Report on an

In-Depth Survey of Silica Flour Dust During Packing, Transfer and Shipping

at

The Central Silica Company
(Glass Rock Plant)
Glass Rock, Ohio

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ABSTRACT

General dust suppression techniques were evaluated at the Central Silica (CS) Company, Glass Rock, Ohio, silica flour plant. These dust control methods were: the handling and transfer of damp materials, exhaust ventilation; work practices including product handling and housekeeping procedures, and the use of respiratory protection. Environmental tests indicate that these methods have provided good dust control at this plant. Additional recommendations are presented to improve the effectiveness of these procedures.

I INTRODUCTION

A. Purpose of Study

A Control Technology Assessment (CTA) of the Silica Flour Industry was conducted by the National Institute for Occupational Safety and Health (NIOSH), at the request of the Mine Safety and Health Administration (MSHA) and in cooperation with the Bureau of Mines (BOM) and the National Industrial Sand Association (NISA). The primary purpose of this CTA was to evaluate innovative and effective control strategies for reducing dust dispersion during the milling, packing, transfer, and shipping of silica flour. Three silica flour mills were investigated during this study.

This report presents the findings, observations and recommendations for the study at the Central Silica Company, Glass Rock, Ohio facility. Two visits were made to this plant, in May and July 1980, to conduct a preliminary investigation and an in-depth study of dust control procedures. At the time of the in-depth study, production schedules were reduced, so that only limited atmospheric dust evaluations could be made. This situation did, however, permit an estimation of the proportionate contribution of background dust levels to total dust exposures in the packing and bag handling areas.

B. Scope of Study

The evaluation of atmospheric dust concentrations and ventilation control systems was limited to the packing and transfer of bags containing silica flour in the Flour Building. Work areas and operations included.

1. Packing area - upper level: Filling 100 pound bags with silica flour at a St. Regis four spout packer.

2. Transfer point - main floor: Transferring bags from the inclined roller conveyor to the rubber belt conveyor.

3. Inside loading trucks: Off-loading bags from the belt or gravity wheel conveyors and stacking them on pallets in trucks.

4. Ambient air - at north and south ends of Flour Building.

Additional observations and recommendations on other dust control procedures are presented in Section V.

II STUDY PROTOCOL

A. Evaluation Criteria

The principal material investigated in this study was crystalline silicon dioxide (often referred to as silica or free silica). Silica may be present in at least three crystalline forms: alpha quartz, cristobalite, and tridymite; and several amorphous (noncrystalline) forms. In this study, only significant amounts of alpha quartz were determined to be present in any of the final products or airborne dust samples. Therefore, all references to silica dust concentrations refer to the respirable fraction of crystalline quartz.

The MSHA standard, or Permissible Exposure Limit (PEL), for respirable crystalline silica (quartz), which is applicable in metal/nonmetal mines and mills, is contained in 30 CFR (Code of Federal Regulations) Part 57. The PEL pertains specifically to the 8-hour, time-weighted average exposure to employees. In this report, however, the PEL is used as an environmental criterion to evaluate the effectiveness of the control techniques under investigation. For respirable dust, containing silica, the PEL is determined by the equation.

$$\text{PEL} = \frac{10}{\%\ \text{silica} + 2} \quad \text{milligrams per cubic meter of air. } (mg/m^3)$$

For 100% respirable silica dust, this calculated PEL is approximately equal to 0.1 mg/m^3 or 100 ug/m^3.

B. Process Description

General

At the Central Silica, Glass Rock facility, quartzite ore is mined and reduced (by jaw crusher) to minus five inch at the quarry. The ore is transported two and one half miles by overhead tram (bucket) line to the processing plant, Figure A, further reduced (by gyratory crusher) to minus one inch, and stored in bins. The ore is conveyed to a rod mill, wet ground to sand grain (minus 20 mesh), and pumped to further processing. Two parallel streams of sand (containing trace amounts of iron) are pumped to further processing. One stream of sand is pumped to an open stock pile. It is then dried, sized, and stored in the silos, prior to shipment either in bulk or bag by railroad car or truck.

The second stream of sand is pumped to the Process Building to remove trace iron, producing "glass grade" sand. This process involves vacuum filtration, iron removal, washing, vacuum filtering, and drying. This "glass grade" sand. Most of this "glass" sand is stored in silos to be shipped either in bulk or bag by railroad car or truck.

Flour Milling and Handling

In addition to its use as a raw material for glass manufacture, a portion of the "glass sand" is used as a feed stock for production of silica flour. The "glass" sand is conveyed to the Pebble Mill, where it is dry ground in Silex block-lined, flint pebble mills to minus 325 mesh flour. The silica flour is then conveyed to the Flour Building, Figure B, and stored in silos. The flour is bagged or bulk loaded from the silos into closed railroad hopper cars or trucks. The bags of flour are also shipped either by truck or railroad car.

