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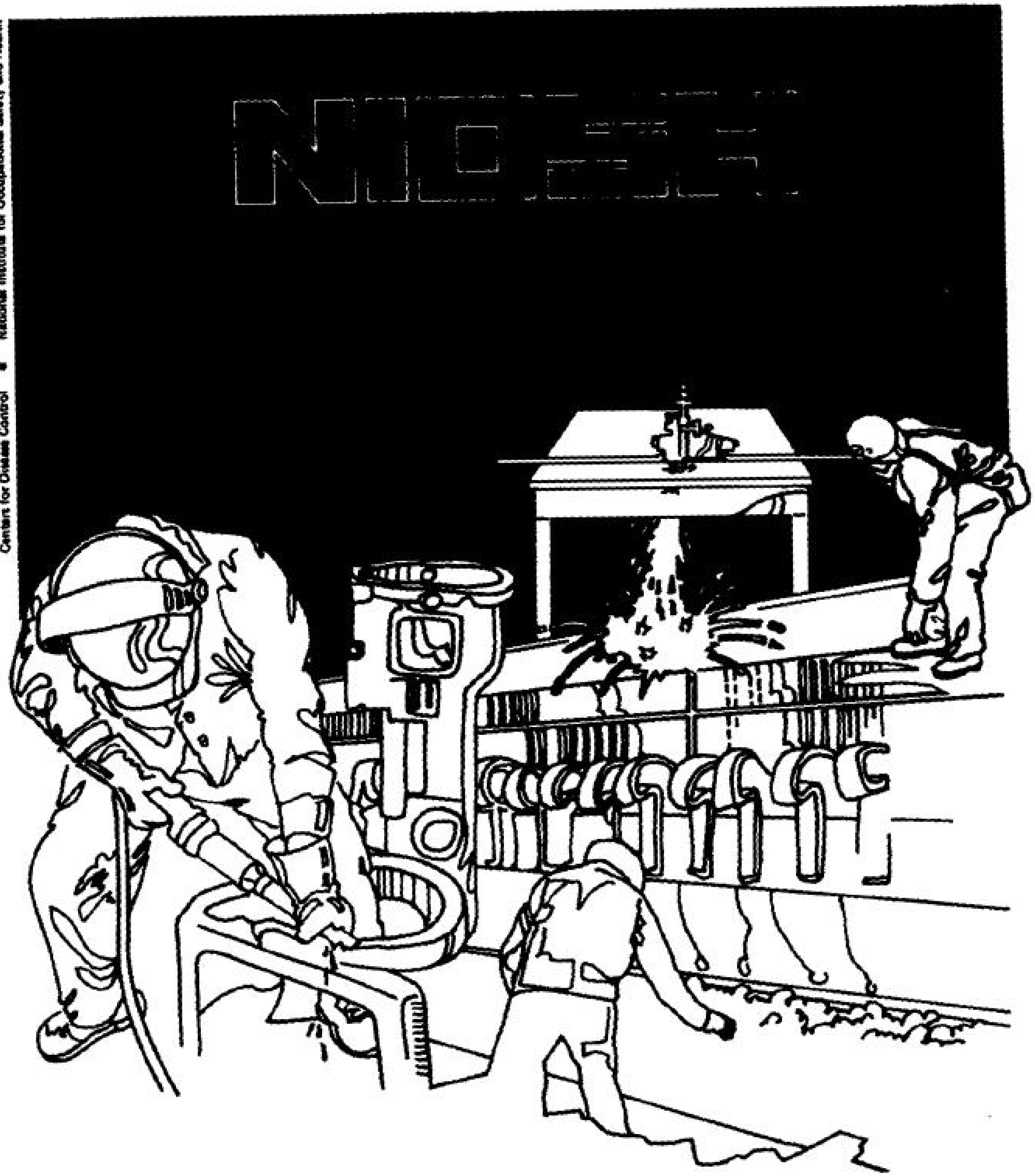

Health Hazard Evaluation Report

HETA 88-192-1998
HITACHI MAGNETICS CORPORATION
EDMORE, MICHIGAN

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.

HETA 88-192-1998
JANUARY 1990
HITACHI MAGNETICS CORPORATION
EDMORE, MICHIGAN

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I. SUMMARY

On March 7, 1988 the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request to investigate exposures to various metals and minerals at Hitachi Magnetics Corporation in Edmore, Michigan and to determine if these exposures had resulted in work related illness. Included in the list of potential exposures were cobalt, nickel, silica, and asbestos. A wide range of illnesses was also mentioned, including asthma, work induced fibrosis of the lung, and dermatitis.

An initial site visit was made on March 30, 1988. During this visit three NIOSH investigators held an opening conference with management, representatives of United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW) Local 1436; and a representative of the Michigan Department of Health. Following the opening conference they toured the facility, reviewed historical environmental exposure data, and interviewed several workers. NIOSH investigators also contacted local physicians, reviewed medical records of workers reported to have pneumoconiosis (occupational dust disease), and reviewed recent annual summary OSHA 200 logs for indications of asthma and dermatitis in the workforce.

Review of 1984-1988 OSHA 200 logs, identified six reported episodes of respiratory conditions and 43 reports of contact dermatitis among approximately 416 hourly workers. The six recorded respiratory conditions was more than 10 times the number expected for industries classified as Miscellaneous Fabricated Metal Products (SIR=10.5, 95% C.I. 7.8-14.5). The incidence of skin disorders at Hitachi Magnetics was also almost ten times that expected for this industry (SIR=9.3, 95% C.I. 4.1-17.7).

During the week of October 17-21, 1988 an environmental and medical survey was performed. The objectives of the survey were to determine the prevalence of respiratory symptoms, restrictive and obstructive respiratory conditions, and pneumoconiosis among employees with ten or more years of experience at the plant. A chest X-ray, pulmonary function test (PFT), and respiratory questionnaire were offered to all current workers with at least ten years of work at the facility. Retired workers were also invited to participate. The environmental component was designed to determine exposure levels to metal dusts and crystalline silica. Personal breathing zone air samples for metals, respirable and total dust, and silica were collected. In addition, cigarette butts discarded by workers in several process areas and the office area of Hitachi Magnetics were collected for analysis of metal contaminants. Urine samples were collected from selected workers for determination of cobalt and nickel concentrations.

The participation rate for current workers was 86% (310 of 362 eligible current workers) which was substantially higher than the 20% (52 of 256 eligible retired workers) participation rate for retired workers. The questionnaire identified 56 (16%) persons with chronic cough, 39 (11%) with chronic bronchitis, 23 (6%) with shortness of breath, and 27 (9%) with wheezing. The prevalences of self-reported chronic cough, chronic bronchitis, wheezing, shortness of breath, and asthma were not higher than expected when compared to a standard population of blue collar workers. Results of pulmonary function testing found 11 (3%) workers with a restrictive pattern and 60 (17%) workers with an obstructive pattern, 8 (2%) of whom may also have had a restrictive pattern. Mean forced expiratory volume in 1 second (FEV1) and mean forced vital capacity (FVC) for current workers were 5% and 4% higher respectively than that predicted for non-exposed blue collar workers. Four workers (3 retired, 1 current worker) had parenchymal signs consistent with pneumoconiosis; this number was similar to that predicted for non-exposed blue collar workers. One worker had bilateral small rounded opacities consistent with silicosis. This individual reported having worked as a core maker for 7 years where he was exposed to silica flour. Two of the workers had findings consistent with moderately severe interstitial fibrosis which was not found in the reference group survey. Two other workers (both current employees) had pleural signs consistent with asbestos exposure.

The medical study had several limitations. A potential selection bias may have occurred based on the cross-sectional study design. Workers who were too ill to work were not evaluated. There was a low participation rate for the retirees. (In NIOSH health hazard evaluations, participation rates among retired employees are typically low.) Most of the Hitachi workers have been exposed to a variety of respiratory toxins and there was no group of unexposed workers to evaluate. This prevented us from examining the association between exposures to the various respiratory toxins and respiratory symptoms, PFT results, or chest X-ray results.

A total of 112 personal breathing zone air samples, for 41 job operations, were collected and analyzed for metals. Time weighted average (TWA) cobalt (Co) exposures from total dust ranged from non-detected to 466 micrograms per cubic meter (ug/m^3). The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for Co is 50 ug/m^3, as an 8-hour TWA. The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for Co is 100 ug/m^3. Exposure to Co was found to exceed the ACGIH TLV in 18 samples (16%) and 10 jobs (24%). The OSHA PEL was exceeded in 7 samples (6%) and 4 jobs (10%). TWA nickel (Ni) exposure levels from total dust ranged from non-detected to 368 ug/m^3. The NIOSH recommended exposure level (REL) for Ni is 15 ug/m^3, per 10-hour TWA. The OSHA PEL for Ni is 1000 ug/m^3. Ni exposure exceeded the NIOSH REL in 15 samples (13%) and 8 jobs (20%). The OSHA PEL was not exceeded. Respirable dust exposure levels ranged from non-detectable to 0.76 mg/^{3}. Respirable crystalline silica was identified in dust samples collected at 8 of 18 jobs sampled. Exposures in three jobs (sand mixer, furnace operator, and a machine molder) exceeded the OSHA PEL (3/18 = 16%) and all 8 jobs exceeded the ACGIH TLV for crystalline silica exposure of 0.1 mg/m^3 and the NIOSH REL of 0.05 mg/m^3.

The correlation between pre- and post-shift urine Co and Ni concentrations and personal breathing zone air sampling was calculated. A total of 261 urine specimens were collected from 39 participants. The limits of detection for Co and Ni were 1.0 ng/ml and 1.5 ng/ml, respectively. On each day, post-shift creatinine-corrected mean urine Co concentrations were higher than pre-shift means. The post-shift adjusted urine Co means were also higher than pre-shift means of the next day, indicating that urine cobalt concentrations returned towards a baseline level within sixteen hours. The Pearson correlation coefficient between cross-shift urine cobalt change and environmental cobalt exposure was similar for all three days (0.25 on Monday, 0.28 on Tuesday, and 0.18 on Wednesday). However, none of these coefficients were statistically significant, indicating that cross-shift urine Co changes were not strongly correlated with air cobalt exposures on the same day and therefore, at least at Hitachi, not useful indications of exposure to airborne cobalt.

Based on the environmental results, the investigators concluded that a hazard from airborne exposure to cobalt, nickel, and silica exists among workers in Departments 310, 340, 350, 810, and 820 at Hitachi Magnetics. The OSHA logs documented an increased risk of dermatitis and respiratory conditions, including asthma, among Hitachi Magnetics workers. The medical survey found that both the prevalence of respiratory symptoms and the pulmonary function tests of current workers were normal when compared with a group of non-exposed blue collar workers. Although the prevalence of occupational dust disease was also similar to a group of non-exposed blue collar workers, two individuals had moderately severe interstitial fibrosis not found in the external reference group. At least one of them probably had silicosis. Recommendations pertaining to the respiratory protection and reduction of exposures are included in Section IX.

KEYWORDS: SIC 3499 (Fabricated Metal Products, NEC), cobalt, nickel, silica, asbestos, metal dust, respiratory effects, pneumoconiosis, asthma, dermatitis, pulmonary function tests, chest radiographs, biological monitoring.

II. INTRODUCTION

On March 7, 1988, NIOSH received a confidential employee request to investigate exposures to, and the potential related health effects of, dusts of heavy metals (cobalt, nickel, lead, zinc, beryllium, tungsten carbide) and other dusts (silica, asbestos) generated during the production of magnets and cutting tools. Workers at this plant were complaining of asthma-like symptoms, chest pains, and dermatitis. These employees are represented by the United Automobile, Aerospace, and Agricultural Implement Workers of America, Local 1436.

An initial site visit was conducted on March 30, 1988. A protocol was developed for a combined environmental and medical evaluation and approved by the NIOSH Human Subjects Review Board (HSRB). NIOSH investigators returned on October 17-21, 1988 to conduct the environmental and medical survey. This medical evaluation consisted of a self-administered questionnaire, pulmonary function testing, chest radiographs, and urine sampling for cobalt (Co) and nickel (Ni). Personal breathing zone air samples were collected and analyzed for metals, respirable and total dust, and silica. Participants were notified of their own test results in June 1989.

III. BACKGROUND

The current workforce consists of 416 hourly workers and 115 salaried employees. The ceramic building has two 12 hour shifts and operates seven days a week. The other processes operate five days a week with three shifts.

