Report on an

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

at

Ottawa Silica Company
Ottawa, Illinois

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ABSTRACT

At Ottawa's silica flour mill, two dust suppression techniques, water injection into the product and water spray onto bag surfaces, were tested. Environmental tests indicate that these methods effectively reduce atmospheric dust concentrations by approximately 60% in the packing area, 80% in the bag handling areas; and 70% in the box car loading areas. The combination of control techniques using water, local exhaust ventilation, and housekeeping reduced dust concentrations at the packing station to the 50 ug/m^3 level; at bag handling areas to the 100 ug/m^3 level; and in the box car loading area to the 200-300 ug/m^3 level.

The relative effectiveness of these controls was not evaluated in this study.

Dust levels can be further reduced by the increased use of bulk loading into closed hopper cars and trucks, with exhaust vacuum dust control. At present, Ottawa ships approximately 85% of its silica sand and flour products in bulk and 15% in paper bags.

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 main purpose of this CTA was to evaluate innovative control strategies for reducing 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 study at the Ottawa Silica Company, in Ottawa, Illinois. At this silica sand and flour milling facility, two new dust suppressant techniques were evaluated, which have shown promise of effective dust reduction. These two techniques are:

1) the addition of water (up to 1.5% by weight) into the silica flour product, as it is loaded into 50 and 100 pound bags, and
2) the spraying of water on filled bags, at strategic locations, to agglomerate and remove the accumulated dust on the bags' outer surfaces.

B. Scope of Study

The evaluation of atmospheric dust concentrations, ventilation control systems, and other dust control techniques was limited to three operations in three work areas of silica flour Mill G. These areas and operations were:

1) Packing area: filling 100 pound, 3 ply paper bags with Sil-Co-Sil Silica Flour (#295 and #290), at the No. 3 packer.
2) Bag handling area: transferring bags from the declining chain conveyor to the transfer conveyor on the main floor.
3) Box car loading area: manually removing and stacking bags on pallets in box cars from the transfer conveyor.

Environmental dust evaluations were conducted under four control conditions which are described in Section III-D.

II. STUDY PROTOCOL

A. Evaluation Criteria

The principal material investigated in this study was crysysalline 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 samples. Therefore, in this report, 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. Although the PEL pertains specifically to the 8-hour time weighted average exposure to employees, 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:

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

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

B. Process Description

At the Ottawa facility, silica sand ore is pumped, as a wet slurry, from the quarry, about one and one-half miles, to the "Processing Building" in the Milling area. In the "Processing Building," the ore is washed and sized on stationary wet screens. Three fractions are produced: Fine (Glass) sand (-200 mesh), Coarse sand, and Tailings (+ 1/8 inch sand, clay and debris). The Tailings are pumped back to a mined-out quarry for wet storage.

The dry Fine (Glass) sand is transported by closed conveyor belt to the "Fine Sand Plant" where it is sized and stored in closed bins, prior to shipment. Fine sand accounts for approximately 12.5% of the total sand produced.

The dry coarse sand is transported by closed conveyor belts to the "Sizing Building" sized on horizontal air classifiers, and stored in closed bins. Most of the Coarse sand is shipped either in bulk or in bags, by rail car or truck. Coarse sand for approximately 80% of the total sand product

The remaining portion of the dry Coarse sand is transported by closed conveyor belt to "Mill G" where it is comminuted into Silica Flour products. Three grinding circuits (two primary grinders and one secondary regrind unit) and a Raymond Air Classifier are used to produce the various flour products. The grinding is done in the tube mills, using either high silica pebbles or ceramic plugs as the grinding media. The silica flour products are also shipped in bulk or in bags, by rail car or truck. Bulk shipment of flour accounts for approximately 6% of the total sand products, bag shipment of flour accounts for the remaining 1.5% of total sand products.

At "Mill G", which also houses the tube milling and drying operations operations (Figure A), the flour products are bagged and loaded into box cars and trucks. A solid wall isolates the bagging and loading sections from the remainder of the mill operations. This wall reduces contamination of the bagging and loading work areas, by dust from the milling and drying operations.

A normal bag handling crew consists of four or five employees. one operating the packer machine, one transferring bags from the declining conveyor to the transfer conveyor; one or two stacking the bags in the box car or truck; and a supervisor assisting, as needed, in these three operations. Normally, the crew members arrange their own schedule by rotating among these jobs during the shift.

Five mechanical packers, manufactured by St. Regis Company, are located on the second floor of this building, approximately 15 feet above the main floor. Two units (packers No 4 and 5) have two fill-spouts each, and three units (packers No. 1, 2, and 3) have four fill-spouts each. Normally, only one packer is in operation at a time. During this study, one hundred pound bags (3 ply, manufactured by Owens-Illinois and Georgia Pacific) were being filled. All bagging was done on Packer No. 3, and all dust evaluations and ventilation tests were performed around this packer.

The bags are placed by hand on the packer spout, filled with product, tipped by hand onto a horizontal conveyor, and transported to the loading area on the main floor of Mill G. During this study, all bags were loaded with Sil-Co-Sil #295 or #290*

In the bag handling area, on the main floor (north end), bags drop from the declining conveyor to the horizontal transfer conveyor. One or two employees are stationed at the transfer point between conveyors, to straighten bags, to prevent pile up of bags, to replace fallen bags onto the conveyor, to remove broken bags, and to wet-sweep any spills as soon as possible.

In the car loading area, one or two operators manually remove the bags from the conveyor and stack them on pallets in a box car or truck. During this study, only box cars were loaded. Conveyor controls are located at each work station.

