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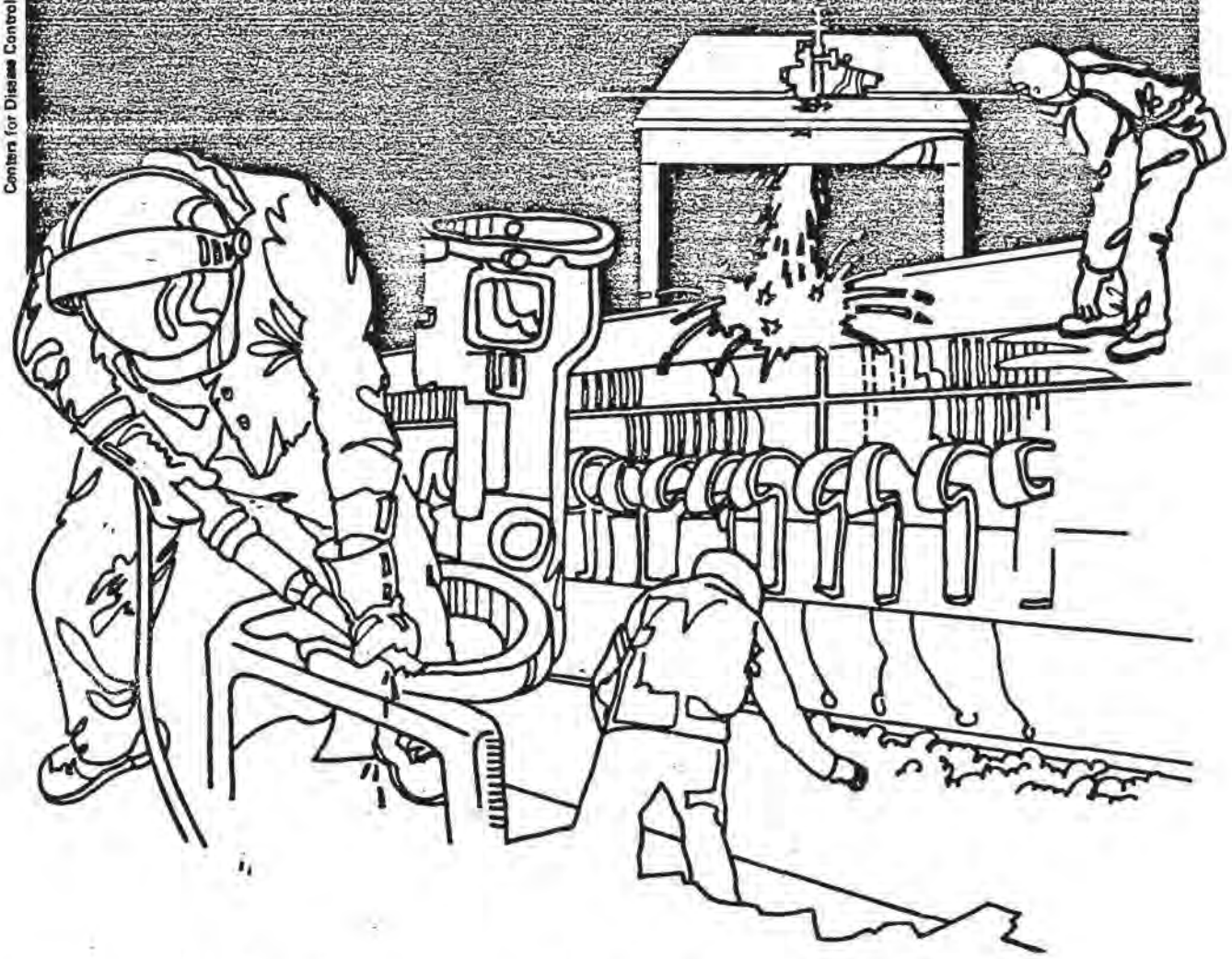

Health Hazard Evaluation Report

HETA 81-187-1417
ARMCO INCORPORATED
BALTIMORE, MARYLAND

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.

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February 1984
ARMCO INCORPORATED
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NIOSH INVESTIGATORS:
David B. McAuley, M.D.
Eric Jannerfeldt, M.D.
Steven Ahrenholz, I.H.

