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INDUSTRIAL HYGIENE SURVEY OF ATLANTIC CEMENT COMPANYREVENA, NEW YORK

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OH

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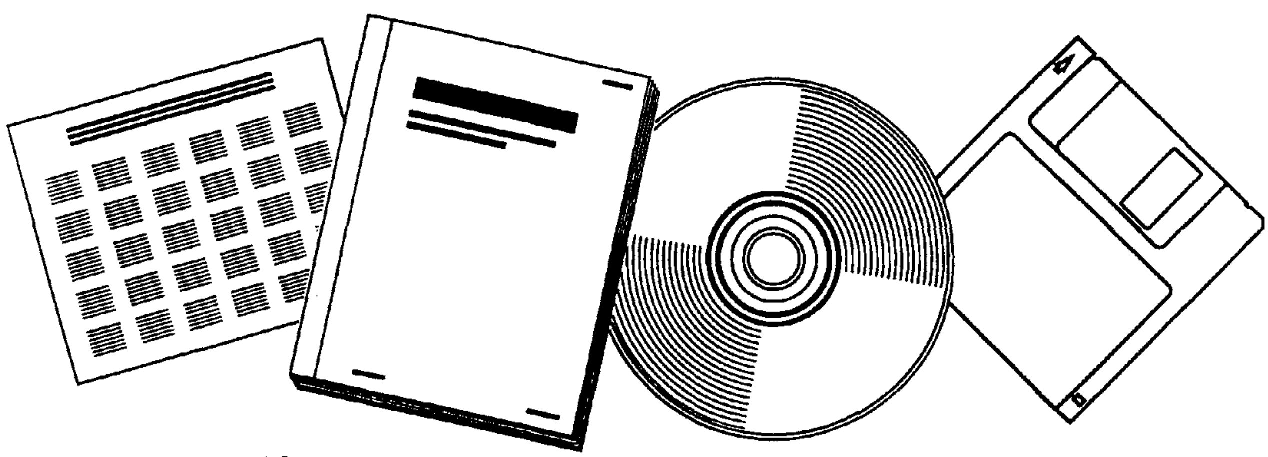

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16. Abstract (Limit: 200 words) As part of a study of associations between dust levels and respiratory health in Portland cement production, environmental sampling was conducted at the Atlantic Cement Company in Ravena, New York. This facility was one of the newer and more technically advanced facilities to be surveyed in connection with this larger study. A subset of workers wore respirable dust samplers, and area samples were collected throughout the facility. Only six of 70 respirable dust samples contained detectable levels of quartz (14808607). No cristobalite (14464461) was detected. The respirable dust concentrations were relatively low for most jobs. Corrective recommendations were made to reduce the worker's exposure to airborne dust and concerned the use of administrative changes and use of personal protective equipment. Engineering controls were the recommended courses of action including ventilation system design and the separation from the dust by enclosing either the worker or the dust. Eye irritation and respiratory irritation were experienced by the workers who cut away plates from inside a ball mill with cutting torches.

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Industrial Hygiene Survey of Atlantic Cement Co.
Ravena, New York

April 1981

Introduction

Environmental investigations were conducted at this facility by a NIOSH field research team consisting of Mr. Steven Lenhart, John Zey, and Wayne Sanderson. This industrial hygiene study was primarily concerned with measuring dust levels in the workplace, and was part of a broader medical/environmental study designed to investigate associations between dust levels and respiratory health in Portland Cement plants. This facility, investigated fron Monday, July 16 through Friday, July 20, 1979, was the first of 17 plants to be studied.

The Atlantic Cement plant is located along the Hudson River, just north of Ravena, New York. The plant began operation in 1963. Atlantic Cement is a relatively new and technically advanced company. Cement production is via the wet process method and the two kilns used for clinker production are two of the largest ever built in North America.

Methods

Since it was not possible to environmentally monitor all individuals at the plant, a subset of workers was randomly chosen to participate in the study. Selected workers were requested to wear a respirable dust sampler. To collect respirable dust, air was pulled through a 10mm nylon cyclone at a flow rate of 1.7 liters per minute (lpm) by a personal sampling pump. This cyclone allowed the separation of airborne dust

particles into those roughly sized $\leq$ 10 u (respirable fraction) and others > 10u (nonrespirable fraction). All dust particles passing through the cyclone were collected on a 37 mm polyvinyl chloride filter.

Nonpersonal area samples were collected at static locations throughout the plant. Total dust was collected by pulling air through an open polystyrene filter holder at a flow rate of 1.5 liters per minute. Any dust in the air was collected on a 37mm polyvinyl chloride filter. Samples for asbestos analyses were collected on celulose ester filters. For this, air was passed through an open-faced polystyrene filter holder at a flow rate of 1.5 liters per minute. An Andersen cascade impactor was used to determine the percent of airborne dust in the respirable size range. Dust was collected in the impactor on glass fiber filters at a flow rate of 28.3 lpm. Bulk material was also collected for chemical analysis.