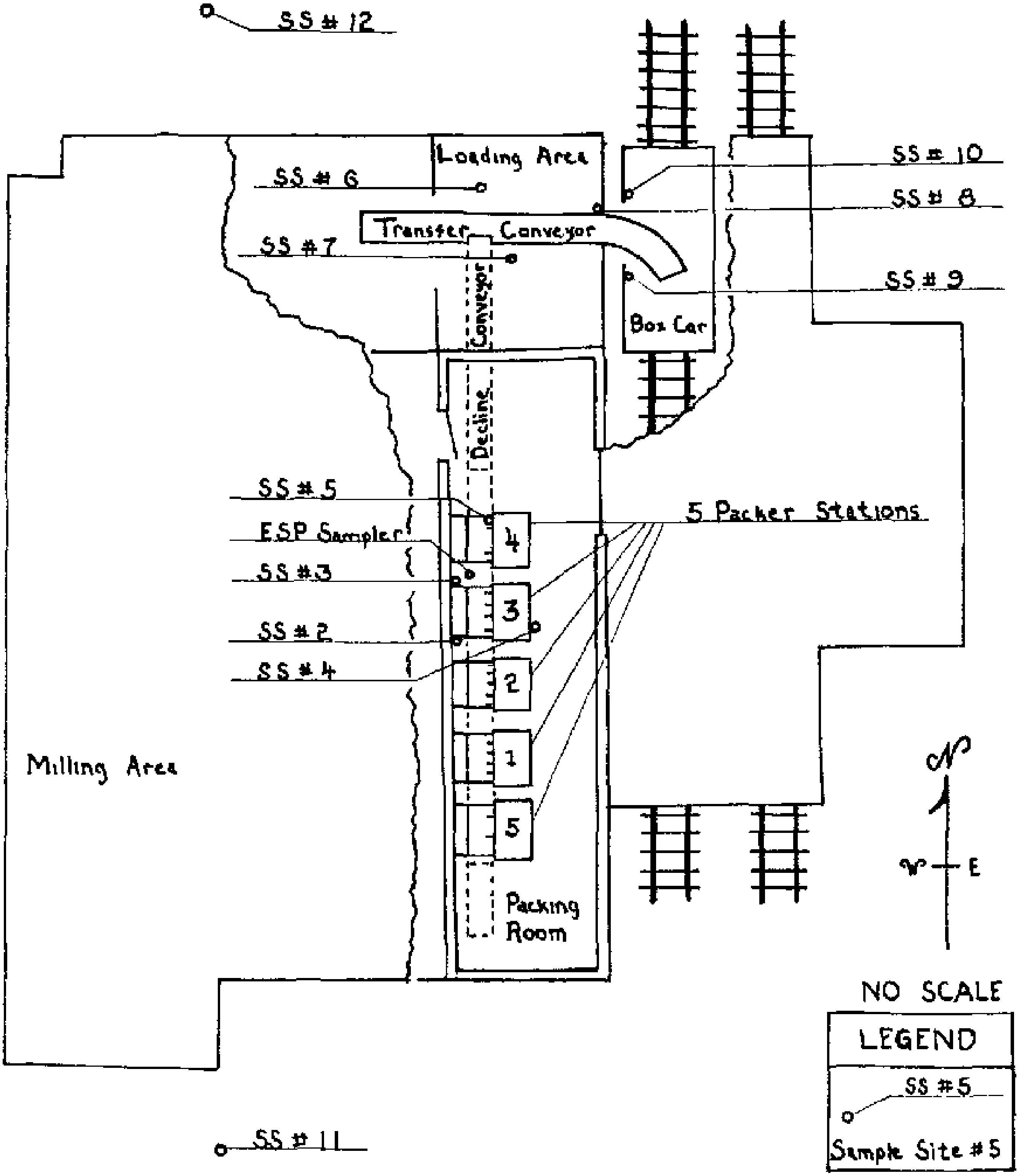

Figure A: Mill G – Milling, Packing, and Loading

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C. Dust Suppression or Control Systems

1. Ventilation systems

Exhaust ventilation is provided at each packer station and consists of several collection points (Figure B). From these collection points, the captured dust goes through 4 or 6 inch ducts into a main 12-inch duct that leads to bag-type dust collectors (manufactured by Allis-Chalmers and Wheelabrator). The dust control system for each bagging station is equipped with manually operated "shut-off" valves. All valves are closed except for those at the packer station being used. Other 6-inch ducts are spaced along the conveyor enclosure to pick up airborne dust from the bags. Any spillage at each packer, which falls through the conveyor (chain-type) belt into a trough, is flushed and carried away in the waste water.

At the transfer point from the declining conveyor to the transfer belt conveyor, a hood enclosure, with a canvas curtain, is used to minimize dust dispersion as the bags drop from one conveyor to the other.

2. Water injection into product

Water, up to a concentration of 1.5%, is injected into the product at each filler spout to reduce the emission of dust from silica flour products (Figure B).

3. Sonic water sprays on bags

Sonic sprayers, manufactured by the Sonic Development Company, have been installed at three strategic locations (Figures B and C):

a) Directly on the packer near the fill spouts. Water is sprayed on the top of the bag to remove dust from the bag valve area.

b) At the transfer point from the horizontal conveyor to the declining conveyor. Water is sprayed upward and downward on the bags to remove dust from the front and back of each bag.

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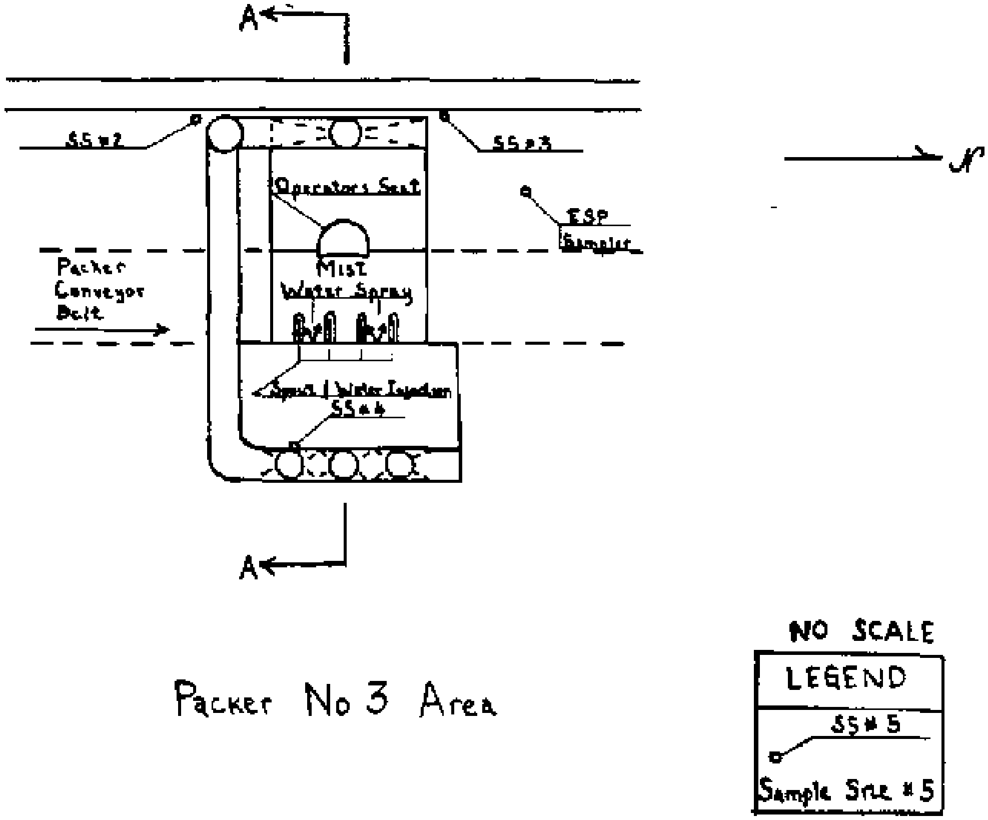
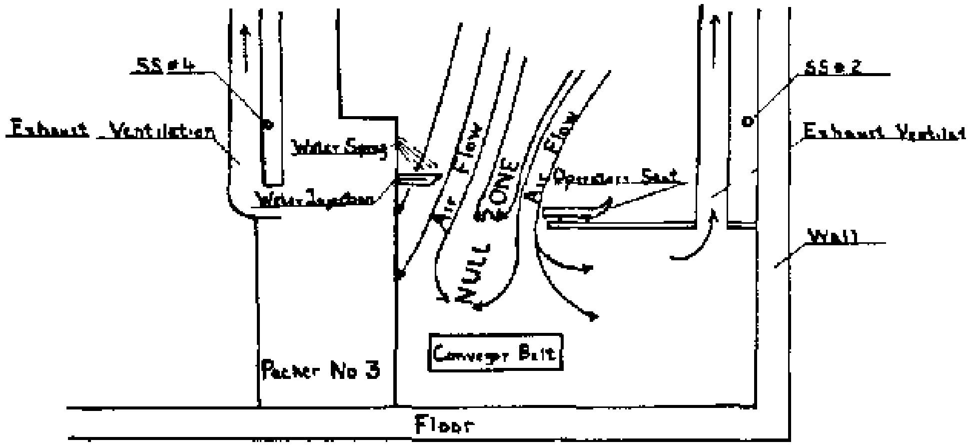
*#295 product: 95% of product passes 200 mesh; #290 product: 90% passes 200 mesh.



