U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 79-90-686

Crouse-Hinds Company
Syracuse, New York
May 1980

I. SUMMARY

Because of an OSHA citation for excessive levels of airborne crystalline silica, the union representing employees at Crouse-Hinds Company requested a NIOSH health hazard evaluation to determine if there was silicosis among the company's foundry workers. To investigate this potential problem, we obtained area and personal breathing zone air samples for measurement of crystalline silica and conducted a medical study of employees who had worked 15 or more years in the foundry. Seventy-seven employees participated in the medical study, which included a respiratory questionnaire, chest X-ray, and pulmonary function tests. Although there was no substantial medical evidence of silicosis, 6 of 28 breathing zone samples for respirable crystalline silica exceeded the NIOSH recommended standard of 0.05 mg/m^3.

While the data from this investigation suggest that for most foundry employees at Crouse-Hinds the risk of developing silicosis under current working conditions is small, the air sampling results indicate a more substantial risk associated with certain jobs, particularly grinding and core knock-out. Recommendations concerning medical surveillance procedures and environmental improvements are discussed on pages 7-8 of this report.

II. INTRODUCTION

On April 19, 1979, NIOSH received a request from the International Brotherhood of Electrical Workers (IBEW) Local 2084 requesting a health hazard evaluation at the iron and non-ferrous foundries (SIC 3320 and 3360, respectively) of Crouse-Hinds Company, Syracuse, New York. The Occupational Safety and Health Administration (OSHA) had previously cited the company for excessive air levels of crystalline silica, and the union was concerned about the possibility of silicosis among foundry employees.

On May 9, Mitchell Singal, M.D., Medical Officer, and Clifford Moseley, Industrial Hygienist, Hazard Evaluations and Technical Assistance Branch, NIOSH, made a walk-through inspection of the foundries and interviewed company and union representatives.

III. BACKGROUND

Crouse-Hinds manufactures a variety of industrial electrical equipment and related hardware such as lighting fixtures, conduit connectors, wiring clamps, and pull boxes. The plant employees 2700 people; 2000 are production and maintenance (hourly) employees, 525 of which worked in the foundries at the time of our study. The foundries produce iron and aluminum components of the products described above and can be considered "small parts" foundries. The iron foundry opened in 1911, and the non-ferrous foundry in 1955. The foundry operations at Crouse-Hinds are similar to those in other foundries described elsewhere.[1-4]

The operations environmentally monitored in this investigation were the molding operations, the related cupola tasks (repair, charging, pouring), fettling (mold removal, core removal, cast finishing), and sand conditioning. Operations such as core-making, pattern-making, etc., were not initially monitored because exposure to crystalline silica in these operations is substantially lower than in other operations.[1,3]

The iron foundry is located in a building separate from the non-ferrous foundry. The iron foundry building also contains offices, core-making operations, and wood and metal pattern shops. There are three casting systems, referred to as the number 11 system, center bay, and number 12 system. Each system has mold-making (semi-automatic Hunter* machines and manual squeezers), pouring, mold separation (shake/knock-out - manual or conveyor-type shaker boxes), and sand conditioning (batch or continuous) areas associated with it. Excess sand from the molding and shake-out operations drops through floor grates onto a conveyor system which then elevates the sand and carries it (over the heads of the workers) back to the sand conditioning system. Once re-conditioned it is transported (elevated) to the hoppers for the molding machines. There is also a fettling (grinding, finishing) area which handles castings from all three systems.

There are 488 production and maintenance employees in the iron foundry, with approximately equal distribution between two shifts. Employment records indicate that employee transfers between the foundries or between job classifications are uncommon.

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*Mention of a company name or product is for information only and does not constitute endorsement by NIOSH.

The non-ferrous foundry manufactures aluminum castings. It consists (in some areas) of more modern equipment, such as a Hunter/roundtable molding and pouring set-up with an automatic conveyor shaker box. There is also a manual core knock-out area. The remainder of the mold/pour operation consists of manual squeezers and pourers. The mold shake/knock-out is actually a dump-out process where molds are manually dumped on a floor-level grate with a sand conveyor beneath. There are two sand conditioning systems in one fettling area. There are 136 production and maintenance employees in the non-ferrous foundry. As in the iron foundry, they are distributed between two shifts, and there are relatively few changes in job classification.

