IN-DEPTH SURVEY REPORT:

CONTROL TECHNOLOGY FOR BAG FILLING OPERATIONS

AT

MANVILLE PRODUCTS CORPORATION

LOMPOC, CALIFORNIA

REPORT WRITTEN BY:

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SURVEY DATE: January 17 - 21, 1983

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ABSTRACT

An in-depth survey of three high volume, valve-type bagging operations of calcined and fluxed calcined diatomite was conducted at Manville Products Corporation in Lompoc, California. Two of the systems were high volume, manual bagging operations which involved filling hand-tucked-valve bags. The third system consisted of a completely automatic, high volume system for filling pasted-valve bags. Controls included automation; ventilated capture hoods at the packers and in the palletizing areas; and a combination of ventilated and non-ventilated hoppers and hoods beneath the packers and conveyor belts.

Area, source, and personal respirable dust samples were collected and analyzed. Air velocity, volumetric flow rates, and flow patterns were obtained and evaluated for the bagging and palletizing areas. The relationship between the occupational atmospheric dust exposures and control systems were evaluated.

The control technology systems at this plant were capable of maintaining average respirable "free" crystalline silica dust (cristobalite) concentrations below 0.03 mg/M^3 at the two manual packaging stations being evaluated. At the automated packaging station, these concentrations were maintained below 0.02 mg/M^3.

I. INTRODUCTION

BACKGROUND FOR CONTROL TECHNOLOGY STUDIES

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. Located in the Department of Health and Human Services (formerly DHEW), it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; cotton dust control in yarn manufacturing; the plastics and resins industry; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of phases. Initially, several walk-through surveys are conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

BACKGROUND FOR THIS STUDY

Dust concentrations around bagging operations are often high. This causes higher potential exposures to the worker than many other processes. NIOSH Health Hazard Evaluation reports and other study reports involving bag filling operations for dry chemicals often mention the high dust concentration in and around the bagging area.[1-9] These reports describe the bagging processes as one of the biggest dust problems in need of effective dust controls and that the highest potential dust exposures is to the operator at the bagging filling machine.

It is estimated by packer manufactures that there are over 20,000 dry chemical packaging operations in the United States. Force flow, auger, gravity feed and other types of packers fill open-top and valve-type bags with powders, granules, and fibers. Many of these packer machines are 10 to 20 (some over 40) years old. Built-in dust controls are often either minimal or nonexistent in the older units. Many of todays packers use only partially effective measures, such as an exhaust hood around the spout, to capture airborne dust during bag filling. More complete control measures must be developed and installed by the user to ensure adequate protection for the equipment operators and others who work in the bagging area.

NIOSH has worked cooperatively with firms in many industries to identify and help solve problems in occupational health. The main purpose of this study is to assess and document the strategies used to control airborne dust in the bag filling areas. These control strategies included engineering measures such as ventilation, automation, isolation; equipment and product modification; monitoring systems; work practices; personal protective equipment; and health and safety training programs. The results of this study will be described in sufficient detail to allow the information to be used to reduce exposures of workers to toxic or hazardous substances that may be encountered in other similar industrial operations.

The product of this research will be resource documents/articles containing practical ideas on control methods. Such documents will enhance the design engineer's understanding of industrial hygiene principles and also enable the industrial hygienist to participate more effectively in the design and improvement of control equipment. The results of the assessment will be disseminated in a manner that will maximize the application of demonstrated control technologies in the workplace. The study will have a positive impact on worker health by pin-pointing and stimulating the across-the-board use of good control methods as solutions to occupational health problems.

BACKGROUND FOR MANVILLE SURVEY

Manville's Lompoc Operation was selected for evaluation because of several demonstrated exemplary controls used in packaging calcined and flux-calcined diatomite (DE). Also, epidemological studies by the Public Health Service indicates that the potentially toxic dust has been well controlled.[10-13] (Diatomite, frequently designated diatomaceous earth, diatomaceous silica, or kieselguhr, is composed of the silicious skeletons of microscopic, cellular, aquatic plants known as diatoms.) The areas of primary interest were the bag filling operations and related packaging operations, such as conveying and palletizing. The control systems evaluated were: the packer control hoods; the control hoods for bag spillage during bag filling, handling, and conveying; the exhaust ventilation systems for the various packaging operations; and automation of an entire packaging, conveying and palletizing system. The sampling strategy was geared to evaluate the effectiveness of these various dust control hoods, the related ventilation systems, the automated system, and other controls.