Packer No 3 Area



Cross Section A-A

Figure B: Packer – Ventilation and Water Controls

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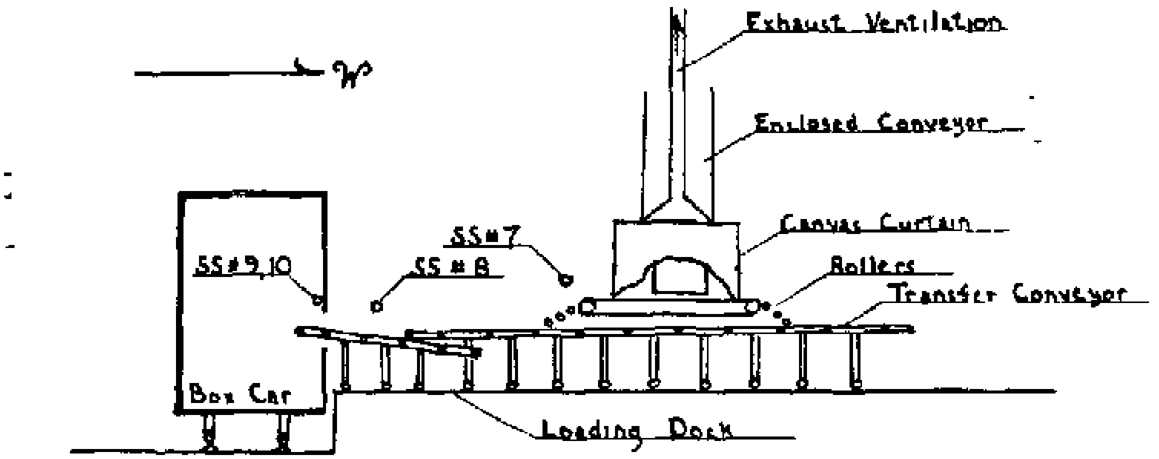


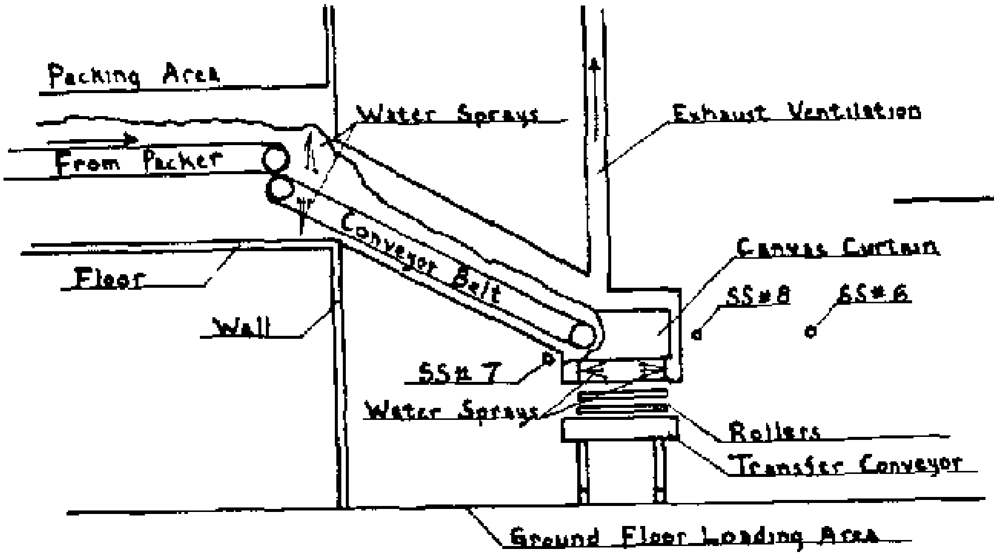
Transfer Points on Lower Level

NO SCALE

LEGEND

○ SS #7

Sample Site #7



Cross Section Transfer Points from Upper to Lower Level

Figure C: TRANSFER POINTS – Ventilation and Water Sprays

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c) At the transfer point from the declining conveyor to the horizontal transfer conveyor. Water is sprayed from both sides to wash the sides of the bags.

The objective of these sprays is to agglomerate or remove the dust from the outer surfaces of each bag.

The spray patterns are overlapped so that all exterior surfaces are thoroughly washed.

The effectiveness of these various dust suppression techniques is discussed in Section V.

D. Study Design

A study protocol was developed to evaluate the effectiveness of the two dust suppression procedures using water. The normal operating conditions, which were maintained constant throughout the study, included:

1. Product - During the study, only products Sil-Co-Sil #290 and #295 were packed.
2. Packer location - All packing was conducted on Packer No. 3, using 100 pound, 3 ply bags.
3. Ventilation systems - The ventilation systems at Packer No. 3, along the closed conveyor, and at the transfer points, were operating.
4. Loading - Pallets were loaded only in box cars.

Atmospheric concentrations of both respirable "silica" dust and respirable "total dust" were determined during four operating conditions:

1. Run B - Normal operating conditions.
2. Run C - Normal operating conditions, with water injection into the product and with water sprayed onto the bags' outer surfaces.
3. Run D - Normal operating conditions, with water injection into the product at the packer spouts.
4. Run E - Normal operating conditions, with water sprayed onto the outside bag surfaces.

A total of nine in-plant air sampling locations were established at the three work areas being evaluated. Two additional outside sampling locations (up-wind and down-wind) were established to estimate background dust levels (Figure A). (Prevailing winds were from the

Southwest on June 17 and 18, and from the Northeast on June 19.) One sample was taken at each location during each of the four test runs. These locations are shown on Figure A. One sample was taken at each location during each of the four test runs.

Experimental Runs (A through E) were conducted under the four operating conditions listed in Section II D. During Run A, a Ritter Electrostatic Fogger was in operation inside the box car being loaded. Its function was to agglomerate airborne dust to reduce the dust concentration. Also, during Run A, abnormal amounts of dust were generated by six broken bags of product, (four bags near packer No. 3 and two bags at the belt transfer on the loading dock). Since these factors were abnormal and extraneous to the experiment, it was decided to exclude the data of Run A from the evaluations of the effectiveness of the two control methods. During the remaining four runs, only two broken bags were observed.

Air flow measurements were made of the ventilation systems at the No. 3 packer and at the top and bottom of the declining conveyor.

E. Evaluation Procedures

1. Atmospheric Dust Concentrations

Respirable dust samples were collected by three types of sampling systems·

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

b) The Del High Volume Electrostatic Precipitator Sampler (ESP). Integrated samples were also collected and analyzed qualitatively and quantitatively for silica and total dust. The main purpose of this sampler was to collect sufficiently large "bulk" air samples for accurate identification of the airborne dust.

c) The TSI Respirable Aerosol Mass Monitor, Model 3500. This instrument permitted direct measurement of particulate concentrations. However, its usefulness was limited, particularly around the sonic sprays, since its detector did not differentiate between solid dust particulates (silica and other minerals) and liquid particulates (water mist from the sprays).

In Appendix A, a discussion of the operating characteristics and specifications of these instruments is presented. Also in Appendix A, test procedures and specifications of analytical laboratory equipment are described.

2. Ventilation studies

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

III. STUDY RESULTS

A. Atmospheric Dust Concentrations

Table I and Figure E-1 through E-3 show the results of atmospheric evaluations for total dust and silica dust during Runs B through E. The results of Run B (dry - with no water control) were used as base concentration levels. The magnitude (%) of reduction of dust levels was calculated for each of the test conditions and are shown in Table I. The results of all test runs, (A through E) are also shown in Table V. As stated previously, the results of Test Run A were not used in this evaluation because of abnormal environmental conditions.