Gravimetric analyses to the nearest .001 milligram allowed calculation of dust concentrations in milligrams per cubic meter (mg/m^3) of respirable dust. The respirable dust samples were then analyzed by x-ray diffraction for content of quartz and cristobalite. (1) The detection range of this method is dependent on the amount of interferring and x-ray absorbing substances present. The total dust samples were analyzed by atomic absorption spectroscopy to determine concentrations of aluminum, cobalt, chromium, magnesium, manganese, and nickel. (2) The detection limit (a defined as that concentration of a given element which produces a signal equivalent to two times the standard deviation of the blank signal for aqueous solutions) for each trace metal in micrograms per cubic meter (ug/m^3) is:

Al - 25 ug/m^3

Cr - 3

Co - 3

Mg - 1

Mn - 2

Ni - 3

The asbestos samples were analyzed by phase contract microscopy for presence of fibers. (3) The Andersen filters were weighed to the nearest .01 milligrams. The bulk material was analyzed by x-ray diffraction for content of quartz, and Cristobalite; atomic absorption spectroscopy for aluminum, chromium, cobalt, magnesium, manganese, and nickel content; and polarized light and dispersion staining microscopy for asbestos content.

Control filters were collected at this facility. These filters received treatment identical to dust laden filters, except no air was drawn through the control filters. These filters were utilized to correct changes on dust laden filters due to handling.

During each shift, each personal and area sampler was periodically checked for proper operation. If the sampler was not operating within specifications, sampler adjustments and appropriate notations were made and, if necessary, the results of such samples were voided.

The environmental investigations team began sampling Monday, July 16, 1979. The sampling schedule was as follows:

Monday, July 16 - 2nd shift

Tuesday, July 17 - 2nd shift

Wednesday, July 18 -1st shift

Thursday, July 19 - 1st shift

Friday, July 20 - 3rd shift

This schedule was utilized in order to adequately measure environmental concentration differences due to day-to-day and shift-to-shift variations.

Plant areas and the workforce were separated into four exposure categories based on the type of airborne dust each was subjected to. The categories were:

raw - exposure to raw materials dust

clinker - exposure to clinker dust

finish - exposure to finished Portland cement dust

mix - exposure to a mixture of two or more types of dust

Results

The concentrations of the personal respirable dust samples are tabulated in Table 1. Respirable dust concentrations are identified with the job, date, shift, and exposure category to which they are associated. Table 2 summarizes the collected respirable dust samples. Plantwide, 70 personal respirable dust samples were collected. The mean dust level was .445 mg/m^3 with a standard deviation of 4.095. We can be 95% confident that the true mean respirable dust level lies somewhere between .318 and .623 mg/m^3.

Of the 70 respirable dust samples collected only 6 of them had detectable levels of quartz present. No cristobalite was detected on any of the filters. Only one of these six samples came from the raw exposure category. The remaining 5 were from the clinker exposure category. The samples ranged from 47.9 to 58.0 ug/m^3 of quartz exposure. The percent quartz present by weight for each of the six filters is presented in Table 3. The filter from the raw exposure category had the highest percent quartz content.

Ten area total dust samples were collected at various locations throughout the plant and analyzed for trace metals. No chromium, cobalt, manganese, or nickel was detected on any of the filters. Six of the ten filters contained detectable amounts of aluminum, while all samples contained magnesium. Results of the trace metal analyses are presented in Table 4.

Nine samples for asbestos were collected in areas subjected to raw material dust. No asbestos or fibers of any nature were detected on the filters.

Based on cascade impactor samples the percent of airborne particles in the respirable size range was determined. The respirable size range is considered to be those particles below 10 microns in diameter. No samples were collected in an area solely subjected to raw material dust. In areas exposed to clinker dust, it was determined that roughly 35% of airborne particles are respirable. In areas where the airborne particles are finished cement, 75% are respirable. In areas where the particles are a mixture of raw material and clinker dust, it is estimated that 12% of the particles are in the respirable size range. Cascade impactor data is presented in Figure 3.

Bulk material samples were collected of raw materials, clinker, finished cement, and mixtures of dust. All of the materials contained detectable amounts of aluminum, magnesium, and manganese. No nickel or asbestos was found in any of the samples. Fifteen of the ninteen contained trace amounts of chromium, while only six contained detectable quantities of cobalt. The results of bulk analyses are presented in Table 5.