II. PLANT AND PROCESS DESCRIPTION

INTRODUCTION

Manville Products Corporation (headquartered in Denver, Colorado) produces a variety of diatomite products at their Lompoc Operation. Most, 85% to 90%, of their product is shipped in bags (10% to 15% in bulk) and is used in many products as a filler or filteraid. The operation is located in a rural area three miles south of Lompoc, California. Diatomite has been produced from this location since 1898 (Manville taking over in 1928). Presently, this large operation consists of a quarry, several horizontal kilns, and numerous processing buildings spread over several acres.

The areas of primary interest are the packaging operations located in Buildings 1148 and 1155, Figure 1. The buildings are steel frame and metal sided structures, concrete floors, no basements, and each having over 100,000 square feet of floor space. Within these two buildings, there are approximately 20 packaging stations containing nearly 50 packer units, with 1 to 6 units per station. Additional packaging stations are located in a third building. Most of these stations are high volume packaging (approximately 1000 to 3000 pounds per hour per packer machine) operations containing 4 to 6 manually operated, force flow, spout-type packers used to fill hand-tucked valve bags. The remaining stations are low volume packaging (averaging less than 400 pounds per hour per packer machine) operations containing one to two manually operated, force flow, spout-type packers used to fill hand-tucked and pasted-valve bags. Most of the dust controls at these stations are similar in design.