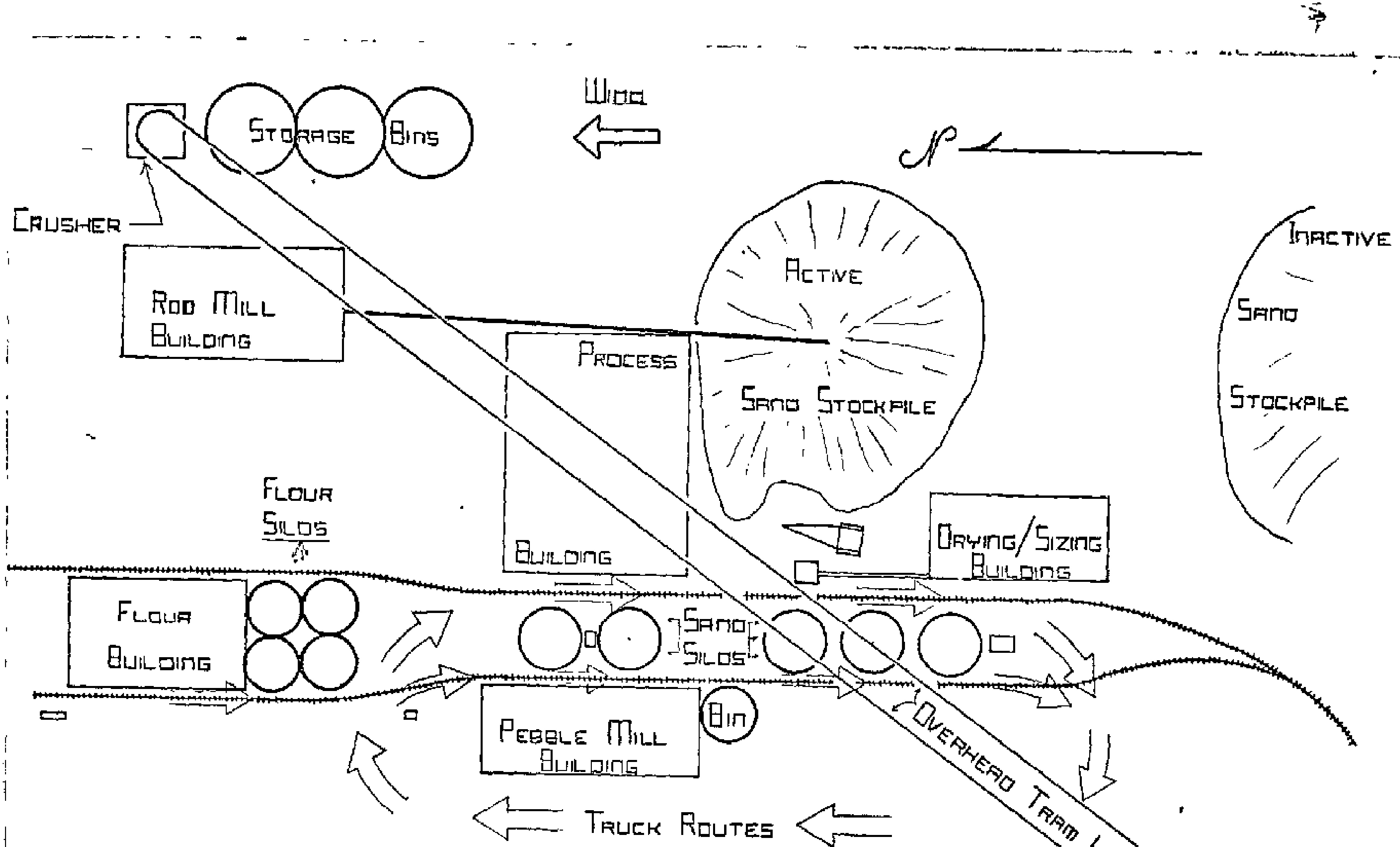

Figure A: Plant Layout

Central Silica Company

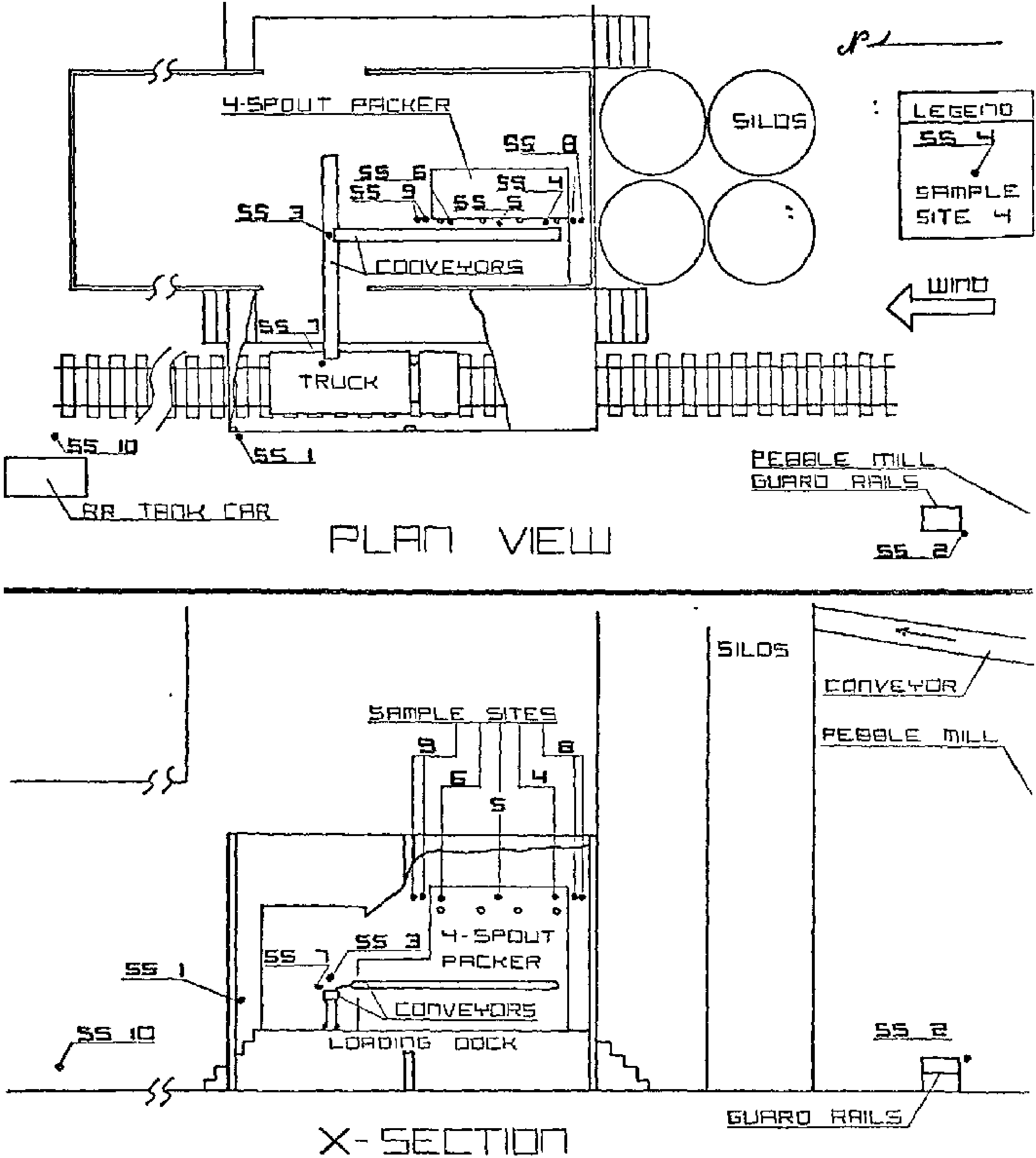

Figure 8: Flour Building

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A normal bag handling crew consists of one supervisor and six workers. One operates the packer machine; four hand-stack the bags in or on trucks; one works either at the transfer point or assists in stacking the bags. The workers rotate from packing, to loading, and to stacking operations during the shift. The normal packing schedule is limited to the first shift, five days a week. A St. Regis four-spout packer is located on the upper deck (second floor) of the Flour Building, approximately 8 feet above the main floor, Figure C. Most of the upper deck is constructed of expanded metal with solid metal flooring in the immediate packer area. During this study, 100 pound bags (3-ply pasted valve bags, manufactured by St. Regis Paper Company) were being filled.