The plant has produced permanent magnets at this site since 1952 and rare-earth permanent magnets since 1973. It was owned by General Electric until March 1973, when Hitachi Magnetics took over operations and expanded the production of magnets. Hitachi Magnetics currently manufactures permanent magnets using five production processes for a variety uses in automotive components, electric motors, and audio speakers. These processes are: 1) Sintered ALNICO; 2) Cast ALNICO; 3) Hicorex Rare Earth Iron; 4) Ceramic (Ferrite Magnets); and 5) Lodex. This plant also made tungsten carbide cutting tools from 1952 through 1986. Cobalt has been used as one of the major components in each magnet making process (except Ceramic). Nickel is one of the metals used in Sintered ALNICO and ALNICO. Exposures to cobalt, nickel, and other metal constituents occur during preparation of raw materials, pressing, casting, break-out, blasting, grinding, and cutting of new tools, and during the resharpening and repair of worn tungsten carbide tools.

Sintered ALNICO magnets are small magnets (3-5 um in diameter) produced from pressed powders of aluminum, nickel, iron and cobalt. The pressed parts ("green parts") are sintered in a furnace. After the heat-treating process, the parts are ground to size with water-bath grinding wheels. Some magnet surfaces may also be polished. The cast ALNICO magnet process produces a similar, but larger, magnet and utilizes a casting step to form the parts.

The Hicorex ND process uses neodymium, iron, and boron as the principal raw materials. Ingots of these materials are pulverized into a pressable powder (3-5 um in diameter). The powder is weighed to required specifications and pressed into green parts. The parts are sintered at 1000°C. Heat treated parts are "finished" by grinding.

Hicorex rare-earth magnets are produced by a similar process, using different raw materials. For this product, samarium, cobalt, and calcium are the additional raw materials required for production.

The Ceramic magnet process uses strontium carbonate, iron oxide, aluminum oxide, and calcium as raw ingredients. These are mixed and heat treated at 1250°C. The mixture is crushed and pelletized to approximately 50um diameter. The pellets are then ground in a ball mill to achieve a 5um diameter powder. Water is added to form a slurry, and the particles are further reduced in size until they are 1um in diameter. The slurry is then molded to form "green parts". The green parts are baked in kilns to remove more water and then sintered and ground smooth.

The Lodex process uses lead, iron, cobalt, and mercury. This process had been cited for excessive lead and mercury exposures several times by the Michigan Department of Occupational Safety. Hitachi has had a biological monitoring program which included periodic urine tests for mercury and blood tests for lead among the workers in the chemical area (Lodex building). The 102 paired blood concentrations of lead and zinc protoporphyrin (ZPP) monitoring data supplied by the company, dated from February 17, 1987 to January 20, 1988 were all within the reference range for occupational exposure (40ug/100 ml for lead and 50ug/ml for ZPP). From December 3, 1986 to February 24, 1988, 307 urine samples were tested for mercury concentration with 5 exceeding 150 ug/L. Values in excess of 150 ug/L of urine have historically been used to indicate excessive occupational exposure to mercury. The biological monitoring data indicated that there has been a potential exposure to mercury in the Lodex area. The company had decided to phase out this process by September, 1988 and it was decided not to include this process in the evaluation.

Since 1978, preemployment physical examinations have been performed on salaried and hourly employees. These include a medical history, physical examination, pulmonary function test, vision test, audiogram, chest X-ray, and routine blood and urine tests. Additionally, the company has initiated annual pulmonary function testing of workers in the core making, casting, heat-treating departments, and ceramic high bay area.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

The environmental assessment of the various areas of the plant on October 17 - 19, 1988, was designed to characterize worker exposures to Co, Ni, other metals, total dust, respirable dust, and silica. This sampling strategy was designed to identify jobs which may result in overexposures to Co, Ni, and silica. The jobs sampled were selected according to the observed potential for exposure, historical exposure data, and information provided by the company and the union. Full-shift personal breathing zone (BZ) air samples were collected during the first shift, over three consecutive days. Workers were monitored for Co, Ni, and other metals. Full-shift personal BZ air samples were collected for total dust, respirable dust, and silica exposure among selected jobs throughout the various processes in the plant. Each job sampled was defined as an individual worker assigned to a specific job in a department area; multiple samples on the same job title in a department area were considered separate jobs for analysis and reporting purposes because of individual work practices and different machine model usage within the same job title.

Total and respirable dust samples were collected using tared, 37-millimeter (mm), 0.5-micron pore-size polyvinyl chloride (PVC) filters connected to battery-powered air sampling pumps. The respirable dust fraction was determined using NIOSH Method 0600 employing standard 10-mm nylon cyclones with a flow rate of 1.7 liters per minute (lpm).[1] The cyclone preselects respirable dust particles (smaller than 10 microns in diameter) by removing larger (nonrespirable) particles. Full-shift total dust sampling, using NIOSH Method 0500, used a flow rate of 2.0 lpm.[1] The quantity of total and respirable dust was determined by gravimetric analysis for each filter sample.

A quantitative determination of trace metals was made by inductively coupled plasma-atomic emission spectrometry (ICP-AES) according to NIOSH Method 7300.[1] The PVC filters were wet-ashed with 10 milliliters (ml) of concentrated nitric acid (HNO_3) and one ml of 70% perchloric acid ($HCLO_4$) and held to dryness. The residues were dissolved with 10 ml of 4% HNO_3/ 1% $HClO_4$ and then analyzed for trace metals content by ICP-AES.[1] The limit of detection (LOD) for this analysis was 0.5 ug/filter, and the limit of quantitation (LOQ) was 1.0 ug/filter.

Quantitative silica analysis was performed on selected respirable dust filters by X-ray powder diffraction (XRD). Each filter was placed in a 50-ml beaker with the unexposed side facing up and transferred to the chamber of a low-temperature radiofrequency plasma asher. The filters and any organic matrix were ashed in a 1.5 torr oxygen plasma at 200 watts power. The resulting ash in each beaker was suspended in isopropanol and dispersed in an ultrasonic bath for 10 minutes. Each suspension was filtered in a filtration apparatus containing a 0.45um pore size silver membrane filter. The filters were mounted on XRD holders and analyzed quantitatively according to the NIOSH Method 7500 utilizing an X-ray powder diffractometer operating with copper K-alpha radiation at 40 KV and 35 mA power level.[1] The resulting quartz peak intensities were converted to micrograms of quartz using a sieved (<10 um) Standard Reference Material, SRM 1878, calibration curve. The LOD for this analysis was 5 ug/filter, and the LOQ was 10 ug/filter.

Cigarette butts (from cigarettes smoked within three hours from the point of collection and placed in ashtrays) were collected from several process areas of the facility, the front office areas, and a smoking room located in the NIOSH Alice Hamilton Laboratory located in Cincinnati, Ohio. Bulk samples of the cigarette butts samples (ash, tobacco, and filters) were analyzed for trace metal content by ICP-AES. Five grams of each bulk sample were placed in solution with 200 ml of 10% HNO_3. The samples were filtered and the filtrate was digested with concentrated nitric and perchloric acids to remove the extracted organic compounds and to reduce the sample volume, to improve sensitivity. The LOQ for this analysis was 7 ug/sample. The purpose of this was to evaluate if a hazard resulted from exposure to metals due to the policy permitting workers to smoke at their workplace.

B. Medical

Review of OSHA 200 logs

Hitachi Magnetics supplied NIOSH with copies of OSHA 200 log summaries for January 1984- September 1988. These summaries listed reportable occupational injuries and illnesses at Hitachi Magnetics. The logs were reviewed for reports of respiratory conditions and contact dermatitis. Incidence rates were estimated by calculating the number of full-time workers as a denominator (416 full-time hourly employees multiplied by the 4 and 3/4 years for which OSHA logs were available) and using the observed number of dermatitis cases or respiratory conditions reported as the numerator. The observed incidence rates were divided by corresponding rates reported for Miscellaneous Fabricated Metal Products by the Bureau of Labor and Statistics in 1984 to calculate a standardized incidence ratio (SIR) with 95% confidence intervals (C.I.).[2-3]

Cross-sectional Study

All current workers with ten or more years of production experience were eligible to participate. Retired workers were notified of the study by mail and invited to participate.

A questionnaire incorporating pertinent parts of the American Thoracic Society (ATS) questionnaire was administered to each participant.[4] It sought basic demographic information, work history, past medical history, active medical problems, and current symptoms (especially respiratory complaints). The questionnaire was administered in the presence of NIOSH personnel trained to administer the instrument. Each questionnaire was reviewed after completion. The following definitions were used:

chronic cough: Cough on most days for 3 consecutive months or more during the year for at least two years.

chronic bronchitis: A cough with phlegm on most days for 3 consecutive months or more during the year for at least two years.

shortness of breath:

grade 1:	Shortness of breath when hurrying on level ground.
grade 2:	Shortness of breath when walking with others of the same age on level ground.

wheezing:

Wheezing on most days and nights.
Wheezing with attacks of shortness of breath (with normal breathing between attacks).

The prevalence of these conditions in the current Hitachi Magnetics workforce was compared with the prevalences in "non-exposed blue collar" standard population.[5]

Pulmonary function testing was performed using an Ohio Medical model 822 dry rolling seal spirometer attached to a Codonics graphics terminal 1550 with a HP4 microprocessor. Procedures conformed to the American Thoracic Society's criteria for screening spirometry.[6] Predicted values were calculated using the Knudson regression equations as described by Hankinson.[7] Predicted values for blacks were determined by multiplying the predicted value by 0.85.[7,8] For purposes of notifying participants of their test results and epidemiologic analysis of the results, an abnormal forced vital capacity (FVC) (less than 80% of predicted) with a normal ratio (forced expiratory volume in 1 second (FEV1)/FVC of 70% or more) was considered a restrictive abnormality. An abnormal ratio (FEV1/FVC less than 70%) and an FEV1 less than 80% was considered an obstructive abnormality.

Predicted values of FEV1 and FVC were also calculated using equations developed from a population of "blue collar" workers and included adjustments for race, sex, age, height, and smoking status.[9] Observed FEV1 and FVC values were subtracted from the values predicted for blue collar workers (observed-predicted) and the mean of the differences (FEV1DELTA and FVCDELTA) were then compared to 0 by the students t-test. The means of the observed FEV1 and FVC were also stratified by the number of working years at the Edmore facility and the difference between these means compared by the students t-test. Two strata were created by dividing the study group into two equal sized groups comprised of those with less than 22 working years and those with 22 or more working years. A similar comparison, controlling for smoking status and age, was made by comparing FEV1DELTA and FVCDELTA by the two working years categories.

Chest X-rays were read by three "B-readers" (physicians trained in the use of the International Labor Organization's standardized interpretation and classification of radiographs in pneumoconiosis[10]). The ILO-80 Classification System requires the coding of a chest radiograph according to its pulmonary and pleural findings and its technical quality. The consensus opinion or median value was used for analysis of results. The findings were interpreted in the following way:

Normal: All three B-readers agreed that there were no interstitial or pleural signs consistent with pneumoconiosis. This category includes profusion scores of 0/0 and 0/1.

Mild or moderate: At least two B-readers indicated signs compatible with mild or moderate interstitial fibrosis or pleural thickening. For workers with interstitial disease the profusion score by both B-readers was 1/0 or 1/1.

Moderately severe: At least two B-readers indicated signs compatible with definite interstitial lung scarring. The profusion score of both B-readers was 1/2, 2/1, or 2/2.

The prevalence of pneumoconiosis in the Hitachi Magnetics workforce was compared with the prevalence of pneumoconiosis in a non-exposed blue collar workforce.[11]

Workers monitored for environmental exposures to metal dusts were asked to provide pre- and post-shift urine samples for analysis of Co and Ni. At most, seven specimens were collected from each person: pre-shift on Monday through Thursday, and post-shift on Monday through Wednesday. Creatinine concentrations were determined for each sample. This information was used to correlate the relationship between environmental exposures to Co and Ni with the concentrations of these metals in workers' urine. Workers wearing respirators were not included in this analysis.