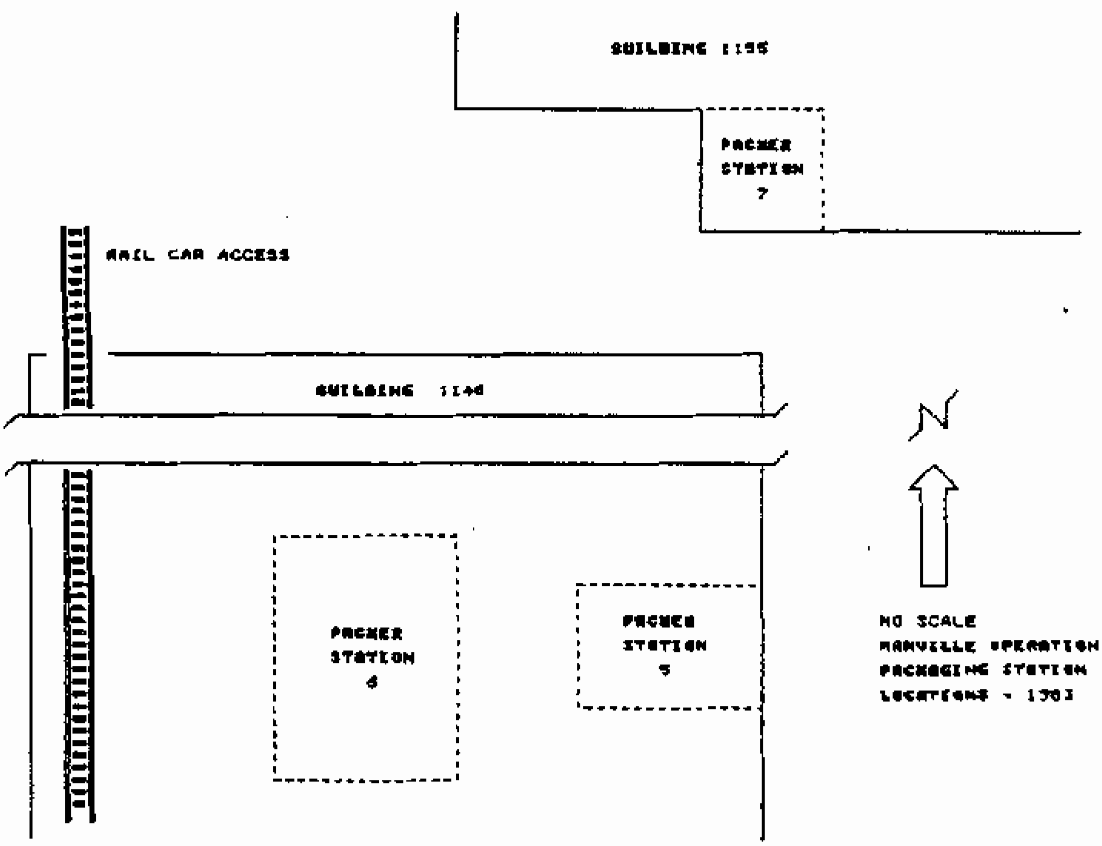


Figure 1: Packaging Stations 5, 6, and 7

The three packaging stations evaluated are high volume packaging operations. The dust control systems, though similar in design, have the following variations: Station 6 is a completely automated operation consisting of a combination of ventilated (control hoods) and non-ventilated (spillage hoppers) controls. Station 7 is a manual operation consisting of extensive ventilated (packer hoods and spillage hoppers) controls. Station 5 is a manual operation consisting of a combination of ventilated (packer hoods) and non-ventilated (spillage hoppers) controls.

An all-automated, high volume, four-spout packaging station (Station 6) for filling pasted valve bags was installed. The company plans to install additional automated stations to upgrade their high volume packaging system.

The workers at this plant are represented by the International Chemical Workers Union, Local 146. The plant operates 24-hours-a-day, 7-days-a-week and presently has a work force of nearly 500. Of these, 115 (14 salary, 45 packers, and 56 janitors, laborers, and fork-lift operators) are in the powder-mills where packaging (bag filling and palletizing) takes place. At the high volume, manual packer stations, the average crew consist of two members, a packer and a palletizer. At the low volume manual packaging stations, one employee both packs and palletizes. At the automatic packaging station, one employee operates the total system of packing, conveying and palletizing.

PROCESS DESCRIPTION

Manville annually processes 250,000 to 350,000 tons of ore from the world's largest and purest diatomite deposit. The diatomite, an amorphous silica, is selectively mined with bulldozers and loaders from a quarry located next to the plant. Loaders fill bottom dump trucks which empty into 13 glory holes. The ore is moved by open, electric trolley, ore cars in underground tunnels from the glory holes to crushers (spike and hammer). Then the ore is conveyed on belts to 15 crude storage bins. A picker manually removes chert and other waste material. The ore, averaging 40% moisture, is dried and processed in one of five rotary kilns at temperatures up to 2000^{o}F yielding natural, calcined, or flux-calcined diatomite. This material is then stored in product bins until either shipped or packaged.

Natural diatomite is a gray product containing less than 1% crystalline silica. Calcined diatomite is diatomite heated to 1600 to 1800°F to produce a pink product containing 10% to 35% crystalline silica as cristobalite. Flux-calcined diatomite is heated to approximately 2000°F while being mixed with a flux such as sodium carbonate yielding a white product containing 16% to 64% crystalline silica (mostly cristobalite). The products being packaged during the study were: Celite 512, calcined product (approximately 40% minus 10 micrometers and 95% minus 40 micrometers); Hyflo Super-Cel, flux-calcined product (approximately 35% minus 10 micrometers and 95% minus 125 micrometers); and Celite 545, flux-calcined product (approximately 5% minus 10 micrometers and 95% minus 125 micrometers).

Most of the bag filling is performed at the eighteen manual and one automatic packaging stations located in Warehouse 1148 and 1155. Multi-ply, kraft paper bags are supplied by International Paper Company, St. Regis Paper Company, and other bag manufactures in 10, 25, amd 50 pound sizes. Both pasted-valve and hand-tucked valve bags are used. The high volume, manual packaging stations are similar in design and operation, filling 50 pound bags. The packers are force flow, spout type packers, manufactured by several different companies, including Manville and St. Regis. (Station 5, built in 1964, consists of St. Regis, model 400, low head, force flow packers. Station 7, built in 1969, packers are designed and built by Manville.)