The bags are placed by hand on the packer spouts, filled with product, and tipped by hand onto a horizontal chain conveyor located below the upper deck. They then travel approximately 20 feet to the decline roller conveyor, and onto the horizontal belt transfer conveyor. (The bags do not drop onto the transfer conveyor as was observed at other plants.) The horizontal transfer conveyor transports the bags to one of the two loading docks on the west or east side of the building.

During this study, flat bed and enclosed trucks were being loaded from the west loading dock. In the truck loading area, two or three operators manually removed the bags from the conveyor and stacked them on pallets in the trucks. Conveyor (on-off) controls are located at the packing station and at the transfer conveyor discharge.

In summary, the transporting systems for the silica processes consist of a tramline, conveyors, pipelines, and an air slide. Coarse damp ore is transported by a bucket tramline from the quarry to the plant area. Enclosed belt conveyors are used to move the ore (minus one inch) and sand between operations. A slurry pipeline has replaced an overhead belt conveyor from the Rod Mill Building to the Process Building and to a sand stock pile. A Fuller Air Slide is used to transfer flour product from the Pebble Mill Building to the Flour Building.

C. Dust Suppression and Control Systems

1. Ventilation Systems

The exhaust ventilation system at the packer station in the Flour Building contains several collection points, Figure C ad D. Dust, which is captured at the collection points, goes through 4 and 6-inch ducts into a main duct that leads to a bag-type dust collector (a 240 bag unit manufactured by W. W. Sly Manufacturing Company). All collection points remain open during packing operations.

Four ventilation hoods (two above and two below the belt) are located along the chain conveyor. These exhaust hoods remove loose surface dust from the bags. Excess silica flour product, which is not captured by the ventilation hoods, falls through the chain conveyor into one of two hoppers. This dust is returned by conveyors to the storage silos at the Flour Building. Each pebble mill in the Pebble