Foundry workers exposed to dust are provided with disposable dust masks. There is no special medical surveillance program for employees exposed to crystalline silica. Except for a pre-placement chest X-ray there are no routine chest X-rays, and only employees who need to wear respirators get pulmonary function tests.

Neither the company nor the union was aware of any employee who had a respiratory problem. Of the 80-100 foundry employees who retired in the past few years, "three or four" had a respiratory problem. The company physician, who had been at the plant for five years, said he had not seen either X-ray or clinical evidence of silicosis. The OSHA Logs of Occupational Injuries and Illnesses for 1978 and 1979 listed two cases of acute fume inhalaton but no other respiratory diseases. According to the company representative, it is uncommon for a long-term foundry employee to transfer out, and there has never been such a transfer for a job-related medical reason.

We reviewed the medical records of two retired employees identified by the union as having had respiratory problems; one had asthma and the other had lung cancer. We also reviewed the medical records of 18 high-seniority employees, nine each from the iron and non-ferrous foundries. There was no evidence of silicosis, but in the absence of a medical surveillance program the data source was limited to occasional chest X-rays done for diagnosis of acute respiratory illnesses.

We conducted environmental sampling and medical testing on August 14-15. On October 24-25 we notified the company and union of our findings and informed each participant of his or her X-ray interpretation and pulmonary function test results.

IV. METHODS

A. Environmental

Personal breathing zone monitoring was conducted with selected employees from various job classifications. Sampling times approximated full-shift exposures. Samples were collected on filter paper using personal sampling vacuum pumps calibrated to draw air at 1.7 liters/minute. To measure respirable particulates, size-selective apparatus (designed to exclude airborne particulates greater than 10 um in aerodynamic diameter) was used in conjunction with the filter. In addition, several "total particulate" samples were taken. These "total dust" samples were collected in the same manner as above, except that the flow rate was 1.5 liters/minute and no size-selective apparatus was used. The environmental samples were analyzed by X-ray diffraction.[5]

B. Medical

The medical study consisted of (a) a respiratory questionnaire based on that developed by the American Thoracic Society and the National Heart and Lung Institute,[6] (b) an occupational history questionnaire focusing on exposure to fibrogenic dusts, (c) a 14x17-inch posterior-anterior chest X-ray interpreted according to the UICC/Cincinnati System[7] by a radiologist with specific training and certification in that system (a "B" reader), and (d) pulmonary function tests. Forced vital capacity (FVC) and one-second forced expiratory volume (FEV-1) were measured with a Medister* electronic spirometer with a pneumotachograph. A test was considered adequate for interpretation and use in the study only if there were three acceptable trials and the two best curves differed by no more than 5% with respect to FVC and FEV-1.[8] Predicted normal values were calculated according to the Morris formula;[9] the predicted normal for black individuals was calculated by multiplying the Morris predicted value by 0.85.[10-12]

All current foundry employees with at least 15 years seniority in the foundry were invited to participate in the study. (Since we could find no information indicating that any employee who had recently retired might have had an illness related to silicosis, and since 41 current employees had more than 20 years seniority, we judged that any under-detection of silicosis due to not including retired employees would be small.) Because the chest X-ray was an important component of the medical evaluation we decided to limit the survey to those employees most likely to manifest evidence of silicosis, with the option of expanding it should sufficient evidence of silicosis be present in this highest-risk group.

