Report on an

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

at

Pennsylvania Glass Sand Corporation
Berkeley Springs, West Virginia

Paul E Caplan, P E , C I H
Laurence D. Reed
Alfred A Amendola, P E.
Thomas C Cooper
Division of Physical Sciences and Engineering

REPORT DATE
September 1981

REPORT NO .
ECTB 120-13a

U S Department of Health and Human Services
Centers for Disease Control
National Institute for Occupational Safety and Health
Cincinnati, Ohio

ABSTRACT

At the Pennsylvania Glass Sand Corporation (PGS) Berkeley Springs, West Virginia, silica flour plant, two dust suppression techniques were evaluated. These techniques were: 1) injection of the agglomerating agent, Deter$_{(R)}$, into silica sand, and 2) bulk loading of silica flour under local exhaust ventilation control. Environmental tests indicate that both of these methods are effective in reducing and controlling dust exposures. The use of Deter$_{(R)}$ reduced dust emissions by 67 percent (%) during the bulk loading of railroad cars. During the bulk loading of an enclosed hopper car using local exhaust ventilation, dust levels were of the same magnitude as ambient background levels. This indicated minimal leakage of dust from the railroad car to the general environment.

The combination of good engineering design, good housekeeping and work practices, and an excellent respiratory protection program have generally provided good dust exposure control at this plant. Additional recommendations are presented to improve the effectiveness of these procedures and programs.

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) in cooperation with the Bureau of Mines (BOM) and the National Industrial Sand Association (NISA). The main purpose of this CTA was to evaluate innovative control strategies to reduce dust dispersion during the milling, packing and transfer of silica flour. Three silica flour mills were investigated during this study.

This report presents the findings, observations and recommendations for the July 1980 study at the Pennylvania Glass Sand Corporation (PGS) plant in Berkeley Springs, West Virginia. At this silica sand and flour milling facility, two dust suppressant techniques were evaluated for dust control effectiveness. These were:

1) The use of an agglomerating/foaming agent, Deter$_{(R)}$, which is sprayed into whole grain sand during its transfer through the Old Screen Tower Building.

2) The bulk loading of silica flour into enclosed hopper cars, with fugitive dust emissions controlled by exhaust ventilation.

B. Scope of Study

Evaluations of atmospheric dust concentrations, ventilation control systems, work practices and other dust control procedures were conducted in the following areas:

1) Super-sil$_{(R)}$ Area, New Screen Tower Building (NSTB):

   a) the filling of 100 pound bags with Super-sil$_{(R)}$ silica flour (120 to 325 mesh) on a four spout St. Regis packer.

   b) the palletizing of bags of Super-sil$_{(R)}$ flour prior to loading on trucks.

2) Min-u-sil$_{(R)}$ (10, 15, 30 micron) Area, Pulverizing Building (PB):

   the filling of 50 pound bags with Min-u-sil$_{(R)}$ (10, 15, 30 micron) flour at two single spout, Black Products, packers.

3) Min-u-sil$_{(R)}$ (5 micron) Area, Micron Building (MB):

   the filling of 50 pound bags with Min-u-sil$_{(R)}$ (5 micron) flour at a one-spout St. Regis packer.

4) Bulk loading (rail) Area, Pulverizing Building (PB):

the bulk loading of Super-sil$_{(R)}$ flour into an enclosed railroad hopper car.

II. STUDY PROTOCOL

A. Evaluation Criteria

The principal material investigated in this study was crystalline silicon dioxide (often referred to as crystaline free silica or silica). Silica may be present in at least three crystalline forms, alpha quartz, cristobalite, and tridymite; and in several amorphous (non-crystalline) forms. In this study, only significant amounts of alpha quartz were 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. However, in this report, it 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:

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

For 100% silica dust (respirable) the calculated PEL is approximately equivalent to 0.1 mg/m^3 (or 100 ug/m^3) of air.

B. Process Description

Milling

At this facility, the annual production exceeds one million tons of whole grain sand. Of this production, 250-300 tons of sand are comminuted to silica flour, as either Super-sil$_{(R)}$ or Min-u-sil$_{(R)}$ products. The sand to be comminuted is dry ground in one of six pebble mills, operating 24 hours per day, in the Pulverizing Building, Figure A. Each pebble mill is an Allis-Chalmers unit, with silex block liners, using flint pebbles for the grinding media. The mill discharge is sized through a Sturtevant air separator, into 12 products (8 Super-sil$_{(R)}$ and 4 Min-u-sil$_{(R)}$) and transported to storage silos by screw conveyors.

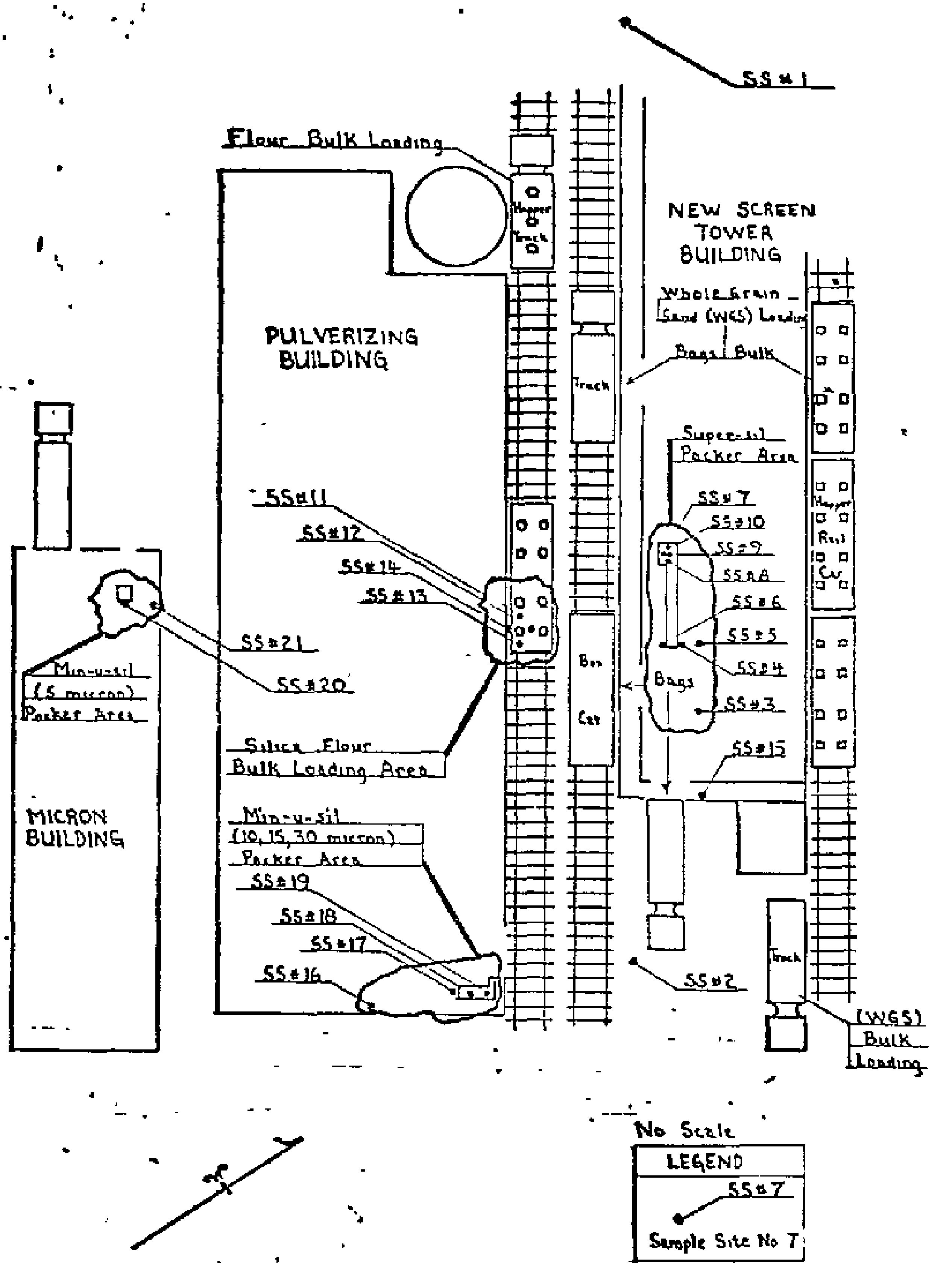


Figure A: Silica Flour - Packing and Loading Areas

Pennsylvania Glass Sand

Packing and Shipping

Silica flour is shipped by bulk (85 to 90%) and by paper bags (10-15%). Super-sil$_{(R)}$ flour is bulk loaded from the Pulverizing Building into closed hopper cars (rail and truck) directly from the storage silos through filler hoses. In the New Screen Tower Building, Super-sil$_{(R)}$ flour is bagged into 50 or 100 pound bags, using a St. Regis four-spout packer. The bags are transported on an enclosed chain conveyor, to the stacking area, Figure B. Three employees stack the bags on pallets, which are moved by forklift into trucks or box cars. Normally, pallets are stacked one load high in the trucks or boxcars. The packing crew consists of five men: one packer, three pallet loaders and one fork truck leader..

In the Pulverizing Building, Min-u-sil$_{(R)}$ (10, 15, 30 micron) is packed into 50 pound bags using two single-spout Black Products packers. One employee fills and hand stacks the bags on a pallet; a second employee transports the pallets by forklift to the storage area in the Micron Building, Figure A.

In the Micron Building, Min-u-sil$_{(R)}$ (5 micron) is packed into 50 pound bags, using a one-spout St. Regis packer. One employee hand stacks the bags on pallets and forklifts them to the storage area in the Micron Building. Subsequently, all Min-u-sil$_{(R)}$ products are loaded by forklift into trucks or box cars.

Normally, silica flour packing is performed during the day shift (8:00am to 4:00pm). The bags consist of Kraft paper, 3 ply (2 - 50 pound plies and 1 - 60 pound ply), with the two inner plies being perforated. The bags contain a pasted valve with a polyethylene film lock sleeve, stepped end.

C. Dust Control Systems

At this silica flour mill, a primary method for the control of dust emissions is collection and containment by local exhaust ventilation. A second control method is the use of good work practices, including housekeeping. Other methods of dust control include: process and equipment modification, preventive maintenance of process equipment, environmental dust suppression by road surfacing and land revegetation, and an effective respiratory protection program.

Ventilation Systems

Exhaust ventilation systems are used to capture point source emissions from the six pebble mills, the three packer stations and the bulk loading stations. The captured dust from these operations is transported by ducts to either Pangborn or American Wheelabrator baghouses. Bags in the baghouses are periodically cleaned by a manually activated shake-out. Inspections and maintenance of the ventilation systems are the responsibility of each building's maintenance crew.

