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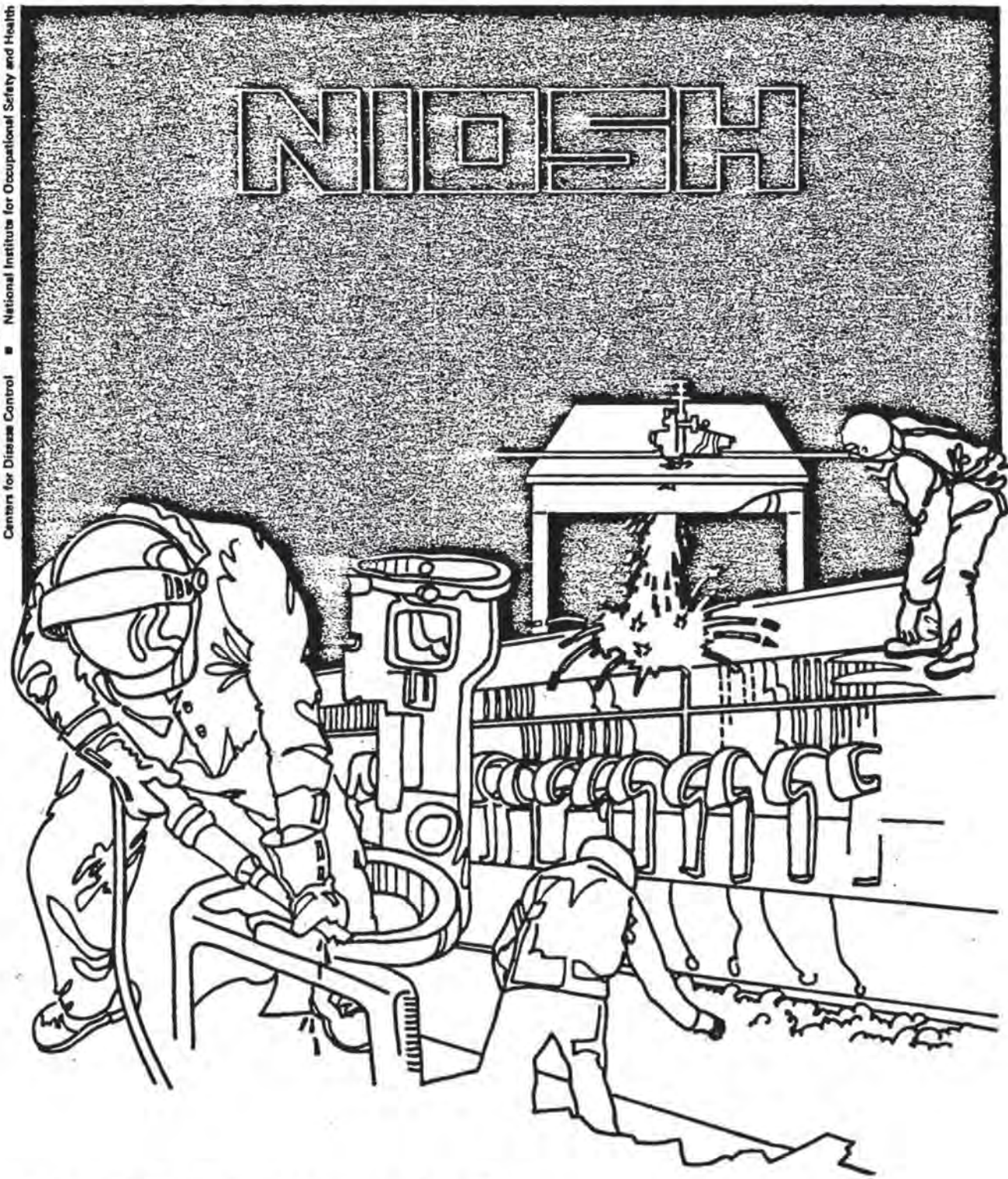

Health Hazard Evaluation Report

HETA 81-434-1404
EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, 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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO

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I. SUMMARY

In August 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate potential employee exposures to dust and fumes and reported respiratory symptoms coincident with the rolling of silicon steel at the Hot Strip Mill of the Empire-Detroit Steel Division, Mansfield, Ohio. In addition, NIOSH was asked to evaluate employee exposures to oil mist generated during the processing of the steel.

On September 15-17, 1982, NIOSH investigators conducted an initial medical survey at the plant. The medical evaluation consisted of an interviewer-directed questionnaire administered to 47 male workers who were employed on operations related to the Hot Strip Mill. Almost half (47%), of the interviewed workforce reported symptoms involving the eyes and upper respiratory system. Symptom prevalence was statistically associated with work in dusty areas. Recurrent cough was reported by 20 men (43%), and chronic bronchitis was reported by eleven men (23%). A clinical history of physician-diagnosed respiratory disease -- asthma, bronchitis, or allergy/hay fever -- which was temporally subsequent to first employment at Empire-Detroit, was reported by 18 workers (38%). Neither the presence of pulmonary symptoms nor the diagnosis of underlying pulmonary disease was statistically associated with work in a dusty area.