V. EVALUATION CRITERIA

Silicosis[13] is a lung disorder caused by the repeated inhalation of crystalline silica particles. Occupational activities in which silicosis has historically occurred include mining, quarrying, tunnelling, sandblasting, foundry work, pottery making, and refractory products manufacturing. The characteristic lesions of silicosis are fibrotic

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nodules in the lungs. Unless exposure is extremely intense, several years of exposure precede any evidence of the disease. In its early stages silicosis is manifested by the appearance on the chest X-ray of small rounded opacities, usually appearing first in the upper lung zones. It is not until the advanced stages that substantially diminished lung capacity and shortness of breath occur, although a slight decrease in lung capacity has been demonstrated epidemiologically to occur earlier, even prior to X-ray changes.[14,15]

The exposure criteria used in this study were (a) the NIOSH recommended standard of 0.05 mg of crystalline silica (all forms) per m^3 of work room air,[16] and (b) the OSHA standard (29 CFR 1910.1000, Table Z-3), which is dependent on the type of silica present. The OSHA standard for quartz (> 1% in sand) is

$$\frac{10\ mg/m^3}{\%\ respirable\ quartz + 2}$$

The OSHA standard for cristobalite and tridymite (> 1%) is

$$1/2 \times \frac{10\ mg/m^3}{\%\ respirable\ quartz + 2}$$

VI. RESULTS AND DISCUSSION

A. Environmental

The environmental results are presented in Table 1. A total of 35 samples were taken, 28 for respirable crystalline silica and seven for total particulates. Six of 28 samples for quartz exceeded the NIOSH exposure criterion of 0.05 mg/m^3. No cristobalite or tridymite was detected in any sample. The information on respirable particulates is not used to determine exposure to crystalline silica, but is presented as an indication of the general dustiness of the foundry operations. Two samples, from a grinder and a sand conditioner, showed excessive exposure to total particulates.

The OSHA data, after being recalculated to represent quartz exposure, are presented in Table 2. (The OSHA data are available from the Syracuse, New York, OSHA Area Office, reference file #D-0817.) Apparently, the OSHA laboratory did not detect cristobalite. The job classifications are general categories, that is, the molding category includes both manual and automatic molding operations; mold removal includes shake-out, knock-out, dump-out, etc.; sand handling includes sand reconditioning and associated sand handling tasks; and the other category includes laborers in all phases of foundry operations, front end loader operators, belt pickers, etc. These data indicate that 10 of 28 employees were excessively exposed to respirable quartz.

In general, levels of crystalline silica measured by OSHA were somewhat higher than those measured by NIOSH approximately one year later. This is possibly due to the updating, repair, and cleaning of process systems and air pollution equipment and the growing awareness by workers of the effect better work practices and careful equipment use have on reducing contaminant levels.

B. Medical

Of the 93 eligible employees, seven were on vacation, and six were on sick leave (all for injuries or other musculoskeletal problems). Of the 80 employees working during the study period, 77 (83% of the 93 eligible) participated; three refused.

The X-ray results are summarized in Table 3. Of the five Category 1 X-rays, only three showed rounded opacities, and none of the five showed opacities in the upper lung zones. Thus, as a group, they were not suggestive of silicosis, although the diagnosis cannot be ruled out in each individual case.

The five persons with Category 1 X-rays ranged in seniority from 21 to 28 years, with a median of 26; the range of the 67 other persons with readable X-rays was 15-39, with a median of 23. Three of the five had no shortness of breath, one - a former smoker - had a history of respiratory problems, including shortness of breath. Three of the five had normal pulmonary function tests (FVC and FEC-1 $\geq$ 80% and FEV-1/FVC $\geq$ 70%); the other two had pulmonary function tests that were not adequate for proper interpretation. However, one would not expect symptoms or overt pulmonary function abnormalities to result from silicosis manifested by Category 1 X-ray changes. None of the five worked in a foundry other than at Crouse-Hinds, and only one reported any other occupational exposure to a fibrogenic dust (coal dust encountered during a 2-year period of work as a laborer in the construction industry).

There were 44 employees whose pulmonary function tests met the criteria for usability. FVC was not significantly associated with seniority in the Crouse-Hinds foundry ($r = -0.11$, $p > 0.5$).