I. SUMMARY

In February, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation at the Armco, Incorporated stainless steel plant in Baltimore, Maryland. The request was submitted because of concern that there was an increased cancer rate among employees exposed to metal fumes, including nickel, silica and chromium dusts, solvents, gases, and cutting oils.

The Armco plant in Baltimore was part of a larger study previously conducted by the University of Michigan School of Public Health, which examined causes of mortality in 4882 stainless steel workers in twelve different plants. The results of that study demonstrated a lower cancer rate than comparable control populations.

The requestors were concerned that the results from their plant (the Armco plant) were buried within an overall study of twelve plants, and wanted an analysis of their plant mortality alone; consequently, the Armco plant was extracted from this study for separate analysis.

A proportionate mortality ratio analysis (PMR) and a proportionate cancer mortality ratio analysis (PCMR) of 163 death certificates for Armco employees failed to demonstrate any meaningful excess of cancer in general or of any specific type. In addition, a separate analysis of deaths occurring in employees of the Grinding Department, an area with higher exposures to potential carcinogens (i.e., nickel and chromium), did not demonstrate a meaningful excess of cancers.

A proportionate mortality analysis, of 163 total deaths in this stainless steel plant, did not demonstrate an excess incidence of non-cancer deaths or of total cancer-related deaths. Additionally, a proportionate cancer mortality analysis, of the 39 cancer deaths in this group, as well as deaths in former grinders, did not demonstrate an excess incidence of any specific type of cancer.

KEYWORDS: SIC 3312 (Stainless steel mill), cancer, lung cancer, metal fumes, nickel, chromium, PMR, PCMR

II. INTRODUCTION

In February 1981, NIOSH received a request for a health hazard evaluation at the Armco Incorporated stainless steel production plant in Baltimore, Maryland. According to the request, the cancer rate among the employees was high, and many employees had died at young ages. Concern was expressed that these health effects may have been due to exposure to hazardous substances in the plant environment. The request stated that production and maintenance employees are exposed to metal fumes and various dusts, including silica and chromium, nickel, solvents, gases and cutting oils.

NIOSH examined 163 death certificates from this plant for the period 1973-1977. Analyses were performed to determine the specific causes of death for the 163 total deaths and to compare the proportions of different causes of deaths with an age adjusted standard United States population. Grinders, a subset of employees more heavily exposed to chromium and nickel than other employees, were analysed separately to determine their mortality experience in comparison with the rest of the plant population.

III. BACKGROUND

A. General Background

1. Facility and Workforce

The Stainless Steel division of Armco Inc. has three plants, of which the Baltimore plant is the largest.

It is approximately eighty years old and covers an area of 85 acres. It has been owned and operated by Armco Incorporated since 1946. The yearly production of stainless steel is approximately 45,000 metric tons.

The plant previously had nearly 1000 hourly employees. Due to reduced demand for stainless steel products, layoffs have taken place, and the production work-force is now 760. The production employees are represented by the United Steel Workers of America, Local 3185.

2. Basis of Request

Based on information from the company newsletter, and other sources, concerning deceased employees, the requestors had gained the impression that cancer rates among the employees were high and that many deaths occurred at young ages. Production workers are exposed to various compounds and substances, and it was thought that this exposure may have contributed to the apparently high cancer rates.

The Maryland Occupational Safety and Health Agency (MOSH) has performed several investigations of the working conditions in the plant; however, the issues raised in the current request had not been studied.

3. Demography

The median age of the current employees is relatively high, 41 years, due to low turnover and the fact that lay-offs take place according to seniority. The voluntary turnover of employees is estimated to be low, about 3% annually, but since several lay-offs and rehirings, involving a considerable proportion of the work force, have taken place, the actual employee turnover is estimated to have been 10% during the last few years. About 64% of the current hourly work-force are white males, 25% black males, 7.5% white females and 2.7% black females.

B. Industrial Hygiene and Environmental Background

1. Process Description

Armco produces stainless steels from stainless steel scrap. Depending upon the composition of the scrap, up to 20 different materials are added to the melt. This process takes place in the melt shop where a 50 ton electric arc furnace is used for the initial melt and an argon oxygen decarbonization furnace for the removal of excess carbon. Materials added are mainly in the form of pigs, briquettes or pre-packed powder with some ores handled in bulk. Most metals used (e.g., chrome) are obtained as ferro-alloys. The plant has no coke ovens, and no ore processing is performed.