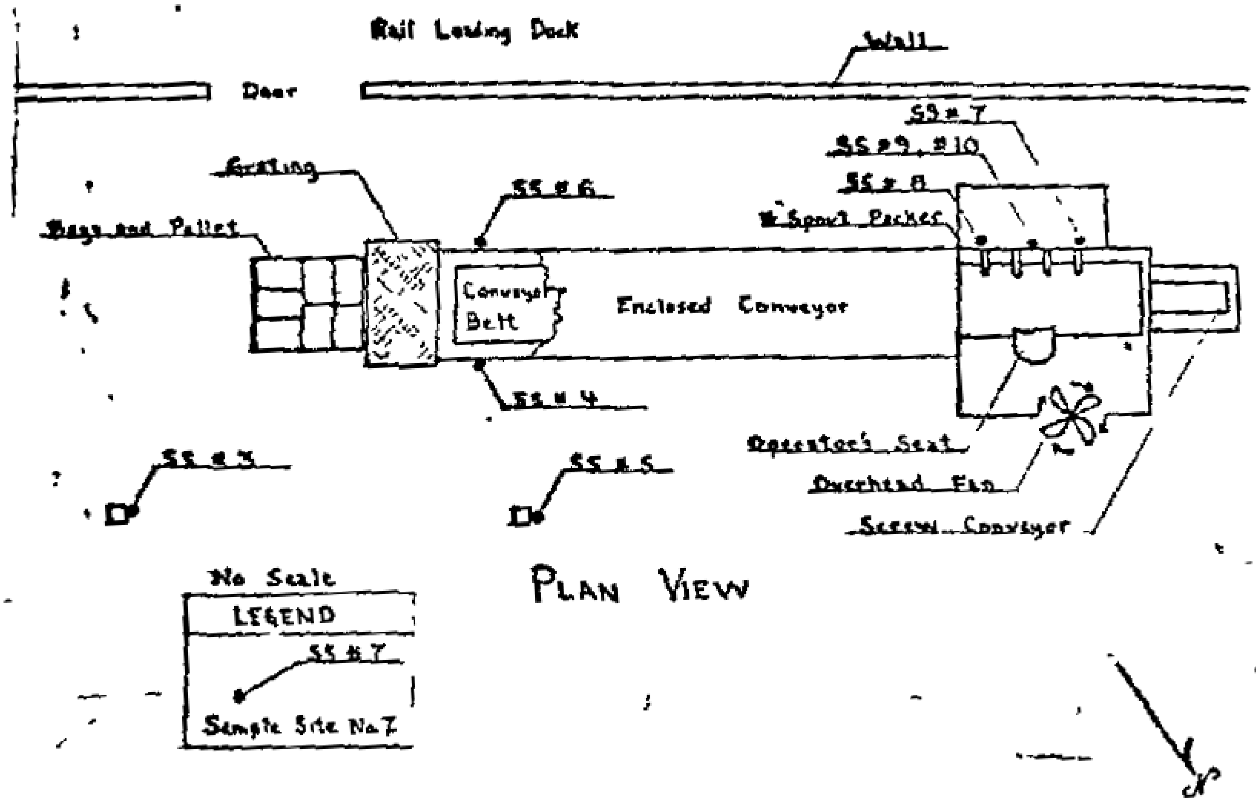
At the Super-sil$_{(R)}$ four-spout packing area, exhaust ventilation hoods are attached to the packer, to the enclosed chain conveyor, and to the floor grating at the conveyor discharge, Figure B. At the packer station, an overhead fan is used as part of a

push-pull method of directing airflow from the packer operator's breathing zone (BZ) toward the exhaust hood. The purpose of the ventilation on the enclosed chain conveyor is to capture, contain and remove the loose dust from the surface and valve of the filled bags. Product spills from bags broken during stacking are dry swept into the floor grating. The remaining product from broken bags is emptied into the floor grating. The empty bags are then stacked for later disposal.

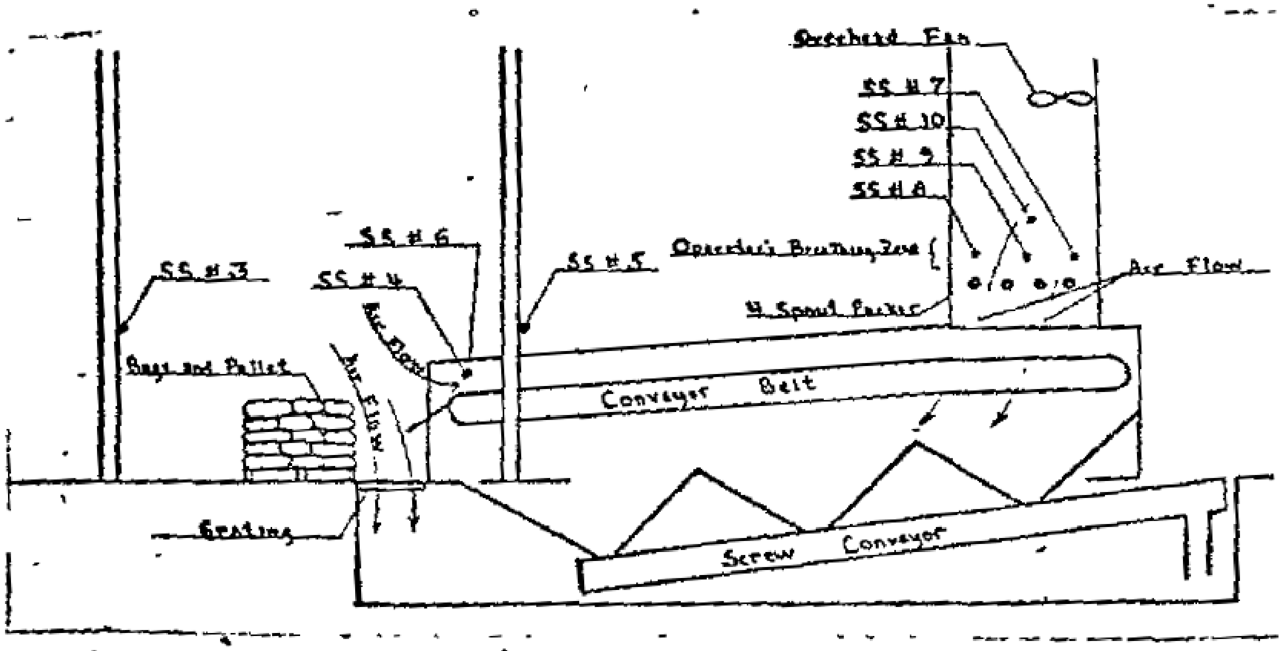
At the Min-u-sil$_{(R)}$ (10, 15, 30 micron) packer, exhaust capture hoods are located at each spout, Figure C. At the No. 1 spout, the hood is located along the side of and 11 inches away from the fill spout. A second hood is located directly behind the No. 2 spout. At the time of this study, a plastic transparent curtain (consisting of 12-inch wide overlapping strips) was being installed around two sides of the packer area. This curtain isolates the packer area from the rest of the Pulverizing Building.

At the Min-u-sil$_{(R)}$ (5 micron) packer, an exhaust hood is located behind the fill spout and connected to a 4-inch duct, Figure D. Product is fed through the spout by an auger feed system rather than by a pneumatic feed system which is used at the other flour bagging stations.

An exhaust ventilation system is also used to control dust emissions during the bulk loading of silica flour into closed hopper trucks and railroad cars. During truck loading operations, all hatches on the hopper are closed except for the filling hatch. Two hoses, approximately 12 inches in diameter, are placed into the filling hatch. One is a product filler hose; the other is an exhaust ventilation hose, Figure E. The filler hose extends two feet into the open hopper, while the ventilation hose extends two inches into the hopper. The purpose of the exhaust ventilation is to capture and remove the displaced air and dust during filling. This prevents dust from escaping to the outside atmosphere.



PLAN VIEW

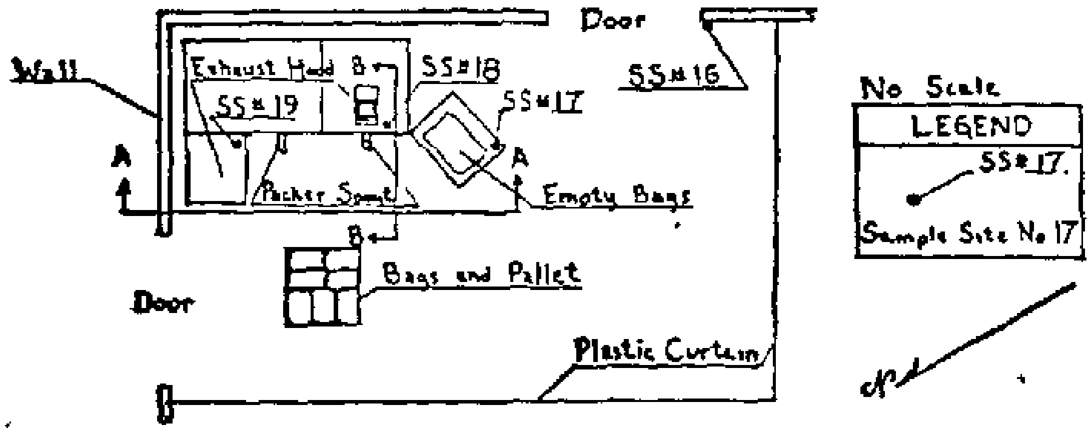


CROSS - SECTION

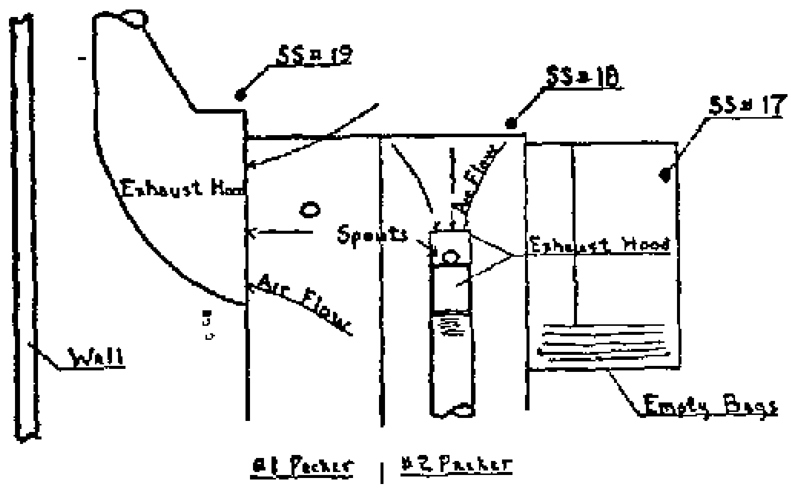
Figure B: SUPER-SIL(R) PACKING AREA

NEW SCREEN TOWER BUILDING

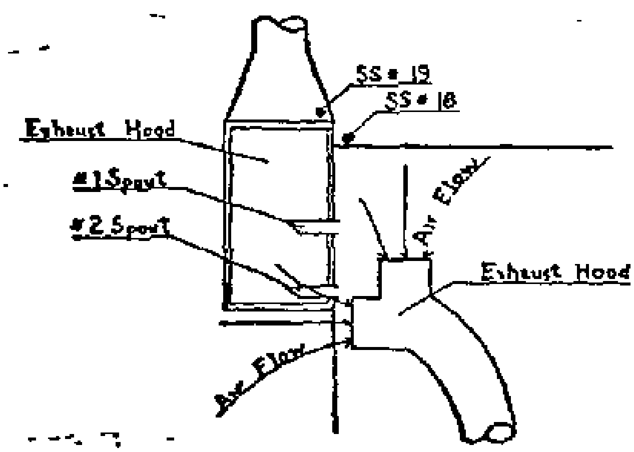
Pennsylvania Glass Sand



PLAN VIEW



CROSS SECTION A-A



CROSS SECTION B-B

Figure C: MIN-U-SIL(R) (10, 15, 30 MICRON) PACKING AREA
PULVERIZING BUILDING
Pennsylvania Glass Sand