Hearing disorders and difficulties were reported by 20 men (43%), nineteen (40%) of them indicating recurrent episodes of tinnitus in the 12 months prior to the NIOSH investigation.

A follow-up environmental survey was performed on December 1-2, 1982. Personal breathing zone and area air samples were collected for measurement of exposure to chromium, hexavalent chromium, iron oxide fume, nickel, oil mist, respirable particulates, and total particulates. Analysis of these personal and area air samples revealed the following range of concentrations which are compared with their respective environmental criteria (EC): chromium, nondetectable (N.D.) - 0.2 mg/m^3 (EC - 0.5 mg/m^3); hexavalent chromium, 0.8-1.8 ug/m^3 (EC - 1.0 ug/m^3 NIOSH; 0.1 mg/m^3 OSHA); iron oxide fume, 0.1-0.9 mg/m^3 (EC - 5.0 mg/m^3); nickel, N.D. - 9 ug/m^3 (EC - 15 ug/m^3); oil mist, 0.05 mg/m^3 (EC - 5.00 mg/m^3); respirable particulates; 0.2-2.1 mg/m^3 (EC - 5.0 mg/m^3); and total particulates, 0.9-5.0 mg/m^3 (EC - 10 mg/m^3).

On the basis of the data obtained during this investigation, NIOSH has determined that a potential health hazard existed at the Empire-Detroit plant due to excessive hexavalent chromium levels. Eyes and upper respiratory system irritation is suggested by a high prevalence of such symptoms reported by employees in dustier work areas. Measures to reduce exposures and improve workers safety and health are recommended in Section VIII of this report.

KEYWORDS: SIC 3312 (Steel Works), upper respiratory system, chronic bronchitis, asthma, bronchitis, tinnitus, silicon steel, hexavalent chromium, Hot Strip Mill.

II. INTRODUCTION

In August 1981, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from a group of employees to conduct a health hazard evaluation at the Hot Strip Mill of the Empire-Detroit Steel Division, Mansfield, Ohio. NIOSH was requested to evaluate potential employee exposures to dust and fumes and reported respiratory symptoms coincident with the rolling of silicon steel. In addition to the above substances, NIOSH was asked to evaluate employee exposures to oil mist generated during the rolling of the steel.

The health hazard evaluation was delayed when the Cyclops Corporation refused to allow NIOSH right of entry to the plant to perform environmental and medical surveys. NIOSH obtained a Federal warrant which was honored by the Empire-Detroit Steel Division. Further delays in the environmental evaluation resulted due to the intermittent nature of silicon steel manufacturing operations.

On September 15-17, 1982, NIOSH investigators conducted an initial medical survey at the plant. A follow-up environmental survey was performed on December 1-2, 1982.

III. BACKGROUND

The Mansfield Plant, in operation since 1900, covers about 300 acres and has nearly 1400 total employees. The facility is divided into 4 divisions: Melt Shop, Hot Strip Mill, and Cold Mill.

The specific area of the request, the Hot Strip Mill, began operations in 1952 and currently employs about 120 workers total on 3 shifts. The 7 departments of the mill include: Soaking Pits, Maintenance, Hot Strip Mill, Motor Room, Coil Storage, Slab Conditioning (Slabyard), and Roll Shop. Eighty percent of the steel produced in the mill is carbon, whereas stainless and silicon make up 15 and 5 percent, respectively. Silicon steel processing runs are usually 3 hours or less and occur infrequently.

Initially, the steel ingots are transferred from the Melt Shop to one of 36 Soaking Pits (gas-fired brick ovens) on flat, open-sided rail cars. About 145 ingots are processed through the pits each shift: average weight /ingot 8 tons; and size range 21-27 inches thick, 25-54 inches wide, and 76-90 inches long. Usually 8-10 ingots are placed in each (automatically temperature controlled) pit for almost 12 hours while they are heated to nearly 2400°F. The ingots are then removed from the pits and taken, via a radio-controlled ingot buggy, to the Blooming Mill to begin the hot rolling operation.

At the Blooming Mill, the ingot is rolled under great pressure until reduced to a slab. An ingot can enter the Blooming Mill up to 26" x 56" x 76" and leave the Blooming Mill and Vertical Edging Mill three minutes later as a slab as large as 6" x 50" x 240". The ends of the slabs are then "squared" in the crop shearer before further processing.

All ingots except stainless steel ingots are rolled directly into coils. Stainless ingots are rolled into slabs, allowed to cool, and then conditioned by grinding. Grinding of the stainless slabs is done in the Slabyard where any of the three (enclosed cab) machine grinders or one manually operated hand grinder is used to remove the "outer skin" impurities. Stainless slabs vary in length from 18-22 feet, in width from 18-50 inches, and are 5-7 inches thick. Each cab of the three machine grinders is equipped with an air-conditioner which is removed during winter months. (At the time of the NIOSH survey some windows of the enclosed cabs were broken out). The machine grinder operators grind an average of 15 slabs every shift. After grinding, the stainless slabs are reheated and transferred to the Hot Strip Mill.