Table II presents the average dust concentrations in the three work areas, during each of the four test conditions. Also listed in Table II are the percentages of silica in the total atmospheric dust. Many of the data points are listed as " < " (less than) a specific value. This indicates that the weight of silica dust or total dust collected was below the analytical limit of detection (18 ug per sample for silica and 10 ug per sample for total dust). The calculated silica composition, using one or two " < " data points, has a low degree of accuracy and reliability. These values are listed in parentheses ( ).

Table III presents a comparison of results obtained by simultaneous sampling with two instruments, the MSA Dust Sampler and the Del ESP Sampler, during three test operating conditions. The MSA Sampler results represent the average of sample sites 2 and 3 behind Packer No. 3.

The Del ESP Sampler was positioned on the horizontal conveyor, approximately five feet from site 3. Many of the silica and total dust concentrations of Runs C and D were calculated from silica and total dust weights below the limits of detection. Therefore, many of the estimates of silica content are of unknown accuracy.

B. Ventilation Results

Table IV describes the ventilation systems and air flow patterns at packer No. 3 and the transfer point on the main floor. In the area of packer No. 3, measurements and flow patterns were made at the packer hood face; one foot from the face of the hood; and at the slot-hood behind the operator (Figures B and D). At the transfer point from the declining conveyor to the transfer conveyor, air flow measurements and flow patterns were made at the canvas curtain of the canopy hood (Figure C).

Table I

Atmospheric Dust Concentrations (Respirable)
During Four Experimental Runs

	RUN B (Dry)				RUN D (water injection)				RUN E (spray on bags)				RUN C (injection and spray)			
	Total dust	Reduction from "Dry"	Silica dust	Reduction from "Dry"	Total dust	Reduction from "Dry"	Silica dust	Reduction from "Dry"	Total dust	Reduction from "Dry"	Silica dust	Reduction from "Dry"	Total dust	Reduction from "Dry"	Silica dust	Reduction from "Dry"
	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%
A <u>Packer Station #3</u>																
2) South side	123	-	99	-	< 39	> 68	< 39	> 61	89	28	56	43	< 36	> 71	< 36	> 64
3) North side	82	-	78	-	< 39	> 52	< 39	> 50	30	63	30	62	< 36	> 56	< 36	> 54
4) East side	41	-	< 41	-	< 39	> 5	< 39	> 5	59	-44*	59	-44*	< 36	> 12	< 36	> 12
5) Bag transfer on conveyor	165	-	165	-	< 39 <	> 76	< 39	> 76	< 30	> 82	< 30	> 82	< 36	> 78	< 36	> 78
Average	103	-	96	-	< 39	> 62	< 39	> 59	< 52	> 48	< 44	54	< 36	> 65	< 36	> 62
B <u>Bag Handling Area</u>																
6) Northwest of transfer point	332	-	332	-	40	88	40	88	-	-	-	-	70	79	< 66	> 80
7) South of transfer point	539	-	456	-	40	> 93	40	91	149	73	149	67	106	80	95	79
8) Northeast of transfer point	329	-	247	-	79	76	79	68	(30)	91	30	88	35	89	< 35	> 86
Average	400	-	345	-	53	87	53	85	90	78	90	74	70	82	< 65	> 81
C <u>Box Car Loading Area</u>																
9) South of entrance	2125	-	1625	-	1440	32	1440	11	898	58	245	85	951	55	387	76
10) North of entrance	1708	-	1417	-	887	48	887	37	653	62	163	88	775	55	246	83
Average	1917	-	1521	-	1164	39	1164	23	776	60	204	87	863	55	317	79
D <u>Outside of Plant</u>																
1) South of plant	13		< 13										< 13		< 13	
2) North of plant	< 13		< 13										< 13		< 13	

< less than
\> greater than
( ) low degree of accuracy and reliability
*during Run E, atmospheric concentration was greater than Run B

Table II

Relationship of Silica Dust to Total Dust Concentration with Water Control Dust Concentrations

Location	RUN B (Dry)			RUN C (Injection and Spray)			RUN D (Injection only)			RUN E (Spray on bags only)			Silica Proportion of Total Dust (averages of Runs B, C, D, E)		
	Total Dust	Silica Dust	Silica Content	Total Dust	Silica Dust	Silica Content	Total Dust	Silica Dust	Silica Content	Total Dust	Silica Dust	Silica Content	Total Dust	Silica Dust	Silica Content
	ug/m³	ug/m³	%	ug/m³	ug/m³	%	ug/m³	ug/m³	%	ug/m³	ug/m³	%	ug/m³	ug/m³	%
1 Packer No. 3 Average 4 samples (2, 3, 4, 5)	103	96	93	< 36	< 36	(100)	< 39	< 39	(100)	< 52	< 44	(85)	57	54	95
2 Bag handling area Average of 3 samples (6, 7, 8)	400	345	86	70	< 65	< 93	53	53	100	90	90	100	153	138	90
3 Box car loading, Average of 2 samples (9, 10)	1917	1521	79	863	317	37	1164	1164	100	776	204	26	1180	801	68

< less than
( ) low degree of accuracy and reliability

Table III

Comparison Between MSA Gravimetric Dust Sampler and Del ESP Sampler

Experimental Run and Control Conditions	*MSA Gravimetric Dust Sampler			DEl ESP Sampler			Ratio of Silica Content in samplers Del Sampler / MSA Sampler	Remarks
	Total dust	Silica dust	Silica Content	Total dust	Silica dust	Silica Content		
	ug/m^3	ug/m^3	%	ug/m^3	ug/m^3	%		
Run A - water injection into product and spray on bags (samples A-2 and A-3	265 313	153 < 94	43	233	115	49	1.14	4 broken bags near No. 3 Packer during run
Average	289	124						
Run B - No water injection into product and no spray on bags (samples B-2 and B-3	123 82	99 78	86	281	281	100	1.16	Normal operations no broken bags
Average	103	89						
Run C & D - water injection into product (50% of time)and spray on bags (100% of time) (Samples C-2,3 and D-2,3)	< 36 < 36 < 39 < 39	< 36 < 36 < 39 < 39	(100)	92	86	93	(0.93)	Normal operations no broken bags.
Average	< 39	< 39						

*Average of samples at locations 2 and 3. Del sampler located approximately 5 ft from MSA at Sample location 3.

< less than

( ) low degree of accuracy and reliability

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Table IV

Ventilation Control Systems in Mill Building "G"

Location Upper Level	Description of System	Velocity Measurements fpm	Remarks
1. Behind No.3, 4-spout, packer machine.	5ft x 4ft side hood, directly behind 4-spouts of packer machine (air moving east.)	1) at hood face avg. vel = 45 fpm 2) 1 ft from hood face, average vel. = 20 fpm	Air velocity fairly uniform around 4-spouts Good control See Figure B
2. Directly behind bagger operator.	4ft X 4" slot pulling dusty air from conveyor belt (air moving west)	*CLV = 1000 fpm	This system operates in opposition to packer slot. Could be more strategically located.
3. Main level transfer from declining conveyor to horizontal conveyor.	Enclosure hoods with canvas curtain	No bags present 20 - 40 fpm inflow. Bags passing by ≈ 50 fpm (random direction)	Hood not completely effective as shown by "sonic" water spray mist inside hood on bags.