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 recommended exposure limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA permissible exposure limits (PELs). 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 RELs, 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 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for Co is 50 ug/m^3, 8-hour TWA.[12] The OSHA PEL for Co is 100 ug/m^3.[13]

NIOSH considers inorganic nickel to be a carcinogen and recommends personal exposures be kept below 15.0 ug/m^3 for a 10-hour TWA.[14] The ACGIH TLV and the OSHA PEL for Ni is 1000 ug/m^3.[12,13]

The current OSHA PEL for siliceous respirable dust is based on the percent of quartz found in the respirable dust fraction.[13] This limit is calculated using the equation:

$$\frac{10 \text{ mg/m3}}{\%SiO_2 + 2}$$

The ACGIH TLV for crystalline silica (quartz) is 0.1 mg/m^3. This level has been proposed as the revised OSHA PEL to be achieved by industry beginning on September 1, 1989.[15] The NIOSH REL for respirable crystalline silica is 0.05 mg/M^3 for a 10-hour TWA.[16]

B. Toxicological

1. COBALT

Cobalt is a naturally occurring element in the environment. It forms an integral part of the cyanocobalanium molecule (vitamin B 12).[17] This vitamin is essential to the human diet to prevent the development of pernicious anemia (low red blood cell count).[17] The average U.S. daily cobalt intake from food, water and community air has been estimated to be 300 ug, 6 ug and 0.1 ug respectively.[18]

While cobalt is an essential element, in high concentrations it is known to have adverse effects on the lungs, heart, thyroid, skin, and blood producing system. Fibrotic lung changes have been observed in workers exposed to airborne cobalt concentration of 100 to 200 ug/m^3. A common pattern of illness is described in these reports.[19-30] The worker may first develop a cough, followed by labored breathing on exertion. This may be followed by substantial weight loss as the individual goes on to develop a progressive interstitial pulmonary fibrosis (scar tissue in the lung). This may be accompanied by cor pulmonale (heart enlargement and failure due to the lung disease), leading ultimately to cardiorespiratory collapse and death.[17] The reported latency period from exposure to disease varies from a few years to 20 years.[17] It is unclear whether this variable latency is related to individual susceptibility or varying levels of exposure between studies.

A series of reports describe lung function test results among 155 Swedish cemented carbide workers and 74 controls matched for sex, age and smoking history.[31-33] Persons exposed to an average of 60 ug/m^3 airborne cobalt showed changes on pulmonary function tests, suggestive of obstructive disease, that did not regress over the weekend. Smokers were more affected than non-smokers.

Several investigators have suggested evidence of bronchitis among hard metal workers.[21-34] Asthma has been reported as early as within one month after initial exposure.[35] The development of asthma seems to be a true sensitization to cobalt. The occurrence of allergic lung sensitization is also plausible in view of the occurrence of documented cobalt allergic dermatitis that has been reported among workers using cobalt-containing materials.[36-37] Sjorgren et.al. has reported three non-smoking hard metal workers, having symptoms and signs compatible with allergic alveolitis.[37] The symptoms, signs and chest x-ray findings cleared following removal from the work environment, but upon re-exposure the symptoms and chest X-ray findings recurred. All three workers had eczematous skin changes and were sensitive to cobalt on skin patch testing.

Other physiological effects associated with cobalt include cardiomyopathy (disease of the heart muscle). This was first reported in the 1960's and was associated with heavy beer consumption (2 to 6 liters per day). Cobalt sulfate or cobalt chloride was commonly used in beer at that time as a foam stabilizer.[39-45] The signs and symptoms of affected individuals included abdominal pain, shortness of breath, lowered blood pressure, heart enlargement, pericardial effusion (fluid around the heart), tachycardia (rapid heart beat), and electrocardiographic (ECG) abnormalities. The amount of cobalt ingested daily by a 6-liter-per-day drinker was estimated to be about 5-10 milligrams per day (5,000 to 10,000 ug/day). Therapeutically, cobalt has been used in the treatment of anemias (low red blood cell counts). It has been shown to increase hemoglobin and hematocrit levels in humans.[46-55] Hypothyroidism and goiter have been associated with daily oral doses of 2-10 milligrams per kilogram of cobalt chloride administered over a 2-4 month period in a small percentage of people.[17] Additional effects reported in humans, but for which there is limited information available, include disturbed kidney function, hyperglycemia, mild to moderate changes in liver function tests and impaired sense of smell.[17]

NIOSH takes the following position concerning the possible carcinogenicity of cobalt:

> "Information on cobalt is inadequate to conclude that cobalt is a carcinogen. The information is also inadequate to conclude that cobalt is non-carcinogenic. In fact, limited data provide suggestive evidence that at least some cobalt containing compounds may prove carcinogenic when subjected to long-term testing by currently accepted protocols. Until such testing is performed, no definitive guidelines can be given. Tumor induction at the injection site, however, would argue for the need to adequately clean any wound contaminated with cobalt."[17]

2. NICKEL

Nickel can exist in both soluble and insoluble forms. Epidemiologic evidence suggests that the hazard presented by insoluble nickel compounds is not as great as that presented by soluble forms.[14] Nickel has been reported to cause "nickel itch," an allergic dermatitis.[54] An increase in nasal, sinus, and lung cancer has been noted in workers employed in nickel refineries, although the specific carcinogenic agent is still not defined.[14] Metallic nickel introduced into the pleural cavity, muscle tissue, and subcutaneous tissue has been shown to be carcinogenic in test animals. NIOSH considers inorganic nickel to be a carcinogen and recommends personal exposures be kept below 15.0 ug/m^3 for a 10-hour TWA.[14]

3. CRYSTALLINE SILICA

The crystalline forms of silica can cause severe tissue damage when inhaled. Silicosis is a form of pulmonary fibrosis caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter time if exposure concentrations are very high. This latter form is referred to as rapidly-developing silicosis, and its etiology and pathology are not as well understood. Silicosis is usually diagnosed through chest x-rays, occupational exposure histories, and pulmonary function tests. The manner in which silica affects pulmonary tissue is not fully understood, and theories have been proposed based on the physical shape of the crystals, their solubility, toxicity to macrophages in the lungs, or their crystalline structure. There is evidence that cristobalite and tridymite, which have a different crystalline form than quartz, have a greater capacity to produce silicosis.[55]

VI. RESULTS AND DISCUSSION

A. Environmental

Industrial hygiene data supplied by the company, including personal and area sampling is summarized in Table I. This sampling was conducted over the years by the Michigan Department of Public Health (state OSHA), the company's insurance carrier, or a consultant hired by the company.

From the sampling results presented in Table I, it is evident that exposure potential to asbestos, various metals, and silica-containing dust has existed in this plant for many years. Several historical exposure results exceeded the relevant OSHA PELs.

In April, 1979, employee exposures to asbestos were as high as 3.1 fibers/cc in the heat treating and shot blast areas. This was due primarily to the use of asbestos strips between the magnets in the oven trays. Exposures of 2.0 and 1.5 fibers/cc were noted in these areas in June, 1979. Asbestos exposures were determined to be 0.005 to 0.02 fibers/cc in May, 1985. The company currently uses Fiberfax (a man made mineral fiber) as a substitute for asbestos.

Measured levels of exposure to nickel and cobalt dust in the powdered Alnico area were 2.5 mg/m^3 and 1.8 mg/m^3 respectively in July, 1971. Cobalt exposure in the sintering department in January, 1976 was 0.4 mg/m^3. The OSHA PELs for these compounds are 0.1 mg/m^3 for cobalt and 1.0 mg/m^3 for nickel.

In April, 1974, worker exposures to dust containing free crystalline silica in the shake-out area of the foundry were measured at 35 times the OSHA PEL. In the sand mezzanine area, exposures were 7 times the PEL, and in the core making area the exposure was 12 times the PEL. In March, 1976, worker exposure to free silica in the rough grinding area of the foundry process was measured at twice that allowed by the OSHA PEL. Worker exposures to free silica in the shake-out area of the foundry exceeded the OSHA PEL in April, 1979.

During the October 1988 NIOSH survey, a total of 112 personal breathing zone air samples for 41 jobs were collected and analyzed for determination of metal exposure.(Table II) Co and Ni were the only two trace metals found to exceed the environmental exposure criteria. Time weighted average (TWA) Co exposures ranged from non-detected to 466 micrograms per cubic meter (ug/m^3). Exposure to Co exceeded the ACGIH TLV in 18 samples (16%) and 10 jobs (24%) and the OSHA PEL in 7 samples (6%) and 4 jobs (10%). TWA Ni exposure levels from total dust ranged from non-detected to 368 ug/m^3. Ni exposure exceeded the NIOSH REL in 15 samples (13%) and 8 jobs (20%). Office workers, who were presumed to be unexposed, had no detectable exposure to Co or Ni. The jobs where over-exposure to Co and Ni occurred during the NIOSH survey included:

Process	Job Title/Dept. #	Co	Ni
ALNICO	Thru-Feed Grinder/350	X	
ALNICO	Press Oper./340	X	
ALNICO	Produc. Grinder/350		X
ALNICO	Powder Mixer/340	X	X
Inspection	Cast Clean Oper./370		X
ALNICO	Grin. Oper./350		X
Hicorex	Pow. Proc./810	X	
Hicorex	Jet Mill/810	X	
ALNICO	Machine Set Up/350	X	X
Hicorex	Press Oper./820	X	
Hicorex	Boat Loader/820	X	

The Powder Mixer Operator/340 was the only worker monitored wearing respiratory protection (powered air purifying respirator with HEPA canister). Other workers in the plant were offered the opportunity, but not required, to use disposable paper dust masks. It is evident that engineering controls to reduce metal dust exposure are necessary to provide adequate protection from respiratory hazards. Until such engineering controls are instituted, other respiratory protection should be provided.

The results of the respirable dust and silica exposure sampling are presented in Table III. Respirable dust exposure levels were all below the OSHA PEL of 5 mg/m^3 and ranged from non-detected to 0.76 mg/m^3. Respirable siliceous dust exposure was identified in 8 of 18 jobs sampled, with exposures in three jobs (sand mixer, furnace operator, and a machine molder) exceeding the OSHA PEL. All 8 jobs exceeded the ACGIH TLV for crystalline silica exposure of 0.1 mg/m^3 and the NIOSH REL of 0.05 mg/m^3.

Total nuisance dust exposure levels for the various jobs sampled are listed in Table IV. Total nuisance dust exposure levels ranged from 0.30 to 4.07 mg/m^3 and were all below the OSHA PEL of 10 mg/m^3.

Results of the trace metal analysis of cigarettes butts collected in the plant production areas, front office areas, and a smoking room at the NIOSH Alice Hamilton Laboratory are provided in Table V. Co concentrations ranged from 46 to 182 ug/ 5 gram sample, and Ni concentrations ranged from 24 to 164 ug/ 5 gram sample. Co and Ni were not found on cigarettes collected from the front office areas, lunchroom, ceramic process area, or in the smoking room at NIOSH. Higher concentrations of aluminum, magnesium, and iron also appear in samples collected from production areas. These results demonstrate that cigarette butts from the production areas of Hitachi Magnetics contained high levels of Co and Ni. It is not clear how the metal contamination occurred. The contaminants may have settled out of the air onto the cigarette, been drawn into the cigarette during smoking, or have been picked-up after the cigarette butt was discarded. These data suggest that workers in the process areas of the plant may have increased exposures to Co and Ni when they smoke.

B. Medical

Review of OSHA 200 logs

There were 6 recorded occurrences of respiratory illnesses in the OSHA 200 log records.(Table VI) Two workers were reported to have had episodes of work-related asthma. In 1984, one worker with asthma lost 47 work days. The same worker experienced work-related dyspnea in 1987. A second worker was reported as having asthma twice in 1988 following exposure to nickel dust. Other recorded respiratory conditions included one episode of chemical bronchitis and 1 case of small airways obstruction. The 6 recorded episodes (in 4 individuals) was more than 10 times the number expected for industries classified as Miscellaneous Fabricated Metal Products (SIR=10.5, 95% C.I. 7.8-14.5).

There were 43 reported episodes of dermatitis yielding an incidence rate of 207 cases per 10,000 full time workers per year. Most were described as contact dermatitis. The incidence of skin disorders at Hitachi Magnetics was almost ten times that expected for industries classified as Miscellaneous fabricated metal products (SIR=9.3, 95% C.I. 4.1-17.7).

Cross-sectional Study

At the time of the survey there were 416 hourly workers and 115 salaried employees. Eligible current workers included 326 hourly employees and 36 salaried workers. A total of 256 eligible retirees were notified of the study by Hitachi Magnetics. The participation rate for current workers was 86% (310 of 362 eligible current workers) and was substantially higher than the 20% (52 of 256 eligible retired workers) participation rate for retired workers.

The average age for those completing the questionnaire was 48 years. Current workers averaged 45 years of age and 21 years of employment at the plant. Retired workers averaged 66 years of age and 26 years of employment at the facility. The majority of all participants (75%) were male (76% of the current workers, 69% of the retired workers).

Fifty-six individuals (16%) met the criteria for chronic cough, and 39 (11%) met the criteria for chronic bronchitis. Both chronic cough and chronic bronchitis were associated with smoking. The rate ratio (RR) for chronic cough was 3.11 (95% Confidence Intervals (C.I.): 1.59, 6.10) for current smokers and 1.04 (95% C.I.: 0.41, 2.62) for ex-smokers alone when compared to never smokers. The RR for chronic bronchitis was 4.76 (95% C.I.: 2.00, 11.30) for current smokers and 2.45 (95% C.I.: 0.92, 6.52) for ex-smokers when compared to never smokers.