At the high volume, manual operations, Stations 5 and 7, the packer operator manually places the hand-tucked valve bags on the six in-line packer spouts; activates a switch to fill; manually removes each bag from the packer spout; hand tucks the valve; and drops the filled bag onto an open, spring-type conveyor. The bags are transported a few feet over a series of conveyors to the palletizing area. The palletizer operator manually lifts each bag from the conveyor and drops it into the Press Well, an opening recessed into the floor, Figure 2. As the pallet fills, the operator activates a switch, lowering the Press Well floor. The full pallet is raised, pressing the pallet load against an overhead squeeze plate (cap). The compressed pallet load is lowered and conveyor discharged onto a gravity-type roller conveyor. (An average of 2.5 to 7.5 pallets, 48 bags per pallet, are filled each hour.) A forklift operator moves the loaded pallet to a storage area. The packer and palletizer operators rotate positions at 2 hour intervals.

Loading Pallet

Pressing Pallet Load

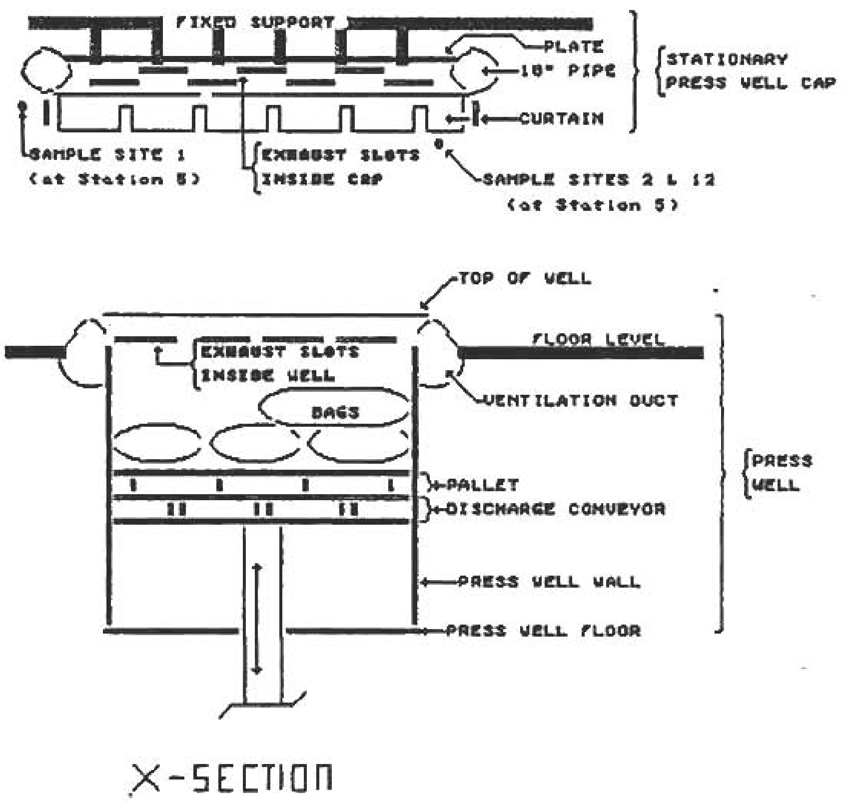


Figure 2: Press Well – Palletizing

Station 6, an automatic packaging/conveying/palletizing system was built in 1981 as a single bag filling unit. In 1982, the station was expanded to four automatic packers (manufactured by Packaging Systems International in Denver, Colorado). An automatic bag placer (manufactured by W. G. Durant in Palcentia, California) takes a pasted-valve bag from a stack of bags and places it onto a fillspout. The bag is filled with 50 pounds of product, automatically ejected onto a chain-type conveyor, and transported over a series of conveyors to an automatic palletizer. A forklift operator moves the loaded pallet to a storage area. One employee operates this station.

Based on customer demand, pallet loads of product are either shrink wrapped or stretch wrapped with plastic prior to shipment. Forklifts are used at the plant to move palletized product into railroad cars and trucks. Pneumatic systems are used to load bulk railroad hopper cars and trucks.

The company recycles bagged product that is either out-of-spec or in damaged bags. For individual damaged bags, bag recyclers are located at the manual packaging stations. The operator empties the contents of the bag into the recycler, setting aside the empty bag for later disposal (usually at two hour intervals), Photo 1. For pallet loads of off-spec material to be recycled, a forklift places the entire pallet load, less the pallet, into an overhead recycler (located between buildings 1148 and 1155), Photo 2. The recycler separates the product and paper. All discarded bags are buried.