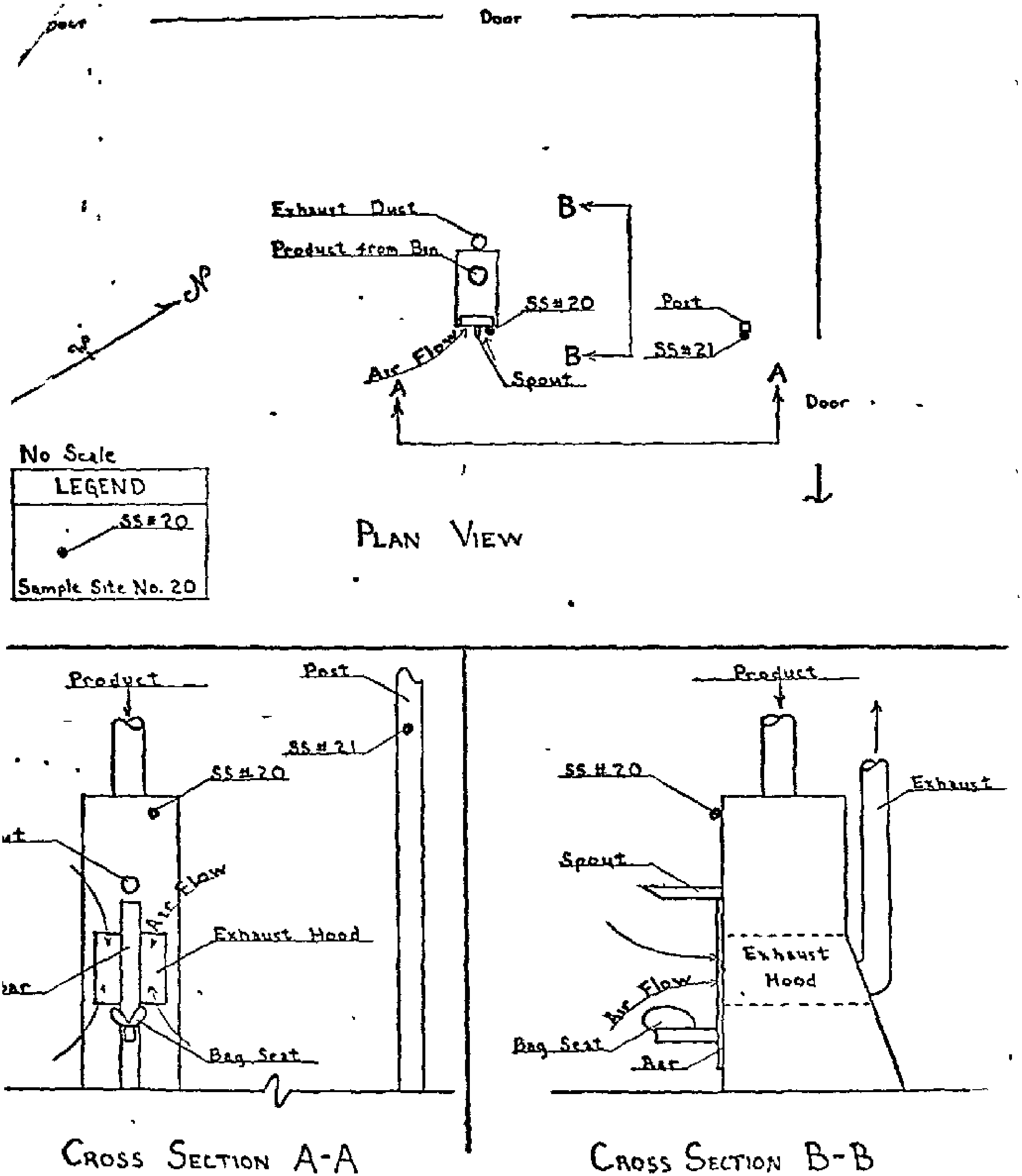
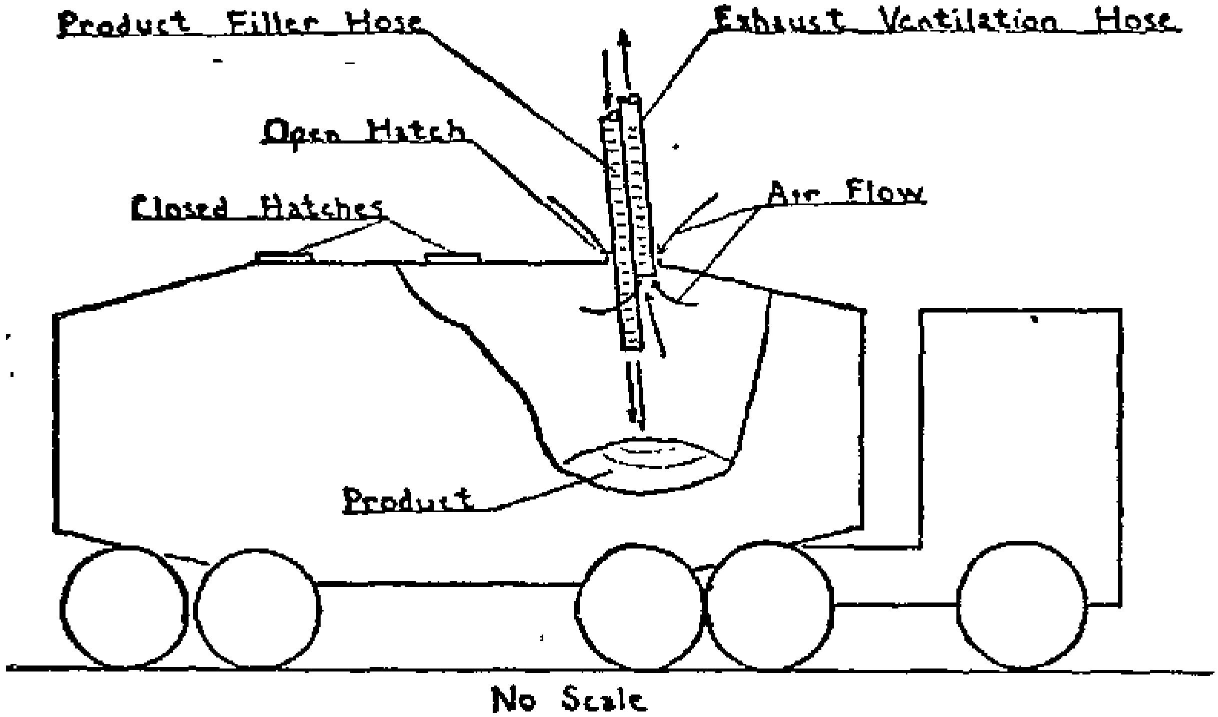
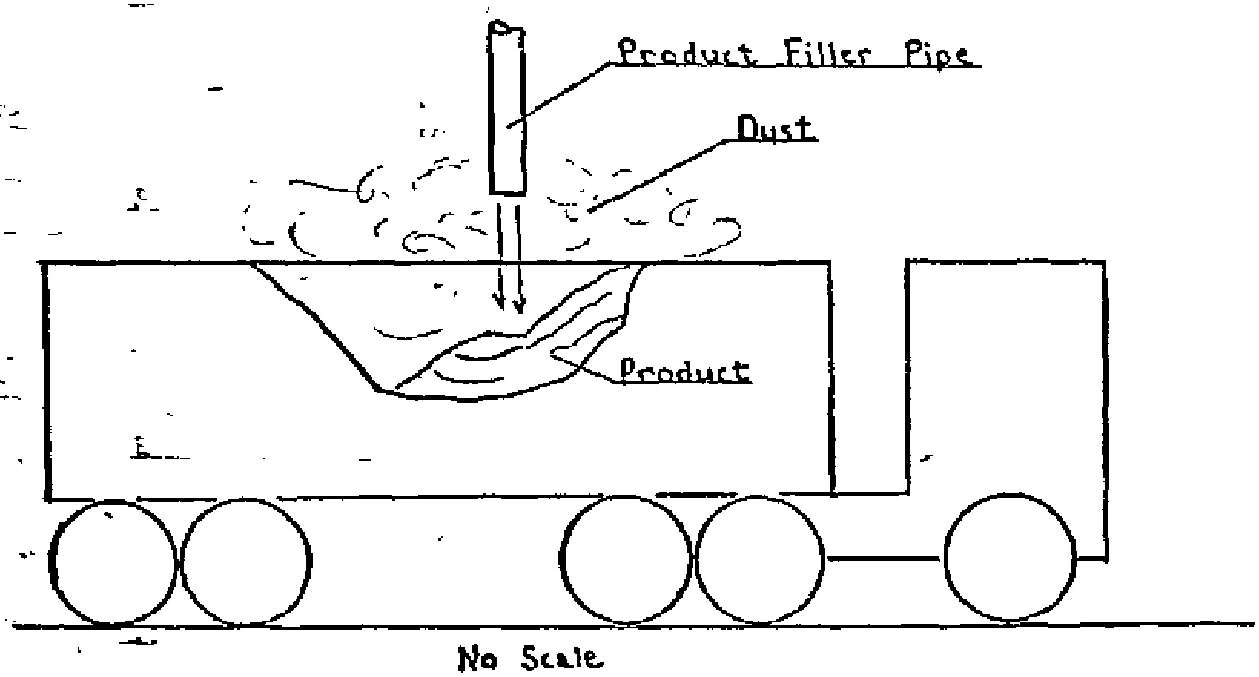


Figure D: Min-u-sil(R) (5 micron) Packing Area
Micron Building
Pennsylvania Glass Sand



CLOSED HOPPER TRUCK (FLOUR) LOADING



OPEN TRUCK (WHOLE GRAIN SAND) LOADING

Figure E: BULK TRUCK LOADING

Pennsylvania Glass Sand

Exhaust ventilation is also used for dust control during the bulk loading of silica flour into closed railroad hopper cars, Figure F. Each railroad hopper car consists of two compart- ments; each compartment has four 30-inch diameter hatches. Two 10-inch diameter filler hoses, connected to a main feedline by a deflector valve, are placed into the two open hatches. Only one filler hose is used at a time for hopper filling. A metal exhaust hood, connected to a flexible exhaust duct, is placed on the third open hatch. The fourth hatch remains closed. The exhaust ventilation, in this system, maintains a negative pressure within the hopper car, creating an inward flow of air. Thus, the airborne dust is captured before escaping to the outside atmosphere. The effectiveness of these ventilation control systems, work practices, process modifications, and respiratory protection programs is discussed in Section V.

D. Study Design and Evaluation Procedures

At the time of this study, the dust agglomerating agent, $Deter_{(R)}$, was being used for dust suppression in the sand system only. Therefore, environmental data, obtained by PGS, were reviewed to evaluate the effectiveness of $Deter_{(R)}$ in reducing dust emission. PGS also plans to test the effectiveness of $Deter_{(R)}$ for flour dust suppression.