Discussion

Personal Samples - There appears to be wide variation in the concentration of dust to which workers are exposed. There are significant differences in exposure between the various jobs and among the areas of the plant. Workers exposed to clinker seem to encounter the highest levels of dust. These exposure categories are somewhat artificial. They are merely intended as guidelines to the type of dust particulasr jobs and groups of jobs are exposed to. They are not intended to imply what concentration levels people working in those categories might be exposed.

The jobs which experience the highest dust exposure are cooler operators, kiln operators and helpers, crane operators, and mill helpers. All of these jobs are associated with material transfer points. At these points there is a good deal of airborne dust generated. For example, kiln operators and helpers are associated with clinkering exiting the kiln; clinker cooler operators with shaking and transferring clinker to bins; mill helpers with clinker and raw materials entering and exiting the ball mills; crane operators with the physical picking up and dumping of materials. All of these jobs are involved with processes which physically generate dust. There is little variation among workers having the same job. That is, there seems to be little individual difference in the dust concentrations to which all workers in the same job are subjected.

It is observed that only two personal respirable dust measurements exceed the federal nuisance dust standard. Both of these measurements were taken from cooler operators.

Figure 2 is a frequency histogram of the personal respirable dust concentrations. This figure shows that the plantwide dust levels fit a typical log normal distribution.

Crystalline Silica - Only 8.6% of the respirable dust samples had any detectable amounts of quartz. Quartz was detected on only the more heavily loaded filters. It is probable that clinker consistently contains 1% quartz. This is such a low concentration of crystalline silica that our analytical method would only detect it if the filter contained greater than 1 milligram of dust. Quarry workers are exposed to dust containing a higher percentage of quartz. The quartz content will vary depending on the composition of the overburden and the ore that employees might be working with. Therefore, the free silica concentration will vary from area to area of the quarry and day to day.

It is possible that in the quarry and clinker subjected areas, the NIOSH recommended standard of 50 ug/m^3 for crystalline silica is occasionally exceeded.

Trace Metals - No measurements of the six trace metals yielded values which exceeded either NIOSH recommended standards or federally mandated standards. Raw material, clinker, and finished cement dust all contain aluminum, magnesium, and manganese. The quantity of these metals in each of the three types of dust remains constant. Chromium and cobalt are not found in the raw material. It is suspected that these metals are introduced through the crushing and milling processes.

Asbestos - This survey suggests that no asbestos is present in the raw materials. It is possible that the quarried rock may be contaminated with asbestos fibers due to the occurrence of small deposits of asbestosbearing rock in the overburden or the quarried strata. If this occurs at all, it will be extremely rare.

Particle Size Distribution - The great majority of the raw material dust and clinker dust is nonrespirable. Finished cement dust, on the other hand, is primarily respirable (75%). As material passes through the production process, from quarried rock to finished cement the respirability of the airborne dust particles tends to increase. Smaller dust particles have a greater chance of reaching deep into the lung.

Background Samples - Samples placed upwind of the cement plant exhibit very low levels of dust. Magnesium seems to be ubiquitous, although in extremely low concentrations. No other metals, asbestos, or free silica were detected. All concentrations measured within the plant should therefore be associated with plant processes rather than outside extraneous sources.

Shift Differences - The personal respirable dust levels of 13 jobs on the first shift were compared to 13 identical jobs on the second shift. The mean dust concentrations and standard deviations are quite similar from shift to shift. Since little variance is displayed, it is proposed that the airborne respirable dust concentrations remain relatively constant throughout the day. See Table 8.

Past Data - Personal respirable and personal total dust data collected at this facility in September, 1978, are presented in Table 9. The plant-wide mean respirable dust value is nearly identical to the plantwide mean value from July, 1979. The 95% confidence interval limits are also very similar for both the 1978 and 1979 data. This suggests that the dust levels remain relatively constant throughout the year. The upper values of the 95% confidence intervals for respirable and total dust are both well below the federal nuisance dust standards of 5 mg/m^3 and 15 mg/m^3 respectively.

Recommendations

To effectively reduce workers' exposure to airborne dust, management must actively seek and implement engineering controls and should maintain these systems in efficient working order at all times.

Jobs such as clinker cooler operators, crane operators, kiln helpers and burners, and mill helpers experience uncomfortable levels of respirable dust. Administrative changes and personal protective equipment (goggles and respirators) may relieve these conditions; however, engineering controls are the recommended courses of action. Ventilation design to remove the dust from the air once it is generated may be an effective means of control. Separation from the dust by enclosing either the worker or the dust is another effective means of control.

One particular operation was observed to be particularly unpleasant. While workers cut away plates from inside a ball mill with cutting torches, they experienced eye and respiratory irritations. When performing this operation it is suggested that a fan be placed behind the workers and so that the fumes are able to be exhausted from inside the ball mill. These workers should frequently be removed from inside the ball mill for rest periods.