*CLV = Center Line Velocity

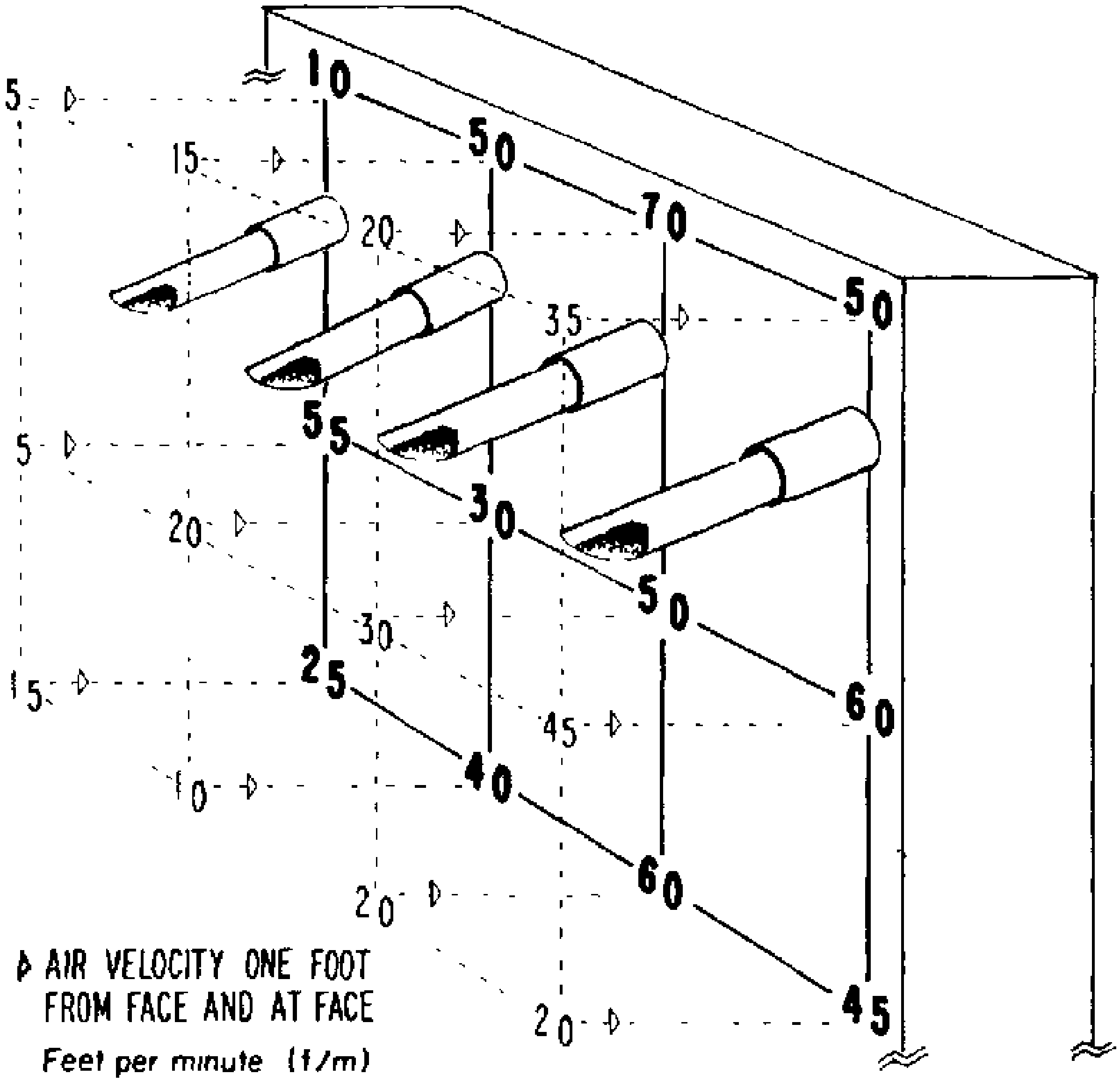

Figure D Ventilation measurements packer No 3

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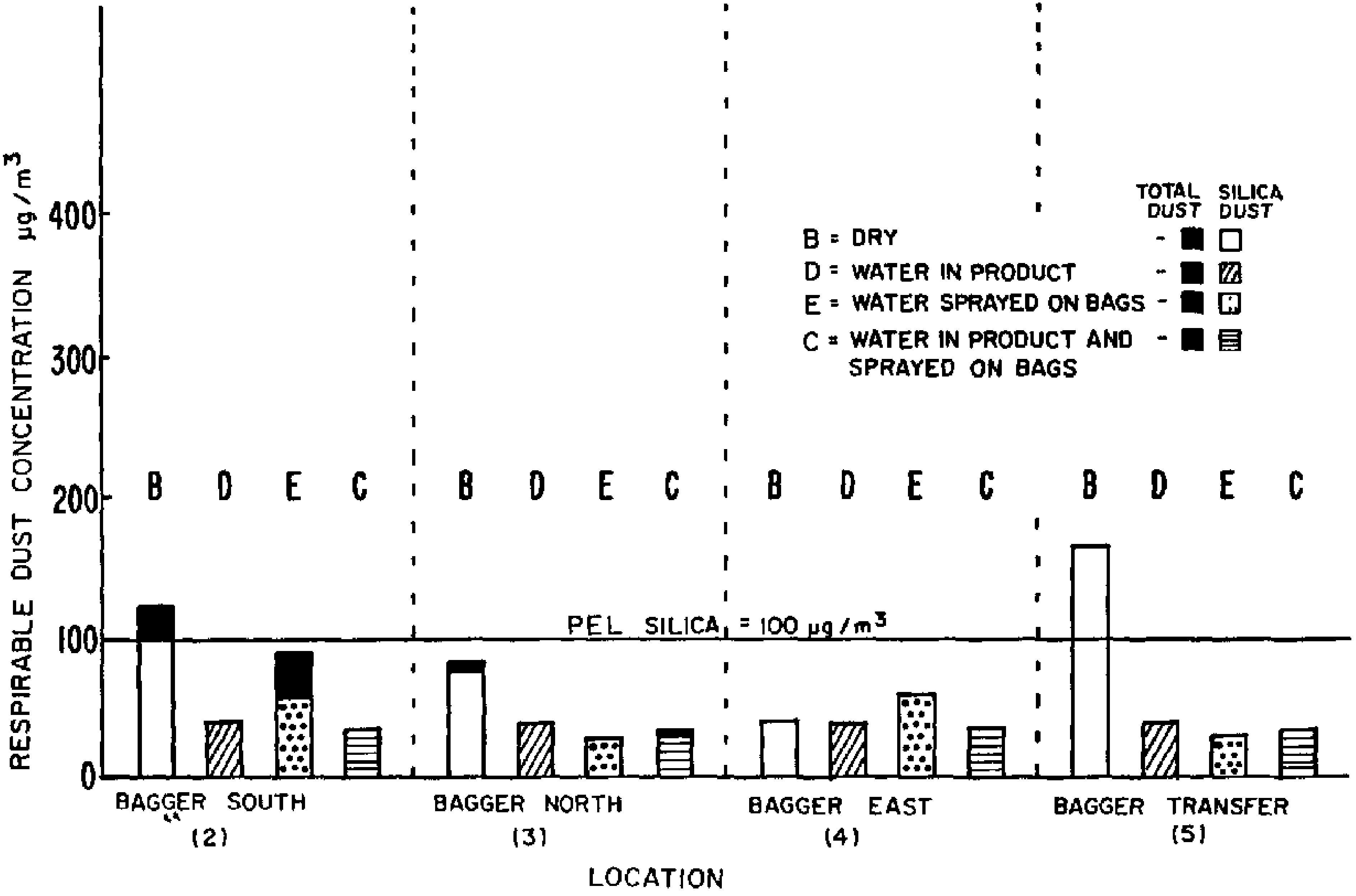