The current Hitachi workforce had prevalences of chronic cough (15%) and chronic bronchitis (9%) that were similar to the prevalences found in a group of unexposed blue collar workers (RR for chronic cough = 1.15, 95% C.I. 0.85, 1.56; RR for chronic bronchitis = 1.05, 95% C.I. 0.76, 1.45).(Table VIII)

Ninety-one (25%) participants reported a history of shortness of breath; 23 (6%) were classified as grade 2 or greater. Eleven (3%) reported symptoms more severe than grade 2. Breathlessness was not associated with a history of smoking when all study participants were considered. However, restricting the analysis to current workers, smokers had a RR of 1.95 (95% C.I.: 1.21 - 3.16) and ex-smokers had a RR of 1.47 (95% C.I.: 0.85 - 2.54) compared to never smokers.

The current Hitachi workforce had a prevalence of grade 1 or higher dyspnea that was slightly lower than observed in a comparison group of blue collar workers (RR=0.90; 95% C.I. 0.73-1.12).(Table VIII) The current Hitachi workforce also had a similar prevalence of Grade 2 or higher dyspnea to the blue collar standard population (RR=0.66; 95% C.I. 0.39-1.10).

Twenty-seven (9%) of the current Hitachi workers complained of wheezing on most days and nights and 17 (6%) had wheezing with periodic attacks of shortness of breath. These percentages were similar to that expected when compared to a standard blue collar workforce.(Table VIII) Twenty-four (9%) workers reporting wheezing believed that this condition began after their employment at the Edmore, Michigan facility.

Twenty-three (8%) of the current workers claimed to have had asthma (20 had been diagnosed by a physician). Ten workers with asthma developed it while working at the Edmore facility. The prevalence of self-reported asthma in the blue collar standard population was 7% (50 out of 736 blue collar workers).(personal communication with authors of reference 5).

Pulmonary Function Testing

The PFT tests were considered to have been reproducible for 90% of the participants. Fourteen subjects had nonreproducible peak flow values, 9 had nonreproducible FEV1 values, 7 had nonreproducible FVC values, and 6 had nonreproducible curves based on some combination of peak flow, FEV1, and FVC. Difficulty was encountered meeting the 1987 American Thoracic Society two second plateau criterion. Sixteen percent of those tested did not achieve a two second plateau. The lack of an adequate plateau may underestimate FVC, thereby underestimating participants with an obstructive pattern and overestimating the number of participants with a restrictive pattern.

Three hundred and fifty-seven (99%) participants completed pulmonary function testing. Eleven (3%) workers demonstrated a restrictive pattern and 60 (17%) an obstructive pattern, with eight of the latter also potentially having a restrictive abnormality. As anticipated, smoking was associated with an obstructive PFT pattern. The RR for an obstructive pattern was 3.49 (95% C.I.; 1.62 - 7.51) for current smokers and 4.31 (95% C.I.; 2.02 - 9.22) for ex-smokers compared to never smokers. Other factors, such as exposure to Co dust, may have contributed to the prevalence of obstruction in this workforce. However because most workers studied were exposed to Co dust, no internal comparison group was available. As a result, the association between Co dust exposure and obstruction could not be studied without reference to an external standard population. There was no association between workers having a restrictive pattern and smoking.

The mean FEV1 and FVC for current workers were 3.51 L (liters) and 4.55 L respectively. These values were slightly higher than those predicted (accounting for race, gender, age, height, and smoking status) for blue collar workers (FEV1DELTA=0.16 L, $p<0.01$; FVCDELTA=0.18 L, $p<0.01$) indicating that ventilatory capacity was better than predicted.

Participants were dichotomized into working years categories of equal size (those with less than 22 years and those with 22 or more years). The mean observed FEV1 for current workers was lower for workers with 22 or more years compared to workers with less experience (3.38 L versus 3.61 L, $p=0.01$). However, this finding may have been due to the difference in age between these categories since the means of the differences between observed and expected FEV1 (FEV1DELTA) were much less and not statistically different (0.12 L in workers with 22 or more years of working experience versus 0.19 L in workers with less than 22 years of working experience, $p=0.21$). The mean FVC did not differ significantly by years worked for current workers (4.50 L versus 4.59 L, $p=0.45$).

Chest radiographs

A total of 359 workers (308 current, 51 retired) had chest radiographs taken as part of the NIOSH survey. Two films were considered unreadable and were not included in the results. The 357 workers with readable chest X-rays had an average age of 48.5. The mean number of years worked at the facility for these workers was 21.8 years. The majority of these workers were men (76%).

The 357 readable films were rated for quality with scores from 1 to 3, with 1 the highest film quality. The majority of the films (184, or 51.5%) were scored with a quality rating of 1 or 2. The remainder of the films (173 or 48.5%) were scored with a quality rating of 3. The predominant reason for films being scored 3 was over-penetration. Early stages of pneumoconiosis may be more difficult to identify when films are over-penetrated. Although the readers determined that films of quality 3 could be satisfactorily read, the possibility that a few cases of pneumoconiosis were not correctly identified cannot be ruled out.

Four workers had interstitial opacities consistent with pneumoconiosis.(Table VII) Two had category 1 profusions: one with regular rounded bilateral opacities in the upper lung fields, another with irregular bilateral opacities in all lung fields. The others had category two profusions. Both had small irregular interstitial bilateral opacities in the lower and middle lung fields. The 1.1% prevalence of interstitial opacities (profusion 1/0 or greater) is comparable to the 0.9% prevalence found in a study of 1422 unexposed blue collar workers.[11] However, none of the 1442 unexposed workers had a profusion score greater than 1/1 while two of the Hitachi Magnetics workers had profusion scores of 1/2 or higher. Although not sufficient to meet our study criteria for classifying a participant as having X-ray evidence of pneumoconiosis, one of the three B-readers indicated 1/0 profusion interstitial opacities in another 12 workers (9 current, 3 retired, and 1/1 profusion interstitial opacities in another worker (retired).

Two additional current workers had pleural thickening consistent with exposure to asbestos.(Table VII) This pleural thickening was unilateral in one worker and bilateral in the other. One of the three B-readers identified pleural thickening in five additional workers four had bilateral signs.

The PFT results for the six workers with findings consistent with pneumoconiosis are also provided on Table VII. For those with interstitial opacities, two had normal PFTs and two had an obstructive pattern. For those with pleural findings, one had a normal PFT while the other had a restrictive pattern.

Discussion of Respiratory Findings

The finding that workers at Hitachi Magnetics have developed asthma, dermatitis, and - in at least one case - probable silicosis is consistent with the history of exposure to various dermatologic and respiratory hazards at this plant.

Four workers were documented in the OSHA 200 logs to have had respiratory conditions (including asthma) and there were 43 reported episodes of dermatitis. The incidence of these conditions at Hitachi was almost 10 times the expected incidence for the

Miscellaneous Fabricated Metal Products industry. This increased risk of respiratory conditions and dermatitis at the Hitachi Magnetics facility may have been a consequence of hazardous exposures to toxic metals that are known sensitizers.

Four workers had chest X-ray findings consistent with pneumoconiosis, and two others had pleural thickening consistent with exposure to asbestos. One worker had bilateral small rounded opacities consistent with silicosis. This individual reported having worked as a core maker for 7 years where he was exposed to silica flour. NIOSH issued a Current Intelligence Bulletin on the association between exposure to silica flour and silicosis.[56] Hitachi Magnetics no longer uses silica flour in its foundry area. Two workers with irregular interstitial opacities worked as grinders in ALNICO (Ni and Co exposures) for 7 years and 10 years and in the foundry area (silica and asbestos exposures) for 6 and 2 years. The fourth worker with irregular interstitial opacities worked as an electrician for more than 15 years and did not report any direct contact with asbestos. One worker with pleural thickening worked as a grinder in LODEX (metal powders and mercury exposure) for more than 15 years and in heat treat ALNICO (asbestos exposure) for 1 year. The second worker with pleural thickening worked as an electrician for more than 25 years and reported frequent exposure to asbestos.

The prevalences of respiratory symptoms, mean FEV1, and mean FVC appear to be similar to those expected for blue collar workers. Prevalence of chronic cough, chronic bronchitis, wheezing and shortness of breath at Hitachi Magnetics were similar to the comparison group.(Table VIII)[5]

The overall prevalence of signs compatible with pneumoconiosis at Hitachi Magnetics was similar to that expected for nonexposed blue collar workers. However, caution should be taken when interpreting these results. Two Hitachi Magnetics workers had findings consistent with moderately severe interstitial fibrosis while none of the workers in the external reference group had such findings. The relatively large number of over-penetrated chest X-ray films (quality 3) may have resulted in some misclassification of pneumoconiosis. A study by Reger et al found that over-penetrated films were scored lower for profusion than films of better quality.[57] However, in Reger's study this difference appeared to be a function of the B-reader's experience as there was less variation between B-readers with the over-penetrated films than with the preferred films. Although a few of the individual Hitachi films may have been misclassified, the number was probably small. This was apparent since none of the films with quality scores of 1 or 2 were considered consistent with interstitial fibrosis.

The investigators also had difficulty examining the association between the various respiratory outcomes and specific exposures at Hitachi Magnetics. Most workers included in the study had potential exposures to metal dusts and an internal comparison group of unexposed workers was not available. As a result, an external comparison group of unexposed blue collar workers was used.

A potential source of bias in any cross-sectional study may result if workers leave their job because of an illness acquired on the job. When this occurs, workers who are presently employed are less likely to have a work-related illness than all workers who had been employed. This survival bias results in an under estimation of work related illness and may have been present in this study.

A selection (or "survival") bias may have prevented us from identifying cases of occupational asthma in this workforce. Participation in this study was restricted to those with ten or more years of experience at the facility. Recently hired workers, who may be at greater risk for asthma than workers with more experience, were not enrolled. The presence of Co and Ni dust at Hitachi Magnetics, at levels in excess of recommended standards, indicates that a potential health hazard from these metals does exist and that some workers would be expected to develop occupational asthma.

C. <u>Correlation Between Biological and Environmental Monitoring for Nickel (Ni) and Cobalt (Co).</u>

Determination of Co concentration in urine and daily measurement of airborne Co was carried out in a previous health hazard evaluation.[58] The purpose was to determine if cross-shift urine sampling for cobalt could be used to estimate daily Co exposures. In the earlier survey, urine Co concentration increased over each shift and returned to a background level by the following morning. The environmental exposures were found to explain 60% of the cross-shift increase in urine Co. Similar testing was done at Hitachi to further characterize the relationship between daily exposure to Co (and Ni) and excretion of Co in the urine. Urine concentrations for Co (and Ni) are a reflection of total Co (and Ni) body burden and individual factors relating to excretion. These results should not be used as an indication of a worker's health status. Rather, they are an indication of personal exposure to, and uptake of these metals. There are no standards for urine Co and Ni concentrations that can, at this time, be related to hazardous exposures levels in the workplace.

A total of 261 urine specimens were collected from 39 participants. At most, seven specimens were collected from each person: pre-shift on Monday through Thursday, and post-shift on Monday through Wednesday. The limits of detection for Co and Ni were 1.0 ng/ml and 1.5 ng/ml, respectively. Lab blanks and field blanks were also collected and analyzed. Creatinine concentrations were also determined for each sample. Insufficient urine volume was collected for 5 creatinine measurements, 3 Co measurements, and 6 Ni measurements. The urine samples from two workers were not considered in the analysis because their extremely high urine Co levels suggested external contamination.

The means, standard deviations, and ranges for total Co and Ni airborne exposures and creatinine-corrected pre- and post-shift urine cobalt concentrations are given in Table IX. On each day, post-shift urine Co concentrations were higher than pre-shift levels. The post-shift urine Co means were also higher than pre-shift means of the next day, indicating that urine cobalt concentrations returned toward a baseline within sixteen hours. The mean increases in urine Co on Monday, Tuesday, and Wednesday were 13.9 ug Co/mg creatinine, 26.8 ug Co/mg creatinine, and 13.8 ug Co/mg creatinine respectively. These increases were statistically significant on Monday and Tuesday ($p=0.039$ and $p=0.006$) but not so on Wednesday ($p=0.083$). The decreases in post- and pre-shift (next day) urine Co were 7.1 ug Co/mg creatinine Monday to Tuesday, 22.8 ug Co/mg creatinine Tuesday to Wednesday, and 10.3 ug Co/mg creatinine Wednesday to Thursday. These decreases were statistically significant on Tuesday to Wednesday ($p=0.025$) but not on Monday to Tuesday ($p=0.187$) or Wednesday to Thursday ($p=0.246$). Only 59 urine samples contained detectable Ni. Overall, urine Ni concentrations were extremely low and did not vary across shifts or from day to day. Further analysis was not conducted using the urine or air Ni concentrations.