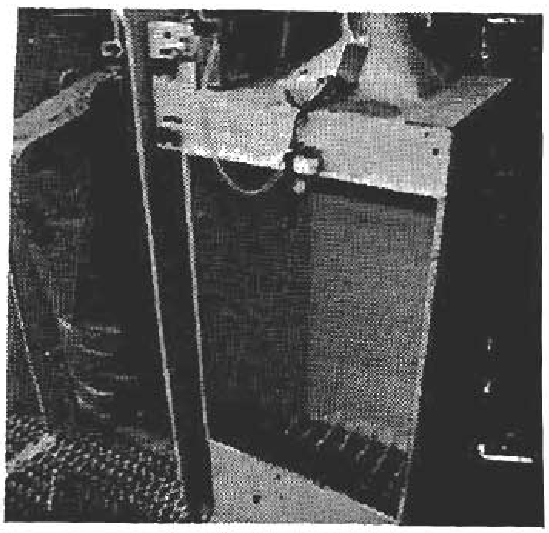


Photo 1: INDIVIDUAL BAG RECYCLER

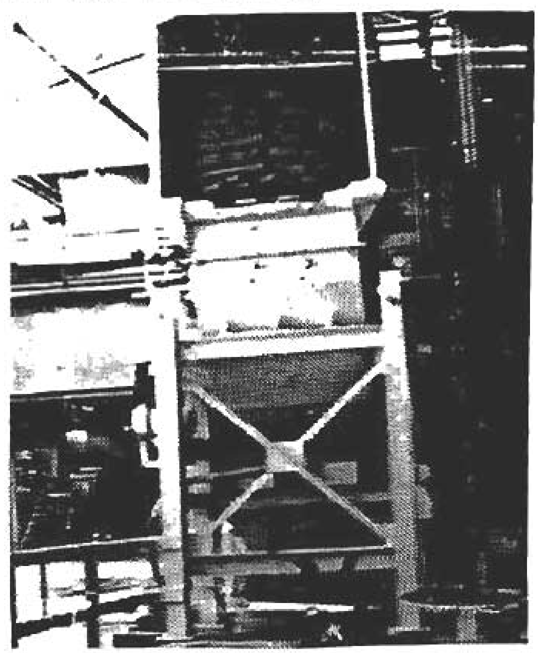


Photo 2: PALLET LOAD BAG RECYCLER

POTENTIAL HAZARDS

The primary health hazard during bagging and handling of calcined and flux-calcined diatomite is inhalation of airborne "free" crystalline silica dust mainly in the form of cristobalite. The dust can enter the workers' environment during normal packaging and other handling operations such as bag filling, bag recycling, conveying, palletizing, and transport. Inhalation is the significant route of exposure and the lungs the main target organ of the particles that are less than 10 micrometers in diameter. Repeated or prolonged exposures may cause diatomite pneumoconiosis; a chronic, nodular pulmonary fibrosis. Usually, with moderate exposure, the disease takes 20 or more years to develop into a chronic form of silicosis. However, symptoms can begin within 4 months in areas of extremely high exposures to cristobalite. The resultant fibrotic damage is irreversible, with no known treatment available and may be superimposed with tuberculosis.[14, 15]

Unrefined diatomite is mostly amorphous (noncrystalline) silica, containing less than 2% crystalline silica. When refined (calcined) at high temperatures, 10% to 30% of the amorphous silica is transformed into cristobalite, a crystalline silica. When calcined with a caustic flux (Na_2CO_3) at high temperatures, approximately 60% of the amorphous silica is transformed into cristobalite. Another crystalline silica form, quartz (usually less than 2%) may also be present in small quantities. Calcined diatomite is one of the main sources of possible human exposure to cristobalite.[16]

The current OSHA standard regulating occupational exposure to respirable "free" crystalline silica is found in 29CFR1910.1000, Table Z-3 and in Table 1 of this report.

Table 1. Summary of Standards, Recommended Standards, and Major Health Effects of Hazards Association with Crystalline "Free" Silica.