Figure E-1. Bagging area — Packer No. 3

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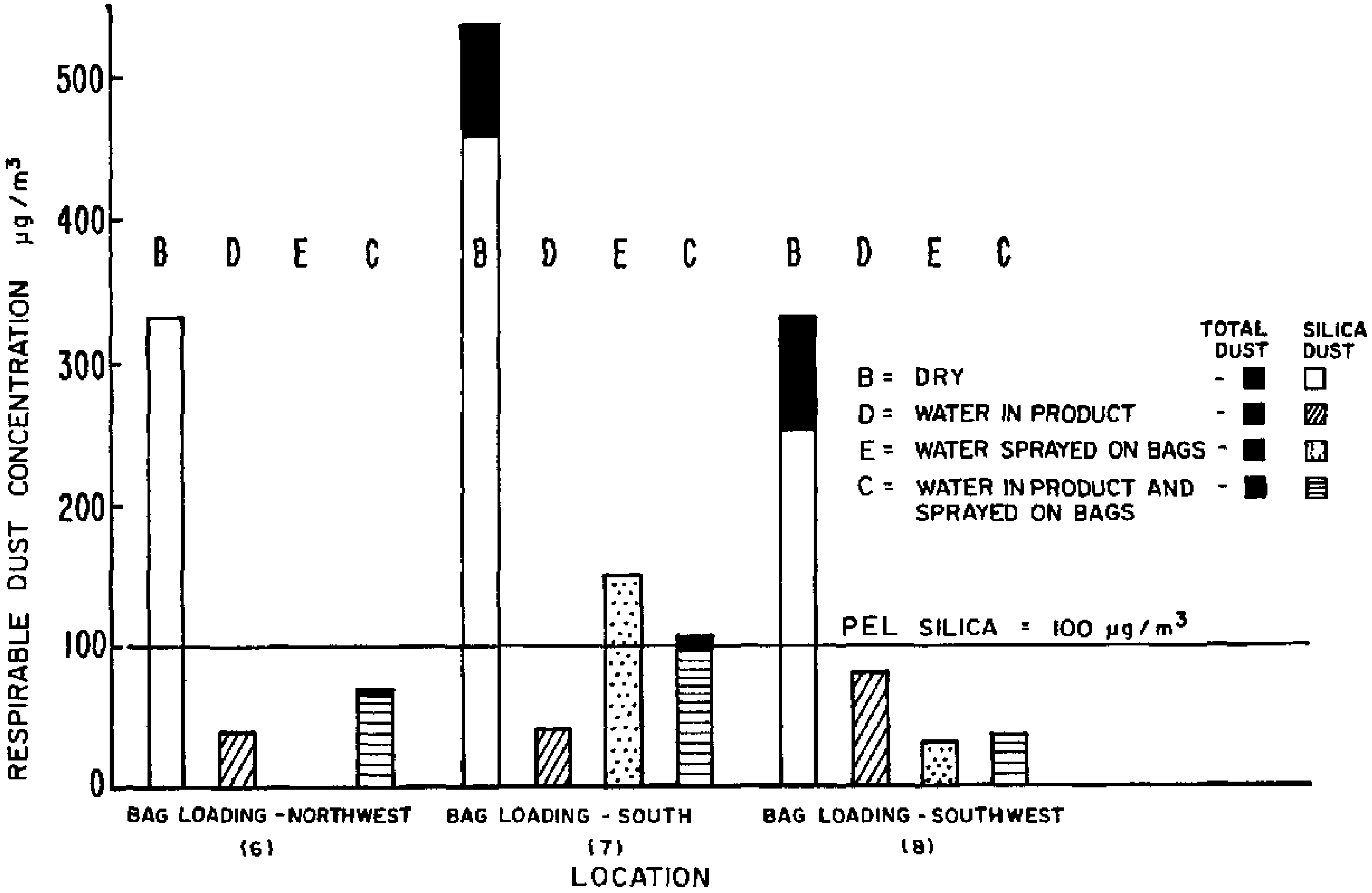

Figure E-2. Bag handling area.

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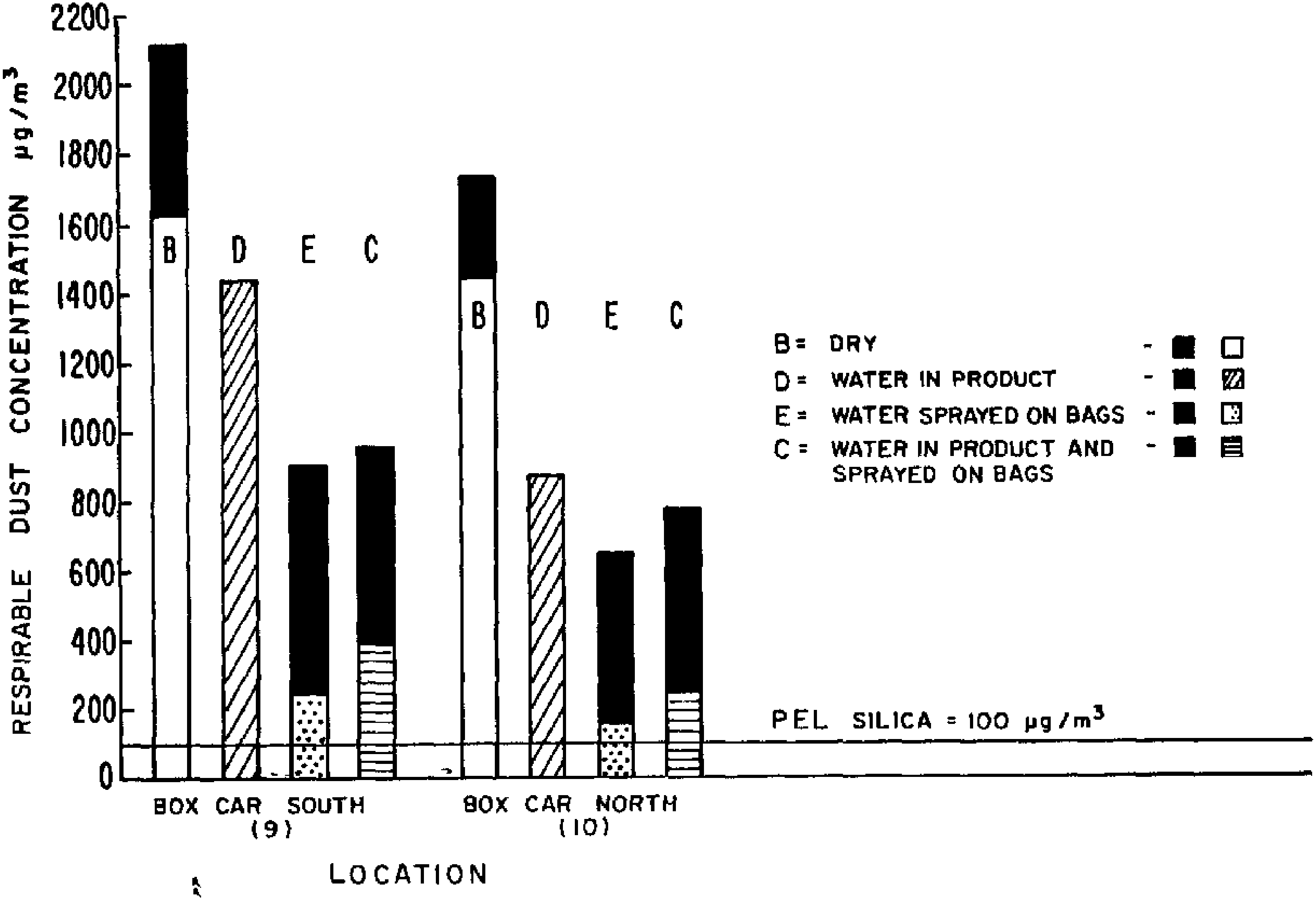

Figure E-3. Box car loading area.