The six-inch thick slab of either stainless, silicon, or carbon steel, is then processed through the Two-High Reversing Roughing Mill and is reduced to a plate about one inch thick. High-pressure water descaling sprays on both entry and exit ends of the Blooming Mill and Roughing Mill remove the scale (iron oxide) from the ingot and slab and help cool the metal.

The final rolling operation in the Hot Strip Mill is at the Six-Stand Finishing Mill. The plate is rapidly passed through six separate sets of rolls. Each set of rolls runs faster than the preceding set, thereby continuously reducing the thickness of the one-inch plate to a sheet of any desired thickness between 0.071 inches and 0.500 inches, and width between 18-50 inches.

From the Six-Stand Finishing Mill the metal sheet travels down a water-quenched run-out table to one of two Downcoilers where it is coiled, marked, and placed in storage. Each coil ranges from 5-12 tons in weight and is about 1300 feet in length. An average of 140 coils/shift are wound through the downcoilers. Finished coils are either shipped or further processed at the plants Cold Mill.

All the mills in the Hot Strip Mill and both Downcoilers are remotely controlled from automated (air-conditioned) pulpits positioned above the Hot Strip Mill floor. Every enclosed-cab crane used in the Hot Strip Mill Area is air-conditioned except the Alliance crane which is primarily used at the North end of the Mill.

The Six-Stand Finishing Mill, largest of all the mills in the Hot Strip Area, is the only mill where some employees' work stations are located alongside the mill. In this case, three workers per shift, an assistant roller, finisher, and finisher-helper make periodic adjustments to the Six-Stand Mill to control metal width and thickness. A rolling mill oil is automatically dispersed on #1 and #2 Mill of the Six-Stand Mill for machine lubrication purposes on certain grades of steel.

IV. EVALUATION DESIGN AND METHODS

A. Initial Survey

1. Environmental

NIOSH investigators had anticipated collecting personal and area air samples during the initial survey, September 15-17, 1982. However, no significant silicon-rolling operations occurred during the initial survey and plans were made to coordinate the air sampling with a silicon steel production run on the follow-up visit. Activities accomplished on the initial survey included a walk-through of the Hot Strip Mill Department to obtain process information and observe work practices and conditions of exposure. Additional activities performed on the first survey included employee interviews and collection of bulk samples.

2. Medical

An interviewer-directed medical screening questionnaire was administered to 47 production workers at Empire-Detroit on September 16-17, 1982. Workers were selected from functionnally related and contiguous areas -- the slabyard, the grinding area, the motor room and the bearing room -- as well as from the Hot Strip Mill line operation. All male workers on the day and evening shifts were interviewed. Workers on the smaller night shift were excluded because work practices were redundant of the previous shifts.

Questions were directed towards basic demographic data, general medical symptoms and diagnosed health problems, work history and personal habits. There was a particular emphasis on respiratory symptoms and chronic respiratory disease. These questions were adapted from the standard American Thoracic Society (ATS) questionnaire.

In order to assess whether industrial exposure contributed to medical symptoms, the workforce was divided into non-dust exposed and dust exposed groups. The former consisted of workers from the motor and bearing rooms and all workers functioning from air-conditioned pulpits and cranes.

For purposes of analysis, all other workers were designated as exposed despite potential variability of exposure for different types of jobs, because of potential unprotected work in Hot Strip Mill operations.

B. Follow-up Survey (Environmental)

Personal breathing-zone and area air sampling was conducted in the Hot Strip Mill Division's Slabyard and Hot Strip Mill line on the follow-up survey, December 1-2, 1982, for measurement of exposure to chromium, hexavalent chromium, iron oxide fume, nickel, oil mist, respirable particulates, and total particulates. The sampling and analytical methodology for these substances, including collection device, flow rate, and referenced analytical procedures', are presented in Table I.

Air samples obtained during a silicon steel production run were taken at the Six Stand Finishing Mill, the Crop Crane Cab, Crop Tank Area, and the Alliance Crane Cab.

Two of three line operators on the Six Stand Finishing Mill refused to wear NIOSH personal sampling pumps. However, stationary area air samples were obtained by placing the samples at the operators' work stations and in a breathing-zone location. Air samples collected inside enclosed work stations (cabs of the Crop Crane and Alliance Crane on the Hot Strip Mill line and machine grinders in the slabyard) are considered as personal samples since the air samples were located in breathing-zone locations.

V. EVALUATION CRITERIA

Environmental Criteria and Toxicological Effects

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 susceptiblility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposure, 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 not usually 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 Confernece of Govermental Industrial Hygienist (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 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 exposure in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely 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 required legally 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 are recognized toxic effects from high short-term exposures.