Table X lists the Pearson correlation coefficients for Co exposures and changes in urine Co concentration for each day. The correlation coefficient for all three days was similar (0.25 on Monday, 0.28 on Tuesday, and 0.18 on Wednesday. None of these coefficients was statistically significant. Since the correlation between urine Co and airborne Co was marginal, no statistical modeling is reported.

VII. CONCLUSIONS

Based on the exposure monitoring results, a hazard from exposure to Co, Ni, and respirable silica exists among employees in various jobs in Departments 310, 340, 350, 810, and 820. From the trace metal content of cigarettes collected through-out the plant, it is apparent that the practices of smoking, eating, and drinking at the work stations could further contribute to exposure to metals. A review of OSHA 200 logs documented an increased risk of dermatitis and respiratory conditions, including asthma, among Hitachi Magnetics workers. The medical survey found that both the prevalence of respiratory symptoms and the pulmonary function tests of current workers were normal when compared with a group of non-exposed blue collar workers. Although the prevalence of occupational dust disease was also similar to a group of non-exposed blue collar workers, two individuals had moderately severe interstitial fibrosis not found in the external reference group. At least one of them probably had silicosis. Based on their known toxicity, exposures to silica, Co, and Ni at Hitachi Magnetics could result in pneumoconiosis, asthma, and allergic dermatitis in exposed workers who are not adequately protected.

VIII. RECOMMENDATIONS

A. Environmental

1. As evidenced by the results of the air sampling conducted in this evaluation, overexposures to Co, Ni, and respirable silica occur among workers in various operations throughout the

plant. The revised OSHA PELs will require Hitachi to achieve the exposure limits of 0.05 mg/m^3 for Co and 0.1 mg/m^3 for respirable silica by any control measure. These limits will ultimately have to be achieved by engineering controls by 1992. In anticipation of these revised standards, we recommend that Hitachi strive to achieve these exposure limits through engineering controls as soon as possible. Ventilation controls should be evaluated for the powder mixer operation, presses, grinders, cast ALNICO, cast cleaner, ALNICO grinder, hicorex jet mill, boat loaders, and hicorex powder process operations. Additional exposure monitoring should be conducted on these jobs/operations, and others which we did not sample, to meet the OSHA requirement for characterizing exposure to determine compliance with the revised PELs.

2. Engineering controls are the preferred means to reduce exposure to respiratory toxins. Until adequate engineering controls can be established, the respiratory control program requires specific attention to be fully effective. The respiratory protection program should be updated and revised to include requirements for the proper use, storage, and replacement of paper dust masks. The program should also specify similar requirements for the other type of respirators in use. We observed workers wearing extremely dirty (contaminated) paper masks, procedures for storing masks which allowed the masks to become contaminated, and masks which had been removed and placed on contaminated surfaces prior to re-use. A suitable cabinet, or similar storage area, for the powder metal mixer operator's powered air purifying respirator should be provided immediately. The current storage method and area will not prevent this respirator from being contaminated with metal dust. The company should administer and enforce the program requirements of proper use, cleaning, and storage of respirators.

3. Monitoring for short term exposure to respirable dust, total dust, and metals should be conducted during the replacement of crucible pots in the foundry. While the exhaust ventilation in this location appears to be effective, the worker was required to place his head and arms inside the plume of dust created during this procedure.

4. Exposure monitoring for respirable silica and metals should be conducted during the dry-wheel dressing procedure to determine if this contributes substantially to personal exposure. Local exhaust ventilation or personal respiratory protection may be required if it is determined this practice results in high peak exposures.

5. Exposure monitoring for amines and isocyanates should be conducted in the sand mixing and core making process area of the foundry to assure that exposure to these compounds does not exceed their respective exposure criteria.

6. The insulation material on the ovens should be checked for asbestos. The insulation on several ovens was noted to be in a poor state of repair. Any asbestos-containing insulation should be properly encapsulated to prevent aerosolization of the fibers, or properly removed and replaced with asbestos-free material.

7. The field strength and field characteristics of the electro-magnetic field (EMF) for each type of press or oven used to magnetize or de-magnetize the magnets should be determined. Such evaluation should determine the exposure potential to EMF when the worker inserts his arms into the press to retrieve the magnets. The potential for full body conductivity should be prevented by eliminating the practice of standing on metal grates (ceramic process). NIOSH can provide consultation or assistance in the evaluation and determination of this type of exposure hazard.

8. The powder mixing area (sintered ALNICO) should be segregated from other areas to prevent workers from traveling through this area, where respiratory protection is required. This may be accomplished by walls, the optimum containment, or by a railing. Such a modification will assist in administering and promoting a consistent respiratory protection program, as well as minimizing exposure potential for workers adjacent to this area.

9. The use of UV light attenuating colored glasses should be required for all who watch the "pour-out" in the foundry. We observed one individual continuously watching the pour out without glasses. This can present a safety hazard (visual disturbances, or spots before the eyes) and, for sufficiently elevated levels of light energy levels, eye injury.

10. All forklift trucks should be checked immediately for visual and audible backup alarms. We saw several trucks which did not have functioning alarms. The forklift truck driver training program should be reviewed to assure that it contains requirements for notification, documentation, and repair of this type of equipment malfunction. The golf carts used in the plant for transportation should be similarly equipped and included in the driver training program.

11. Hitachi should review, and perhaps revise, its policy and methods to enforce administrative requirements for personal protective equipment usage and work practices. We observed deviations from the required use of hard hats and hearing protection. All employees, supervisors, and visitors should be required to use appropriate personal protection in designated areas. Allowing individuals to deviate from the requirements disrupts the integrity and continuity of the health and safety program, and fosters a false sense of security among employees. The use of safety glasses is very well

administered. To assure safety glasses as worn are truly impact resistant, they should be ANSI approved. We observed several prescription glasses which are not impact resistant glass.

12. Heat stress should be evaluated during the summer months. It was apparent to us that this may be a problem during hot weather in the Ceramics building and the foundry area.

B. Medical

1. Workers should be clearly informed of the hazards of working with metal dusts. The association between the various forms of pneumoconiosis and exposure to cobalt (hard metal disease), silica (silicosis), and asbestos (asbestosis) should be discussed with current employees and with new workers prior to placement. In addition, education should include discussions of the associations between cobalt and nickel and development of asthma and allergic contact dermatitis.

2. Each worker who develops occupational asthma or allergic contact dermatitis should be assessed and treated by a physician knowledgeable in the management of these conditions. Workers should then be offered a work assignment, without economic penalty, that would minimize their exposure to the offending agent. Drugs that prevent asthmatic attacks should be considered an adjunct to, not a substitute for, minimizing potential exposure to the substances that cause the attacks.

3. Hitachi Magnetics should develop an effective surveillance program for respiratory disorders including occupational asthma and pneumoconiosis, particularly asbestosis.

4. The plant and the union should take steps to discontinue eating, drinking, and smoking at the work station. These practices can make a considerable contribution to the full exposure dose received by a worker, as was suggested in this study. In order to assist employees in this regard, the company could sponsor a smoking cessation program to ease the transition from current habits to new requirements.

5. To assure that pulmonary function testing is done properly in the medical surveillance program, the plant nurse (or whoever will be administrating these tests) should receive formal pulmonary function test training.

6. The health and safety committee should become actively involved in identifying and resolving health and safety concerns such as those identified during this survey. A joint management/union safety committee, which is in place, can be very effective in improving the overall health and safety of the Hitachi workforce. It is our understanding that the company is planning to hire an industrial hygienist. This is commendable as it would benefit any comprehensive health and safety program.

7. All former workers should be notified of the results of this study so that they can seek medical care if they are symptomatic and be evaluated by appropriate screening methods.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH Manual of analytical methods. 3rd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. DHHS (NIOSH) Publication No. 84-100.

2. Occupational Injuries and Illnesses in the United States - 1984. Bureau of Labor Statistics. US Dept of Labor. Bulletin 2259.

3. Rothman KJ, Boice JD, Epidemiologic Analysis with a Programmable Calculator. US Dept. HEW, PHS, NIH, NIH Pub. No. 79-1649. June 1979.

4. Ferris BG, Principal Investigator. Epidemiology Standardization Project. Am Rev Respir Dis 1978; 118:1-20.

5. Petersen M, Castellan RM. Prevalence of chest symptoms in non-exposed blue-collar workers. J Occ Med 1985; 26:367-374.

6. American Thoracic Society. ATS statement -- Standardization of Spirometry. Medical Section of the American Lung Association. Am Rev Respir Dis 1987; 136:1285-1298.

7. Hankinson JL, Pulmonary function testing in the screening of workers: Guidelines for instrumentation, performance, and interpretation. J Occup Med. 1986; 28:1081-1091.

8. Lanese RR, Keleer MD, Foley MF, Underwood EH. Differences in pulmonary function tests between whites, blacks, and American Indians in a textile company. J Occup Med 1978; 20:39-44.

9. Peterson M, Castellan RM, Prevalence of chest symptoms in non-exposed blue-collar workers. J Occ Med 1984; 26:367-374.

10. International Labour Organization. Guidelines for the use of ILO international classification of radiographs for pneumoconiosis, revised edition. Geneva: International Labour Organization, 1980. (Occupational Safety and Health Series, No. 22 (rev)).

11. Castellan RM, Sanderson WT, Petersen MR. Prevalence of radiographic appearance of pneumoconiosis in an unexposed blue collar population. Am Rev Resp Dis 1985; 131:684-686.

12. American Conference of Governmental Industrial Hygienists. Threshold limit values and biological exposure indices for 1988-89. Cincinnati, Ohio: ACGIH, 1988.

13. Occupational Safety and Health Administration. OSHA safety and health standards for general industry. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1983.

14. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic nickel. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-164).

15. Occupational Safety and Health Administration. Air contaminants - Permissible Exposure Limits, OSHA safety and health standards for general industry. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised March 1989.

16. National Institute for Occupational Safety and Health. Criteria for a recommended standard: Occupational Exposure to Crystalline Silica. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1974. DHEW publication no. (NIOSH) 75-120.

17. National Institute for Occupational Safety and Health. Occupational Hazard Assessment: Criteria for Controlling Occupational Exposure to Cobalt. HEW Publication No. (NIOSH) 82-107. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1982.

18. Schroeder HA, Nason AP, Tipton IH: "Essential Trace Metals in Man--Cobalt," J Chronic Dis 20: 869-90, 1967.

19. Coates OE and Watson J,: Diffuse Interstitial Disease in Tungsten Carbide Workers', Annals of Internal Medicine 75: 709-716, 1971.

20. Scherrer M, Parambadathumalail A, Burki H, Senn A, Zurcher R: [Three cases of "hard metal" pneumoconiosis.] J Suisse Med 100:2251-55, 1970 (Ger).

21. Reber E, Burckhardt P: [Hard-metal pneumoconiosis in Switzerland.] Respiration 27:120-42, 1970 (Ger)

22. Bech AO: Hard metal disease and tool room grinding. J Soc Occup Med 24:11-16, 1974.

23. Husten K: [Hard-metal fibrosis of the lungs.] Arch Gewerbepathol Gerwerbehyg 15:721-92, 1959 (Ger).

24. Einbrodg HJ, Kuhne W: [Lung dust and morphological picture of a hard metal lung.] in Reploh H, Klosterkotter W (eds.): Fortschritte der Staublungenforschung. Monograph on the Fourth International Dust-Lung Meeting of April 3-5, 1962, in Munster, Westfalen. Dinslaken, Niederrheinische Druckeri, 1963, pp 217-26 (Ger.).

25. Collet A, Liot F, Gallouedec C, Roussel G, Martin J, Reuet C, Brouet G: [Electron microscopy study of various cellular aspects of pulmonary fibroadenomatoses with diffusion disorders--Discussion on the etiological role of cobalt and tungsten carbide.] Rev Tuberc (Paris) 27:357-81, 1963 (Fre).

26. Rochemaure J, Ancla M, Trinquet G, Meyer A: [A case of pulmonary bifrosis--Possible role of tungsten dust.] J Fr Med Chir Thjorac 26:305-12, 1972 (Fre).