When workers are exposed to airborne finished cement dust, they should be provided with highly efficient respirators. Since the majority of these dust particles are in the respirable size range, paper masks may not be adequate. Employees should be advised to wear respirators when working as a crane operator, cooler operator, kiln operator or helper, mill helper, or working with finished cement dust.

Conclusion

Atlantic Cement Company is one of the newer and more technically advanced facilities that will be surveyed by the Morbidity Study of Portland Cement Workers. The data collected is to be considered representative of worker exposure to airborne dust at this facility and concentrations are relatively low for most jobs.

The corrective actions recommended should be viewed as scientific guidance. There is no legal requirement that you implement any of these recommendations, and no assurance that these actions, if implemented, would be sufficient to prevent future citations for noncompliance. Nevertheless, it is anticipated that implementation of the recommendations listed in this report will reduce airborne dust levels at this facility.

References

NIOSH Manual of Analytical Methods, "Free Silica (Quartz, Cristobalite, Tridymite) in Airborne Dust," 2nd Edition, USDHEW Publication, 1977, P & CAM 259.

NIOSH Manual of Analytical Methods, "General Procedure for Metals," P & CAM 173.

NIOSH Manual of Analytical Methods, "Asbestos Fiber in Air," P & CAM 239.

Personal Respirable Dust Samples Collected At
Atlantic Cement
July 16-20, 1979

Table 1

Job	Date	Shift	Conc.-mg/m^3	Exposure Category
Primary Crusher Operator	7/16	2	.380 mg/m^3	Raw
Quarry Supervisor	7/16	2	.358	Raw
Primary Conveyor Tend.	7/16	2	.145	Raw
Quarry Mechanic	7/16	2	.277	Raw
Quarry Truck Driver	7/16	2	.163	Raw
Secondary Crusher Operator	7/16	2	.898	Raw
Feed End Operator	7/16	2	.370	Raw
Quarry Reliefman	7/16	2	.145	Raw
Conveyor Tend.	7/16	2	.619	Raw
Shovel Loader	7/16	2	.212	Raw
Cooler Operator	7/16	2	27.457	Clinker
Kiln Operator	7/16	2	.605	Clinker
Kiln Operator	7/16	2	.402	Clinker
Crane Operator	7/16	2	2.600	Clinker
Kiln Operator	7/16	2	1.143	Clinker
Crane Operator	7/16	2	2.067	Clinker
Kiln Helper	7/16	2	2.752	Clinker
Kiln Burner	7/17	2	.190	Clinker
Cooler Operator	7/17	2	3.632	Clinker
Kiln Helper	7/17	2	.522	Clinker
Crane Operator	7/17	2	1.189	Clinker
Cooler Operator	7/17	2	8.209	Clinker
Supervisor Finish	7/17	2	.230	Finish
Miscellaneous Labor	7/17	2	1.342	Finish
Conveyor Tender	7/17	2	.165	Finish
Barge Loader	7/17	2	.127	Finish
Repairman	7/17	2	.579	Mix
Mill Helper	7/17	2	2.066	Mix
Electrician	7/17	2	.511	Mix
Storeroom man	7/17	2	.083	Mix
Mill Operator	7/17	2	.349	Mix
Kiln Burner	7/18	1	.454	Clinker
Kiln burner	7/18	1	.665	Clinker
Crane Operator	7/18	1	.891	Clinker
Kiln Helper	7/18	1	2.156	Clinker
Cooler Operator	7/18	1	2.633	Clinker

Table 1
Continued

Job	Date	Shift	Conc.-mg/m^3	Exposure Category
Miscellaneous Labor	7/18	1	.086 mg/m^3	Finish
Supervisor - Finish	7/18	1	.606	Finish
Forklift Operator	7/18	1	.340	Finish
Conveyor Tend.	7/18	1	.960	Finish
Tunnel Man	7/18	1	1.264	Finish
Barge Loader	7/18	1	.251	Finish
Bulk Loader	7/18	1	.559	Finish
Maintenance	7/18	1	.710	Finish
Mix Chemist	7/18	1	.959	Mix
Laborer	7/18	1	.170	Mix
Quarry Clerk	7/19	1	.131	Raw
Welder - Quarry	7/19	1	.507	Raw
Driller	7/19	1	.596	Raw
Laborer	7/19	1	.233	Raw
Kiln Helper	7/19	1	1.034	Clinker
Kiln Burner	7/19	1	.447	Clinker
Kiln Burner	7/19	1	.363	Clinker
Crane Operator	7/19	1	1.201	Clinker
Pipefit/Plumber	7/19	1	.124	Mix
Lab. Worker	7/19	1	.320	Mix
Oiler - General	7/19	1	1.258	Mix
Machinist	7/19	1	.070	Mix
Painter	7/19	1	.279	Mix
Welder	7/19	1	.001	Mix
Secondary Conveyor Tend.	7/20	3	.535	Raw
Shovel Loader	7/20	3	.199	Raw
Supervisor	7/20	3	.124	Raw
Mechanic	7/20	3	.107	Raw
Kiln Burner	7/20	3	.178	Clinker
Crane Operator	7/20	3	.068	Clinker
Kiln Operator	7/20	3	.150	Clinker
Kiln Helper	7/20	3	.704	Clinker
Cooler Operator	7/20	3	4.192	Clinker
Mill Helper	7/20	3	1.971	Mix