The stainless steel ingots produced by the melt shop are transferred to other areas of the plant where they are reheated and forged, or rolled, into pieces suitable for working through the various mills into finished rods or bars. Reheating is performed in furnaces fired by natural gas or No. 2 heating oil. Coiled stainless steel rods are annealed and subjected to various surface preparation, or coating processes, in the wire pickling and coating area before being processed into wire.

Grinding is done in two main areas, the press shop and the grinding area. It is performed on the cold metal by one of four automatic units or at a swing frame grinder station.

Surface finishing areas have an assortment of lathes, straightening equipment, saws, and polishing and grinding units. The main cutting fluid observed in use was of the water emulsion type, with equipment connected to cutting fluid cleaning and recirculation systems. The majority of this surface preparation equipment required little worker participation outside of set up and removal.

The two furnaces in the melt shop were connected to a bag house exhaust system, installed in 1969, and a large three section canopy hood was located over the electric arc furnace. The melt shop crane operator worked in a cab with filtered and conditioned air supply. Swing frame grinders are operated in a semi-enclosed area with large wall fans exhausting the area. Automatic grinders in the grinding area are exhausted to one of three bag houses. These bag houses were installed in 1977.

The wire pickling and plating area has numerous wall exhaust fans, located above the tanks, situated on both sides of the area. The pickling tanks located along the south wall have a partial enclosure along the ceiling; however, the necessity of getting a lift truck along the full length of the wall prohibited any further enclosure.

Solvent use appeared to be limited. A drum of 1,1,1-trichlorethane in the machine shop with a small pan of solvent was the only place where solvents were observed. A non-functional vapor degreaser was noted in the bright anneal area. It has been replaced by a caustic wash process.

No changes in the process or future installation of environmental control equipment were indicated during the survey. Asbestos containing materials were phased out in the mid-seventies, and the plant hygienist and physician consult on the health effects associated with new materials before they are introduced into the plant. No master list of chemicals in use at the plant was available. Company policy requires that employees be made aware of precautions listed on material safety data sheets.

2. Personal Protective Equipment

The company provides safety glasses, hard hats and a yearly safety shoe allowance. Special items, (e.g., leggings, heat-retarding clothes, face shields, etc.), are issued to individuals on a job by job basis. Safety glasses are mandatory in all plant areas; on the day of the investigation this requirement was generally observed.

3. Plant Industrial Hygiene Summary

Environmental surveillance at the plant is conducted both by the plant industrial hygienist and by the corporate industrial hygienist. The results of environmental sampling, performed in various areas, and for different job classifications during 1977 and 1980, were obtained from the company.

Armco provided sampling results for total dust, chromium (total) and nickel, conducted in the Grinding Department. Time periods in which the sampling had been conducted were June 1980, February 1980, during an OSHA inspection, and April and June 1977.

The request did not specify a specific department or plant location as being of concern; however, the Grinding Department was considered an area most likely to have the highest exposures to the metals being worked. This resulted in an inquiry into what data the company had on this area during conduction of the initial survey.

C. Medical and Mortality Study Background

1. Personnel Records

Since 1939, the company has provided death benefit coverage for qualified hourly employees. The coverage continues after retirement, and death benefits are claimable upon receipt of a death certificate. Copies of death certificates are kept in the personnel files of deceased employees. Employees that have been discharged or that have worked for less than 520 hours are not qualified and thus not covered.

2. Medical Facilities

The plant maintains a clinic with a full-time nurse and part-time physician. A pre-employment medical questionnaire and examination is required.

3. Mortality Studies

The requestors had gathered information from the company news letter on approximately 300 deceased employees during the time period 1950-1979. No determination of how many of these deaths were associated with cancer had been made, since death certificates had not been studied. However, based on anecdotal information, a considerable proportion of the deaths were, according to the requestors, caused by cancer.

In 1977, NIOSH published a criteria document concerning occupational exposure to inorganic nickel. In this document, it was stated that metallic nickel must be considered a suspect carcinogen [11]. Due to concern over the possible health effects of exposure to metallic

nickel, in the production and handling of stainless steel, the American Iron and Steel Institute undertook a study of mortality patterns among workers engaged in the production of stainless steel.