Respirable Crystalline Silica

Materials or Agents	PEL[1] (mg/M^3)	TLV[2] (mg/M^3)	NIOSH[3] Recommended level (mg/M^3)	Major[4] Health Effects
Quartz	$\frac{10}{\% SiO_2 + 2}$	$\frac{10}{\% SiO_2 + 2}$	0.05	Diatomite Pneumoconiosis
Cristobalite	$\frac{5}{\% SiO_2 + 2}$	$\frac{5}{\% SiO_2 + 2}$	0.05	Diatomite Pneumoconiosis
Amorphous silica (including natural DE)	$\frac{80}{\% SiO_2}$	5	NA	

[1] Permissible Exposure Limit; this is the legally enforceable standard by OSHA, 29CFR1910.1000, 1976[17]. For quartz and cristobalite, this is the legally enforceable standard by California OSHA, Title 8, Section 5155.[18] For amorphous silica (including natural DE), the Cal-OSHA PEL is 20 mppcf (million particles per cubic foot).

[2] Threshold Limit Value; this is a voluntary level recommended by the American Conference of Governmental Industrial Hygienists[19]. In 1983-4, the ACGIH is recommending a change to eliminate the formula, so that the standard will be 0.1 mg/M^3 for respirable quartz dust, 0.05 mg/M^3 for respirable cristobalite dust, and 5 mg/M^3 respirable DE (uncalcined).

[3] Revised Recommended Occupational Exposure to Crystalline Silica. NIOSH PUB. 75-120[20]

[4] Pneumoconiosis in Diatomite Mining and Processing. [21]

For this study, the time-weighted averages (TWA) limits are; for quartz (0.10 mg/M^3), cristobalite (0.05 mg/M^3), and amorphous silica (5 mg/M^3). For mixtures of cristobalite and amorphous silica (quartz content, being less than 2%, does not significantly affect the PEL's and is omitted), Table 2 list the calculated PEL's at various % cristobalite levels.

Table 2. Calculated PEL's in mg/M^3 based on % cristobalite and % amorphous silica are;

% Cristobalite	PEL in mg/M^3
0	5
15	0.32
16	0.30
19	0.25
20	0.24
50	0.10
100	0.05

$$PEL = \frac{1}{\frac{f_1}{PEL_1} + \frac{f_2}{PEL_2}}$$

f_1 = % cristobalite

f_2 = % Amorphous silica = 100% - % cristobalite. (Quartz treated as 0%)

PEL_1 = 0.05 mg/M^3 for cristobalite.

PEL_2 = 5 mg/M^3 for amorphous silica, $PEL = \frac{10}{\% SiO_2 + 2}$, where SiO_2 = 0%.

III. METHOLOGY

LIST OF EQUIPMENT

The equipment used in the study to measure airborne silica concentrations (area, personal, and sources) and ventilation rates are listed in Table 3.

The Model G pumps, calibrated at 1.7 liters/minute, draws the sample through a 10 mm nylon cyclone (the high volume, 9.0 liters/minute samples, through a 0.5 inch HASL cyclone) onto a preweighed, 37 mm polyvinylcholride (PVC) membrane filter. The filters, 5 micrometers pore size, were housed in closed-faced, two-piece cassettes.

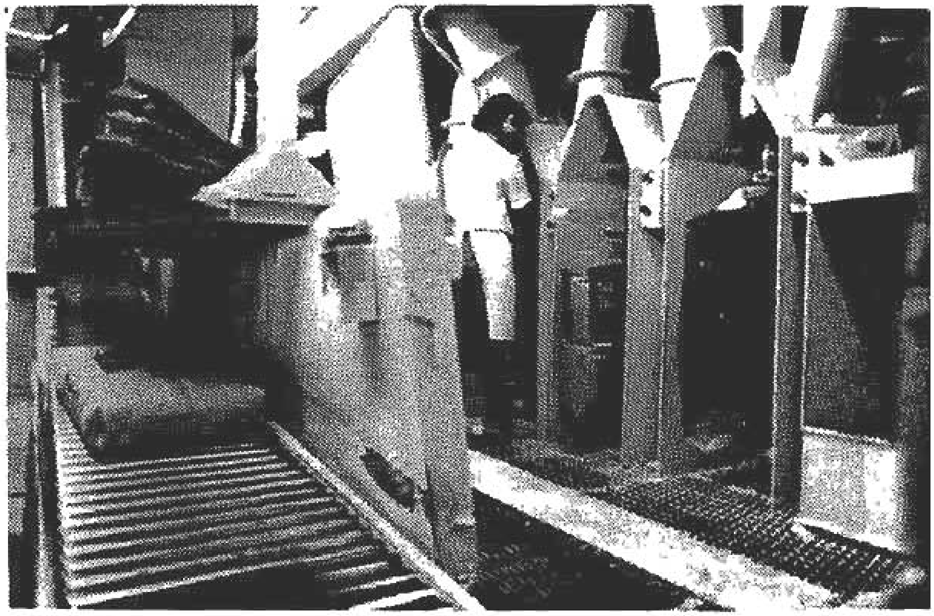
Table 3. Equipment Used in the Study;