mg/m^3 = milligrams per cubic meter of air

Personal Respirable Dust Calculations
Collected at Atlantic Cement
July 16-20, 1979

Table 2

	N	GM	GS	Range Min.	Range Max.	C.I. - 95
Plantwide	70	.445 mg/m^3	4.095	.001 mg/m^3	27.457 mg/m^3	.318 $mg/m^3 \leq u \leq$ .623 mg/m^3
Raw	18	.281	1.36	.107	.898	.205 $\leq u \leq$ .386
Clinker	26	.984	3.76	.068	27.457	.576 $\leq u \leq$ 1.680
Finish	12	.394	2.49	.086	1.342	.222 $\leq u \leq$ .699
Mix	14	.211	6.88	.001	2.066	.070 $\leq u \leq$ .637

N = number of samples collected
GM = geometric mean
GS = geometric standard deviation
CI - 95 = 95% confidence interval of true mean

Quartz Concentration on Personal Respirable Dust Samples
Collected at Atlantic Cement
July 16-20, 1979

Table 3

Job	Date	Shift	% Quartz by weight	Quartz Concentration ug/m^3	Exposure Category
Quarry Super.	7/16	2	16.1%	57.7 ug/m^3	Raw
Cooler Oper.	7/16	2	1.9	518.0	Clinker
Kiln Helper	7/16	2	1.8	48.3	Clinker
Cooler Oper.	7/17	2	1.1	88.8	Clinker
Kiln Helper	7/18	1	2.2	48.5	Clinker
Cooler Oper.	7/18	1	1.8	47.9	Clinker

ug/m^3 = micrograms per cubic meter of air

$$\% \text{ quartz} = \frac{\text{weight of quartz on filter}}{\text{total weight of dust on filter}} \quad 100$$

Trace Metal Concentration of Area Total Dust Samples
Collected at Atlantic Cement
July 16-20, 1979

Table 4

Area	Date	Shift	Al. Conc.=ug/m^3	Mg conc. ug/m^3	Exposure Category
Primary Crusher	7/16	2	—	73 ug/m^3	Raw
Front end Kiln	7/16	2	180 ug/m^3	157	Clinker
Finish Mills	7/16	2	49	69	Finish
Crane Cab	7/16	2	76	86	Mix
Primary Crusher	7/17	2	—	40	Raw
Front end Kiln	7/17	2	—	23	Clinker
Finish Mills	7/17	2	39	42	Finish
Ball Mills	7/17	2	40	43	Mix
Front end Kiln	7/20	3	—	46	Clinker
Clinker Cooler	7/20	3	105	115	Clinker

— = below limits of detection

Bulk Material Analysis
Collected at Atlantic Cement
July 16-20, 1979

Table 5

Material	Location	% Al	% Cr	% Co	% Mg	% Mn	% Ni	Asbestos
Raw	secondary Crusher	.56	--	--	.78	.02	--	--
Raw	Primary Crusher	1.2	--	--	1.6	.02	--	--
Clinker	Clinker Storage	1.4	.007	--	1.8	.02	--	--
Clinker	Frontend Kiln	2.0	.003	.004	2.1	.02	--	--
Clinker	Frontend Kiln	1.5	--	--	1.3	.02	--	--
Clinker	Clinker Cooler	.98	.01	--	1.5	.01	--	--
Clinker	Clinker Cooler	1.6	.006	--	1.8	.02	--	--
Clinker	Frontend Kiln	1.1	.004	--	1.4	.02	--	--
Clinker	Clinker conveyor	1.4	.007	--	1.8	.02	--	--
Clinker	Clinker Cooler	1.4	.008	--	2.0	.02	--	--
Clinker	Clinker Cooler	.91	.005	--	1.2	.01	--	--
Clinker	Transfer Belt	1.4	.004	.005	2.1	.002	--	--
Finish	Railway Loading	2.0	.006	.004	1.9	.02	--	--
Finish	Inside bargw	2.0	.007	--	2.3	.02	--	--
Finish	Buffer Silo	2.0	.004	.005	2.0	.02	--	--
Mix	Under Finish Mill	1.9	.005	.004	1.8	.02	--	--
Mix	Truck Load	1.0	.003	--	1.5	.02	--	--
Mix	Transfer belt	.54	.005	--	1.2	.02	--	--
Mix	Ball Mills	1.9	--	.004	2.0	.02	--	--