The study was designed and executed by the University of Michigan School of Public Health. The Baltimore division of Armco Incorporated was one of the twelve plants included in the study. Death certificates were analyzed for the time period 1973-1977, and proportion of deaths associated with cancer was compared to that of various control groups. Information concerning 163 deaths, that had occurred among former and present employees of the Baltimore plant, was included in the study, which analyzed a total of 4882 deaths. Based on this information, the age-standardized proportional mortality ratio for total cancers, and for specific types of cancer, in the composite 4882 deaths, was lower than what would be expected.

The NIOSH mortality study examined the Baltimore Armco facility separately, in order to determine if this particular facility was representative of the entire population studied in the University of Michigan study.

IV. EVALUATION DESIGN AND METHODS

In March 1981, a NIOSH industrial hygiene and medical team visited the plant in response to the request. A walk-through survey was conducted and representatives of management and the requestors were interviewed. Information was collected in the following areas: 1) the cases of cancer that had occurred, 2) past and present usage of chemicals and other potentially hazardous substances, 3) changes in the production processes and environmental controls, 4) the demographic characteristics and turnover rate of the workforce, and 5) employee insurance coverage and availability and contents of personnel records.

171 death certificates were obtained for the period 1973-1977; seven were invalid, one for lack of birthdate, and six for illegible cause of death. The remaining 163 deaths, for the Baltimore plant, were analyzed separately by means of a proportionate mortality analysis. All cancer deaths from this group, (thirty-nine), were then analyzed with a proportionate cancer mortality analysis, in order to determine the specific types of cancers and their relative proportions.

In addition to the overall mortality analysis for the plant, a seperate cancer mortality analysis was performed for grinders as a separate cohort. According to an OSHA survey of the plant, and personal sampling for levels of total nickel and total chromium, it was determined that employees in the grinding department had one of the higher exposures to both nickel (range 0.063 mg/M^3 - 0.54 mg/M^3) and total chromium (range 0.11 mg/M^3 - 0.58 mg/M^3).

Consequent to this information, a chi-square analysis was performed for grinders to determine if there was an increased proportion of specific types of cancer deaths for this group.

V. EVALUATION CRITERIA

A. Environmental 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 (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. Nickel Carcinogenicity

Nickel in its natural form is found mainly as either oxide (laterite) or sulfide ore [1]. The roasting of the sulfide ore results in the formation of nickel subsulfide (Ni_3S_2), nickel oxide (NiO), and inorganic nickel metal (Ni). It is in the roasting-smelting operations where most of the epidemiologic studies have demonstrated an increased incidence of nasal sinus cancers, cancer of the larynx, and lung cancers [11]. The problem is in the determination of whether the carcinogenic form of nickel is in one or a combination of these three forms. It has been difficult to study a population with a pure exposure to one of these forms of nickel. Animal studies have demonstrated the carcinogenicity of pure Ni_3S_2 and NiO [9,12].

Based on these data and supporting animal studies, NIOSH considers nickel subsulfide to be a respiratory carcinogen. However, many of these roasting and smelting workers were exposed to nickel oxide as well, and since others develop nasal cancers after using nickel salts, such as nickel chloride and nickel sulfate, these compounds are probably also carcinogenic [11]. Although the evidence implicating metallic nickel is not as strong, metaplastic changes have been noted in animals exposed to nickel metal [5], and the air-oxidation of dusts of inorganic nickel metal probably results in the inhalation of nickel oxide by workers exposed to airborne nickel metal. Metallic nickel, therefore, is considered a suspect carcinogen [11]. As a consequence of this information, NIOSH has recommended a standard of 0.015 mg/M^3, for all forms of nickel, as a 10 hour TWA. The OSHA standard is 1.0 mg/M^3.

C. Chromium Carcinogenicity

Chromium compounds are numerous and varied in certain industries. The only industry which has been extensively studied has been the chromate-bichromate producing industry in the United States [2,3]. Some chromium(VI) compounds have been found to be associated with an increased incidence of lung cancer [7,8]. It has been determined that there is a great likelihood that solubility of a chromium(VI) material influences its carcinogenicity. Less-soluble chromium(VI) compounds, such as lead and zinc chromate pigments, calcium chromate of ill-defined origin, and chromate roast material -- are suspect carcinogens, while the highly soluble chromium(VI) materials have not been found to be carcinogenic [10].