27. Joseph M: Hard metal pneumoconiosis. Australas Radiol 12:92-95, 1968.

28. Bartl F, Lichtenstein ME: Tungsten carbide pulmonary fibrosis -- A case report. Am Ind Hyg Assoc J 37:668-70, 1976.

29. Teyssier L, Guerin L, Frey N, Lesobre R: [Pulmonary fibrosis observed in the hard metal industry.] Arch Mal Prof 36:53-56, 1975 (Fre).

30. Siegesmund KA, Funahashi A, Pintar K: Identification of metals in lung from a patient with interstitial pneumonia. Arch Environ Health 28:345-49, 1974.

31. Alexandersson R: [Studies on Effects of Exposure to Cobalt. II. Reactions of the Respiratory Organs of Various Exposure Levels in the Hard metal Industry.] Arbete Och Halsa 2:1-34, 1979 (SWE).

32. Alexandersson R: [Studies on Effects of Exposure to Cobalt. VI. Exposure, Uptake, and Pulmonary Effects on Cobalt in the Hard Metal Industry.] Arbete Och Halsa 10:1-24,1979 (Swe).

33. Alexandersson R, and Hedenstierna G: [Studies on Effects of Exposure to Cobalt: III. Ventilation Capacity, Distribution of Inhaled Gas, and closing of Respiratory Passages During Ongoing Work and After Periods of Non-exposure.] Arbete Och Halsa 7:1-25,1979 (Swe).

34. Jobs H and Ballhausen C: [The Medical and Technical Viewpoints of Metal Ceramics as a Source of Dust.] Vertrauensorzt KranKenKasse 8:142-48, 1940 (Gre).

35. Coates EO, and Watson JH, "Diffuse Interstitial Lung Disease in Tungsten Carbide Workers," Ann Intern Med 75:709-16, 1971.

36. Pirila V, "Sensitization to Cobalt in Pottery Workers" Acta Derm Venereol 33:193-198, 1953.

37. Rystedt I and Fischer T, "Relationship Between Nickel and Cobalt Sensitization in Hard Metal Workers", Contact Dermatitis 9:195-200.

38. Sjorgren I, Hillerdal G, Anderson A and Zelterstrom O, "Hard Metals Lung Disease: Importance of Cobalt in Coolants", Thorax 35:653-659, 1980.

39. Alexander CS, Cobalt-beer cardiomyopathy -- A clinical and pathologic study of twenty-eight cases. Am J Med 53:395-417, 1972.

40. Morin YL, Foley AR, Martineau G, Roussel J: Quebec beer-drinkers' cardiomyopathy -- Forty-eight cases. Can Med Assoc J 97:881-83, 1967.

41. The mystery of the Quebec beer drinkers' cardiomyopathy. Can Med Assoc J 97:930-31, 1967 (editorial).

42. Sullivan JF, Egan JD, George RP: A distinctive myocardiopathy occurring in Omaha, Nebraska--Clinical aspects. Ann NY Acad Sci 156:526-43, 1969.

43. Kesteloot H, Roelandt J, Willems J, Claes JH, Joossens JV: An inquiry into the role of cobalt in the heart disease of chronic beer drinkers. Circulation 37:854-64, 1968.

44. Kerr A Jr: Myocardiopathy, alcohol, and pericardial effusion. Arch Intern Med 119:617-19, 1967.

45. Berk L, Burchenal JH, Castle WB: Erythropoietic effect of cobalt in patients with or without anemia. N Engl J Med 240:754-61, 1949.

46. Kato K: Iron-cobalt treatment of physiologic and nutritional anemia in infants. J Pediat 11:385-96, 1937.

47. Coles BL: The use of cobalt in some common anemias of childhood. Arch Dis Child 30:121-26, 1955.

48. Robinson JC, James GW III, Kark RM: The effect of oral therapy with cobaltous chloride on the blood of patients suffering with chronic suppurative infection. N Engl J Med 240:749-53, 1949.

49. Lindblad G, Wegelius R: Effect of cobalt on the reticulocyte counts of young premature infants. Ann Paediat Fenn 3:103-08, 1957.

50 Rohn RJ, Bond WH: Observations on some hematological effects of cobalt-iron mixtures. J Lancet 73:317-24, 1953.

51. Wolf J, Levy IJ: Treatment of sickle-cell anemia with cobalt chloride. AMA Arch INtern Med 93:387:96, 1954.

52. Coles, BL, James U: Use of cobalt and iron in the treatment and prevention of anemia of prematurity. J Lancet 75:79082, 1955.

53. Duckham JM, Lee HA: The treatment of refractory anemia of chronic renal failure with cobalt chloride. Q J Med 45:277-94, 1976.

54. Proctor NH, Hughes JP. Chemical hazards of the workplace. Philadelphia: J.B. Lippencott Company, 1978.

55. Ziskind M, Jones RN, Weill H. Silicosis, state of the art. Am Rev Respir Dis 1976;113:643.

56. Silica Flour Silicosis, Current Intelligence Bulletin 36. National Institute for Occupational Safety and Health. US Dept. HHS. Pub. No. 81-137. June, 1981.

57. Reger RB, Smith CA, Kibelstis JA, Morgan WKC. The effect of film quality and other factors on the roentgenographic categorization of coal workers' pneumoconiosis. Am J Roentgenography, Radiion Therapy, and Nuclear Medicine. 1972; 3:462-472.

58. Burr G, Sinks TH. Health Hazard Evaluation Report 85-295-1907. Cincinnati: Hazard Evaluations and Technical Assistance Branch, DSHEFS, NIOSH, US Dept of Health and Human Services, June 1988.

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1. Hitachi Magnetics, Edmore, MI.
2. United Auto Workers Local 1436, Edmore, MI
3. United Auto Workers International, Detroit, MI
4. Occupational Safety and Health Administration (OSHA) Region V.
5. Michigan Department of Public Health, Lansing, MI.

For the purpose of informing affected workers, 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

Historical Personal and Area Air Samples
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

Substance Sampled	Time Period	Number Sampled	Area	Concentration (mg/m^3) Range	Mean
Aluminum	8/1982	1	Alnico	0.028	
Antimony	8/1982	2	Hicorex	ND*	
Asbestos	4/1979-5/1985	18	Foundry	ND - 3.1+	0.96
Beryllium	1/1976	2	Sintering	ND	
Cadmium	1/1976	1	Braze Dept.	ND	
Cobalt	7/1971-11/1985	11	Alnico, Sintering	ND - 1.8	0.23
Copper	4/1974	8	Braze Dept.	ND - 0.11	0.03
Iron Oxide	4/1974-8/1986	12	Foundry, Ceramics	0.02 - 0.38	0.15
Lead	1/1976	2	Sintering	ND	
Nickel	7/1971	7	Alnico	ND - 2.5	
% Silica	7/1974-8/1982	14	Foundry	5 of 14 samples were 7 to 35 times higher than the OSHA PEL	
Strontium	8/1986	5	Ceramics	ND - 0.20	

*ND - not detected
+ - concentration in fibers/cubic centimeter

Table II

Personal Full Shift Exposure to Metals
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

Job Title/Dept. No.	Sample Time (min.)	Sample Volume (liters)	Concentration of Metals mg/m³ Al	Ca	Co	Cu	Fe	Mg	Na	Ni	P	Ti	Zn	Nd	Sm
Thru-Feed Grin./350	518	932	0.024	0.023	0.036	0.009	0.17	0.003	0.010	0.024	0.001	0.004	ND	0.001	0.002
" "	510	969	0.007	0.014	0.009	0.001	0.03	0.002	0.008	0.007	0.001	0.003	ND	0.002	ND
" "	503	905	0.010	0.010	0.034	0.004	0.03	ND	0.007	0.022	ND	0.007	ND	ND	ND
Press Operator/340	508	1016	0.116	0.016	0.137	0.008	0.16	0.003	0.007	0.299	0.001	0.059	0.001	0.003	0.003
" "	496	917	0.046	0.004	0.071	0.005	0.06	0.001	0.006	0.123	ND	0.032	ND	0.003	0.003
" "	514	950	0.113	0.003	0.392	0.045	0.10	ND	0.004	0.368	ND	0.091	ND	0.002	0.003
Press Operator/340	511	919	0.059	0.014	0.104	0.005	0.07	0.002	0.002	0.143	0.001	0.046	0.007	0.003	0.002
" "	499	948	0.036	0.003	0.065	0.003	0.03	0.001	0.007	0.070	0.001	0.039	ND	0.003	0.003
" "	511	971	0.032	0.002	0.068	0.005	0.02	0.001	0.003	0.062	ND	0.038	ND	0.002	0.002
Cast Alnico/320	466	838	0.025	0.032	0.005	0.002	0.05	0.019	0.022	0.002	ND	0.001	ND	ND	ND
" "	490	882	0.033	0.041	0.008	0.003	0.08	0.033	0.030	0.005	ND	0.002	ND	0.002	ND
" "	493	936	0.105	0.028	0.011	0.015	0.06	0.016	0.092	0.005	ND	0.002	0.006	ND	ND
Bench Molder/310	516	929	0.008	0.333	0.001	0.026	0.04	0.038	0.005	ND	ND	ND	ND	0.002	ND
" "	511	945	0.005	0.148	0.003	ND	0.05	0.018	0.004	0.002	ND	0.001	ND	0.002	ND
" "	517	1008	0.006	0.288	0.002	0.001	0.04	0.032	0.008	0.001	ND	ND	ND	ND	ND
Thru-Feed Grin./350	517	930	0.022	0.033	0.027	0.004	0.09	0.004	0.032	0.010	0.002	0.003	ND	0.002	ND
" "	483	917	0.008	0.009	0.015	0.002	0.04	0.002	0.015	0.010	ND	0.003	ND	0.001	0.002
" "	503	905	0.008	0.008	0.015	0.003	0.03	0.002	0.010	0.010	ND	0.003	ND	ND	ND
Produc. Grinder/350	506	910	0.009	0.027	0.011	0.001	0.07	0.004	0.023	0.007	ND	0.002	ND	0.003	0.002
" "	511	971	0.011	0.014	0.020	0.003	0.05	0.002	0.018	0.014	ND	0.005	ND	0.002	0.002
" "	511	894	0.011	0.040	0.026	0.003	0.05	0.003	0.010	0.016	ND	0.004	ND	ND	ND
Powder Mixer/340	492	910	0.149	0.013	0.278	0.05	0.230	0.002	0.004	0.365	0.005	0.084	ND	0.003	0.002
" "	497	944	0.187	0.005	0.466	0.03	0.271	ND	0.006	0.328	0.003	0.153	0.002	0.003	0.004
" "	280	505	0.120	0.003	0.267	0.43	0.152	0.002	0.010	0.142	0.003	0.008	ND	ND	ND.

Evaluation Criteria (mg/M³)

	Al	Ca	Co	Cu	Fe	Mg	Na	Ni	P	Ti	Zn	Nd	Sm
OSHA Permissible Exposure Limit (PEL)	--	5.0	0.1	1.0	10.0	15.0	2.0	1.0	--	--	5.0	--	--
NIOSH Recommended Exposure Limit (REL)	--	--	--	--	--	--	2.0	0.015	--	--	5.0	--	--
ACGIH Threshold Limit Value (TLV)	10.0	2.0	0.05	1.0	5.0	10.0	2.0	1.0	0.1	10.0	5.0	--	--

Symbols for metals: Al = Aluminum, Ca = Calcium, Co = Cobalt, Fe = Iron, Mg = Magnesium, Na = Sodium, Ni = Nickel, P = Phosphorus, Ti = Titanium, Zn = Zinc, Nd = Neodymium, Sm = Samarium.
mg/m³ = milligrams of metal per cubic meter of air
ND = None Detected
Limit of Detection = .001 mg/m³