A. Chromium

Chromium compounds can cause an allergic dermatitis in some workers. Acute exposure to chromium dust and mist may cause irritation of the eyes, nose, and throat. Chromium exists as chromates in one of three valence states: 2+, 3+, and 6+. Chromium compounds in the 3+ state are of a low order of toxicity. In the 6+ state, chromium compounds are irritants and corrosive. This hexavalent form may be carcinogenic or non-carcinogenic, depending on solubility. The less-soluble forms are considered carcinogenic. Workers in the chromate-producing industry have been reported to have an increased risk of lung cancer (Bidstrup and Case, 1956).[2] ACGIH has adopted an 8-hour TLV of 0.5 mg/m^3, for chromium (3+) compounds,[3] whereas the OSHA standard for chromium metal and insoluble salts is 1.0 mg/m^3,[4]. NIOSH's recommended standard for carcinogenic chromium (6+) compounds is 0.001 mg/m^3. NIOSH also recommends a standard of 0.025 mg/m^3 for non-carcinogenic hexavalent chromium compounds, along with a 15-minute ceiling level of 0.05 mg/m^3 [5].

B. Iron Oxide Fume

Inhalation of iron oxide fume or dust causes an apparently benign pneumoconiosis termed siderosis. Iron oxide alone does not cause fibrosis in the lungs of animals, and the same probably applies to humans. Exposures of 6 to 10 years are usually considered necessary before changes recognizable by x-ray can occur; the retained dust gives x-ray shadows that may be indistinguishable from fibrotic pneumoconiosis. In one study, eight of 25 welders exposed chiefly to iron oxide for an average of 18.7 (range 3 to 32) years had reticulonodular shadows on chest x-rays consistent with siderosis but no reduction in pulmonary function; exposure levels ranged from 0.65 to 47 mg/m^3. In another study, 16 welders with an average exposure of 17.1 (range 7 to 30) years also had x-rays suggesting siderosis and spirograms which were normal; however, the static and functional compliance of the lungs was reduced. Some of the welders were smokers. The welders with the lowest compliance complained of dyspnea.[6]

ACGIH[3] recommends an 8-hour TLV® of 5.0 mg/m^3 for iron oxide fume. The OSHA[4] standard for iron oxide fume is an 8-hour TWA of 10 mg/m^3.

C. Nickel

Metallic nickel and certain soluble nickel compounds as dust or fume cause sensitization dermatitis and probably produce cancer of the paranasal sinuses and lung;[6] nickel fume in high concentrations is a respiratory irritant. Severe but transient pneumonitis in two workers resulted from exposure to nickel fume; in one case, exposure was for six hours, and post-incident sampling suggested a nickel concentration of 0.26 mg/m^3. "Nickel itch" is a dermatitis resulting from sensitization to nickel; the first symptom is usually itching, which occurs up to seven days before skin eruption appears. The primary skin eruption is erythematous or follicular; it may be followed by superficial discrete ulcers, which discharge and become crusted; or by eczema; in the chronic stages, pigmented or depigmented plaques may be formed. Nickel sensitivity, once acquired, is apparently not lost; recovery from the dermatitis usually occurs within seven days of cessation of exposure, but may take several weeks. A worker who had developed cutaneous sensitization also developed apparent asthma from inhalation of nickel sulfate; immunologic studies showed circulating antibodies to the salt, and controlled exposure to a solution of nickel sulfate resulted in decreased pulmonary function and progressive dyspnea; the possibility of developing hypersensitivity pneumonitis could not be excluded.

In animals, finely divided metallic nickel was carcinogenic when introduced into the pleural cavity, muscle tissue, and subcutaneous tissues; rat and guinea pigs exposed to a concentration of 15mg/m^3 of powdered metallic nickel developed malignant neoplasms. Several epidemiologic studies have shown an increased incidence of cancer of the paranasal sinuses and lungs among workers in nickel refineries and factories; suspicion of carcinogenicity has been focused primarily on respirable particles of nickel, nickel subsulfide, nickel oxide, and on nickel carbonyl vapor.[6]

NIOSH's recommended standard[8] for nickel is 15 micrograms of nickel per cubic meter of air (15 ug/m^3). The ACGIH[3] TLV® and OSHA[4] standard for nickel is an 8-hour TWA of 1.0 mg/m^3.