There are insufficient data available, however, to accurately identify carcinogenic chromium(VI) compounds solely on the basis of their solubility.

Because of the data available, and the lack of more specific details on the carcinogenicity of various chromium(VI) compounds, NIOSH recommends a standard of 0.001 mg/M^3 for carcinogenic chromium(VI), 0.025 mg/M^3 TWA for other chromium(VI), and 0.05 mg/M^3 for a 15 minute ceiling exposure. The OSHA standard is 1.0 mg/M^3 for total chromium.

VI. RESULTS AND DISCUSSION

A. Total Deaths

1. Proportionate Mortality Analysis

The proportionate mortality analysis examined the proportion of deaths for all causes. The single most common cause of death was for deaths due to diseases of the circulatory system, particularly arteriosclerotic heart disease, a result not significantly different from expected (Observed=64, Expected=65.86). Death due to neoplasm was the second most common cause of death; however, this result was not significantly different from expected (Observed=39, Expected=37.18). In order to determine if a specific type of cancer, within this group, was more prevalent than expected, a proportionate cancer mortality analysis examining only these cancer deaths was conducted.

2. Proportionate Cancer Mortality Analysis

There were 39 cancer deaths out of 163, validly reported, deaths for the study period. Cancer of the respiratory system was the most common cause of cancer; however, the observed number was not significantly greater than would be expected in that group, (Observed=15, Expected=13.69). Thirteen of these deaths were due to cancer of the lung, while 2 were due to cancer of the larynx. Although nickel exposure has been associated with cancer of the larynx, this result was not statistically significant (Observed=2, Expected=0.56), nor was the result for lung cancer alone (Observed=13, Expected=13.03). There were no reported nasal cancers, another cancer shown to be associated with nickel exposures. The second most common cause of cancer was for cancer of the digestive organs and peritoneum (Observed=10, Expected=9.71); again, this is not a statistically significant result. All other specific types of cancer were less common and none were significantly elevated from the expected results.

B. Analysis of Grinders

NIOSH did not conduct sampling of the workplace. The company provided sampling data collected by themselves and the Maryland Occupational Safety and Health Agency which sampled for total chromium and nickel. The form of chromium in the different work areas of this plant is unknown; however, there is evidence of the presence of chromium(VI) compounds in some types of stainless steel exposures. With stainless steel welding, about 70% of the total chromium in the aerosol is in the hexavalent, chromium(VI), form as soluble sodium or potassium monochromates [6], and fume particles have been shown to be mutagenic [4]. Both the relative amount of hexavalent and the solubility of these salts seem, however, to vary with the type of welding [15,16]. It is impossible to accurately determine the carcinogenic potential of an individual worksite based on total chromium levels. It would be more useful to sample for various chromium(VI) compounds and judge exposures based on these levels.
Grinders were assumed, according to the available sampling data, to have one of the higher exposures to nickel and chromium of all groups in the plant. If an excess of deaths, particularly lung cancer deaths, would be found in the plant, it would presumably be found in this group. The range of exposures for nickel in this group was 0.08 - 0.54 mg/M^3 and the range of total chromium exposure was 0.11 - 0.58 mg/M^3. A mortality analysis in this group did not reveal a measurable increase in lung cancer deaths, or other causes of death, compared with non-grinders in the plant. There were 20 grinders' deaths, four of which were due to lung cancer, seven due to coronary heart disease, and one due to each of the following: 1) brain tumor, 2) diabetes mellitus, 3) Pickwickian syndrome, 4) leukemia, 5) multiple myeloma, 6) cerebrovascular accident, 7) peritoneal abcess, 8) gunshot wound, and 9) hepatic and renal failure of unknown origin. A chi-square analysis, comparing these proportions with the rest of the employees, did not reveal an excess of cancer deaths, or any specific cause of death, in this group; however, this result is difficult to interpret because of the relatively small numbers involved and lack of information concerning years of exposure.

C. Table of Results

Deaths by type of cancer and also by non-malignant causes are listed, by their observed and expected frequencies of occurrence, in Table I.