Table II (continued) - Page 2

Job Title/Depart. No.	Sample Time (min.)	Sample Volume (liters)	Al	Ca	Co	Cu	Fe	Mg	Na	Ni	P	Ti	Zn	Nd	Sm
			Concentration of Metals mg/m³												
Furn. Oper. Alnico/330	511	970	0.013	0.005	0.003	0.003	0.026	0.002	0.003	0.004	0.003	0.001	ND	0.001	ND
" "	503	930	0.014	0.009	0.005	ND	0.028	0.003	0.008	0.004	ND	0.001	ND	ND	ND
" "	497	919	0.014	0.005	0.005	ND	0.026	0.003	0.008	0.004	0.002	0.001	ND	ND	ND
Cast Cleaning/320	466	839	0.011	0.028	0.010	0.001	0.079	0.004	0.006	0.007	0.005	0.002	ND	0.003	0.002
" "	459	895	0.016	0.021	0.014	0.001	0.101	0.017	0.009	0.009	0.009	0.003	ND	0.002	ND
" "	497	944	0.012	0.027	0.013	0.002	0.108	0.005	0.010	0.008	0.003	0.003	ND	ND	ND
Cast Melter/320 10/18	486	899	0.051	0.047	0.014	0.004	0.156	0.097	0.044	0.007	0.004	0.004	0.002	.002	0.002
" " 10/19	511	945	0.078	0.067	0.016	0.005	0.181	0.050	0.107	0.007	0.003	0.003	0.003	ND	ND
Hicorex Grin./820 10/18	499	923	0.003	0.005	0.035	ND	0.011	ND	0.018	0.001	0.002	0.002	ND	0.005	0.021
" " 10/19	511	945	ND	0.004	0.031	ND	0.007	0.001	0.013	ND	0.002	ND	ND	0.003	0.014
Sort. Sep. Insp./370	512	1024	0.004	0.045	0.004	ND	0.024	0.006	0.005	0.002	0.002	ND	ND	0.002	ND
" "	503	955	0.005	0.011	0.007	ND	0.026	0.002	0.009	0.004	0.002	0.002	ND	0.002	0.002
" "	494	988	0.009	0.036	0.017	0.003	0.060	0.005	0.011	0.008	0.002	0.004	ND	0.001	0.001
Cast. Clean. Oper./370	508	1016	0.013	0.024	0.012	0.002	0.084	0.003	0.003	0.008	0.002	0.002	ND	0.002	0.001
" "	512	1014	0.015	0.023	0.023	0.003	0.097	0.005	0.009	0.017	0.004	0.002	ND	0.001	0.001
" "	502	1004	0.013	0.017	0.019	0.003	0.089	0.003	0.012	0.012	0.002	0.002	ND	0.001	0.001
Alnico Grin. Oper./350	506	1012	0.007	0.021	0.008	0.001	0.038	0.003	0.021	0.006	0.003	ND	ND	0.003	0.001
" "	504	983	0.022	0.126	0.032	0.004	0.095	0.003	0.015	0.019	0.002	0.003	ND	0.001	ND
" "	502	979	0.009	0.028	0.017	0.002	0.045	0.003	0.031	0.008	0.002	0.002	ND	0.002	0.003
Hicorex Pow. Proc./810	499	973	ND	0.016	0.043	ND	0.008	ND	0.003	ND	0.004	ND	ND	0.007	0.021
" "	510	1020	ND	0.029	0.086	ND	0.011	0.001	0.003	ND	0.003	ND	ND	0.011	0.042
" "	497	994	ND	0.020	0.084	ND	0.007	ND	0.006	ND	0.001	ND	ND	0.009	0.043
Hicorex Reduc. Oper./810	509	1018	0.002	0.142	0.020	ND	0.012	0.002	0.004	0.003	0.006	ND	ND	0.042	0.481
" "	499	998	0.002	0.169	0.022	ND	0.013	0.002	0.010	0.004	0.005	ND	ND	0.041	0.509
" "	489	978	0.003	0.190	0.018	ND	0.013	0.003	0.010	0.004	0.004	ND	ND	0.037	0.528
Hicorex Jet Mill/810	502	1004	ND	0.015	0.029	ND	0.011	0.001	ND	ND	0.003	ND	ND	0.008	0.021
" "	497	994	ND	0.017	0.052	ND	0.009	ND	0.006	ND	0.002	ND	ND	0.008	0.030
" "	510	1020	ND	0.009	0.050	ND	0.009	ND	0.003	ND	0.003	ND	ND	0.008	0.020
Production Grin./350	506	1012	0.007	0.040	0.007	ND	0.033	0.005	0.015	0.005	0.005	0.013	ND	0.003	0.001
" "	504	982	0.009	0.026	0.015	0.002	0.045	0.002	0.022	0.010	0.002	0.004	ND	0.001	ND
" "	504	1008	0.011	0.039	0.020	0.003	0.049	0.004	0.025	0.013	0.003	0.003	ND	ND	ND
Demag and Wash/350	502	1004	0.007	0.005	0.009	0.001	0.037	0.007	0.010	0.006	0.003	0.002	ND	0.003	0.001
" "	509	1018	0.013	0.021	0.017	0.002	0.051	0.004	0.009	0.015	0.001	0.008	ND	0.002	0.002
" "	501	1002	0.010	0.052	0.014	0.002	0.050	0.007	0.011	0.009	0.002	0.003	ND	0.002	0.002
M-36, Machine Set up/350	518	1036	0.009	0.025	0.011	0.001	0.058	0.004	0.029	0.006	0.004	0.002	ND	0.003	0.002
" "	520	1040	0.044	0.266	0.065	0.007	0.164	0.005	0.022	0.038	0.003	0.006	ND	0.002	0.002
" "	512	1024	0.018	0.026	0.014	0.002	0.038	0.004	0.017	0.008	0.003	0.003	ND	0.001	ND

Table II (continued)- Page 3

Job Title/Dept. No.	Sample Time (min.)	Sample Volume (liters)	Concentration of Metals mg/m^3 Al	Ca	Co	Cu	Fe	Mg	Na	Ni	P	Ti	Zn	Nd	Sm
Precision Grind/360	505	1010	0.003	0.025	0.008	ND	0.020	0.004	0.009	0.004	0.004	0.002	ND	0.003	0.001
" "	491	982	0.005	0.005	0.009	0.001	0.029	0.002	0.015	0.005	0.002	0.002	ND	0.001	0.001
" "	508	1016	0.004	0.009	0.007	ND	0.074	0.002	0.011	0.005	0.002	0.002	ND	0.002	0.002
Sort & Sep. Found./370	515	1030	0.011	0.011	0.005	ND	0.048	0.002	0.007	0.004	0.004	0.001	ND	0.002	0.001
" "	511	1022	0.006	0.009	0.006	ND	0.036	0.002	0.006	0.004	0.004	0.002	ND	ND	ND
" "	512	1024	0.008	0.014	0.011	0.001	0.056	0.003	0.008	0.006	0.003	0.001	ND	0.002	0.001
Precision Grinder/360	510	1020	0.004	0.009	0.014	0.002	0.034	0.002	0.005	0.008	0.003	ND	ND	0.003	0.001
" "	503	955	0.002	0.004	0.008	ND	0.020	0.002	0.010	0.004	0.003	0.001	ND	0.001	ND
" "	502	979	0.002	0.004	0.007	ND	0.013	0.001	0.014	0.003	0.002	0.001	ND	0.001	0.001
Utility Alnico/350	500	925	0.005	0.021	0.005	ND	0.028	0.003	0.005	0.004	0.003	0.002	ND	0.003	0.003
" "	496	967	0.009	0.027	0.012	0.001	0.068	0.003	0.009	0.008	0.003	0.003	ND	0.002	0.002
" "	464	928	0.006	0.018	0.012	0.003	0.029	0.003	0.009	0.009	0.003	0.003	ND	ND	ND
Sort & Sep. & Insp/370	505	959	0.004	0.048	0.004	0.002	0.021	0.007	0.007	0.002	0.004	ND	ND	0.002	0.002
" "	513	975	0.004	0.014	0.006	ND	0.024	0.003	0.011	0.004	0.002	0.002	ND	0.002	0.002
" "	517	1034	0.003	0.022	0.005	0.002	0.018	0.004	0.008	0.002	0.002	0.002	ND	ND	ND
Hicorex Powd. Proc/810	483	917	ND	0.021	0.062	ND	0.013	0.002	0.002	ND	0.004	ND	ND	0.010	0.041
" "	490	980	ND	0.020	0.055	ND	0.009	0.002	0.007	ND	0.003	ND	ND	0.008	0.038
" "	459	918	ND	0.024	0.049	ND	0.012	0.002	0.004	ND	0.002	ND	ND	0.011	0.027
Press Oper./820	517	982	ND	0.009	0.110	0.146	0.002	0.002	ND	0.003	0.005	ND	ND	0.020	0.049
(Press Operator)	516	1032	ND	0.006	0.021	ND	0.015	0.001	ND	0.003	0.003	ND	ND	0.011	0.011
" "	480	960	ND	0.009	0.036	ND	0.057	0.002	0.004	0.001	0.003	ND	ND	0.046	0.021
Press Oper./820 10/17	515	1030	ND	0.003	0.028	ND	0.007	ND	ND	ND	0.003	ND	ND	0.007	0.012
" " 10/19	508	1016	ND	0.004	0.053	ND	0.026	ND	0.004	ND	0.002	ND	ND	0.024	0.022
Assembler/820	525	1050	ND	0.003	0.011	ND	0.008	ND	0.009	ND	0.002	ND	ND	0.002	0.004
" "	523	1046	0.001	0.007	0.014	0.002	0.006	ND	0.029	ND	0.004	0.004	ND	0.003	0.006
" "	522	1044	0.002	0.003	0.018	ND	0.007	0.001	0.009	0.005	0.002	0.002	ND	0.002	0.006
Utility/820 10/17	450	900	0.002	0.005	0.011	ND	0.010	0.002	0.007	0.001	0.004	ND	ND	0.005	0.007
Sort & Sep/820 10/17	501	1002	ND	0.002	0.003	ND	0.003	ND	ND	ND	0.003	ND	ND	0.002	0.006
" " 10/18	504	1008	ND	0.001	0.003	ND	0.004	ND	0.003	ND	0.001	ND	ND	0.002	0.004
Boat Loader/820	497	994	0.001	0.012	0.059	ND	0.015	0.001	0.006	ND	0.004	ND	ND	0.020	0.028
" "	506	1012	ND	0.006	0.039	ND	0.017	0.001	0.002	ND	0.002	ND	ND	0.016	0.017
" "	506	1012	0.001	0.022	0.005	0.002	0.018	0.004	0.008	0.002	0.002	0.001	ND	ND	ND

Table II (continued) - Page 4

Job Title/Depart. No.	Sample Time (min.)	Sample Volume (liters)	Concentration of Metals mg/m3 Al	Ca	Co	Cu	Fe	Mg	Na	Ni	P	Ti	Zn	Nd	Sm
Furn. Oper./820	499	998	0.003	0.004	0.007	ND	0.008	0.002	0.007	0.001	0.003	0.001	ND	0.002	0.008
" "	503	1006	0.001	0.006	0.006	ND	0.009	0.011	0.007	0.001	0.002	ND	ND	0.003	0.007
" "	489	978	0.005	0.069	0.022	0.001	0.023	0.020	0.020	0.005	0.004	0.004	0.006	0.029	0.256
Produc. Grin. Set up & Oper./820	497	994	0.003	0.008	0.019	ND	0.008	0.002	0.012	0.001	0.004	0.002	ND	0.005	0.011
" "	497	994	0.001	0.004	0.014	ND	0.009	0.010	0.003	ND	0.003	0.002	ND	0.004	0.008
" "	497	994	0.001	0.005	0.027	ND	0.029	0.001	0.018	0.002	0.002	ND	ND	0.004	0.015
Engin. Office 10/17	395	790	ND	0.001	ND	ND	0.002	0.001	ND	ND	0.005	ND	ND	ND	ND
" " 10/18	397	794	ND	ND	ND	ND	0.002	ND	0.005	ND	0.003	ND	ND	ND	ND
Sales Office	391	782	ND	ND	ND	ND	ND	ND	ND	ND	0.003	ND	ND	ND	ND
" "	394	788	ND	ND	ND	ND	ND	ND	0.005	ND	0.002	ND	ND	ND	ND
" "	440	880	ND	ND	ND	ND	ND	ND	0.006	ND	0.001	ND	ND	ND	ND
Person. Office 10/17	417	834	ND	0.003	ND	ND	0.007	ND	0.004	ND	0.004	ND	ND	0.002	ND
" " 10/18	488	976	ND	0.008	ND	ND	0.002	ND	0.001	ND	0.001	ND	ND	0.001	ND
Prod./Eng. Off. 10/18	396	792	ND	ND	ND	ND	0.002	ND	0.001	ND	0.003	ND	ND	0.002	ND
" " 10/19	440	880	ND	ND	ND	ND	0.002	ND	0.006	ND	0.003	ND	ND	0.001	ND
Sales Office	394	788	ND	ND	ND	ND	ND	ND	0.007	ND	0.003	ND	ND	ND	ND
" "	437	437	ND	ND	ND	ND	ND	ND	0.003	ND	0.001	ND	ND	0.001	0.003
" "	389	778	ND	ND	ND	ND	ND	ND	0.004	ND	ND	ND	ND	ND	ND
Raw Mat. Handler/532	465	930	0.009	0.008	0.002	ND	0.045	0.006	0.005	ND	0.002	ND	ND	0.052	0.007
Evaluation Criteria (mg/M3)															
OSHA Permissible Exposure Limit (PEL)			--	5.0	0.1	1.0	10.0	15.0	2.0	1.0	--	--	5.0	--	--
NIOSH Recommended Exposure Limit (REL)			--	--	--	--	--	--	2.0	0.015	--	--	5.0	--	--
ACGIH Threshold Limit Value (TLV)			10.0	2.0	0.05	1.0	5.0	10.0	2.0	1.0	0.1	10.0	5.0	--	--