Atmospheric dust evaluations were made by NIOSH to measure the effectiveness of the dust control procedures at three flour packing palletizing, box car loading and bulk loading operations. Gravimetric dust samples were collected during two days of operation under normal operating conditions. The effect of outdoor dust contamination on in-plant exposure levels was estimated by collecting air samples upwind and downwind of the New Screen Tower Building.

Respirable dust samples were collected by two types of sampling systems:

1) The MSA Gravimetric Dust Sampler. Integrated air samples (several hours in duration) were collected and analyzed both qualitatively for silica, and quantitatively for total dust and silica dust (by weight).

2) The TSI Respirable Aerosol Mass Monitor, Model 3500. This instrument directly measures particulate concentrations. However, its usefulness was limited, since its detector does not differentiate between silica particles and other mineral dusts.

Discussions of the operating characteristics and specifications of these instruments and the procedures for total dust and silica dust analysis are presented in Appendix I.

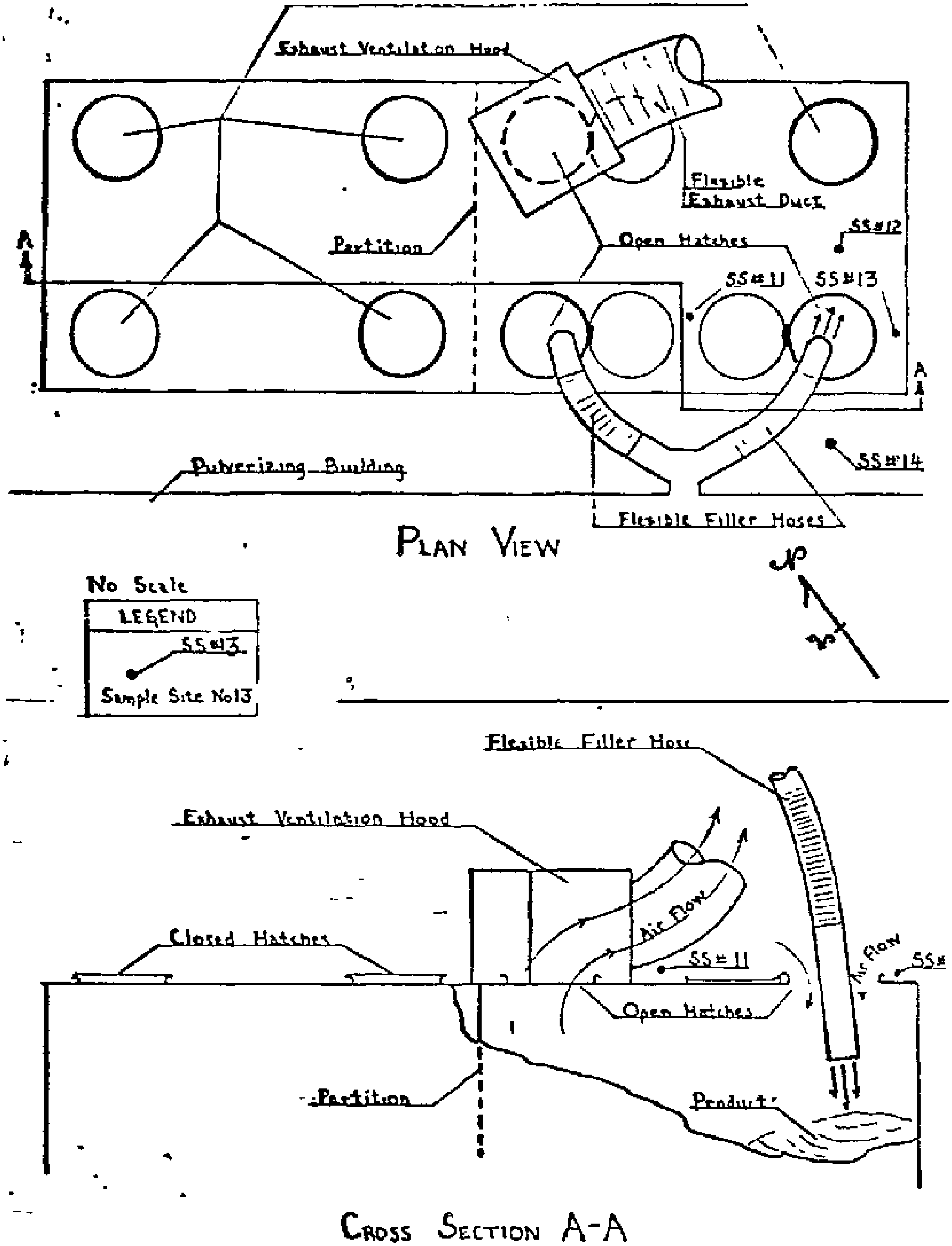


Figure F: Bulk Rail Hopper Car Loading

Pennsylvania Glass Sand

Ventilation measurements and air flow patterns at the work areas under investigation were evaluated with a Kurz Air Velocity Meter, Model 441 and Gastec Smoke Tester Tubes.

III. STUDY RESULTS

A. Atmsopheric Dust Concentrations

Table 1. and Figures G and H show the results of atmospheric evaluations for total dust and silica dust, collected by the MSA Gravimetric Dust Sampler. Two days of packing, palletizing, and loading Super-sil$_{(R)}$ (120-325 mesh) and Min-u-sil$_{(R)}$ (10, 15, 30 micron and 5 micron) flour were observed. Figure A shows the location of the 21 sampling sites in and around the New Screen Tower Building, the Pulverizing Building and the Micron Building. This includes two outdoor sites, upwind and downwind from the processing buildings.

Concentrations of silica dust were approximately 65 micrograms per cubic meter of air (ug/m^3) at the Super-sil$_{(R)}$ packer; 600 ug/m^3 at the Min-u-sil$_{(R)}$ (10, 15, 30 micron) packer; 200 ug/m^3 at the Min-u-sil$_{(R)}$ (5 micron) packer; and less than 80 ug/m^3 at the bulk loading of a railroad hopper car. Outdoor silica dust concentrations (upwind and downwind) were fairly constant, at approximately 35 ug/m^3.

The percentage of silica in the dust samples, also shown in Table 1 and Figures G and H ranged from approximately 25% to 90%. Outside dust sources normally contain less than ($<$) 40% silica, as shown in the analyses of the up-wind air samples. (Table 1.V.I), whereas, the silica flour products are essentially 100% silica. Therefore, the silica content of a dust may serve as an indication of its sources.

Table 2. presents the PGS data, describing the effect of adding the agglomerating agent, Deter$_{(R)}$ to whole grain silica sand in its transfer through the New Screen Tower Building. These tests indicated that the addition of Deter$_{(R)}$ reduced total respirable dust concentrations by as much as 67%. Apparently, Deter$_{(R)}$ agglomerated small respirable dust particles into larger, heavier and non-respirable sized particles. Deter$_{(R)}$ appeared to be particularly effective during the bulk loading of whole grain sand into railroad hopper cars.

Table 3. and Figures B through F, I and J present and describe the ventilation control systems associated with the packing, palletizing and hopper railcar loading of silica flour. The most effective controls were observed at the Super-sil$_{(R)}$ packer and the hopper railcar bulk loading stations, where dust concentrations were maintained below the 100 ug/m^3 PEL. Less effective were the dust

Table 1. Atmospheric Concentrations of Respirable Dust.

Location/Operation	Sample No.	RUN #1 Total Dust ug/m	RUN #1 Silica Dust ug/m	RUN #1 Silica Content (%)	RUN #2 Total Dust ug/m	RUN #2 Silica Dust ug/m	RUN #2 Silica Content (%)	AVERAGE Total Dust ug/m	AVERAGE Silica Dust ug/m	AVERAGE Silica Content (%)
I. Super-sil Flour Packing and Palletizing (NSTB)[b]										
A. Packer machine										
1. West side of packer	(7)	a	a	--	104	52	50	104	52	50
2. East side of packer	(8)	186	80	43	139	70	50	163	75	46
3. Center of machine	(9)	163	63	39	122	70	57	143	67	47
4. BZa of packer opr.	(10)	197	65	33	139	52	37	168	59	35
Average		182	69	38	126	61	48	145	63	43
B. Palletizing area										
1. NE of conveyor	(3)	203	63	31	184	84	46	194	74	38
2. No side of conveyor	(4)	384	256	67	366	244	67	375	250	67
3. NW of conveyor	(5)	153	59	39	244	105	43	199	82	41
4. So side of conveyor	(6)	61	68	26	243	139	57	252	104	41
Average		250	112	45	259	143	55	255	128	50
II. Min-u-sil(R) (10-15-30-micron) Flour packing (PB)[c]										
C. Packer machine										
1. So side of packer	(18)	--	--	--	505	451	89	505	451	89
2. No. side of packer	(19)	--	--	--	866	704	81	866	704	81
Average		--	--	--	686	578	84	686	578	84
D. Packer area background										
1. East entrance door	(16)	--	--	--	162	41	25	162	41	25
2. So. of bag rack	(17)	--	--	--	18	18	( )	18	18	( )
Average		--	--	--	90	30	( )	90	30	( )
III. Min-u-sil(R) (5 micron) Packing (MB)[d]										
E. Packer machine										
1. At pallet loading	(20)	--	--	--	344	199	58	344	199	58
F. Packer area background										
1. At No. door-upwind	(21)	--	--	--	18	18	( )	18	18	( )
IV. Railroad Hopper Car Bulk Loading Flour										
G. Top of car										
1. West of loading port	(11)	34	34	(100)	--	--	--	34	34	(100)
2. No. of loading port	(12)	206	172	83	--	--	--	206	172	83
3. East of loading port	(13)	a	a	a	--	--	--	a	a	a
4. So. of loading port	(14)	34	34	(100)	--	--	--	34	34	(100)
Average		91	80	88	--	--	--	91	80	88
V. Background Samples (NSTB)										
H. East loading dock	(15)	--	--	--	262	122	47	262	122	47
I. West (upwind)	(1)	119	34	29	16	16	(100)	67	25	37
J East (downwind)	(2)	76	35	46	83	38	46	80	37	46
Average (upwind/downwind)		98	35	36	50	27	54	74	31	42

Notes:

[a] Dust sample invalid, contaminated

[b] NSTB - New Screen Tower Building

[c] PB - Pulverizing Building

[d] MB - Micron Building

[d] MB - Micron Building

[e] Bz - Breathing zone

[f] - Less than

[g] ( ) - Value imprecise

Pennsylvania Glass Sand Corp.

Table 2. Effect of Addition of $Deter_{(R)}$ to Sand Product (PGS data of 7/10/80)

Location	Total Dust Concentration Without Deter (mg/m)	With Deter (mg/m)	Reduction (%)
New Screen Town Building 5th floor - inside conveyor 4 ft. from $Deter_{(R)}$ nozzle	218	275	20
New Screen Tower Building inside conveyor transfer point to storage side	164	111	33
Bulk loading covered hopper railroad car, inside hopper	884	27	67

Pennsylvania Glass Sand Corp.

Table 3. Effectiveness of Ventilation Control System1.