Background Levels of Respirable Dust,
Free Silica, Trace Metals, and Asbestos

Table 6

Date	Shift	Respirable Dust Conc. - mg/m^3	Free Silica Conc.-ug/m^3	Al. conc.-ug/m^3	Mg conc. ug/m^3	Asbestos fibers/cc
7/16	2		--	--	28	--
7/17	2	.008	--	--	7	--
7/19	1	.018	--			--
7/20	3		--	--	3	--

-- = below limits of detection

Table 7

Contaminant	# Samples Collected	# Samples With Detectable Conc.	# Samples Above Recommended Level	Limit of Detect.	NIOSH Criteria	MSHA Standard
Respirable Dust	70	70	2	.001 mg/m^3	—	5 mg/m^3
Quartz	70	6	3	30 ug/m^3	50 ug/m^3	—
Cristobalite	70	0	0	30 ug/m^3	50 ug/m^3	—
Aluminum	13	6	0	25 ug/m^3	—	10,000 ug/m^3
Chromium	13	0	0	3 ug/m^3	1 ug/m^3*	1,000 ug/m^3
Cobalt	13	0	0	3 ug/m^3	—	100 ug/m^3
Magnesium	13	13	0	1 ug/m^3	—	10,000 ug/m^3
Manganese	13	0	0	2 ug/m^3	—	5,000 ug/m^3
Nickel	13	0	0	3 ug/m^3	15 ug/m^3	1,000 ug/m^3

* = standard for carcinogenic hexavalent chromium

Comparison of 13 Corresponding Jobs
of 1st versus 2nd shift

Table 8

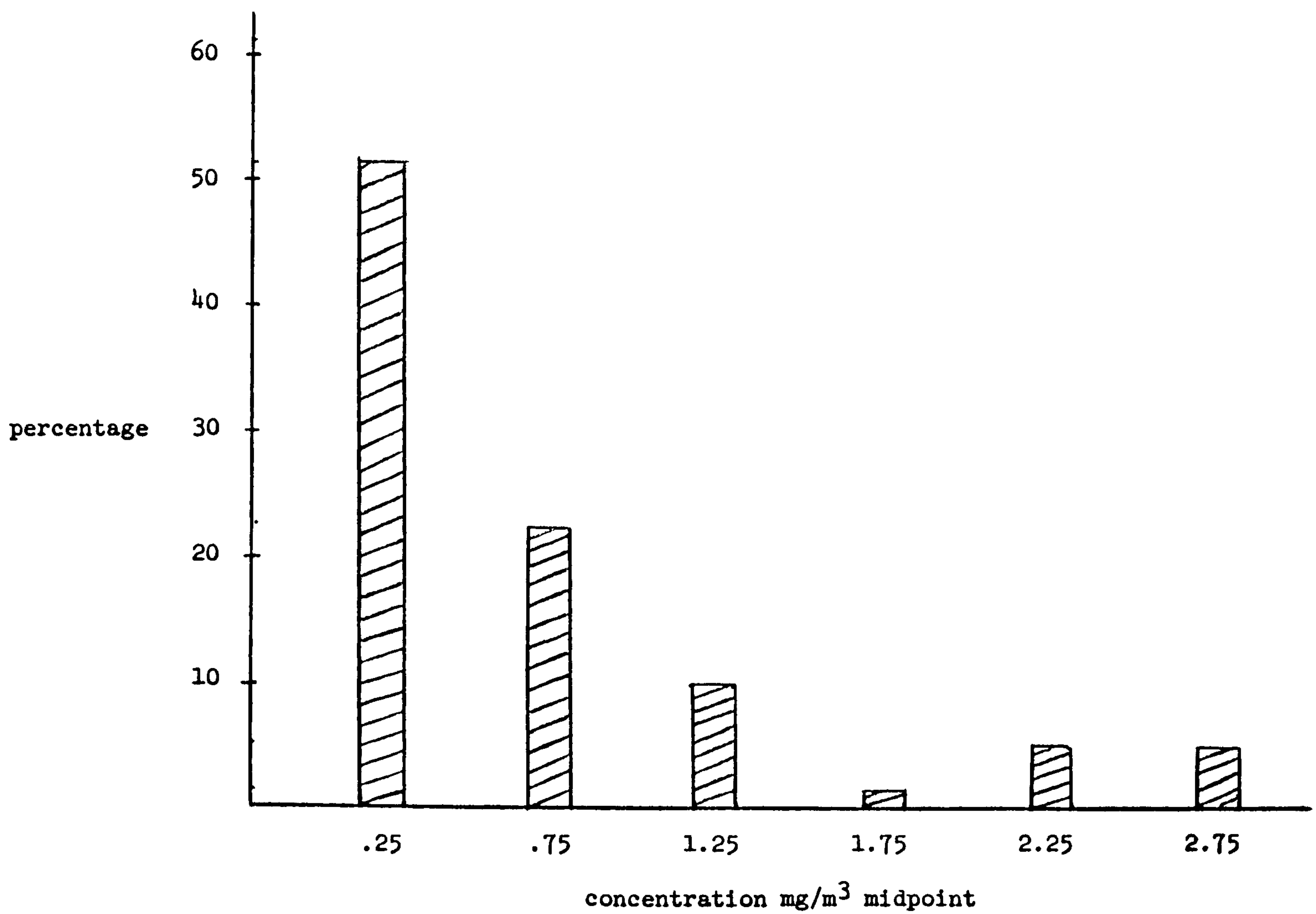
Shift	N	GM	GS
1	13	.699	3.23
2	13	.652	2.47