Symbols for metals: Al = Aluminum, Ca = Calcium, Co = Cobalt, Fe = Iron, Mg = Magnesium, Na = Sodium, Ni = Nickel, P = Phosphorus, Ti = Titanium, Zn = Zinc, Nd = Neodymium, Sm = Samarium.
mg/m^3 = milligrams of metal per cubic meter of air
ND = None Detected
Limit of Detection = .001 mg/m^3

Table III

Personal Full Shift Exposure
Respirable Dust and % Silica (SiO_2)
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

Job Title/Dept. #	Sample Time (min.)	Sample Vol. (liters)	Respirable Dust (mg/m^3)	% Silica (SiO_2)	OSHA Acceptable Respirable Siliceous Dust Exposure (mg/m^3)
Machine Molder/310	435	740	0.46	5.6	1.32
Sand Mixer/310	432	734	[0.41]	27.0	0.34
Core Checker/320	430	731	0.28	20.0	0.45
Demag & Blast/330	429	729	0.19	8.6	0.94
Cast Clean Oper./320	76	129	0.31		
Furnace Oper./330	415	705	0.10		
Breakout & Blast/320	390	663	0.38	5.6	1.32
Furnace Oper./820	341	580	[0.76]	14.0	0.63
Press Oper./340	446	758	0.09	ND	5.0
Furnace Operator/340	459	780	0.12		
Thru-Feed Grinder/350	448	762	0.12	ND	5.0
Cast-Clean Oper./320	50	85	0.00		
Ceramic Grinder/630	450	765	0.05		
Hicorex Power/810	440	748	0.08		

(continued)

Table III (Continued)

Job Title/Dept. #	Sample Time (min.)	Sample Vol. (liters)	Respirable Dust (mg/m^3)	% Silica (SiO_2)	OSHA Acceptable Respirable Siliceous Dust Exposure (mg/m^3)
N.D. Press Oper./710	455	774	0.09		
Powder Mixer/710	460	782	0.15	ND	5.0
Slice & Dice/820	436	741	0.30	ND	5.0
Press Oper./710	439	746	0.09		
Raw Material Handler	431	733	0.22	10.0	0.83
Machine Molder/310	425	723	[0.87]	10.0	0.83
ND Press Oper./710	440	748	0.07		
Ceramic Proc. S.U./630	670	1140	0.09	ND	5.0
Ceramic Powder Proc./610	618	1050	0.27	ND	5.0
Breakout & Blast/320	457	777	0.42	ND	5.0
Ceramic Process Oper./620	676	1149	0.08		
Ceramic Process Oper./620	677	1150	0.08	ND	5.0
Ceramic Grinder/630	433	736	0.11		
Ceramic Powder Anal./562	675	1148	0.10	ND	5.0
Ceramic Sort & Sep./630	435	739	0.04		
Ceramic Sort & Sep./630	442	751	0.03		
Ceramic Process Oper./620	670	1139	0.06		
Ceramic Powder Proc./610	675	1148	0.35	ND	5.0

(continued)

Table III (Continued)

Job Title/Dept. #	Sample Time (min.)	Sample Vol. (liters)	Respirable Dust (mg/m^3)	% Silica (SiO_2)	OSHA Acceptable Respirable Siliceous Dust Exposure (mg/m^3)
Ceramic Sort & Sep./630	432	734	0.10		
Ceramic Press Oper./620	446	758	0.11		

[] = Respirable dust level which exceeds the OSHA PEL for respirable siliceous dust.
ND = None Detected
Limit of Detection for quartz per sample - 5 ug/filter.
The Acceptable Respirable Siliceous dust level is calculated using the following formula in accordance with the OSHA permissible exposure limit for siliceous respirable dust: $\frac{10}{\%SiO_2+2}$.
The NIOSH Recommended Exposure Level for respirable dust containing crystalline silica - $SiO_2 = 0.05\ ug/m^3$.
The ACGIH Threshold Limit Value for crystalline silica - $SiO_2 = 0.1\ ug/m^3$.

Table IV

Total Dust Exposure Levels
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

Job Title/Dept #	Sample Tim (min.)	Sample Volume (liters)	Total Dust (mg/m^3)
Cast Alnico Melter/320	452	813	1.73
Machine Molder/310	428	770	3.62
Furnace Operator/330	423	846	0.72
Inspector/561	395	790	0.22
Prod. Grinder Oper./350	372	744	1.26
Inspector/561	306	612	0.31
Boat Loader/340	457	868	0.31
Raw Materials/532	446	892	0.28
Press Oper./820	421	799	0.36
Production Grinder/710	456	866	2.08
Wash & Dry/810	430	817	0.26
Ceramic Proc. Oper./620	673	1346	0.64
Powder Proc. Oper./610	280	560	4.07
Press-Slurry S-U Oper./620	665	1330	1.74
Ceramic Proc. Oper./620	419	838	0.64
Press-Slurry S-U Oper./620	664	1261	3.55
Ceramic Grinder Oper./630	440	880	0.66
Ceramic Grinder Oper./630	449	898	0.82
Ceramic Process Oper./620	663	1260	1.77
Ceramic Sort & Sep./630	439	878	0.33
Ceramic Sort & Sep./630	434	868	0.30

Table V

Relative Metal Content of Cigarettes
Hitachi Magnetics
Edmore Michigan
October 17-19, 1989

HETA 88-192

Ashtray Where Cigarettes were Collected	Al	Co	Cu	Fe	Mg	Na	Ni	P	Zn
	Concentration of Metals ug/5 gram sample								
Workstation in Hicorex ND	642	46	132	1024	16420	256	ND	6840	178
Hallway Entrance to Plant	694	84	202	790	18260	3000	24	9440	202
Foundry Pour Line Area	872	132	646	1020	11800	1866	82	5820	230
East Wall Behind Sintering Furnace	954	56	1260	956	13020	2100	42	6760	420
Desktop in Alnico Grind Area	336	164	56	560	6700	1744	164	3880	66
Work Station Alnico Grinder	672	124	204	662	5440	1180	78	3620	90
Alnico Test Area	1112	ND	30	674	14720	1726	ND	6040	254
Time Clock Alnico-Foundry	808	64	676	704	14680	2020	56	7800	230
Ceramic Grinder Work Station	540	ND	138	690	15120	2360	ND	7440	164
Ceramic Process	412	ND	176	454	11880	1996	ND	7680	132
Handwash Area, Outside Lunchroom	344	182	292	646	14180	2080	ND	7480	166
Lunchroom, Southwall	216	ND	440	198	7040	926	ND	3340	144
Desktop, Front Office	118	ND	204	114	3560	664	ND	1494	76
Men's Restroom, Front Office	204	ND	218	156	5200	926	ND	2500	90
NIOSH Smoke-Room, Cincinnati	188	ND	328	190	7180	1098	ND	3060	100

Al = Aluminum, Co = Cobalt, Cu = Copper, Fe = Iron, Mg = Magnesium,
Na = Sodium, Ni = Nickel, P = Phosphorus, Zn = Zinc
ND = None Detected
Limit of Detection = 7 ug/5 gram sample

Table VI

Reports of Respiratory Illnesses and Contact Dermatitis
OSHA 200 logs 1984-1988.
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

Year	Dust Diseases of lungs	Respiratory Conditions due to toxic agents	Dermatitis
1984	1	0	6
1985	0	0	3
1986	0	0	6
1987	0	2	16
1988	2	1	12
Total	3	3	43
Expected	0.06	0.5	4.64
SIR		10.5	9.27
95% Confidence Intervals		7.8-14.5	4.1-17.7

Respiratory conditions due to toxic agents included:
- 1 case of chemical bronchitis.
- 1 case of dyspnea due to inhalation of neodymium-iron powder.
- 1 case of small airways obstruction.

Dust Diseases of the lungs included:
- 3 reports of asthma. (The individual with asthma in 1984 was the same with dyspnea in 1987. The two episodes of asthma in 1988 occurred in one worker.)

Table VII

Workers with chest X-ray findings consistent with pneumoconiosis.
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

Worker	Profusion Scores B-reader 1	2	3	Opacities Shape	Distribution by lung fields	PFT results	Years Worked
A	n*	1/0	1/0	irregular	all fields	obstruction	33
B	u/r@	2/2	1/2	irregular	lower/middle	obstruction	30
C	1/0	1/0	1/0	rounded	upper fields	normal	34
D	n	2/1	1/2	irregular	lower/middle	normal	

Worker	Pleural Thickening Location	Diffuse or Circumscribed	PFT results	Years Worked
E	Left costophrenic angle and left chest wall.	diffuse	restrictive	26
F	Bilateral costophrenic angles and chest wall.	diffuse	normal	34

* n=normal, @ u/r=unreadable

Table VIII

Prevalence of Chronic Cough, Chronic Bronchitis, Whhezing, and Dyspnea by Smoking Status; Current Workers and a Standard Population*.
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

	Smokers n	(% affected)	Ex-smokers n	(% affected)	Never Smokers n	(% affected)
Chronic Cough						
Hitachi	107	(26%)	80	(9%)	119	(8%)
Standard	592	(18%)	182	(8%)	452	(8%)
Chronic Bronchitis						
Hitachi	107	(21%)	80	(8%)	119	(3%)
Standard	590	(17%)	181	(11%)	452	(8%)
Dyspnea (Breathlessness)						
Grade 1 or higher						
Hitachi	104	(34%)	79	(25%)	116	(17%)
Standard	589	(32%)	182	(32%)	450	(25%)
Grade 2 or higher						
Hitachi	104	(7%)	79	(2%)	116	(6%)
Standard	588	(9%)	182	(8%)	450	(7%)
Wheezing						
Hitachi	106	(19%)	80	(2%)	113	(4%)
Standard	651	(10%)	207	(7%)	512	(5%)
Wheezing with attacks of shortness of breath						
Hitachi	106	(13%)	80	(0%)	113	(3%)
Standard	651	(10%)	207	(10%)	512	(8%)

*- The standard population refers to a cross-sectional study of blue collar workers 20-59 years of age, not exposed to respiratory hazards (Table 2, pg 370).[54]

Table IX

Air and Urine Cobalt (Co) and Nickel (Ni) Concentrations
Means, Standard Deviations, and Ranges
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

	Air Co (ug/m^3)	Urine Co (ug Co/mg creatinine)		Air Ni (ug/m^3)	Urine Ni (ug Co/mg creatinine)	
		pre-shift	post-shift		pre-shift	post-shift
Day 1						
Mean	20.7	21.3	44.3	17.1	4.0	4.3
SD[1]	30.1	28.6	65.7	55.5	9.5	10.0
range	ND[3]-137	0.6-135	3.2-331	ND-299	ND-44.2	ND-47.3
n[2]	34	33	32	34	33	33
Day 2						
Mean	20.9	26.4	50.4	10.8	3.9	2.2
SD	22.8	32.1	71.7	23.2	8.9	4.6
range	ND-86	2.4-108	3.3-379	ND-123	ND-41.8	ND-21.6
n	36	34	34	36	34	34
Day 3						
Mean	31.9	36.3	50.2	17.7	2.3	2.7
SD	66.5	56.7	78.0	62.8	4.4	8.3
range	ND-392	2.0-252	2.2-297	ND-368	ND-21.4	ND-43.2
n	34	36	36	34	36	37
Day 4						
Mean	NS[4]	40.8	NS	NS	2.6	NS
SD	NS	58.6	NS	NS	4.5	NS
range	NS	1.4-289	NS	NS	ND-20.9	NS
n	NS	35	NS	NS	32	NS

1 standard deviation
2 number of samples
3 not detected
4 no sample

Table X

Pearson Correlation Coefficients (PCC) for the Correlation
Between Cross-shift Creatinine Corrected Urine
and Personal Breathing Zone Cobalt Concentrations.
Hitachi Magnetics
Edmore, Michigan
October 17-19, 1988

HETA 88-192

	Day 1	Day 2	Day 3
PCC	0.25	0.28	0.18
p-value	0.17	0.11	0.30
Number of Participants	31	33	34

Comments:

Airborne Personal Breathing Zone Samples were measured as the $\log_e$ (ug/m^3) as an 8-hour time-weighted average.

Urine cross-shift cobalt concentration is the post-shift - pre-shift concentration in ug Co/mg creatinine.