Location/Operation	Description of Ventilation system	Air Velocity FPM	Dust Concentration: Total Dust (ug/m)	Dust Concentration: Silica Dust (ug/m)	Silica Content (%)	Remarks
I. New Screen Tower Building A. 4-Spout packer - Super-sil(R) product	53" x 33" lateral hood behind packer spouts, plus area fan above worker	At hood face top: 134; middle: 116; bottom: 28	145	63	43	Good control, air movement away and down from OBZ. Most dust emanates from general environment.
B. Transfer from chain conveyor to pallet loading station. 1. Conveyor enclosure	38" x 15" opening at belt discharge	325 (avg.)	255	128	50	Good air movement, but handling of bags causes contamination. Ventilation not completely effective.
2. Floor grill at pallet loading station	90" x 43" downdraft	127 (avg.)				
II. C. Pulverizing Building 2-Spout packer Min-U-sil(R) (10, 15, 30 micron) product	22" x 14" side hood adjacent to #1 packer spout	Hood face: top: 180; middle: 100; bottom: 40	686	578	84	Uneven airflow; good control for #1 packer; poor for #2 packer; crossdrafts permit dust dispersion;
	7" x 4-3/8" side slot	At slot: 4800				
	behind # packer spout	At spout: 900	At spout: 900			most dust emanates from packer spouts and bag handling
III.E. Micron Building 1-spout packer Min-U-sil(R) (5 micron) product	18-3/8" x 11-1/2" hood, behind and below spout	At hood face: top: 200; middle: 470; bottom: 105	344	119	58	Good velocity; open sides and remoteness of hood from spout reduces efficiency; spills on floor and air cross drafts reduce efficiency
IV. F. Railroad hopper car loading hatch	30" diameter loading hatch, 30" diameter duct attached to loading hatch, 10" diameter filling hose.	Open hatch: 230 (avg.)	91	80	88	Good dust control; all visible dust drawn into hopper car.

Pennsylvania Glass Sand Corp.

DUST CONCENTRATIONS
PENNSYLVANIA GLASS SAND

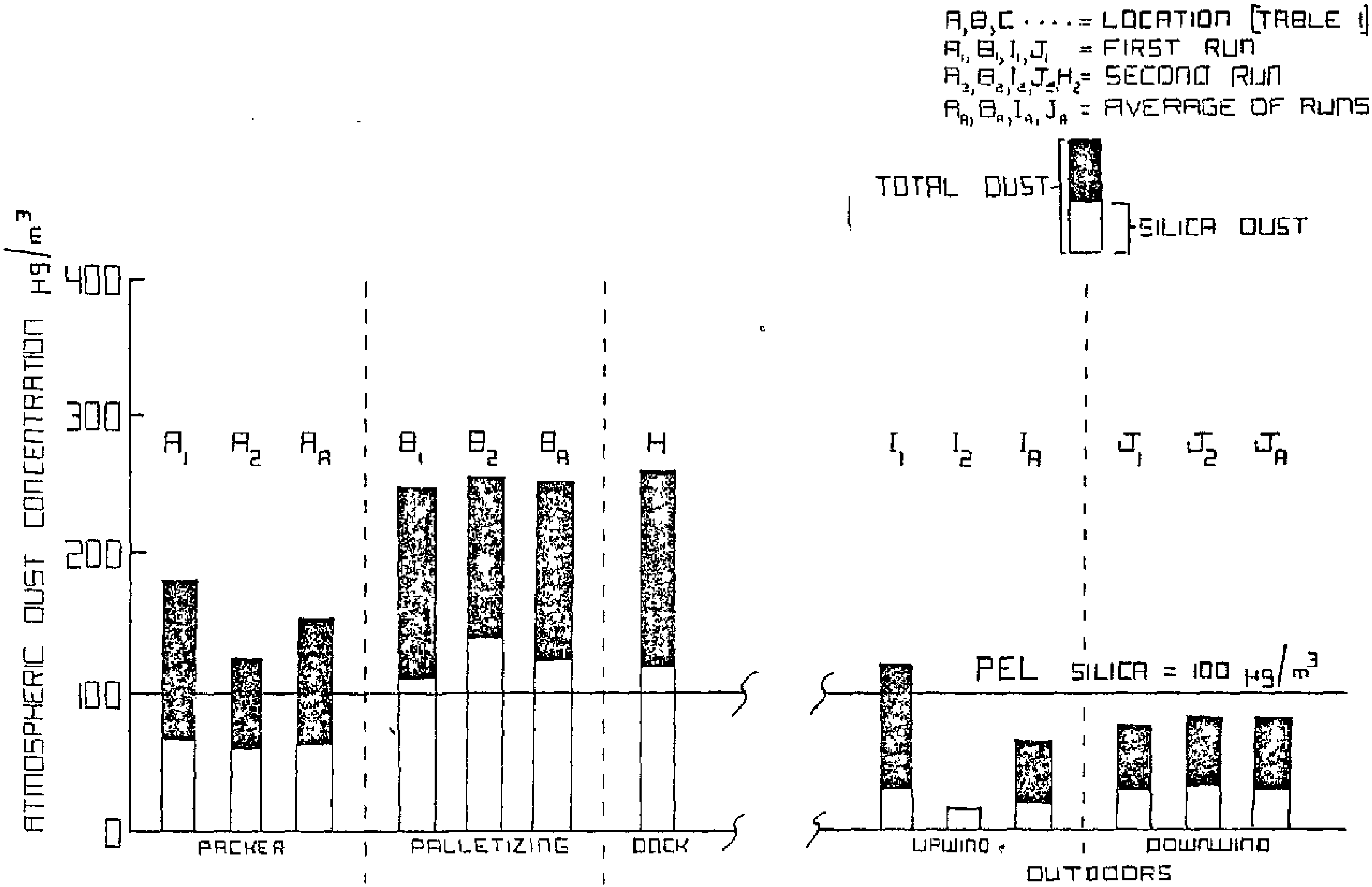


Figure 6: New Screen Tower Building - Super-Sil and Fast Loading Dock

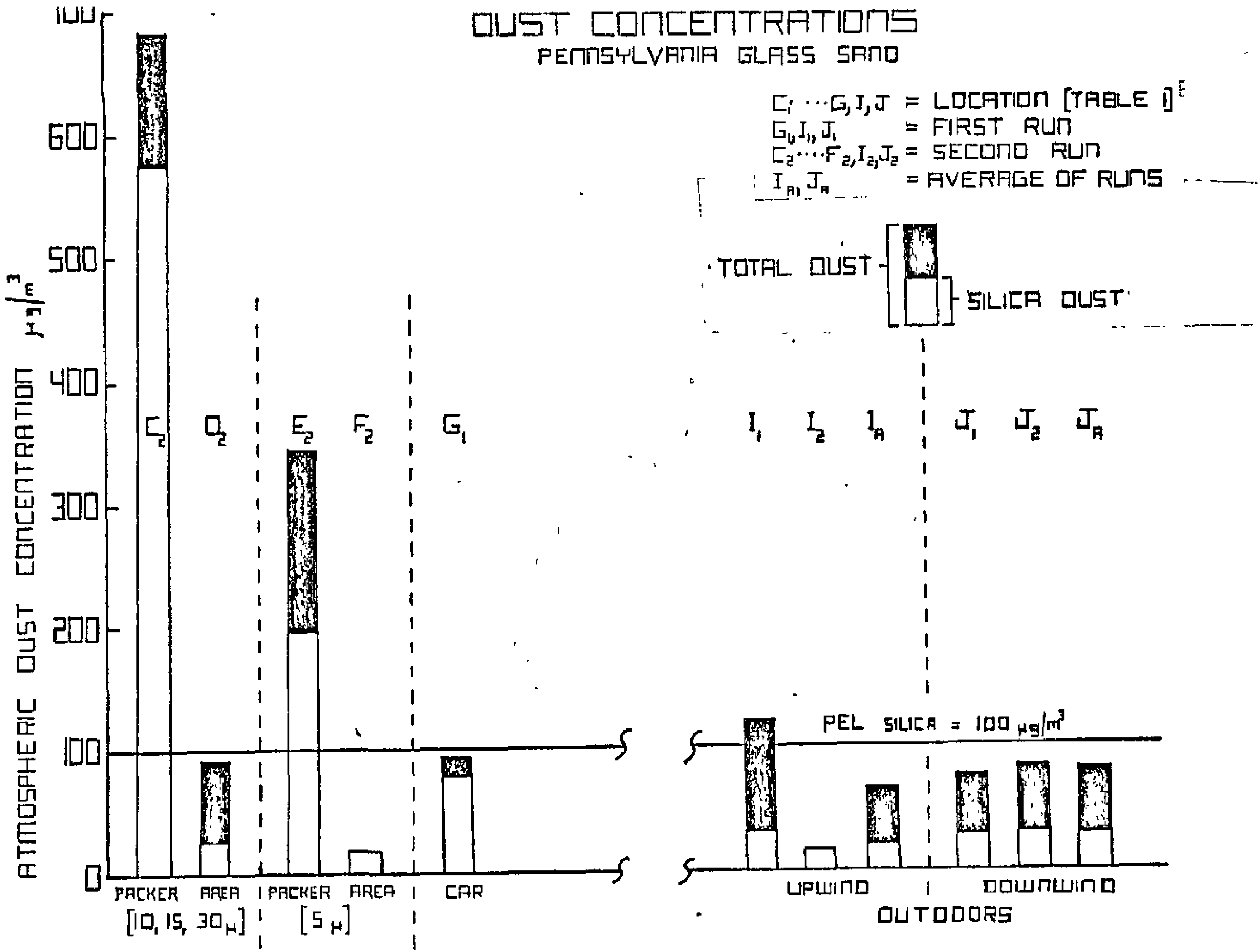
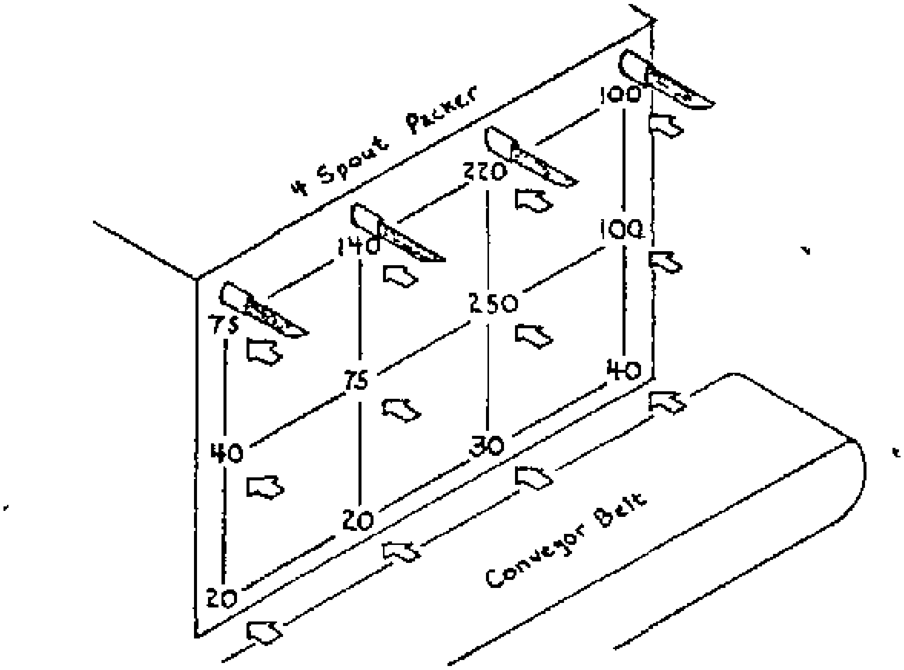