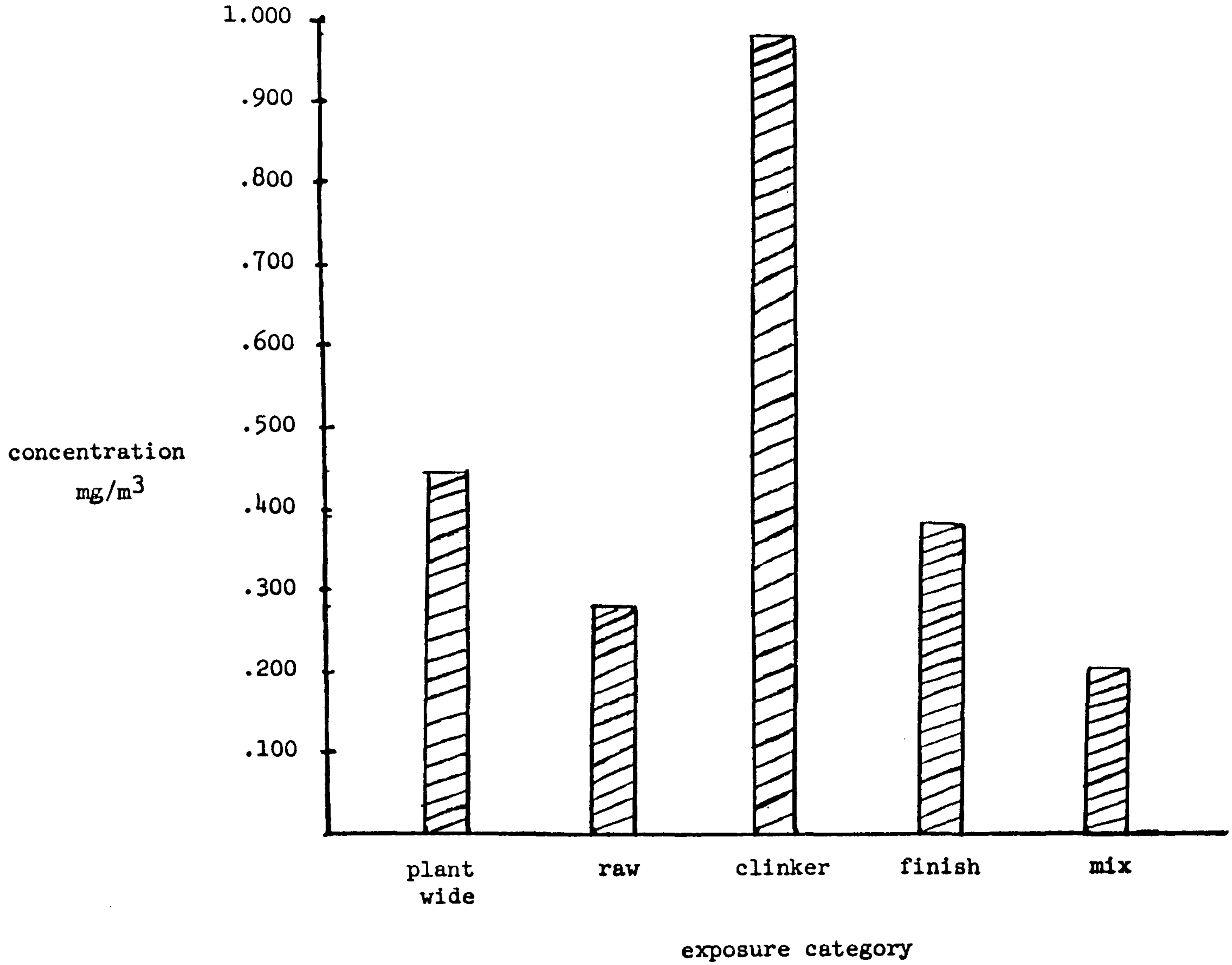
Personal Respirable and Total Dust Cncentrations
Collected at Atlantic Cement
September 2-26, 1978