To evaluate the effect of silica exposure on FVC, we categorized the participants' exposure according to their predominant job, which we defined as the specific job (or more than one job involving similar intensities of silica exposure) held for at least half of the total time employed in occupations, at both Crouse-Hinds and other employers, involving exposure to fibrogenic dusts. Because exposure data was limited to present conditions and available for only some jobs, exposure categorization was necessarily based to a large extent on non-quantitative observation of the work environment at Crouse-Hinds and on general knowledge of the foundry industry. Because of this lack of quantitative exposure data, and because many employees had a work history involving jobs of different exposure intensities, we limited the number of exposure categories to two. Seventeen of the 44 employees with usable pulmonary function tests had predominant jobs involving relatively low silica exposure, 25 had predominant jobs involving higher exposure, and two could not be categorized because of incomplete work histories. The mean FVC of the higher exposure group (88.0% of predicted normal) was not less than that of the lower exposure group (84.9% of predicted normal).

If the actual prevalence of silicosis (as defined by the X-ray finding of small rounded opacities in the upper lung zones) is 1%, 2%, 3%, 4%, or 5%, the probability of finding no cases among the 72 interpretable X-rays is 0.48, 0.23, 0.11, 0.05, or 0.02, respectively. Therefore, there is less than a 5% chance that the prevalence of silicosis among long-term Crouse-Hinds foundry employees exceeds 4%.

VII. RECOMMENDATIONS

1. The company should institute a pre-placement examination and periodic medical surveillance program (to include periodic clinical evaluation, pulmonary function testing, and chest X-rays) for all foundry employees and any others whose job involves exposure to crystalline silica.[7]

   An employee with or without evidence of silicosis who has significant respiratory symptoms or physical findings and/or significant abnormalities on pulmonary function tests should be evaluated by a physician (preferably a chest specialist) qualified to advise the employee whether he/she should continue working in a dusty environment. Employees with definite or suspected silicosis should be evaluated by a chest specialist.

   An employee with silicosis, even if manifested only by Category 1 X-ray changes, should be removed from further "exposure" to crystalline silica. Removal of an employee from "exposure" does not necessarily require reassignment to an area free of crystalline silica, although this is ordinarily the preferred control measure. For employees with simple silicosis who have no pulmonary function impairment, "removal from exposure" can also be accomplished, in effect, by a combination of environmental dust-control measures, reduced exposure time, and respiratory protection equipment. If respirators are used, there must be an appropriate program of fitting, training, maintenance, and supervision (29 CFR 1910.134). In general, however, respirators are considered a "last resort" control method, to be used temporarily pending the implementation of environmental dust-control measures, for operations where sufficient dust control is not feasible, and for short-term or non-routine exposures.

2. The overhead sand conveyor system should be inspected frequently for leaks. Elimination of cracks through which sand could fall

will reduce airborne concentrations of crystalline silica and make housekeeping easier.

3. The number 12 system sand muller should be enclosed. The operator at this machine, in addition to being exposed to crystalline silica, is exposed to almost intolerable amounts of dust. This dust also spreads to other areas of the foundry.

4. In order to reduce dust concentrations, further measures should be taken to enclose other sand mulling systems.

5. Duct tape, rather than masking tape should be used for duct repair; it will last longer. Ideally, broken or torn pipe and joints should be replaced in order to maintain air flow as close as possible to the design specifications.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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External Distribution

International Brotherhood of Electrical Workers Local 2084
Crouse-Hinds Company
U.S. Department of Labor, OSHA, Region II
New York State Department of Labor
New York State Department of Health

X. REFERENCES

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TABLE 1 (Continued)