Figure H: Pulverizing and Micron Buildings - Min-u-sil & RR Hopper Car Areas



At Face of Packer

At Face of Conveyor Discharge and Floor Grate

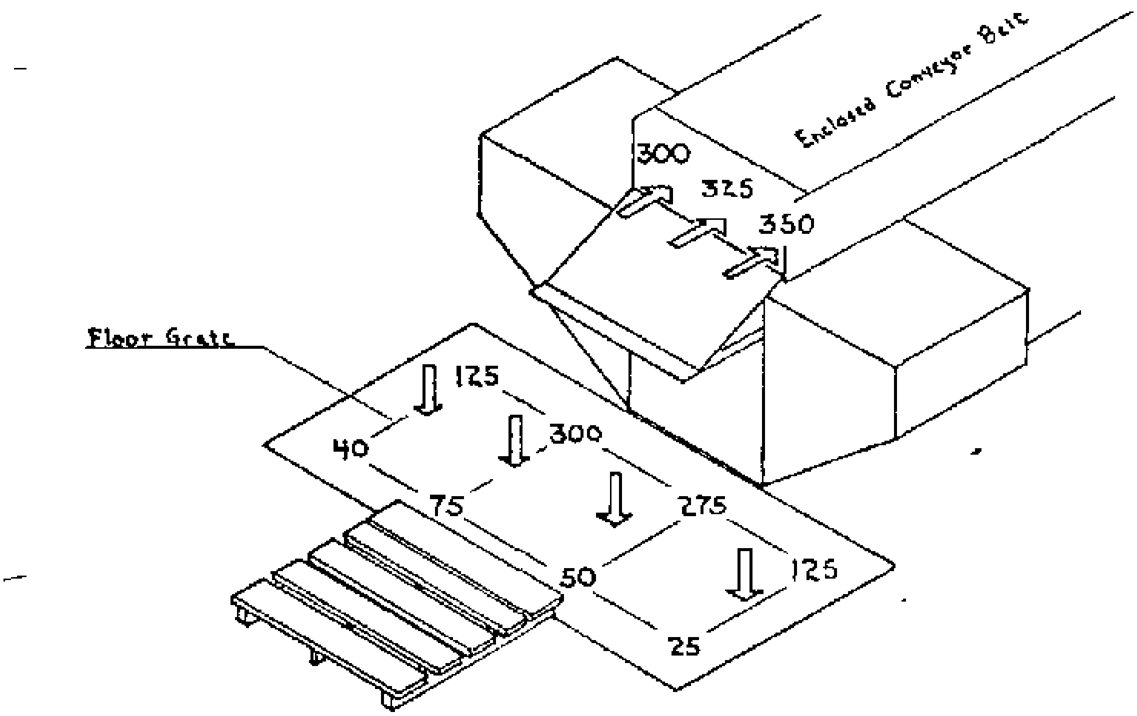


Figure I: Ventilation at Super-Sil(R) Packer Area

(Air Velocity in Feet per Minute, f/m)

Pennsylvania Glass Sand

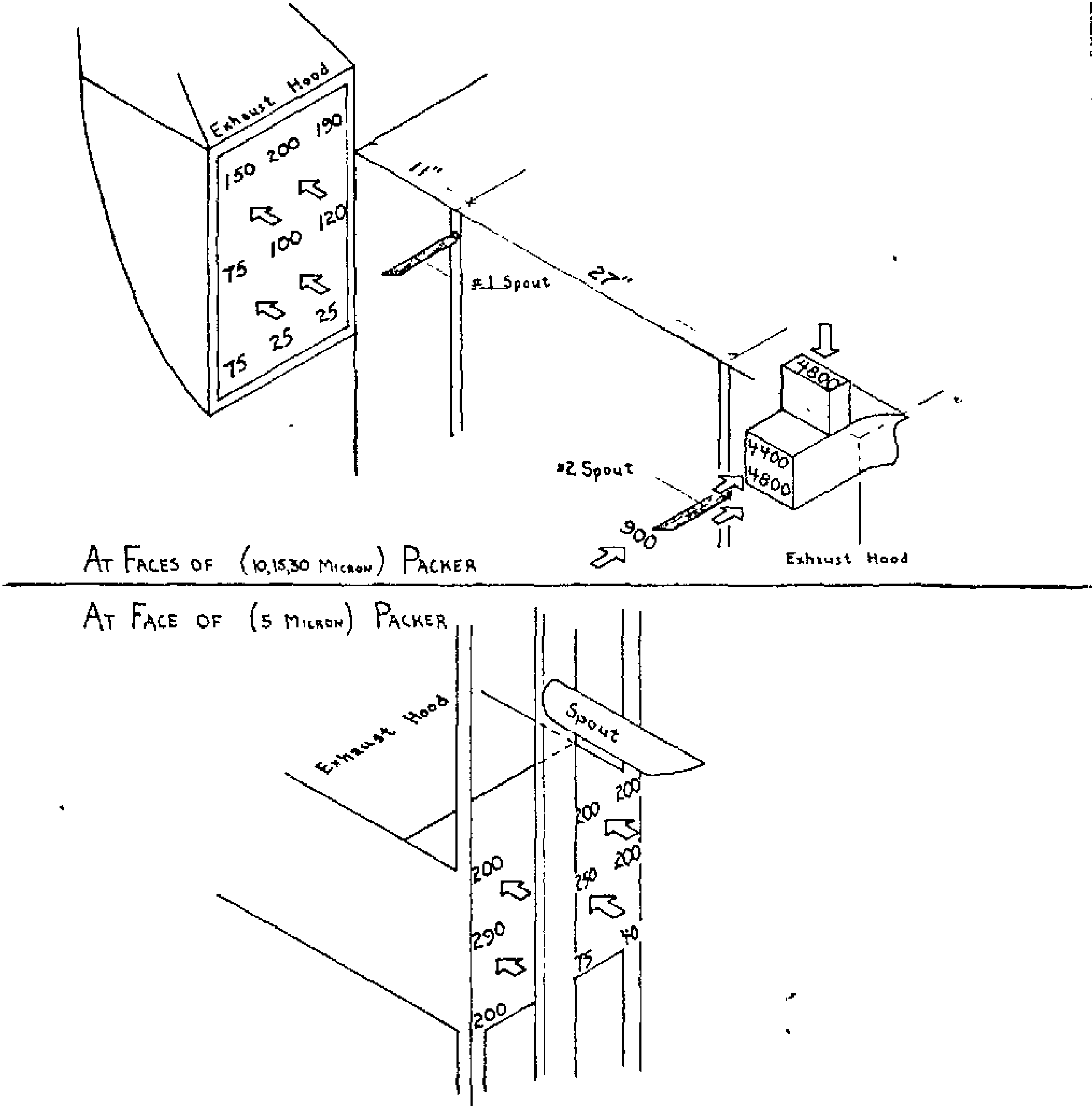


Figure J: Ventilation at Min-u-sil(R) Packer Areas

(Air Velocity in Feet per Minute, f/m)

Pennsylvania Glass Sand

control systems at the Min-u-sil$_{(R)}$ packers, where cross drafts and uneven air velocities into the hoods permitted dust dispersion during bag loading and palletizing. In these areas, silica levels ranged from about 200 to 600 ug/m^3.

Table 4. presents a comparison between dust concentration measurements made simultaneously with the TSI Respirable Mass Monitor and the MSA Gravimetric Dust Sampler. The TSI instrument provides direct, short term (up to 2 minutes) direct concentration measurements. The MSA instrument measures time-weighted average dust concentrations, usually, for periods of 4- to 8-hour duration. The ratio of measurements between these two instruments is variable, depending upon the operations in progress during the sampling period.

IV. DISCUSSION OF RESULTS

The following discussions are based on environmental data obtained from two experimental runs at several sampling locations, plus data provided by PGS on the use of Deter$_{(R)}$, see Appendix II. The environmental data include atmospheric dust measurements, meteorological observations and ventilation evaluations.

A. Area Results

1. New Screen Tower Building

Table 1. and Figure B indicate that total dust concentrations in the Super-sil$_{(R)}$ packer area were approximately 150 ug/m^3 under normal operating conditions. The average silica dust concentra- tion in this area was approximately 65 ug/m^3. The silica content of the dust samples in this packer area was 43%, indicating that a significant portion of the dust originated from outside sources. Table 3. and Figures B and G show effective control ventilation in the Super-sil$_{(R)}$ packer area. The overhead fan, located behind the operator, moves the air past his breathing zone and into the capture hood.

Table 3. and Figures B and G also indicate that dust concentrations in the Super-sil$_{(R)}$ palletizing area were approximately 250 ug/m^3 of total dust and 130 ug/m^3 of silica dust. The higher dust concentrations in this area may be due to bag leakage and breakage during pallet loading. The average silica content of the dust samples in this area was less than 50%. The silica content of these samples was also highly variable (ranging from 26% to 67%), indicating a significant contribution from outside sources.

Table 4. Comparison of Dust Concentrations Obtained by TSI Respirable Aerosol Mass Monitor and MSA Gravimetric Dust Sampler.

Location	Date	Location/Operation	TSI data Max. (ug/m3)	TSI data Min. (ug/m3)	TSI data Avg. (ug/m3)	MSA data[d] TWA (ug/m3)	Ratio of Readings TSI/MSA	Remarks
(1)	7/15/80	Outside, west, upwind, NSTB[a]	100	70	85	119	0.7	
(2)	7/15/80	Outside, east, downwind, NSTB[a]	110	60	65	76	1.1	
(4)	7/15/80	No. side conveyor, NSTB[a]	340	230	285	384	0.7	
(10)	7/15/80	Breathing zone, packer operator, NSTB[a]	270	230	250	197	1.3	
(1)	7/16/80	Outside, west, upwind, NSTB[a]	360	110	223	16	14.0	TSI readings during truck loading of sand.
(15)	7/16/80	Outside, east side truck loading dock, NSTB[a]	630	370	530	262	2.0	TSI readings during truck loading of sand.
(3 thru 10)	7/16/80	Inside, packing/palletizing area, NSTB[a]	220	200	210	193	1.1	
(18&19)	7/16/80	Inside, packing area, PB[b]	1190	970	1125	686	1.6	TSI readings during packing of flour.
(18&19)	7/16/80	Inside, packing area, PB[b]	240	230	235	--	--	TSI readings during no packing of flour.
--	7/16/80	Outside, between PB & MB[b]	140	110	125	--	--	
(20)	7/16/80	Inside, near packer, MB[c]	230	180	207	344	0.6	TSI reading during packing of flour.
(20)	7/16/80	Inside, near packer, MB[c]	120	80	100	344	0.3	TSI readings during no packing of flour.
			Median		217	262	1.1	

Notes:
a NSTB - New Screen Tower Building
b PB - Pulverizing Building
c MB - Micron Building
d TWA - Time-weighted average concentration

Pennsylvania Glass Sand Corp.