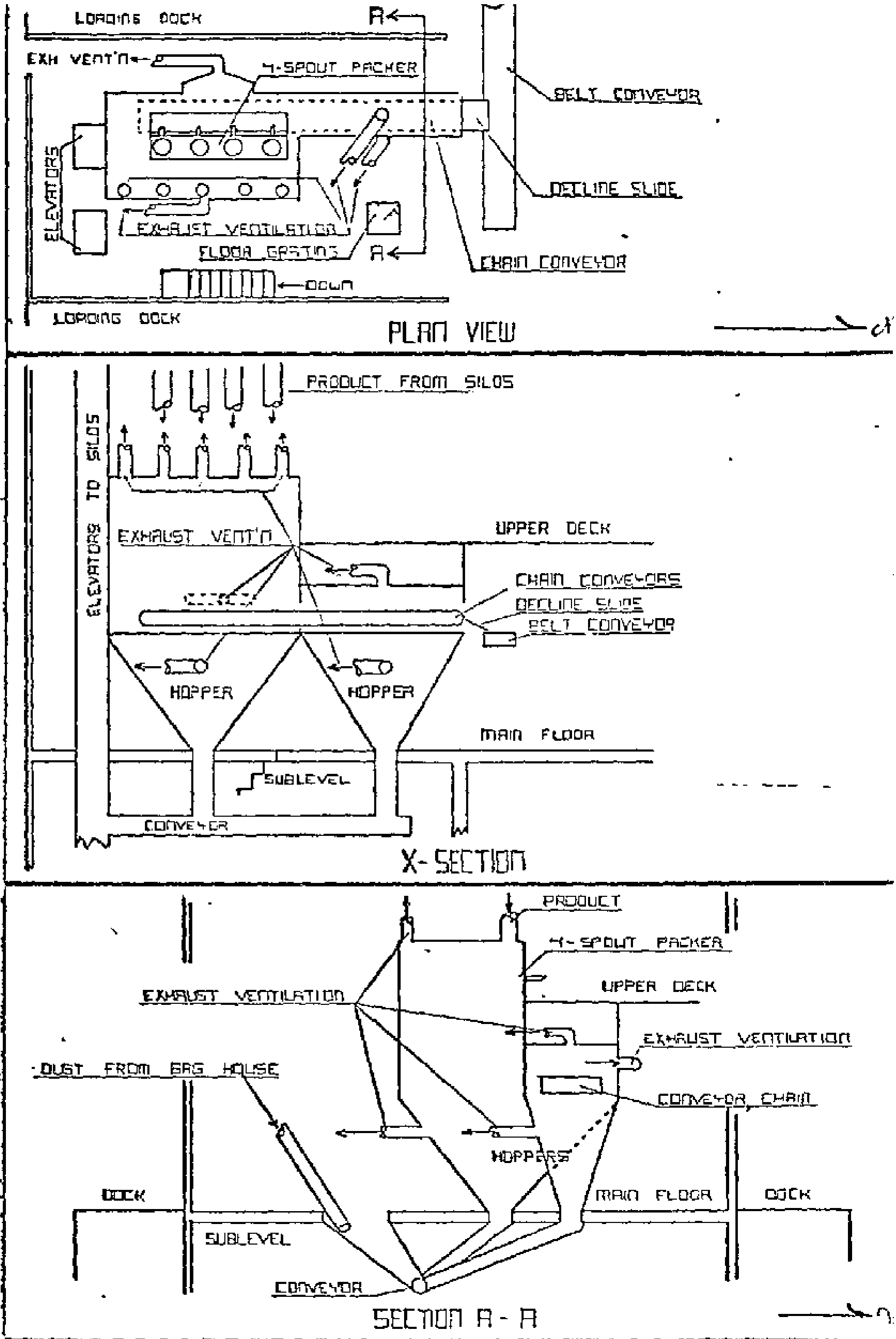

Figure C: Packer/Dust Collection

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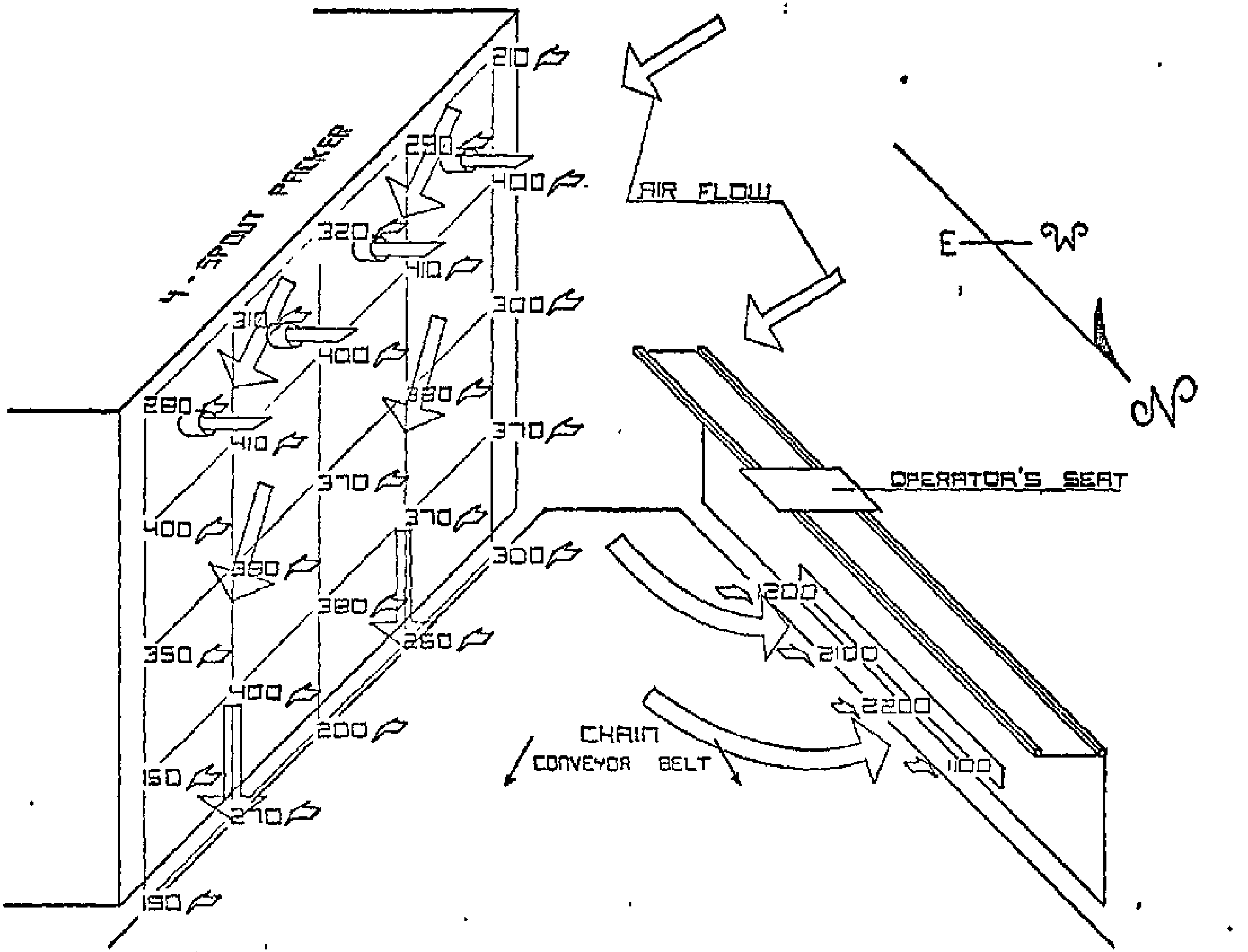

Figure D: Ventilation at Face in Packer Area

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Mill Building is connected to a bag-type dust collector (a 240 bag unit manufactured by W. W. Sly Manufacturing Company).

2. Houskeeping

Wet washing (hosing of the concrete floors) is used to flush and carry away dust, which has accumulated within the buildings and on the loading docks. A water truck sprays a brine solution on the roadways to supress dust. The effectiveness of the dust control systems is discussed in Section IV.

D. Study Design

A study protocol was developed to evaluate the effectiveness of the existing dust control procedures at the flour packing station and at the truck loading station in the Flour Building, Figure A. Dust levels were evaluated at ten sampling locations inside and around the Flour Building, Figure B.

Atmospheric evaluations were made during two sets of operating conditions. During the first run, operations of ore crushing, acid treatment, milling, bagging, and bulk loading of whole grain sand were in progress. There was no flour packing or loading of trucks. During the second run, flour packing and truck loading operations were in progress in addition to the above operations. Based on these tests, estimates were made of the relative contributions of the flour packing, truck loading, and general mill operations to the overall dust levels in the Flour Building. Duplicate samples were collected by NIOSH and Central Silica Company staff.

E. Evaluation Procedures

1. Environmental Dust Evaluations

Samples were collected by three methods to evaluate atmospheric dust concentrations.

a. The MSA Gravimeter Dust Sampler. Integrated air samples (several hours in duration) were collected and analyzed qualitatively for silica content and quantitatively for total dust and silica dust concentration (by weight).

b. The Del High Volume Electrostatic Precipitator (ESP) Sampler. A bulk air sample was collected with this instrument to identify the airborne dust at the packer area. Analyses for silica content, total dust, and particle size distribution were made of this sample.

c. Bulk and rafter samples were analyzed for silica content and for particle size distribution.

Discussions of the operating characteristics of these sampling devices and the laboratory analytical procedures are presented in Appendix I.