Job Description	Sample Volume (m^3)	Time Sampled (min.)	CONCENTRATION (mg/m^3) Quartz	Cristobalite	Respirable Particulate[2]
FERROUS FOUNDRY					
Mold dumper (A side)	.68	450	0.13T	ND[1]	1.93T
Mold dumper (A side)	.77	450	ND	ND	0.25
Mold dumper (#12 line)	.71	418	ND	ND	0.41
Mold dumper (#12 line)	.76	448	ND	ND	0.24
Laborer (#11 line)	.73	428	ND	ND	0.34
Laborer (center bay)	.75	443	ND	ND	0.24
Laborer (center bay)	.72	422	ND	ND	0.46
Molder (center bay)	.75	443	ND	ND	0.41
Front end loader oper.	.71	415	ND	ND	0.32
Grinder	.70	413	0.09	ND	0.79
Grinder	.61	409	0.08T	ND	0.62T
Grinder	.69	408	ND	ND	0.16
Grinder	.69	405	ND	ND	0.09
Grinder	.69	404	ND	ND	0.22
Grinder	.68	402	ND	ND	0.13
Cupola charger	.62	365	ND	ND	0.11
Cupola charger	.60	353	ND	ND	0.15
Cupola operator	.64	375	0.09	ND	0.27
Cupola repairer	.52	305	ND	ND	0.50
Sand conditioner	.50	330	1.40T	ND	36.64T
Sand conditioner	.56	330	0.07	ND	1.27
Exposure Criterion (see text)			.05 mg/m^3 (NIOSH)	.05 mg/m^3 (NIOSH)	5 mg/m^3 (ACGIH)

1 - None detected.
2 - T denotes a total particulate sample. Recommended exposure criteria for total particulate is 10 mg/m^3(ACGIH).

TABLE 1

Personal Air Sampling Data

Crouse-Hinds Company
Syracuse, New York
HE 79-90

August 13-15, 1979

Job Description	Sample Volume (m^3)	Time Sampled (min.)	CONCENTRATION (mg/m^3) Quartz	Cristobalite	Respirable Particulate[2]
NON-FERROUS FOUNDRY					
Core knock-out oper.	.65	436	1.08T	ND[1]	2.75T
Core knock-out oper	.74	435	0.18	ND	0.66
Core knock-out oper.	.74	435	0.08	ND	0.45
Sand conditioner (Northside)	.71	418	0.04	ND	0.30
Laborer (Northside)	.62	415	0.26T	ND	1.08T
Grinder	.76	445	ND	ND	1.03
Grinder	.67	445	1.24T	ND	34.00T
Grinder	.75	442	0.11	ND	0.76
Grinder	.75	440	0.04	ND	1.32
Grinder	.74	438	ND	ND	0.39
Hunter operator	.75	440	ND	ND	0.23
Hunter operator	.66	440	1.44T	ND	5.02T
Hunter operator	.73	432	ND	ND	0.21
Hunter operator	.75	440	ND	ND	0.24
Exposure Criterion (see text)			.05 mg/m^3 (NIOSH)	.05 mg/m^3 (NIOSH)	5 mg/m^3 (ACGIH)

1 - None detected.
2 - T denotes a total particulate sample. Exposure criterion for total particulate is 10 mg/m^3 (ACGIH).

(Continued)

Table 2
Personal Air Sampling Data
Obtained by OSHA, July-August, 1978
Crouse Hinds, Company
Syracuse, New York
HE 79-90

Respirable Quartz Concentration

Molding	Mold Removal	Sand Handling	Other
0.04*	0.14	0.08	0.05
0.03	0.06	0.06	0.24
0.04	< 0.01	0.05	None detected
0.03	0.29	< 0.01	< 0.01
0.03	< 0.04	< 0.01	
0.03	0.07	< 0.01	
0.04	0.04		
0.05			
< 0.04			
0.03			
0.03			

Exposure criterion (see text): 0.05 mg/m^3 (NIOSH)

*All results in mg/m^3

Table 3
Chest X-ray Findings
Crouse-Hinds Company
Syracuse, New York
HE 79-90

August 1979

Participants	77		
X-ray of adequate quality for interpretation	72		
No evidence of pneumoconiosis		67 (93%)[B]	
Category 0/0[A]			57 (79%)
Category 0/1			10 (14%)
Evidence of pneumoconiosis (Category 1/0)		5 (7%)	
Small, rounded opacities			3 (4%)
Small, irregular opacities			2 (3%)
Evidence of silicosis (small, rounded opacities, Category 1/0 or greater, upper lung zones affected)		0	

A - See text and reference 7.
B - All numbers in parentheses are percentages of the 72 interpretable X-rays.