2. Pulverizing Building

Table 3. and Figures C and H show that at the Min-u-sil$_{(R)}$ (10, 15, 30 micron) packer, total dust and silica dust concentrations were approximately 700 ug/m^3 and 600 ug/m^3, respectively. These high concentrations were probably due to bag breakage, ineffective ventilation at the packer spouts, and poor housekeeping. Flour spillage observed throughout the packer area was often not immediately removed. Open doors also reduced the effectiveness of the ventilation control system. Cross-currents of air from the two adjacent open doorways tended to increase the dispersion of settled dust. The recently installed plastic curtains in this area should help reduce dust contamination from other areas of the building.

3. Micron Building

Table 3. and Figures D and H indicate that in the Min-u-sil$_{(R)}$ (5 micron) packer area total dust and silica dust concentrations were approximately 350 ug/m^3, and 200 ug/m^3, respectively. The high dust concentrations were due, in part, to inadequate ventilation design. Table 3. shows adequate face velocities. However, the open-sided hood design and the remoteness of the hood from the packer spout reduced dust collection efficiency. In addition, flour spillage, not promptly removed, resulted in increased dust concentrations.

4. Railroad Hopper Car

Table 3. and Figure F indicate that on the loading hatch of the railroad hopper car, dust concentrations were approximately 90 ug/m^3 total dust and 80 ug/m^3 silica dust. Effective dust control was achieved by general atmospheric dilution and the exhaust ventilation control system used during loading operations. This exhaust system consists of a 30-inch flexible duct which is located over one open port. Two filler hoses are located - one in each open port. The exhaust system continuously removes air from within the hopper car, thereby confining dust during loading operations. The dust concentrations around the loading spout (90 ug/m^3 total dust) were of the same order of magnitude as the ambient air concentration (70 ug/m^3 total dust).

B. Deter$_{(R)}$ Results

Table 2 shows that around the New Screen Tower Building the addition of Deter$_{(R)}$ to whole grain silica sand resulted in reductions of total respirable dust concentrations ranging from 20% to 67%. These agents agglomerate respirable size dust particles into larger, heavier, and non-respirable particles, thereby reducing respirable dust concentrations.

C. Comparison of Sampling Instruments

Table 4. indicates that there is not close correspondence between the average dust concentration measurements of the TSI Respirable Aerosol Mass Monitor and the MSA Gravimetric Dust Sampler. For example, Table 4. presents the ratios of TSI to MSA dust concentration results at 10 locations. Although the median ratio of the 10 comparisons is 1.1, the ratios range from 0.3 to 14. These highly variable ratios are due primarily to highly fluctuating dust levels created by operational variables. These variables include truck movements, meteorological conditions and production rates. Since the TSI instrument measures short-term (maximum and minimum) dust concentrations, it is useful for locating dust emission sources and for making rough comparative measurements. For this reason, the TSI instrument is not suitable for estimating 8-hour, time-weighted average dust exposures. On the other hand, the MSA Gravimetric Dust Sampler is appropriate for measuring 8-hour time-weighted average dust exposures.

V. Observations, Conclusions and Recommendations

A. Control of dust in all areas requires a combination of good engineering controls, such as the use of dust suppressant additives, exhaust ventilation, and controlled bulk loading of products; 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 proportionally.

B. The effectiveness of two innovative methods of dust control was evaluated.

1. Injection of the agglomerating agent, $Deter_{(R)}$, into whole grain sand products, reduced dust emissions by 20 to 67%. According to the PGS environmental data, $Deter_{(R)}$ was particularly effective in reducing dust concentrations during the bulk loading of railroad cars. For example, the dust concentration inside the loading hopper was reduced by 67%, from 84 mg/m^3 to 27 mg/m^3.

2. Bulk loading of silica flour into railroad cars, under local exhaust ventilation control, was also effective in suppressing dust dispersion to the general environment. Dust levels around the hatch of a railroad hopper car, during loading, averaged approximately 90 ug/m^3 total dust and 80 ug/m^3 silica dust. These levels were of the same order of magnitude as background around the New Screen Tower Building, 98 ug/m^3 total dust and 34 ug/m^3 silica dust. By observation leakage from

the hopper car appeared to be minimal. Figure K which depicts an open truck, closed truck and a closed hopper railroad car during loading, clearly show the effectiveness of this technique. The company feels that the best solution for dust control is to eliminate bagging completely and ship all products in bulk.

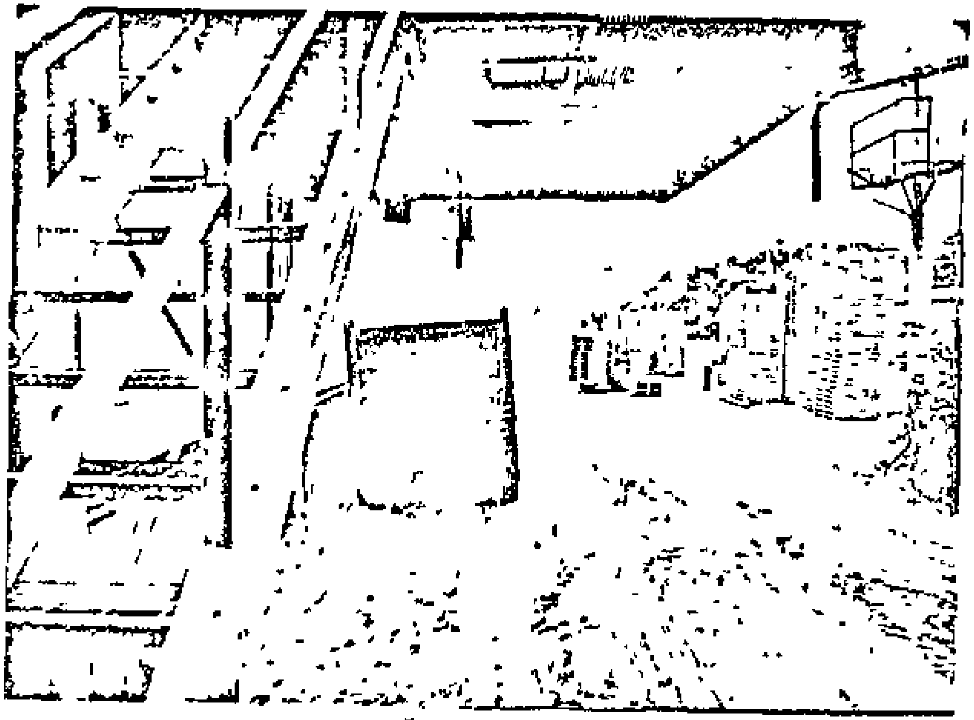
C. The local exhaust ventilation systems at the three silica flour packing stations showed varying degrees of effectiveness. Their effectiveness depends upon design, total air movement control, and housekeeping practices.

1. At the Super-sil$_{(R)}$, 4-spout packer, the local exhaust ventilation system, in combination with an air supply "curtain" above the operator, maintained average dust concentrations of 150 ug/m^3 total dust and 65 ug/m^3 silica dust. Since these levels were of the same order of magnitude as ambient dust levels, 74 ug/m^3 total dust and 30 ug/m^3 silica dust, it appears that most of the dust emanated from the general environment rather than directly from the bag loading operation. Additionally, the immediate and automatic removal of spilled product by means of a ventilated conveyor belt, also increased the effectiveness of the dust control system.

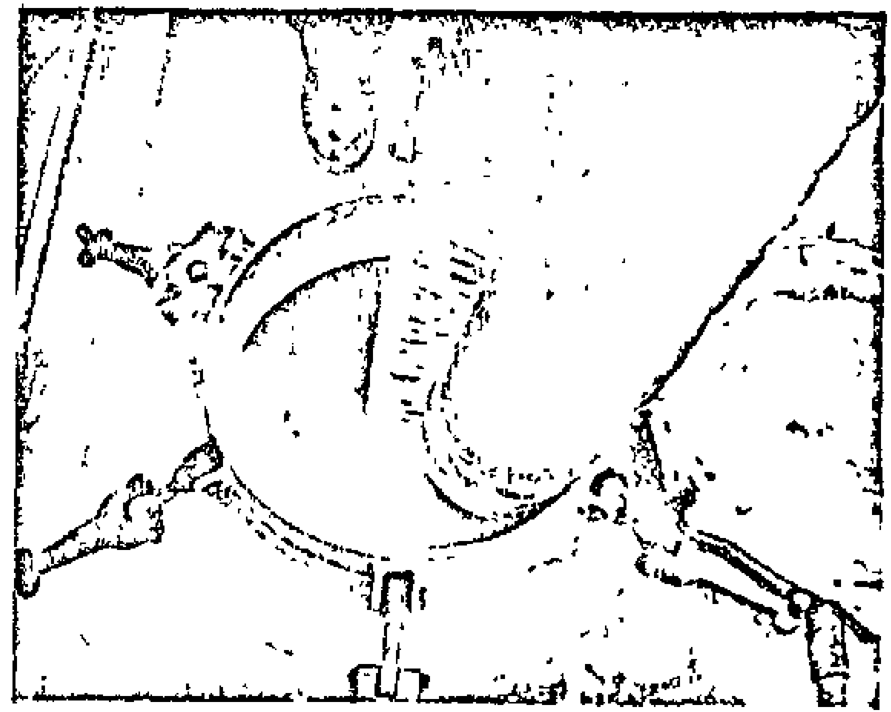
2. At the Min-u-sil$_{(R)}$ (10, 15, 30 micron) packer, the exhaust ventilation system was less effective than the Supersil$_{(R)}$ packer ventilation system. Uneven exhaust flow patterns and cross drafts in the area tended to reduce the exhaust sytem's effectiveness. The average dust levels, 686 ug/m^3 total dust and 578 ug/m^3 silica dust, were considerably higher than ambient dust levels, 90 ug/m^3 total dust and 30 ug/m^3, silica dust. The differences in dust level and probable silica content suggest that most of the dust in this area emanated from the packer operation.

3. At the Min-u-sil$_{(R)}$ (5 micron) packer, the dust control system was also ineffective. The exhaust hood was located remotely from the primary dust source, the fill spout. The hood did not contain side baffles to develop efficient flow contours. Spills of product on the floor were not immediately removed. Cross drafts in the general area also reduced the effectiveness of the exhaust control sytem. Dust levels at this packer station, 344 ug/m^3 total dust and 199 ug/m^3 silica dust, were significantly higher than background dust levels, 18 ug/m^3 of both total dust and silica dust. The high dust levels and relatively high silica content indicate that the main dust sources in this area were the packing and pallet loading operations.

D. Several additional engineering control strategies were observed or planned at this facility. These included:



-1-



-2-

-3-

Figure K

1. Bulk loading sand into open top truck
2. Bulk loading flour into enclosed hopper truck - with local exhaust ventilation
3. Bulk loading flour into enclosed hopper rail car - with local exhaust ventilation

Pennsylvania Glass Sand

1. The company plans to concentrate all bulk flour loading operations in one building, to replace the two present locations. This consolidation will increase loading rates to 100 cars in a 4- or 5-hour period. It will also permit more effective dust control with local exhaust ventilation. At present, as much as 85% to 90% of flour product is bulk loaded into railroad hopper cars or trucks.

2. Plastic curtain strips have been installed in the Min-u-sil$_{(R)}$ (10, 15, 30 micron) packing room to reduce air cross currents. These strips permit easy traffic flow and increase the effectiveness of the local exhaust control system.