Item	Model	Used for
Air Sampling:		
Pumps with Cyclones	MSA Model G Pumps	Collecting respirable airborne dust samples at a flow rate of 1.7 liters/minute
High Volume Pumps with Cyclones		Collect respirable airborne dust samples at a flow rate of 9.0 liters/minute
2 piece Filter Cassettes	M5 PVC Millipore	To collect airborne samples
Ventilation Measurements:		
Air Vel. Meter	TSI Model 1650	Ventilation measurements
Air Vel. Meter	Kurz Model 441	Ventilation measurements
Pitot Tube		Ventilation measurements
Incline Manometer		Ventilation measurements
Smoke Tubes	Gastec	Determine air movement

MEASUREMENT OF CONTROL PARAMETERS

At the Manville Plant, three separate bag filling operations were studied; Stations 5 and 7 (high volume, manual packaging) and Station 6 (high volume, automatic packaging). The effectiveness of the control methods for airborne respirable dust were evaluated quantitatively by taking airborne dust samples and ventilation measurements. Also, side-by-side samples were collected by Manville Products Corporation at several NIOSH sampling sites.

Atmospheric Dust Measurements - To evaluate the effectiveness of the dust control systems at the three packaging stations, airborne samples were collected by NIOSH. These samples were used to determine respirable dust exposures to the packaging operators; to locate and quantify possible sources of environmental respirable dust contamination; and to determine background respirable dust levels for the stations. Sampling was performed over 6 to 8 hour periods, starting on second shift (8 A.M.) and extending into third shift when needed. Personal samplers were removed from the operator during their lunch breaks, set in the packer station area, and left running. Sample sites are shown in Figures 3, 4, and 5. Sites sampled for potential airborne respirable dust sources were; near the packer hoods, along the conveyor line,