D. Oil Mist[6]

Inhalation of mineral oil mist in high concentrations may cause pulmonary effects, although this has rarely been reported. A single case of lipoid pneumonitis suspected to have been caused by exposure to very high concentrations of oil mist was reported in 1950; this occurred in a cash register serviceman, whose heavy exposure occurred over 17 years of employment. No other cases have been recorded. Experimental animal studies to white mineral oil mist (untreated, and with no additives) for repeated daily 6-hour exposures for 1 year at 5mg/m^3 were entirely negative in all criteria used for measuring response. A similar study at 100mg/m^3 resulted in slight changes in some but not all species exposed; no histologic changes of significance were noted. Exposure to oil mist did not appear to accelerate the production of lung tumors in a lung-tumor-susceptible strain of mice. A second parallel study of sulfurized, solvent-extracted naphthenic-base oil to which animals were exposed daily at 50mg/m^3 for 18 months failed to reveal a single animal with any sort of injury or indisposition as a result of the oil mist inhalation. A review of exposures to mineral oil mist averaging 15mg/m^3 (but often higher) in several industries disclosed a striking lack of reported cases of illness related to these exposures. A study of oil mist exposures in machine shops, at mean concentrations of 3.7 mg.m^3 and maximum of 110 mg/m^3, showed no increase in respiratory symptoms or decrement in respiratory performance attributable to oil inhalation among men employed for many years. There is no evidence to suggest any relation between inhalation of oil mist and lung cancer. On the other hand, there are some reported cases of skin cancer from contact with certain oils. Contact with liquid oils may cause dermatitis.

The OSHA standard[4] and ACGIH[3] TLV® for oil mist is 5 mg/m^3.

E. Particulates and Respirable Dusts

In contrast to fibrogenic dusts which, when inhaled in excessive amounts, cause scar tissue to be formed in the lungs, so called "nuisance" dusts are stated to have little adverse effect on lungs and do not produce significant organic disease or toxic effects 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 dusts in the workroom air may seriously reduce visibility, may cause irritation of 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.(3)

Respirable dusts, called such due to their size characteristics and ability to be inhaled, include particulates with more restrictive size range parameters than total nuisance dusts. In general, particulates between 5 and about 0.5 micrometers in size are deposited in the alveoli and respiratory bronchioles and some types of dust of such sizes can cause pulmonary fibrosis. Most of the particles five micrometers and larger are collected in the upper respiratory passages. Like nuisance dusts, the overall effects of respirable particulates are dependent on their site of deposition and on their toxic and antigenic properties.(7)

OSHA's standard for inert or nuisance dusts (less than 1% crystalline silica) is 15mg/m^3 and 5mg/m^3 for respirable dusts.(4) ACGIH has a TLV of 10mg/m^3 for total dust (less than 1% quartz) and 5mg/m^3 for respirable dust.(3)

VI. RESULTS

A. Environmental

Results of the environmental air samples obtained on the follow-up NIOSH survey December 1-2, 1982, are presented in Tables II-IV. Personal breathing zone and stationary area air samples were taken for assessment of employee exposures during silicon steel rolling processes (Hot Strip Mill Line) and stainless steel grinding operations.

On the Hot Strip Mill Line iron oxide air sample results ranged from 0.1-0.9mg/m^3, well below the ACGIH[3] recommended standard of 5.0mg/m^3. Air sample values for nickel ranged from non-detectable (ND) to 8ug/m^3 or up to 53% of the NIOSH recommended standard[8] of 15ug/m^3. One airborne oil mist sample was found at 0.05mg/m^3; one hundredth of ACGIH's recommended standard[3] of 5.0mg/m^3. Air samples for total particulates revealed concentrations of 1.2mg/m^3-2.8mg/m^3, well below the ACGIH TLV[3] of 10mg/m^3. Respirable particulate levels ranged from 0.2-1.4mg/m^3, with the highest concentration being 28% of the OSHA standard[4] and ACGIH TLV[3] of 5.0mg/m^3. No airborne chromium was detected in the Hot Strip Mill Line area.

Air samples collected during stainless steel grinding operations in the slabyard were taken inside and outside the cabs of the machine grinders. Two air samples for hexavalent chromium were 0.8ug/m^3 (personal sample) and 1.8ug/m^3 (area sample). The area sample for hexavalent chromium, 1.8ug/m^3, exceeds the NIOSH criteria and the personal sample, 0.8ug/m^3, is 80% of the NIOSH recommended standard[5] of 1.0ug/m^3. Total chromium levels ranged from ND - 0.2mg/m^3 all within the ACGIH recommended standard[3] of 0.5mg/m^3 and OSHA[4] 1.0 mg/m^3 standard. Iron oxide concentrations ranged from 0.1-0.9mg/m^3 and were well below the ACGIH TLV[3] of 5.0mg/m^3. Air sample values for nickel ranged from ND - 9ug/m^3.

Of the four air samples for nickel, two were non-detectable, and the remaining two, 7 and 9ug/m^3, were 47% and 60% respectively, of the NIOSH recommended standard[8] of 15ug/m^3. Respirable particulates were found in one sample at 2.1mg/m^3, within the ACGIH recommended standard[3] of 5.0mg/m^3. Total particulate values ranged from 0.9 - 5.0mg/m^3, below ACGIH[3] TLV of 10.0mg/m^3.