3. Stream driers in the ball mill area are being replaced with enclosed fluid bed driers which are less dust producing.

4. Planting and paving of outside surfaces and regular wetting of roads will reduce the dispersion of dust into the general environment. Covering of tailing dumps with shrouds (similar to parachutes) or disposing of tailing wastes in wet ponds also would reduce dust dispersion.

5. According to plant engineers, raising of stacks on baghouse exhaust and other ventilation systems has resulted in a reduction of background dust concentrations to the 50 ug/m^3 level.

6. At present, baghouse cleaning by shakeout is manually operated. Automatic shakeouts on a timed cycle would improve the operation of the baghouses and reduce employee exposures. Plans are being made to reduce background contamination by sealing buildings and recirculating all plant air through bag collectors.

7. On the 4-spout Super-sil$_{(R)}$ packer, the full bags removed from the fill spouts by an automatic bag remover. The use of this device resulted in less product spillage from spouts, since the automatic bag remover does not operate until the feed valve shuts off.

8. With the use of 3-ply bags, breakage has been reduced during filling, conveying and pallet loading.

9. A floor clean-up grill, with exhaust ventilation, was located between the conveyor discharge and the pallet loading area. This system reduced dispersion of dust caused by bag breakage or spillage.

10. The use of an auger feed for bag filling silica flour has recommended to replace the currently used pneumatic feed. Although auger feed is slower than pneumatic feed, it produces much less dust. Auger packers should be developed which have greater feed rates and still maintain low dust emissions.

E. Good work pactices and effective housekeeping procedures are also essential for maintaining dust exposures at a safe level. Plant management has estimated that approximately one-half of their dust control program involves effective housekeeping and maintenance procedures. Observations and recommendations are:

1. At this plant, employee compensation plans are not based on "incentive pay" schedules. Incentive pay is normally a poor policy since it may result in poor work practices, such as cutting corners, improper and delayed clean-up of spills and unsafe materials handling procedures.

2. Proper bag handling, as they are placed on pallets, conveyor belts, or stacked in box cars is essential for minimizing dust dispersion. This would preclude such practices as throwing or dropping of bags, which result in excessive bag breakage.

3. Wet washing of work surfaces, walls, and floors results in less dust dispersion than dry sweeping. The relative effectiveness of wet sweeping versus dry vacuum cleaning has not been evaluated under controlled conditions. However, both methods are superior to dry sweeping.

4. The practice of uncontrolled blowing dust off worker's clothes with a high pressure air hose, is both a safety hazard and a source of atmospheric dust contamination. The safety hazard can be minimized by using low pressure air and by attaching a wire or expanded metal spacer guard to the air hose discharge. This arrangement keeps the hose nozzle from direct body contact. Also, an enclosed blow-off booth with floor exhaust ventilation would minimize dust dispersion.

5. A regularly scheduled inspection and preventive maintenance program is essential for effective dust control. According to plant management, approximately 30% of the engineering construction budget has been spent on environmental dust control. Five maintenance men are needed to maintain the 28 dust collection and associated ventilation systems in good operating condition. The environmental control maintenance staff should be as well trained and experienced as the production maintenance staff. Also, the use of duct tape for "permanent" repair of duct work should be minimized.

F. An effective respiratory protection program has been instituted. For a detailed description of the program see Appendix III. One full-time technician, accountable to the plant manager, is responsible for the proper selection, maintenance, repair, and cleaning of respirators used by the employees. Two or three respirators are assigned to each employee. Therefore, the worker has at least one clean, repaired and properly fitted quarter-mask respirator at all times. One building in the plant area has been dedicated for respirator maintenance, cleaning and fitting. Areas of high dust exposure are designated for mandatory respirator use. All supervisors are responsible for monitoring the use and condition of respirators.

G. Medical and environmental monitoring is carried out by the company staff.

1. The medical monitoring program is under the direction of Dr. E.P. Quarentello, in Berkeley Springs, West Virginia. Biennial chest x-rays are taken on all employees, and are forwarded to Drs. Miller and Pendergrass, at the University of Pennsylvania, College of Medicine, for diagnostic interpretation. Pulmonary function testing should be included in the medical monitoring program for all personnel potentially exposed to silica dust.

2. At present environmental monitoring is limited to personnel monitoring. No general area or potential dust source monitoring is performed by company staff. Source monitoring, in conjunction with routine inspection and measurement of dust control ventilation systems, would help detect and evaluate significant sources of dust contamination. Several direct reading dust monitors, such as GCA Respirable Dust Monitor or the TSI Respirable Aerosol Mass Monitor, may be useful in locating dust sources.

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 PVC filter, No. M5, manufactured by Millipore Corporation or a FWS-B filter, manufactured by Mine 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. TSI Respirable Aerosol Mass Monitor, Model 3500, manufactured by Thermo-Systems, Inc. This instrument permits direct measurement of dust concentrations, at either two-minute or 24-second intervals. It collects particles from 0.01 to 10 um in diameter. In a one-minute sampling time it will measure mass concentrations in the range of 100 ug/m^3 $\pm$ 10 accuracy.

4. 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.

Environmental Data - MSA Gravimetric Sampler

Field # Sample	Location	Filter #	Time			Volume m^3	Mass ug		Concentration ug/m	
			Start	Stop	Min.		Total Dust	Silica Dust	Total Dust	Silica Dust
A (7/15/80)										
1	Outdoors (West-end)	622	1011	1648	397	.675	80	23	119	34
2	Outdoors (East-end)	606	1017	1646	389	.661	50	23	76	35
3	Palletizing Super-sil(R)-NE	674	1023	1415	232	.394	80	25	203	63
4	Palletizing Super-sil(R) No. side of conv. belt	604	1026	1416	230	.391	150	100	384	256
5	Palletizing flour bags NW of belt	608	1028	1418	230	.391	60	23	153	59
6	Palletizing flour bags So. side of belt	621	1031	1416	225	.382	100	26	261	68
7*	Flour bagging machine-West	612	1037	1419	222	.377	-	-	-	-
8	Flour bagging machine-East	603	1038	1419	221	.376	70	30	186	80
9	Flour bagging machine-Ctr.	623	1043	1419	216	.367	60	23	163	63
10	Flour bagging machine-OBZ	602	1050	1419	209	.355	70	23	197	65
11	Railroad hopper-West of loading point	618	1420	1711	171	.291	10	10	34	34
12	Railroad hopper-No. of loading point	605	1420	1711	171	.291	60	50	206	172
13**	Railroad hopper-East of loading point	614	1420	1553	93	.158	-	-	-	-
14	Railroad hopper-So. of loading point	620	1420	1711	171	.291	10	10	34	34
B (7/16/80)										
1	Outdoors (West-end)	918	0822	1415	353	.600	10	10	16	16
2	Outdoors (East-end)	928	0827	1423	356	.605	50	23	83	38
3	Palletizing flour bags-NE	914	0826	1418	352	.598	110	50	184	84
4	Palletizing flour bags No. side of conv. belt	930	0826	1418	337	.573	210	140	366	244
5	Palletizing flour bags NW side of conv. belt	913	0826	1418	337	.573	140	60	244	105
6	Palletizing flour bags So. side of conv belt	929	0826	1419	338	.575	140	80	243	139
7	Flour bagging machine-West	920	0826	1419	338	.575	60	30	104	52
8	Flour bagging machine-East	926	0826	1419	338	.575	80	40	139	70
9	Flour bagging machine-Ctr.	931	0826	1419	338	.575	70	40	122	70
10	Flour bagging machine-OBZ	925	0826	1419	338	.575	80	30	139	52
15	Outdoors-East loading dock	922	0844	1421	337	.573	150	70	262	122
16	Packer (10-30u)-East door	927	0857	1424	327	.556	90	23	162	41
17	Packer(10-30u)-So. bag rack	911	0858	1424	326	.554	10	10	18	18
18	Packer(10-30u)-So. packers	915	0858	1424	326	.554	280	*250	505	451
19	Packer(10-30u)-No. packers	909	0858	1424	326	.554	480	390	866	704
20	5 Micron-packer	924	0901	1426	325	.552	190	110	344	199
21	5 Micron-No. door	917	0906	1426	320	.544	10	10	18	18

* Sample discarded, used twice.
**Sample discarded, heavily contaminated.
Less than

APPENDIX III

RESPIRATORY PROTECTION PROGRAM
BERKELEY WORKS

The basic purpose of the respiratory protection program is to provide the worker with a healthful environment. The primary method of protecting the worker against respiratory hazards is engineering controls that either eliminate or reduce the dust hazard. However, when situations occur where engineering or administrative controls are impractical or ineffective, personal respiratory protection must be worn.

In order to have adequate protection against respiratory hazards by the use of respirators, a comprehensive program detailing the use of respirators must be carried out.

All employees of the Berkeley Works will be furnished with two respirators and the following shall govern their use:

Respirators

Mine Safety Appliance "Dustfoe 66" or "Dustfoe 77" respirators will be provided.

Training

Respirator training shall be provided as mandated under 30 CFR 48.25(2) - "Self Rescue and Respiratory Devices" - MSHA Training.

Maintenance

1) Each employee who has used a respirator during the shift shall deposit it in the assigned container.

2) Each respirator shall be collected daily.

3) Each respirator shall be disassembled, inspected, cleaned, dried, repaired as required, and enclosed in an individual plastic bag.

4) Each cleaned respirator shall be returned to its assigned bin by 3:00 p.m. each day.

5) The respirators shall be sanitized with "MSA Cleaner & Sanitizer."

6) A daily log shall be kept of each person's respirator use.

Supervision

All supervisors shall routinely monitor the use and condition of the respirators.

Administration

One qualified person shall be responsible for the program and shall be accountable to the plant manager.

April 29, 1980

HISTORY OF THE RESPIRATOR PROGRAM
BERKELEY PLANT

In the initial planning stages the various elements of a respirator protection program were discussed and it quickly became apparent that a location for a cleaning station had to be devised. As no suitable area existed within the plant, it was decided to purchase a 40' used trailer and refurbish it to become the respirator clinic.

The trailer was located at the north end of the plant office and was equipped with a dishwasher, a heated air dryer for drying washed respirator straps, formica work stations, two offices, heating and air conditioning.

A technician was hired to be responsible for the program. Two respirators were assigned to each employee and certain employees were assigned three respirators. Each respirator was marked with the employee's own number and department number. This identifies each respirator.

A number of pigeon-hole storage racks were located in the various departments and individual pigeon-holes were labeled to match each employee's individual number.

A plastic container was located in each department by the pigeon-hole rack and after an employee uses his respirator he deposits it in the plastic container. The technician collects the used respirators daily.

The respirator is disassembled into its 6 or 7 individual parts, depending upon the style respirator, and inspected for wear. The Berkeley plant has standardized on the MSA Dustfoe 66 & 77 respirators. The respirators are repaired and cleaned in the dishwasher with "MSA Cleaner & Sanitizer" for 70 minutes. The respirator headstraps are dried in the strap dryer and then the respirator is assembled and placed in an individual plastic bag. The technician then enters into the daily log the use of each respirator. Thus the pattern of use can be determined from the log. The technician then returns the cleaned respirator to its proper pigeon-hole before 9:00 a.m. each day.