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IV. DISCUSSION OF RESULTS

The following discussions are based on environmental data, derived from one experimental run under each of the four water controlled conditions.

A. Environmental Results

1. Bag packing area

Table I and Figure E-1 indicate that, at Packer No. 3, the ventilation system alone (Run B) was capable of maintaining silica dust concentrations at the 100 ug/m^3 level, under normal operating conditions and with minimal bag breakage. The two existing exhaust systems, one behind the packer machine, and the other behind the machine operator, worked in opposition to each other. As shown in Figure B, the packer machine exhaust system moved air laterally toward the packer and exhausted it behind the packer machine. Simultaneously, the conveyor belt exhaust system moved air laterally, away from the operator and exhausted it behind him. A null zone of air movement could be created in the vicinity of the packer operator.

The exhaust system behind the operator would be more effective if the air flow were toward the conveyor, creating a flow of clean air past the operator's breathing zone.

The addition of water, by injection into the product and/or spraying on bags, was effective in reducing dust levels around the packer area to the 50 ug/m^3 level under normal operating conditions. Each water control procedure reduced dust levels by about 55%, with a combined reduction of approximately 60%. These reductions occurred during minimal dust dispersion from bag breakage. At the packer, most of the air- borne dust (about 98%) was silica flour. (According to studies conducted by Ottawa Silica Co., farming soil from the surrounding area may contain 40-45% silica.) Since outside air contains minerals other than pure silica, most of the dust in the packer area probably emanated from the product rather than the outside air.

2. Bag handling area (north loading dock)

Table I and Figure E-2 show that silica dust levels in the bag handling areas averaged about 350 ug/m^3 under normal operating conditions (no water control by spray or injection). The ventilation system, at the hood over the conveyor transfer point, was partially effective. Air flow into the exhaust hood, ranging from 20 to 40 fpm, was often insufficient to overcome drafts. This phenomenon was observed by the use of smoke tubes.

The use of water, both injected into the product and sprayed on the bags, reduced the silica levels in the bag handling areas to approximately 70 ug/m^3. This was an approximately 80% reduction, of both silica and total dust levels, when compared to dust levels without water control. Both methods were effective. Water injection produced approximately an 85% reduction, bag spraying resulted in approximately a 75% reduction.

Respiratory protection is necessary in this area, especially when bags break or other sources of dust develop. Periodic water sweeping of floors and surfaces, plus immediate clean up of spills, helps reduce dust exposures.

Table II and Figure E-2 indicate that most of the dust in this area consisted of pure silica (about 95% of the airborne "total dust" was silica). Therefore, most of the dust probably evolved from the bags of product rather than from outside air. An effective dust control program in this area should be directed mainly toward control of product dust from bags.

3. Box car loading area

Box car loading operations create the major silica exposure hazard Without water injection or spraying, silica dust concentrations were approximately 1500 ug/m^3. Effective use of water sprays and injection reduced exposures to the 300-400 ug/m^3 level (approximately an 80% reduction, compared to dust levels with no water control). Table II and Figure E-3, show that the silica content of airborne dust was highly variable (from 20% to 100%) with an average silica content of approximately 65%. Thus, the contribution of outside air to the dust load is highly variable.

The most effective procedure to reduce exposures during box car and truck loading is the use of bulk loading in place of hand loading of bags. During bulk loading, dust control is achieved by using an exhaust ventilation duct, located either in the same loading hatch or in an adjacent hatch. This method was observed at Ottawa during the loading of sand into enclosed hopper trucks. However, since silica flour was not being bulk loaded during the time of this study, no quantitative evaluations were made during this operation.

B Sampling procedures

Table III shows the results of simultaneous dust sampling with the MSA Gravimetric Dust Sampler and with the Del (ESP) Sampler. Both units used cyclone separators to remove "non-respirable" dust from the samplers. The primary purpose of the Del Sampler was to collect large samples of atmospheric dust for subsequent dust characterization, including both chemical and particle size analyses. Two MSA Samplers were located 5 to 10 feet from the Del Sampler. Both types of instruments collected approximately the same composition of dust as shown by the comparative silica content of simultaneous samples (Run A: 43% and 49%, Run B. 86% and 100%, Run C. 100% and 93%).

However, the two samples did not compare well in estimating atmospheric dust concentrations near Packer No. 3. This disparity may have been caused by the non-uniformity of the dust clouds being sampled by each instrument. For example, during Run A, four bags were broken near Packer No. 3. These excessive dust clouds probably contributed a proportionally higher dust load to the nearby MSA samplers than to the Del Sampler, more than five feet away.

V. OBSERVATIONS, CONCLUSIONS, AND RECOMMENDATIONS

A. Control of dust in all areas requires a combination of good engineering controls, such as the use of water sprays, water injection, and ventilation; good work practices, including housekeeping; and effective respiratory protection. As dust emissions are reduced from point sources, it normally follows that the levels of personnel exposures to dust are also proportionally reduced.

B. Two engineering control methods involving water were used to reduce dust levels. The first, injection of water (up to 1.5% by weight) into the product, was an effective method for reducing dust emission. It was particularly effective at the packer and bag handling areas. The second, water spray onto the outer surfaces of product bags, was also an effective method for reducing dust levels, particularly around bag handling and box car loading operations. This reduction occurred only during minimal bag breakage and spillage.

C. Bag breakage results in increased short-term dust levels, especially near the breakage site. Residual dust from bag breakage may also contribute to background dust levels within the immediate and adjacent buildings. When breakage occurs, cleaning by water wash-down and wet-sweeping is more effective than dry broom sweeping and should be carried out immediately. The relative effectiveness of water wash-down versus central vacuum cleaning needs to be evaluated. In addition, dust dispersion from bags may be further reduced by plastic wrapping of loaded pallets.

D. About 85% of the total silica product at Ottawa is shipped by bulk, by loading rail road hopper cars and trucks through a telescopic loading spout. An exhaust duct is attached to the loading spout to reduce the dispersion of dust to the general atmosphere. This use of bulk loading, with controlled ventilation, also helps to reduce exposures to dust by minimizing bag loading and handling operations.

E. Another effective dust control technique is the proper treatment of outside surfaces. As atmospheric contamination from bag surfaces, leakage, and other operational dust sources is reduced, the outside sources of dust become more significant. At Ottawa, outside contamination is minimized by paving and wetting of roads and parking spaces with water and surfactants; by planting of fields with cover vegetation; and by storing wet or damp wastes in tailing ponds within the mined-out quarries.

F. The use of respiratory protection in all work areas is strongly advised. It is particularly useful as a preventive measure when bags break, fill spouts malfunction, or other dust control measures fail. Ottawa Silica Co. has a written respirator program which requires the use of quarter-mask dust respirators in certain work areas. The program also assigns the monitoring and enforcement of respirator use to department foremen. Under the present system, each worker is responsible for his own respirator cleaning, maintenance, and filter changing. The recommended procedure would be to assign these responsibilities to an individual trained in all aspects of a respiratory protection program, including choosing, fitting, cleaning, and maintaining respirators.