2. Ventilation Evaluations

Ventilation measurements and air flow patterns were evaluated with a Kurz Air Velocity Meter, Model 441, and Gastec Smoke Tester Tubes.

III STUDY RESULTS

A. Atmospheric Dust Concentrations

Table 1 and Figure E present the results of atmospheric evaluations during two operating conditions 1) milling only, and 2) milling, packing and truck loading of silica flour. Sampling sites are shown in Figure B. During both days of this study, prevailing winds were from the south.

During the first sampling period, product leakage was observed from the northeast corner of the Pebble Mill Building, near site location Number 2. This condition existed from approximately 8.30 a.m. to 9:30 a.m.

Ambient dust levels at the south and north ends of the Flour Building were of the same order of magnitude during both packing and non-packing operations (approximately 40 ug/m^3 total dust and 30 ug/m^3 silica dust). At the packer station, dust levels were also of the same order of magnitude during packing (approximately 212 ug/m^3 total dust and 112 ug/m^3 silica dust) and during non-packing (approximately 220 ug/m^3 total dust and 75 ug/m^3 silica dust). Dust levels were significantly elevated during truck loading operations in the Flour Building area. For example, at site location No. 7 (the off-loading point from the horizontal belt conveyor to the gravity wheel conveyor) dust levels increased from $<$ 28 ug/m^3 (total dust and silica dust) to 330 ug/m^3 total dust and 264 ug/m^3 silica dust.

B. Bulk Sample Analyses

A bulk air sample, collected with the Del ESP Sampler near the packer station, was analyzed for silica content and particle size distribution. As shown in Table 2, the sample contained approximately 77% silica and the mass median diameter (MMD) of the particles was approximately 2.6 micrometers (um). Since this instrument was operated with a cyclone pre-separator, only "respirable" particles ($<$ 10 um) were collected.

Six bulk samples (product and rafter) were collected in the Pebble Mill and Flour Mill Buildings to estimate the silica content and particle size distribution of products and potential airborne dusts. All of these samples were essentially pure silica, as shown in Table 2. The MMD's of the rafter samples ranged from 2.6 to 9.2 um.

Table 1. Atmospheric Concentrations of Respirable Dust during Two Experimental Runs

Location/Operation	Run A Sample #	No bagging or Truck loading: Total dust, ug/m^3	No bagging or Truck loading: Silica dust, ug/m^3	No bagging or Truck loading: Silica Content %	Run B Sample #	Bagging and Truck loading: Total dust ug/m^3	Bagging and Truck loading: Silica dust ug/m^3	Bagging and Truck loading: Silica Content %	Average: Total dust, ug/m^3	Average: Silica dust, ug/m^3	Average: Silica Content %	Ratio Run B / Run A: Total dust	Ratio Run B / Run A: Silica dust
I. Outside Mill Building													
1. North-near mill	A1	< 25	< 25	( )	B1	< 11	< 11	( )	< 18	< 18	( )	( )	( )
2. North - 50 feet from mill					B10	48	< 16	< 33	48	< 16	< 33		
3. South-near mill	A2	51	51	100	B2	46	46	100	48	48	100	0.90	0.90
Average outside mill		< 38	< 38	(100)		< 35	< 24	69	< 38	< 27	(71)	(0.92)	(0.63)
II. Main flour packer area													
1. a. South (right) side of packer	A4	131	105	80	B4	286	110	38					
b. South (right) side of packer					B8	163	140	86					
Average (right) side of packer		131	105	80		225	125	55	178	115	65	1.72	1.2
2. Center of packer	A5	369	40	11	B5	220	132	60	295	86	29	0.60	3.3
3. a. North (left) side of packer	A6	160	80	50	B6	286	88	31					
b North (left) of packer					B9	95	71	75					
Average north (left) side of packer		160	80	50		190	80	42	175	80	46	1.19	1.00
Average at packer area		220	75	34		212	112	53	216	94	44	0 96	1.5
III. Bag handling area													
1. Transfer point between conveyors	A3	180	64	36	B3	66	66	100	123	65	53	0.37	1 0
2. Conveyor discharge	A7	< 28	< 28	( )	B7	330	264	80	179	< 146	< 82	> 11.8	> 9 4
Average at bag handling		< 104	< 46	(44)		198	165	83	151	< 106	< 70	> 1.9	> 3.6