Table 9

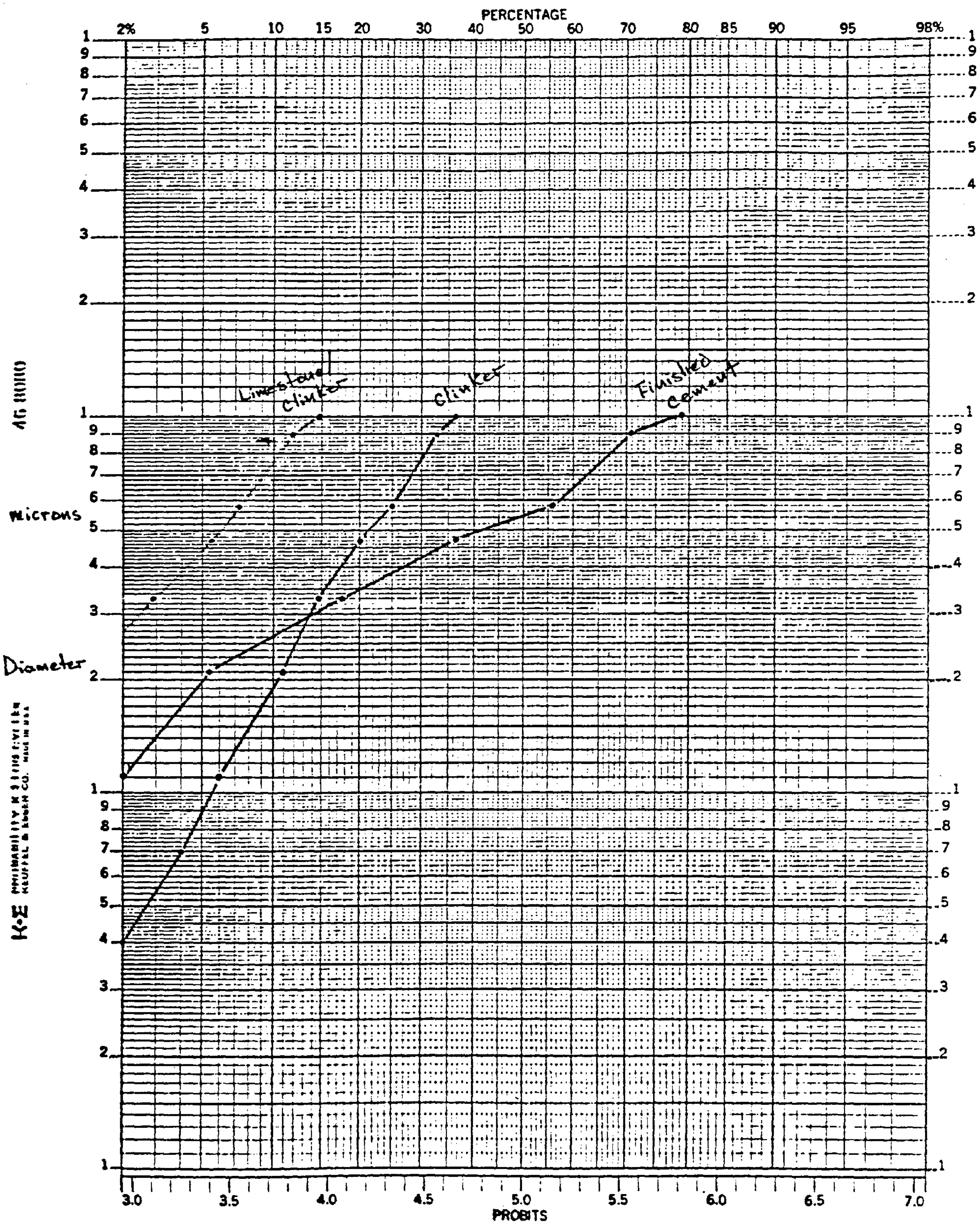
	N	GM mg/m^3	GS	CI95 mg/m^3
Respirable	46	.46	.55	$.348 \le u \le .607$
Total	47	2.73	2.85	$2.007 \le u \le 3.714$

Frequency Distribution of Personal Respirable Dust Concentrations





Average Personal Respirable Dust Concentrations by Exposure Category


PERCENTAGE
2%
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Limestone/ Clinker
Clinker
Finished Cement
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