G. Good local control ventilation is essential at bagging operations and bag transfer points to remove airborne dust. Proper ventilation design requires both sufficient air movement and the development of effective flow patterns. Also, an effective ventilation control program requires preventive maintenance of ventilation systems, including scheduled evaluation of equipment and designed air flows.

Appendix A

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; 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 .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 ± 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.

Appendix B

Environmental Data - MSA Gravimetric Sampler

Run	No	Location	Date	Filter	#	Time		Durat min	Volume* Liters	Total Dust		Silica Dust		Silica Content	Control Condition and Remarks
						Start	Stop		L	Mass ug	Conc ug/m^3	Mass ug	Conc ug/m^3	%	
A	2	Packer No 3 - South	6/17	M5	135	0931	1122	111	189	50	265	29	153	58	Water injection
	3	Packer No 3 - North			146	0931	1124	113	192	60	313	<17	< 94	<30	and spray on bags
	4	Packer No 3 - East			148	0931	1126	115	195	40	205	23	118	58	
	5	Conveyor Transfer - Upper Level			149	0931	1127	116	197	90	457	20	102	22	Six broken bags
	6	Bag Transfer - Northwest			143	0934	1130	116	197	70	355	<17	< 91	<26	and use of Ritter
	7	Bag Transfer - South			155	0934	1135	121	206	50	243	<17	< 87	<36	sonic sprays
	8	Bag Transfer - Northeast			134	0934	1131	117	119	60	302	<17	< 91	<30	
	9	Box Car Loading - South of Entr			133	0931	1133	119	202	310	1535	80	396	26	
	10	Box Car Loading - North of Entr			147	0934	1133	119	202	290	1463	70	347	24	
	11	Outside plant - South			136	0858	1614	436	741	10	13	10	13	-	
	12	Outside plant - North			151	0852	1614	442	751	< 10	< 13	<10	< 13	-	
B	2	Packer No 3 - South	6/17	M5	156	1341	1604	143	243	30	123	24	99	80	Dry, no water in-
	3	Packer No 3 - North			141	1341	1604	143	243	20	82	19	78	95	jection or spray
	4	Packer No 3 - Eaest			153	1341	1604	143	243	10	41	<10	< 41	<100	on bags
	5	Conveyor Transfer - Upper Level			152	1341	1604	143	243	40	165	40	165	100	Normal operations
	6	Bag Transfer - Northwest			142	1340	1602	142	241	80	332	80	332	100	
	7	Bag Transfer - South			137	1340	1602	142	241	130	539	110	456	85	
	8	Bag Transfer - Northeast			138	1340	1603	143	243	80	329	60	247	75	
	9	Box Car Loading - South of Entr			154	1340	1601	141	240	510	2125	390	1625	76	
	10	Box Car Loading - North of Entr			140	1340	1601	141	240	410	1708	340	1417	83	
C	2	Packer No 3 - South	6/18	FW	7396	0802	1045	163	277	< 10	< 36	<10	< 36	(100)	Water injection
	3	Packer No 3 - North			7400	0802	1045	163	277	< 10	< 36	<10	< 36	(100)	and spray on bags
	4	Packer No 3 - East			7398	0802	1045	163	277	< 10	< 36	<10	< 36	(100)	
	5	Conveyor Transfer - Upper Level			7417	0801	1045	164	279	< 10	< 36	<10	< 36	(100)	Normal operations
	6	Bag Transfer - Northwest			7409	0758	1045	167	284	20	70	<17	< 66	< 94	
	7	Bag Transfer - South			7403	0758	1045	167	284	30	106	27	95	90	
	8	Bag Transfer - Northeast			7408	0758	1045	167	284	10	35	<10	< 35	<100	
	9	Box Car Loading - South of Entr			7392	0758	1045	167	284	270	951	110	387	41	
	10	Box Car Loading - North of Entr.			7404	0758	1045	167	284	220	775	70	246	32	
	11	Outside - South			7395	0737	1511	454	772	< 10	< 13	<10	< 13	-	
	12	Outside - North			7397	0745	1508	443	753	< 10	< 13	<10	< 13	-	
D	2	Packer No 3 - South	6/18	FW	7411	1204 1324	1254 1504	150	255	< 10	< 39	<10	< 39	(100)	Water injection into product
	3	Packer No 3 - North			7415	1204 1324	1254 1504	150	255	< 10	< 39	<10	< 39	(100)	Normal operations
	4	Packer No 3 - East			7399	1204 1324	1254 1504	150	255	< 10	< 39	<10	< 39	(100)	

Appendix B (Cont'd)

Environmental Data - MSA Gravimetric Sampler

Run	No	Location	Date	Filter #		Time Start	Time Stop	Durat min	Volume* Liters L	Total Dust Mass ug	Total Dust Conc ug/m 3	Silica Dust Mass ug	Silica Dust Conc ug/m 3	Silica Content %	Control Condition and Remarks
D	5	Conveyor Transfer - Upper Level	6/18	FW	7414	1204 1324	1254 1504	150	255	< 10	< 39	< 10	< 39	(100)	
	6	Bag Transfer - Northwest			7410	1203 1323	1252 1500	146	248	10	40	< 10	< 40	100	
	7	Bag Transfer - South			7393	1203 1323	1254 1501	149	253	< 10	< 40	< 10	< 40	(100)	
	8	Bag Transfer - Northeast			7394	1203 1323	1254 1500	148	252	20	79	20	79	100	
	9	Box Car Loading - South of Entr			7413	1203 1323	1252 1501	147	250	360	1440	360	1440	100	
	10	Box Car Loading - North of Entr			7406	1203	1252	146	248	220	887	220	887	100	
E	2	Packer No 3 - South	6/19	M5	144	0813 1103	1038 1157	199	338	30	89	19	56	-	Spray on bags
	3	Packer No 3 - North			139	0813 1103	1038 1157	199	338	10	30	< 10	< 30		Normal operations
	4	Packer No 3 - East			150	0813 1103	1038 1157	199	338	20	59	< 20	< 59	< 100	
	5	Conveyor Transfer - Upper Level		FW	7412	0813 1103	1038 1157	199	338	< 10	< 30	< 10	< 30	(100)	
	6	Bag Transfer - Northwest			no sample taken										
	7	Bag Transfer - South			7416	0815 1103	1039 1156	197	335	50	149	50	149	100	
	8	Bag Transfer - Northeast			7405	0815 1103	1039 1156	197	335	< 10	< 30	< 10	< 30	(100)	
	9	Box Car Loading - South of Entr			7407	0815	1039	144	245	220	898	60	245	27	
	10	Box Car Loading - North of Entr			7402	0815	1039	144	245	160	653	40	163	25	

< less than
( ) low degree of acuracy and reliability
*all samples run at 1 7 liters per minute (lpm)

Appendix C

Environmental Data - Del Electrostatic Sampler

Run	Location	Date	Sampler Tube	Time		Durat. min.	Volume* CF	Total Dust		Silica Dust		Silica Content
				Start	Stop			Mass	Conc	Mass	Conc	
								mg	ug/m^3	mg	ug/m^3	%
A	Conveyor, left of operator, Packer No. 3	6/17	3	0988	1349	241	4097	27	233	13.23	115	49
B	Conveyor, left of operator, Packer No. 3	6/17	1	1351	1604	133	2261	18	281	18.0	281	100
C-D	Conveyor, left of operator, Packer No. 3	6/18	12	1034	1504	270	4590	12	92	11.16	86	93

* all samples run at 17 cubic feet of air per minute (CFM)

Ottawa Silica Company