Notes: ug/m^3 micrograms per cubic meter of air

( ) low degree of accuracy and reliability

< less than, > greater than

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DUST CONCENTRATIONS

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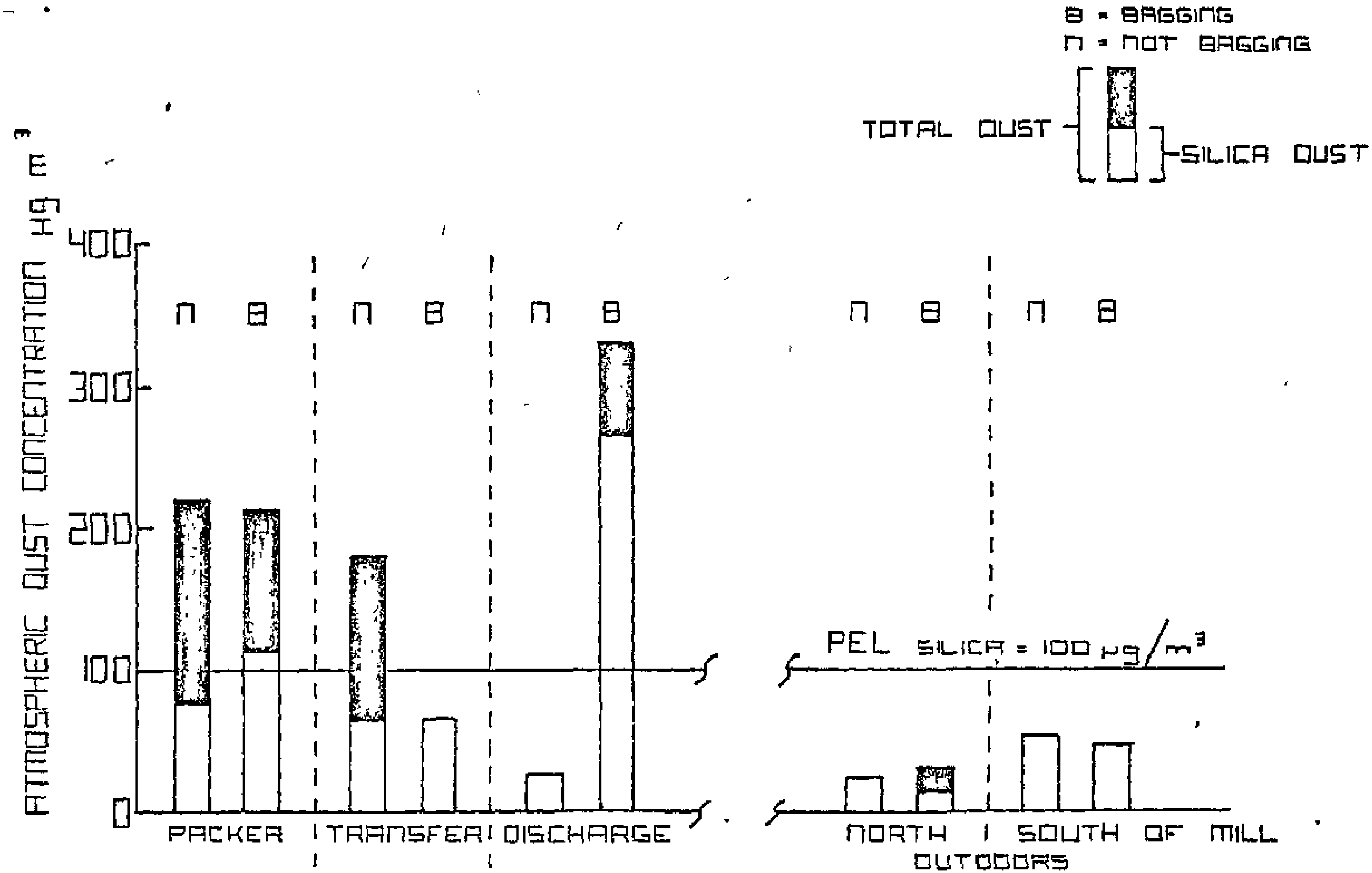

Figure E: Flour Building - Packing, Transfer Point, and Discharge Point

Table 2. Chemical and Size Analysis* of
Bulk Air (Product, and Rafter) Samples

Type Sample	Location/Source	Silica Content %	Particle Size (um)			
			Median Area Equivalent Diameter	Mass Median Diameter	Aerodynamic** Diameter	Magnification
1. Bulk Air (Electrostatic Precipitator	Behind Packer Upper level	≈ 77	1 1	3.0	5.0	400X
			0 6	2.6	4.2	3000X
2. Bulk Product	Flint Silica Flour #325	≈ 100	1 2	14.9	24.3	400X
			0 4	3.1	5 0	4000X
3. Bulk Product	Flint Silica Flour #324	≈ 100	1 2	13.8	22 5	400X
			0 6	6.9	11.3	2000X
4. Rafter	Pebble Mill	≈ 100	1.2	19.4	31 7	400X
			0 3	9.2	15.0	2000X
5. Rafter	South Side of Packer Level with Packer	≈ 100	1 2	7 6	12 3	400X
			0 5	6.6	10 7	2000X
6. Rafter	Main Floor Level, East Side Behind Packer Machine	≈ 100	1 4	17.4	28 4	400X
			0 3	4.0	6.5	2000X
7. Rafter	West Walls Behind Packer, at Packer Level	≈ 100	1 0	29 8	48 6	400X
			0.2	2.6	4 2	2000X

*Size analysis by electron microscope

**Aerodynamic diameter and mass median diameter calculated assuming particle density of 2.66 g/cc.

≈ Approximately

um micrometer

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The MMD's of the bulk product samples ranged from about 15 to 30 um. The significance of these results is discussed in Section IV.

C. Ventilation Measurements

Figure C shows the dust collection system around the packer station, and Figure D presents the air flow patterns and velocity measurements around the 4-spout St. Regis packer. The ventilation flow patterns were developed by exhaust ducts behind the spouts, and below and behind the chain conveyor. Velocities and flow patterns were measured approximately one foot from the face of the packer hood and at the exhaust slot directly beneath the packer operator. Velocities, ranging from approximately 200 to 400 feet per minute (fpm), moved air from above and behind the packer operator's breathing zone (OBZ) downward and to the rear of the packer machine.

IV DISCUSSION OF RESULTS

The following discussions are based on observations and environmental data obtained during the two conditions of mill operations, as mention in Section III. During the first morning's operation (milling only), a flour leak was observed from about 8.30 a.m. to 9.30 a.m. at the upper northeast corner of the Pebble Mill Building, near location No. 2. Since the wind was from the south, this leakage probably contributed to the elevated atmospheric dust levels in the Flour Building areas. Contamination reached as far as the packer station (no packing in progress), where dust levels averaged 220 ug/m^3 total dust and 75 ug/m^3 silica dust. Leakages and background contamination were a major contributor to dust exposures in the Pebble Mill Building, the Flour Building, and other plant areas.

During the second operating condition, including packing and truck loading, there was no visible dust leakage from the Pebble Mill. Background dust levels (location Nos. 1, 2, and 10) were low, averaging <35 ug/m^3 total dust and <24 ug/m^3 silica dust. Average dust levels at the packer station were of the same order of magnitude during packing (212 ug/m^3 total dust and 112 ug/m^3 silica dust), as those of the previous day with no packing (220 ug/m^3 total dust and 75 ug/m^3 silica dust). Apparently, the ventilation control system effectively removed most of the dust generated by the packing operation. The excellent air flow patterns down and away from the operator (averaging approximately 250 fpm) kept airborne dust away from the operator's breathing zone.