During NIOSH's initial and follow-up surveys, deficiencies in work process controls were recognized. In the Slabyard, errant pieces of hot metal slag from the machine grinding on the stainless steel slabs, occasionally spewed beyond the immediate grinding area. Some areas in the Hot Strip Mill may have excessive noise levels. The fan motor for the local exhaust ventilation system provided for the #5 and #6 mills of the Six Stand Finishing Mill was not in place. Roof exhaust fans in the Hot Strip Mill, all of which were functional during NIOSH's follow-up survey, had a history of poor maintenance and some being non-operational.

B. Medical

Reported symptoms and their frequency are presented in Table V, without delineation by exposure category. Symptoms involving mucosal tissue -- the eyes and nose -- were reported in 41% and 43%, respectively of the total interviewed population. The other principal complex of symptoms are pulmonary: recurrent cough in 43% and chronic bronchitis in 23%. The other major reported symptom category involved problems with hearing. Twenty workers (43%) considered their hearing to be insufficient; nineteen of them (95%) reported problems of recurrent tinnitus in the 12 months prior to the NIOSH investigation.

To test the hypothesis that work in dustier areas might be associated with respiratory symptoms, symptom and disease prevalence were compared between workers whose jobs had a potential for dust exposure and workers who were physically segregated or protected from areas with potentially high dust levels. Demographic comparisons between workers from dust exposed and non-dust exposed areas are made in Table VI.

Demographic comparison shows that workers in the non-dusty areas are slightly older than workers in the dusty areas, although cumulative employment at Empire-Detroit (plant-years) does not differ statistically between the two groups. Current and former smokers are almost equally represented in the two groups -- 80% among the dust exposed workers, and 77% among the non-dust exposed workers. However, current and former smokers in the non-dust exposed jobs have actually smoked 1.84 times as many cigarettes as current and former smokers in the dustier jobs. These are potentially important observations because both increased age and smoking have been associated with a decline in respiratory health.(9, 10, and 11)

Because a cross-sectional analysis is confined to a static point in time and does not easily incorporate past effects, dust exposed and non-dust exposed workers were also assessed for recent changes in work location. None of the current 47 workers had transferred from an exposed to non-exposed job or from a non-exposed to exposed jobs for six years previous to the study.

In Table VII reported symptoms and adverse medical conditions are compared between workers in dust exposed and non-dust exposed jobs. Eye and nasal irritation were statistically associated with work in a dustier job ($p<0.05$) but recurrent cough and chronic bronchitis did not share this type of association. Chronic bronchitis is defined as morning cough, productive of sputum, occurring on most days of the week for at least three months a year for at least two years.

Chronic bronchitis was reported by 7 of 17 current smokers (41%) and 4 of 30 former smokers or non-smokers (13%), which is the association that would be expected between smoking and chronic bronchitis symptoms ($p<0.05$). The four workers who reported chronic bronchitis, who were not current smokers, were evenly distributed between dusty and non-dusty jobs.

Physician-diagnosed respiratory diseases -- asthma, bronchitis or allergy/hay fever -- occurring since employment at Empire-Detroit were almost equally common in dust exposed and non-dust exposed jobs (36% and 41%).

At the conclusion of the questionnaire, workers were asked to rank their occupational health concerns or problems. Twenty-four (51%) considered high dust levels as the pre-eminent problem, eleven (24%) specifically listed the rolling of silicon steel as their most noxious exposure.

VII. DISCUSSION AND CONCLUSIONS

There is a high prevalence of upper respiratory and mucosal complaints among Hot Strip Mill workers, associated with work in dust exposed areas. Lower respiratory system complaints were unrelated to dust exposure. Hence, although irritant symptoms can be related to work in dusty or non-protected areas, there is no evidence on the basis of the available data that symptomatic pulmonary disease is related to dusty work.

There are important qualificatons to these conclusions. The simple dichotomization of work into two categories -- exposed and non-exposed -- necessarily obscures a range of exposures and previous work histories. Furthermore, cross-sectional analysis would fail to ascertain such problems as a gradual decrement in respiratory function over time or a selective drop-out or voluntary job transfer of workers who worked in exposed jobs and who had developed respiratory problems. The number of workers tested may not have been adequate to detect small differences in the prevalence of respiratory disease.

Although NIOSH's questionnaire data supports symptoms of upper respiratory and mucosal complaints among Hot Strip Mill workers who work in "dust exposed" areas, personal and area air sampling conducted in these areas during typical silicon steel manufacturing processes documented levels of contaminants not thought to cause such symptoms. The only exception to this was a potential overexposure to hexavalent chromium, (found in one area air sample) limited to a machine grinding operation in the slabyard.

VIII. RECOMMENDATIONS

In view of the findings of the environmental and medical investigations, the following recommendations are made to ameliorate existing or potential hazards, and to provide a better work environment for the employees covered by this determination.

