mean of 15 micrograms/deciliter (ug/dL) in the pouring crews (range: 4-32.5 ug/dL) and 8 ug/dL in the maintenance workers (range: 1-18 ug/dL). The company data regarding blood lead levels (provided in the November 24, 1982 letter) for the years 1980 and 1981 indicated 92 and 95%, respectively, to be below 30 ug/dL. (OSHA requires removal from lead exposure at blood lead concentrations $\geq$50 and permits return at $\leq$40. Blood lead concentrations in adults without occupational exposure are usually well under 30 ug/dL.)

   b. Chest X-rays. One hundred sixty-one films were read by a "B" reader in accordance with the ILO/UC system for pneumoconioses.[6] Only one had lung tissue changes suggestive of pneumoconiosis (dust disease); this person worked as a grinder in a foundry prior to working at U.S. Steel. Another had had findings suggestive of asbestos exposure, but the person had been previously employed only as a clerk, with no known asbestos exposure.

c. Pulmonary function tests. Age-adjusted pulmonary function test data were available for 86 (92%) of 93 workers in the BOP shop and 57 (81%) of 70 in the C&D area. The data were divided into three categories of restrictive lung disease based on percent of predicted forced vital capacity (FVC), with the one-second forced expiratory volume (FEV_1)/FVC ratio greater than or equal to 0.7: mild, FVC 66-79% of predicted; moderate, FVC 51-65% of predicted; and severe, FVC less than 50% of predicted.

FVC (% of predicted)	Number of Employees	Average Age ± Standard Deviation	Years at Plant
	BOP Shop		
≥80	61	44+13.6	21.2+13.8
≤79	27	51+13.9	30.4+9
66-79	20	52+11.2	30+10.7
51-65	6	54+5.4	31.3+3.8
≤50	1		
	C&D Area		
>80	43	44+11.7	24.3+18.8
<79	14	48+12.8	25+13.3
66-79	9	46+15.5	21+15
51-65	5	53+4.8	32.6+2.5
≤50	0		

These data indicate that workers with low FVC tended to be older and to have been employed longer at the plant. Since the equation for predicted FVC takes age into account, it appears that the important relationship with respect to an abnormal FVC is not necessarily age, but may be duration of employment at the plant or some other factor.

In 12 (14%) of 86 BOP workers and 12 (21%) of 57 C&D workers, there was pulmonary function test evidence of obstructive or mixed obstructive/restrictive lung disease. This would be indicated by an FEV_1/FVC ratio less than 0.7 (less than 0.65 in those age 60 or older) (obstructive), or an FVC less than 80% of predicted and an FEV_1/FVC ratio less than 0.7 (mixed). In addition, one employee in the C&D area met the criterion for severe obstructive pulmonary disease (FEV_1/FVC less than 0.45).

In the BOP shop, smokers were twice as likely to have some form of pulmonary function abnormality as non-smokers, and in the C&D area, 1.9 times as likely. However, 33% of BOP workers and 46% of C&D workers with abnormal pulmonary function tests were non-smokers.

	BOP Shop (86 workers)		C&D Area (55 workers)	
	Smoker	Non-Smoker	Smoker	Non-Smoker
Obstructive	3	1	3	1
Mixed	6	2	4	4
Restrictive	17	10	7	7
TOTAL	26	13	14	12
Normal	17	30	7	22
TOTAL	43	43	21	34

2. <u>Questionnaire and spirometry survey</u>. The significance of the apparently high prevalence of pulmonary abnormalities resulting from the analysis of company data was unclear, so NIOSH decided to repeat the pulmonary function tests and administer a work and respiratory history questionnaire. FVC and FEV_1 were measured with an Ohio Medical Products Model 822 dry rolling seal spirometer attached to a Spirotech 200B dedicated computer. A test was considered adequate for interpretation only if there were three acceptable trials and the two best differed by no more than 5% with respect to both FVC and FEV_1.[7] Predicted values were calculated according to the Knudson equations[8]; the predicted values for Black persons were calculated by multiplying Knudson predicted values by 0.85.[9]

One hundred-nineteen (73%) of the original 163 workers participated in the NIOSH testing. Twenty-three (35%) of 65 workers with a history of silica exposure reported shortness of breath, as did 18 (34%) of 53 without such a history. Similarly, three (5%) of 65 silica-exposed and three (6%) of 54 unexposed workers had symptoms of chronic bronchitis (at least two years of cough productive of phlegm, on most days, at least three months of the year[10]). Regression analyses using age, pack-years of cigarette smoking, and years of reported silica exposure as independent variables revealed no significant association between years of silica exposure and either FEV_1/FVC or percent predicted FVC.

Reanalysis of the U.S. Steel data for the 119 NIOSH study participants revealed 48 (40%) with FVC less than 80% of predicted, while the NIOSH-administered pulmonary function tests indicated only 17 (14%) with a low FVC. While 19 (16%) of 119 had an FEV_1/FVC ratio less than 0.7 in the U.S. Steel testing, NIOSH retesting showed 24 (20%) of 119 with a reduced ratio. This difference is not surprising, since it is partially a function of the increased FVC's observed in the NIOSH tests. The markedly lower rate of reduced FVC in the NIOSH tests suggests that the U.S. Steel testing did not elicit maximal expiratory effort by the workers examined.

V. RECOMMENDATIONS

1. Repair/replace the baghouse pressure drop gauges on the Pouring Floor #5 platform.

2. Provide Baghouse workers and sand blast operators with air-supplied respirators and decontamination facilities.

3. Evaluate workers' noise exposures in the Flux Floor operations.

4. Search for products with lesser silica content and substitute those for the currently used fiberboard and hot top preparations. Also, continued employee monitoring for silica exposure should be performed. Unless feasible engineering controls can be provided, respiratory protection for exposed workers should be continued.

5. Routinely monitor the flux operator's exposure to contaminants eminating from the BOP shop. Evaluate his workstation and activities to determine if changes can be made to reduce his exposure. Two possibilities are better ventilation to the control booth and relocation of either the booth or the operating panel to bring the panel within the ventilation system.

6. Monitor the Trim Station activities for chromium exposure, both Cr^{+3} and carcinogenic Cr^{+6}.

7. Consider engineering control, especially exhaust ventilation, to reduce the PNA exposure to workers.

8. Continue the medical screening programs for employees exposed to potentially hazardous substances. Pulmonary function tests should be performed using standardized procedures, such as those recommended by the American Thoracic Society,[7] to ensure accurate, reproducible results.

VI. REFERENCES

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VII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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VIII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. 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. The United Steel Workers of America, Local 1044
2. Lorain-Cuyahoga Works, Lorain, Ohio
3. NIOSH, Region V
4. 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.

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