At the lower level transfer point, from the inclined roller conveyor to the rubber belt conveyor, location No. 3, dust levels were lower on the second day (packing and loading) than on the first day (no packing). High levels on the first day were probably due to the Pebble Mill Building leak. On the second day, bags were observed to be clean and there was no bag breakage. Furthermore, the drop distance from the inclined roller conveyor to the horizontal rubber belt conveyor was less than two inches, which minimized bag breakage and dust generation, (Photo - 1) At the discharge end of the gravity wheel conveyor, where bags are off-loaded and stacked on pallets

Photo - 1

Conveyor Transfer Point

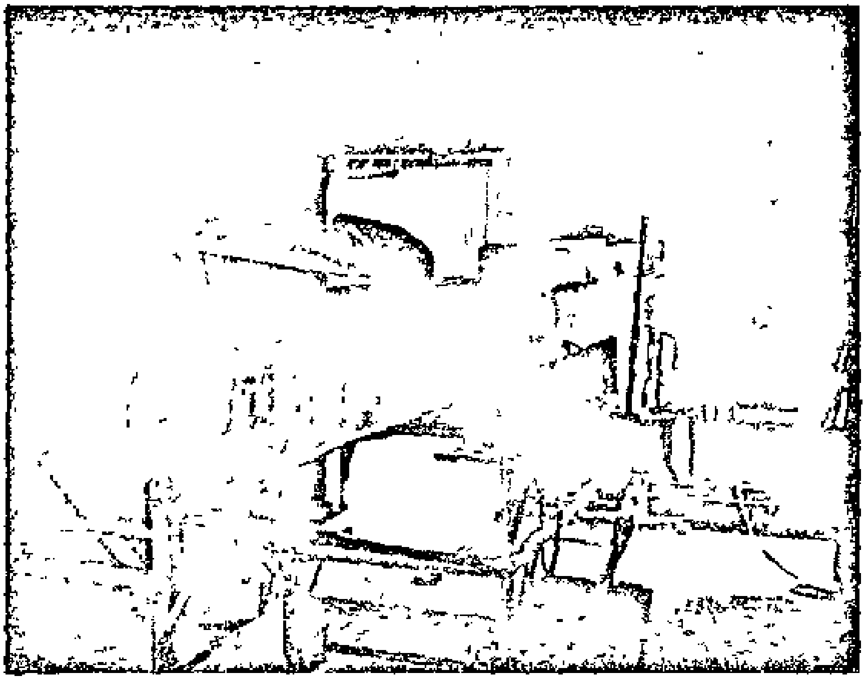

Photo - 2

Loading Truck Trailer

in trucks, Photo - 2, dust levels were an order of magnitude higher during loading (264 ug/m^3 silica dust) than during no loading (< 28 ug/m^3 silica dust). Since the airborne dust at this point was both high in concentration and silica content (80%), it apparently emanated from the bags, either as leakage, spilled product or surface contamination. Truck loading was the only operation in the Flour Mill Building area where silica dust levels significantly exceeded the PEL of 100 ug/m^3.

V. OBSERVATIONS, CONCLUSIONS, AND RECOMMENDATIONS

A. Dust control in all areas requires a combination of good engineering controls, such as exhaust ventilation and controlled bulk loading of product, good work practices including product handling and housekeeping procedures; and an effective respiratory protection program. As dust emissions from point sources are reduced, it normally follows that the levels of personal exposures to atmospheric dust are also reduced proportionately.

B. Management has made a firm commitment to the improvement of internal and external dust control at their Glass Rock and Millwood facilities. This was indicated by the following examples

1. MSHA's dust survey report of November 1979 indicated no outstanding dust citations.

2. Medical and environmental monitoring programs are being developed and implemented at both plants. The medical program is under the direction of Dr. Paul Jones, radiologist from Zanesville, Ohio. The environmental monitoring and control program is under the direction of Mr. Joseph Fodo, mining engineer. The design and installation of dust control equipment are being carried out in consultation with staffs of the Fairfield Engineering Company, Marion, Ohio and Weston Environmental Consultants, West Chester, Pennsylvania.

C. The effectiveness of the ventilation control at the packer station was evaluated by measuring dust concentrations during periods of packing and no packing. Levels of total dust and silica dust were of the same order of magnitude during both operating conditions, indicating good dust control at the packer operation.

D. Several additional engineering control strategies were observed or are being considered for this facility. These include.

1. Ore is moved as a damp material by overhead conveyor from the quarry to the secondary crusher, from the secondary crusher to the storage bins, and from the storage bins to the rod mills. The handling of damp ore minimizes dust dispersion and reduces maintenance problems.

2. According to plant personnel estimates, outside areas may contribute to approximately one-third of the in-house dust contamination problem. Background air samples normally contain 25-30% silica. Outside dust sources are now being reduced by. a) resurfacing roads, b) planting vegetation, and c) wetting road surfaces with salt water. (According to plant officials, salt water is a better dust suppressant than water alone.) This outdoor dust contamination may be further reduced by additional revegetation and paving of road surfaces.

   The active and inactive sand stock piles also may be significant contributors to outdoor dust contamination. If this is confirmed, covers (such as sealants, shrouds or sprinkling systems) should be utilized to reduce these sources.

3. Bulk loading and shipping of product results in less dust contamination than bag packing, handling, and shipping. The company presently ships 80-95% of its flour products in bulk. Dust generated by the pneumatic loading of hopper cars and trucks is now being controlled by exhaust ventilation ducts placed in the hopper cars.

4. The use of plastic wrapping (shrink or stretch) around pallet loads would be effective in reducing bag breakage and dust dispersion during product shipping.

5. A filtered air system is used in the Pebble Mill control room to maintain low dust levels.

6. Plant personnel report minimal bag breakage (approximately 2%). Bags are supplied by Black Manufacturing Company and St. Regis Company. In addition, the use of pallets made with new wood covered with slip sheets would result in reduced bag breakage and spillage.

7. At the Process Building, enclosed screens, manufactured by the Derrick Manufacturing Company (Buffalo, New York), operate under negative pressure to separate fines from coarse product. This newly installed system should reduce a dust source to the environment.

E. The following work practices, in conjunction with the handling of damp intermediate products, help reduce dust levels.

   1. Wet washing of work surfaces, particularly in the packer area.

   2. Cleaning of work surfaces and floors in the Ball Mill area using a centralized vacuum system and mopping with a kerosene emulsion.

F. The company has a respirator program which is strictly enforced in "high silica" areas. Since the NIOSH visit the respirator program has been expanded and now includes the assignment of responsibility for maintenance, repair, and cleaning to one trained individual on a scheduled basis. Each supervisor should be responsible for enforcement of respirator use.