1. Employee over exposure to excessive hexavalent chromium within the machine grinding area of the Slabyard should be immediately reduced to the lowest level possible through the implementation of improved effective engineering controls of workplace contaminants such as automation, redesign or replacement of existing mechanical ventilation systems and/or process equipment, or a combination of these measures. Broken windows in the enclosed cabs of the machine grinders should be replaced, and all cabs should be equipped with permanent, air-filtration, ventilation systems that would create a positive pressure within the cabs.

   Furthermore, NIOSH suggests that Empire-Detroit conduct periodic environmental evaluations of employee exposures to hexavalent chromium to assure the controls attempted are adequate to protect the affected employees.

2. Empire-Detroit management should initiate an annual pulmonary program of pulmonary function testing for all workers in the Hot Strip Mill. This should include a respiratory disease questionnaire and history.

3. Safety glasses with side shields should be required to be worn in and around the machine grinding area of the Slabyard.

4. Initial monitoring of employee exposure to noise in the Hot Strip Mill should be conducted. If excessive noise levels exist, plant management should implement and administer a continuing hearing conservation program including pre-employment and periodic audiometric tests, utilization and maintenance of hearing protective equipment, and employment of feasible administrative and/or engineering controls.

5. Existing exhaust ventilation systems in the Hot Strip Mill Division should be periodically evaluated for proper operation.

6. A continuing education program conducted by qualified persons should be instituted to ensure that all employees have current knowledge and understanding of job safety and health hazards, proper work practices, and maintenance procedures. Current Material Safety Data Sheets and all available information (including health effects) concerning products used should be obtained and made available to all personnel. Greater involvement from both management and union representatives at Empire-Detroit is needed in establishing a joint occupational safety and health program.

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1. Empire-Detroit Steel Division, Mansfield, Ohio
2. United Steel Workers, Local #169
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.

TABLE I

AIR SAMPLING AND ANALYSIS METHODOLOGY

EMPIRE DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-434

Substance	Collection Device	Flow Rate (liters per minute)	Analysis	References[1]
Chromium	AA-MCEF Filter	1.5	Atomic Absorption or Inductively Coupled Plasma - Atomic Emission Spectroscopy	NIOSH P&CAM 173 NIOSH P&CAM 351
Hexavalent Chromium	Tared PVC Filter	1.5	Colorimetric	NIOSH P&CAM 319
Iron Oxide Fume	AA-MCEF	1.5	Atomic Absorption or Inductively Coupled Plasma-Atomic Emission Spectroscopy	NIOSH P&CAM 173 NIOSH P&CAM 351
Nickel	AA-MCEF	1.5	Atomic Absorption or Inductively Coupled Plasma-Atomic Emission Spectroscopy	NIOSH P&CAM 173 NIOSH P&CAM 351
Oil Mist	AA-MCEF Filter	1.5	Fluorescence	NIOSH P&CAM 159
Respirable Particulates	Tared PVC Filter	1.7	Gravimetric	-
Total Particulates	Tared PVC Filter	1.5	Gravimetric	-

TABLE II

RESULTS OF ENVIRONMENTAL AIR SAMPLES FOR CHROMIUM, IRON OXIDE FUME, NICKEL, RESPIRABLE PARTICULATES, AND TOTAL PARTICULATES

EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-434

Sample Location	Date/Time	Sample Volume (liters)	Chromium (mg/m^3)	Iron Oxide Fume (mg/m^3)	Nickel (ug/m^3)	Total Particulates (mg/m^3)	Respirable Particulates (mg/m^3)
Personal Sample[1,2] Operator of Mills #1&2 6 Stand Mill	12-2-82 2412-0145	139	ND[3]	0.9	ND	-	-
Area Sample[1,2,4], Mill #3 B.Z.[5] Area Finisher Helper Work Station 6 Stand Mill	12-2-82 2411-0152	171	ND	0.2	ND	-	0.5
Area Sample[1,2] Mill #6 at the Operator's Station 6 Stand Mill	12-2-82 2412-0153	151	ND	0.3	ND	-	-
Personal Sample[6,7] Alliance Crane Operator Inside Cab Hot Strip Mill	12-2-82 2408-0230	213	ND	0.3	8	2.8	1.4[8]
Evaluation Criteria normal workday, 40hr/wk time-weighted average			0.5	5.0	15	10	5

1. Laboratory analytical limit of detection in ug/sample for metals = 3.0
2. Laboratory analytical method: atomic absorption spectroscopy
3. ND = nondetecable concentration. See note #1 and #6 for interpretation.
4. All values on this air sample represent the respirable fraction.
5. B.Z. = breathing zone
6. Laboratory analytical limit of detection in ug/sample for metals = 1.0
7. Laboratory analytical method: inductively coupled plasma - atomic emission spectroscopy.
8. Sample volume = 241.4 liters
   All concentrations are time - weighted averages for the period sampled.