D. Limitations of Analysis

Analysis of all workers, for all causes of death in the period 1973-1978, did not reveal any excess deaths for any particular cause. Additionally, an analysis of all cancer deaths for the group, (39), did not reveal any excess of a particular type of cancer within that group.

Although it appears that there is no increased cancer risk for these workers, all deaths at this plant were included in the analysis, regardless of the type of work performed; consequently, another analysis of more highly exposed workers was performed. Data was unavailable on environmental exposures for most of the employees. However, based on company and OSHA sampling of the workplace, for nickel (mostly metallic) and chromium (total), it was estimated that the Grinding Department had the highest exposure in the plant to these potential carcinogens. However, exposure data for the rest of the workers, as well as, work histories for these deaths were unavailable. Therefore, analysis for grinders, was the only separate analysis performed for a high exposure group.

The separate analysis of grinders' death experience, who were most exposed to the potential carcinogens nickel and chromium, also did not reveal an excess of deaths; however, there were relatively few grinders (20) and only 4 of these deaths due to lung cancer. Small numbers, such as these, do not provide sufficient power in the statistical analysis to definitively answer this question. Based on this mortality study, and the University of Michigan study, there is no indication that a more detailed or extensive study would be indicated for this population.

VII. RECOMMENDATIONS

On the basis of this analysis, and the data presently available, there is currently no evidence that employees at this plant have had an increase risk of cancer of any type. However, because of the known carcinogenicity of some compounds of nickel and chromium, and because of the suspected carcinogenicity of most other nickel and chromium compounds, it would be prudent to maintain levels of these compounds as low as possible. The current NIOSH recommended standard for nickel is 0.015 mg/M^3; the current OSHA standard is 1.0 mg/M^3. The NIOSH recommended standard for chromium is 0.001 mg/M^3 for carcinogenic chromium(VI), 0.025 mg/M^3 TWA for other chromium(VI), and 0.05 mg/M^3 for a 15 minute ceiling exposure. The OSHA standard is 1.0 mg/M^3 for total chromium.

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VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

David B. McAuley, M.D.
Medical Officer
Medical Section

Eric Jannerfeldt, M.D.
Medical Officer
Medical Section

Steven Ahrenholz, M.S., C.I.H.
Industrial Hygienist
Industrial Hygiene Section

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

Report Typed By:

Stephanie M. Harris
Clerk Typist
Medical Section
Cincinnati, Ohio

Table I

ALL CAUSES OF DEATH

DISEASE	OBSERVED	EXPECTED
All Malignant Neoplasms	39	37.18
Cancer of buccal cavity and pharynx	1	1.13
Cancer of digestive organs and peritoneum	10	9.71
Cancer of esophagus	1	0.88
Cancer of stomach	2	1.56
Cancer of large intestine	2	3.42
Cancer of rectum	2	1.04
All cancer of liver	2	0.55
Cancer of pancreas	1	2.05
Cancer of respiratory system	15	13.69
Cancer of larynx	2	0.56
All cancer of lung	13	13.03
Cancer of prostate	3	2.76
Cancer of testis	1	0.15
Cancer of bladder	1	1.18
Cancer of skin	1	0.57
Cancer of brain and central nervous system	1	0.91
Leukemia and aleukemia	1	1.34
Cancer of other lymphatic tissue	1	1.00
All lymphopoietic cancer	2	3.36
Benign neoplasms	1	0.40
Allergic, endocrine, metabolic, nutritional diseases	6	3.11
Diabetes mellitus	4	2.50
All diseases of nervous system and sense organs	14	13.46
All vascular lesions of CNS	13	12.16
All diseases of circulatory system	74	77.76

Arteriosclerotic heart disease, including CHD	64	65.86
All respiratory diseases	5	11.53
Emphysema	1	3.20
All diseases of digestive system	10	7.44
All gastric and duodenal ulcer	1	0.82
Cirrhosis of liver	4	4.06
All diseases of genito-urinary system	1	1.84
All disease of the bones and organs of movement	1	0.30
All external causes of death	11	12.29
All accidents	3	7.82
Suicide	5	2.99
Total residual	8	0.68
Cancer residual	4	2.59

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. Armco Incorporated
2. United Steelworkers of America, Local 3185
3. NIOSH, Region III
4. OSHA, Region III

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.