G. The majority of samples collected by NIOSH were in compliance with the PEL of MSHA ($\approx$ 100 ug/m^3 of respirable silica). Simultaneous samples were collected by the company at the Bagger Operation's location. An eight hour, Breathing Zone sample, at the Bagger operator's location, indicated an exposure of .397 mg/m^3 of Total Dust. This was below its calculated PEL of .503 mg/m^3, based on a silica content of 17.9%, Appendix III.

Appendix I

Description of Air Sampling and Analytical Equipment

1. MSA Gravimetric Dust Sampler, Manufactured by Mine Safety Appliances, Inc. This sampling system consists of a 10 mm plastic cyclone separator to remove "non-respirable" dust, a three-piece plastic filter holder cassette, containing a 37 mm PV filter, No. M5, manufactured by Millipore Corporation or a FWS-B filter, manufactured by Mines Safety Appliances, Inc., and an MSA portable, battery powered pump, Model G. This sampler is operated at 1.7 liters per minute, which is the standard flow rate for collecting (respirable) silica and total dust samples.

2. Del High Volume Electrostatic Precipitator Sampler, Model ESP-100A, manufactured by Del Electronic Corp. This sampler, with respirable cyclone separation, operates at 17 cubic feet per minute.

3. Crystalline silica was analyzed with a Phillips automated powder diffractometer, Model ADP-3501, with the "limit of detection" Of 18 ug per sample. Total dust weights were measured on a Perkin-Elmer Electrobalance, Model AD-2, with a "limit of detection" of 10 ug per sample. All samples were desiccated for 48 hours to obtain constant weight.

4. Particle size analyses were conducted in the NIOSH/DBBS, laboratory. using a LeMont Scientific Image Analyzer, Model B-10, attached to a JEOL JXA-50A electron probe microanalyzer, samples were magnified either to 400X or 2000X, depending upon the size of the largest particles.

Appendix II

Environmental Data-MSA Gravimetric Sampler
(NIOSH Data)

Field #	Location/Operation	Date	Filter #	Time Start	Time Stop	Total Time min	Volume* m^3	Total Dust ug	Total Silica ug	Dust conc TWA Total Dust ug/m^3	Dust conc TWA Silica Dust ug/m^3	Silica Content %	PEL** ug/m^3	Remarks
A 1	Outside - north-of-mill	8/5	PV 4426	0722	1120	238	405	< 10	< 10	< 25	< 26		( )	No packing
2	Outside - south-of mill	"	" 4428	0724	1117	233	396	20	20	51	51	100	98	in morning
3	Transfer point from conveyor	"	" 4425	0728	1117	229	389	70	25	180	64	36	260	of 8/5
4	Packer-south (right) side	"	" 4423	0733	1117	224	381	50	40	131	105	80	120	
5	Packer - center	"	" 4429	0734	1117	223	379	140	15	369	40	11	770	
6	Packer-north (left) side	"	" 4424	0736	1117	221	376	60	30	160	80	50	190	
7	Conveyor discharge	"	" 4430	0745	1117	212	360	10	10	< 28	< 28	( )	( )	
B 1	Outside-north, downwind	8/5	MS 730	1316	1517									Packing
		8/6		0658	1332	515	876	< 10	< 10	< 11	< 11	( )	( )	flour in
2	Outside-south, upwind	8/5	" 729	1312	1516									afternoon
		8/6		0700	1333	517	879	40	40	46	46	100	98	of 8/5 and
3	Transfer point	8/5	" 726	1315	1405									morning of
		8/6		0719	0906									8/6
		"		1015	1100									
		"		1145	1250	267	454	30	30	66	66	100	98	
4	Packer (south) right (duplicate with B8)	8/5	" 738	1314	1405									
		8/6		0719	0906									
		"		1016	1100									
		"		1145	1250	267	454	130	50	286	110	86	250	
5	Packer (center)	8/5	" 740	1314	1405									
		8/6		0710	0906									
		"		1016	1100									
		"		1145	1250	267	454	100	60	220	132	60	160	
6	Packer (north) left (duplicate with B9)	8/5	" 736	1314	1405									
		8/6		0719	0906									
		"		1016	1100									
		"		1145	1250	267	454	130	40	286	88	75	300	
7	Conveyor discharge	8/5	MS 731	1315	1405									Trucks
		8/6		0719	0906									loaded
				1015	1100									4 trucks
				1145	1250	267	454	150	120	330	264	80	120	loaded,
8	Packer (south) right (duplicate with B4)	8/5	725	1329	1405									3 open,
		8/6		0719	0906									1 closed
		"		1015	1100									
		"		1145	1250	253	430	70	60	163	140	38	110	
9	Packer (north) left (duplicate with B6)	8/5	744	1333	1405									
		8/6		0719	0906									
				1015	1100									
				1145	1250	249	423	40	30	95	71	31	130	
10	Outside (far north) downwind	8/5	732	1344	1518									
		8/6		0700	1332	486	826	40	<13	48	<16	< 33	290	

* based on sampling rate of 1 7 lpm
ug micrograms
ug/m^3 micrograms per cubic meter of air
**PEL Based on MSHA formula $PEL = \frac{10}{\% SiO_2 + 2} \times 1000 = ug/m^3$

< less than, > greater than
( ) low degree of accuracy and reliability

Central Silica Company
Glass Rock, Ohio

Appendix III

Environmental Data - MSA Gravimetric Sampler
Central Silica Company

	Date	Time Start	Time Stop	Location	Sample Weight mg	Silica Content %	TWA (1) mg/m 3	PEL (2) mg/m 3
1.	8/5	0730	1030	Center of bagger	.067	36.0	.219	.263
2.	8/5	1230	1530	Center of bagger	.007	( )	.023	(>.100)(3)
3.	8/5	0730	1530	Bagger operator (OBZ) (4)	.323	17.9	.397	.503

(1)All TWA's based on a sampling rate of 1.7 lpm

(2)PEL based on MSHA formula PEL $= \frac{10}{\% SiO_2 + 2}$ mg/m^3

(3) >.100 - greater than .100 mg/m^3, on assumption of 100% SiO_2

(4) OBZ Operator's Breathing Zone