(continued)

TABLE II (continued)

Sample Location	Date/Time	Sample Volume (liters)	Chromium ($mg/^3$)	Iron Oxide Fume (mg/m^3)	Nickel (ug/m^3)	Total Particulates (mg/m^3)	Respirable Particulates (mg/m^3)
Area Sample[1,2] Outside Cab of #2 Machine Grinder Slabyard	12-2-82 1006-1433	400	0.01	0.1	ND[8]	0.9	-
Personal Sample[1,2] Inside Cab of #3 Machine Grinder South End of Machine Grinding Area Slabyard	12-2-82 0805-1433	582	0.1	0.4	9	5.0	2.1[3,4]
Personal Sample[4,5] Inside Cab of #1 Machine Grinder North End of Machine Grinding Area Slabyard	12-2-82	595	0.2	0.4	7	-	-
Area Sample[4,5] Crop Tank Area Hot Strip Mill Line	12-2-82 2402-0200	177	ND	0.9	ND	1.2[6]	-
Personal Sample[1,2] Crop Crane Operator Inside Cab Hot Strip Mill Line	12-2-82 2400-0159	178	ND	0.1	ND	1.6	0.2[7]
Evaluation Criteria (normal workday, 40hr/wk, time-weighted average)			0.5	5.0	15	10	5

1. Laboratory analytical limit of detection in ug/sample for metals = 1.0
2. Laboratory analytical method: inductively coupled plasma-atomic emission spectroscopy.
3. Sample volume = 659.6 liters
4. Laboratory analytical method (for metals): atomic absorption spectroscopy.
5. Laboratory analytical limit of detection in ug/sample for metals = 3.0
6. Sample volume = 295 liters. This sample had a flow rate of 2.5 liters per minute.
7. Sample volume = 202.3 liters
8. ND = nondetectable concentration. See note #1 and #5 for interpretation.
   All concentrations are time-weighted averages for the period sampled.

TABLE III

RESULTS OF ENVIRONMENTAL AIR SAMPLES FOR OIL MIST

EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-434

Sample Location	Date/Time	Sample Volume (liters)	Oil Mist (mg/m^3)
Area Sample at Work Station of Mill # 1 of the Six Stand Mills	12-2-82 0823-1446	573	0.05[1]
Evaluation Criteria (normal workday, 40hr/wk Time-weighted average)			5.0

Laboratory analytical limit of detection (ug/sample) = 10

1. The concentration is a time-weighted average for the period sampled.

TABLE IV

RESULTS OF ENVIRONMENTAL AIR SAMPLES FOR HEXAVALENT CHROMIUM

EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-434

Sample Location	Date/Time	Sample Volume (liters)	Hexavalent Chromium (ug/m^3)
Personal Sample Inside of Cab of Machine Grinder #1 North End of Slabyard	12-2-82 0756-1433	595	0.8
Area Sample Outside Cab of #2 Machine Grinder	12-2-82 1006-1433	400	1.8
Evaluation Criteria (normal workday, 40hr/wk time-weighted average)			1.0
Laboratory analytical limit of detection (ug/sample) =			0.2

1. The concentrations are time-weighted averages for the period sampled.

Table V

RECURRENT SYMPTOMS AND DISEASE PREVALENCE
FOR HOT STRIP MILL EMPLOYEES (N = 47)

EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-434

Sample	Number of Cases	Percent of Workers
Headache	19	45%
Nasal Symptoms	20	43%
Coughing Spells	20	43%
Eye Irritation	17	41%
Tinnitus	19	40%
Fatigue	15	32%
Chest Pain	11	23%
Bronchospasm	7	15%
Symptomatic Shortness of Breath	6	13%
Diseases and Conditions		
Hearing Loss	17	36%
High Blood Pressure	14	30%
Hay Fever/Allergy	12	26%
Chronic Bronchitis	11	23%
Asthma	10	21%

TABLE VI

GENERAL COMPARISONS BETWEEN WORKERS IN DUSTY
AND NON-DUSTY AREAS (N = 47)

EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-434

Factor	Dusty Area	Non-Dusty	p-value
Workers	25	22%	NS*
Mean Age	44 (25-61)	48 (33-64)	<0.01**
Plant-Years	23 (4-34)	24 (15-44)	NS
Smoking(Pack-Years)	21	32	<0.01**
Current Smoke	8	9	NS

*NS means not significant
**Statistical Significance is Assessed by the T-test.

TABLE VII

COMPARISON OF SYMPTOMS AND DISEASES BETEEEN
WORKERS IN DUSTY AND NON-DUSTY AREAS

EMPIRE-DETROIT STEEL DIVISION
MANSFIELD, OHIO
HETA 81-433

Symptom or Disease	Dusty Area Numbers	Prevalence.	Non-Dusty Area Numbers	Prevalence.	p-value
Upper Respiratory and Eye irritation	15	0.60	7	0.32	<0.05
Recurrent Cough	12	0.48	8	0.36	NS
Chronic Bronchitis	7	0.28	4	0.18	NS
Respiratory Disease*	9	0.36	9	0.41	NS

*Physician diagnosed bronchitis, asthma, or allergy/hay fever