Bag Filling Station

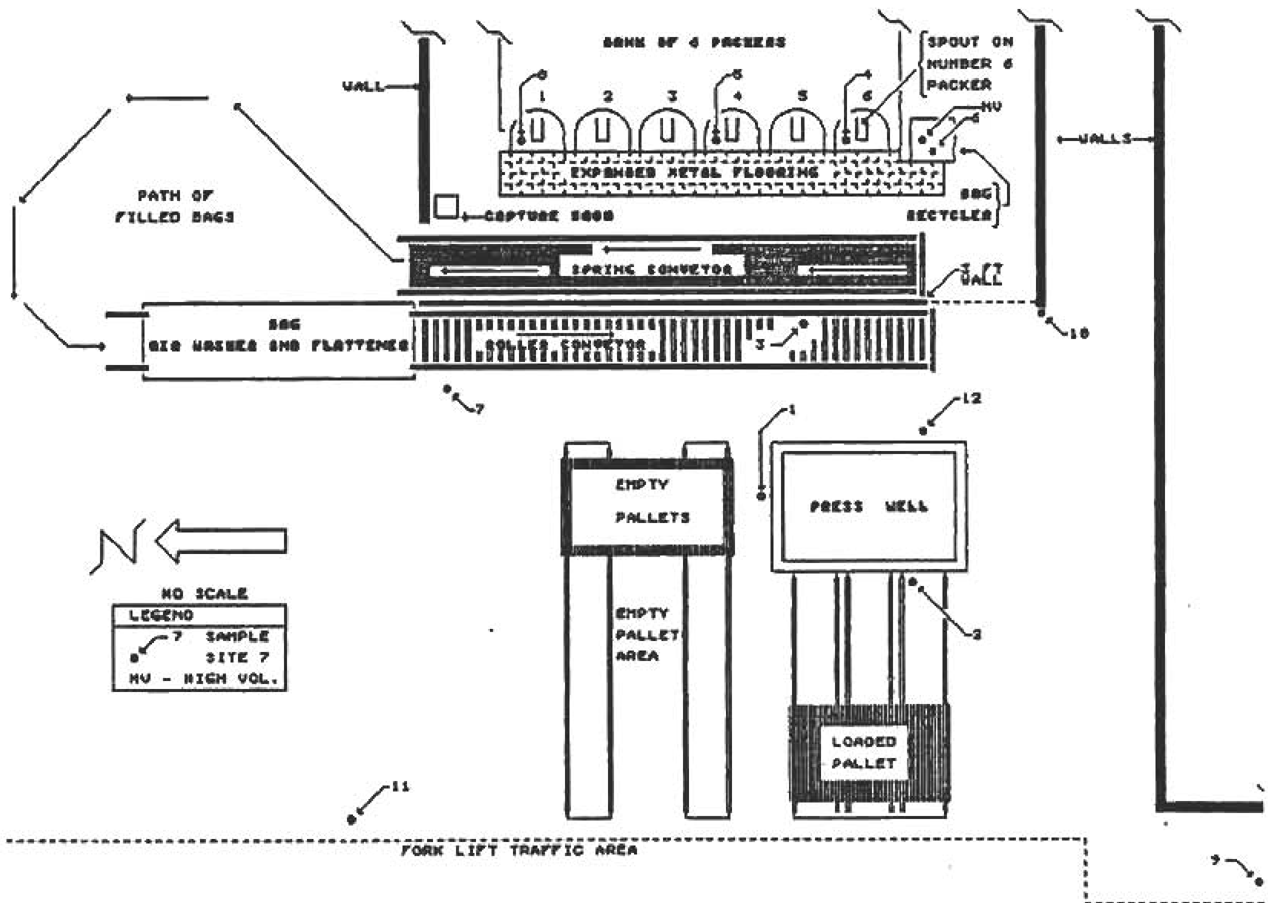
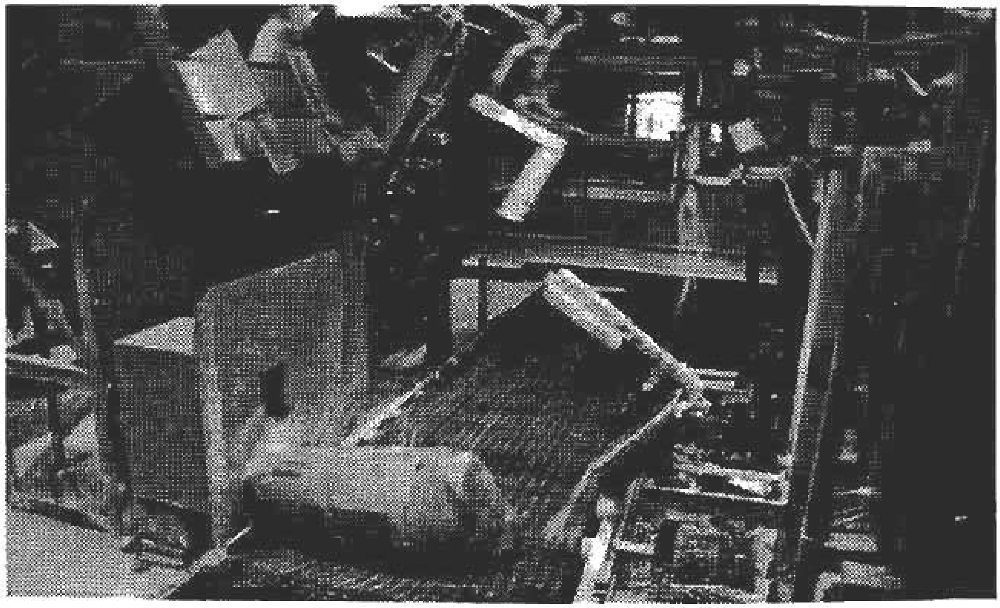
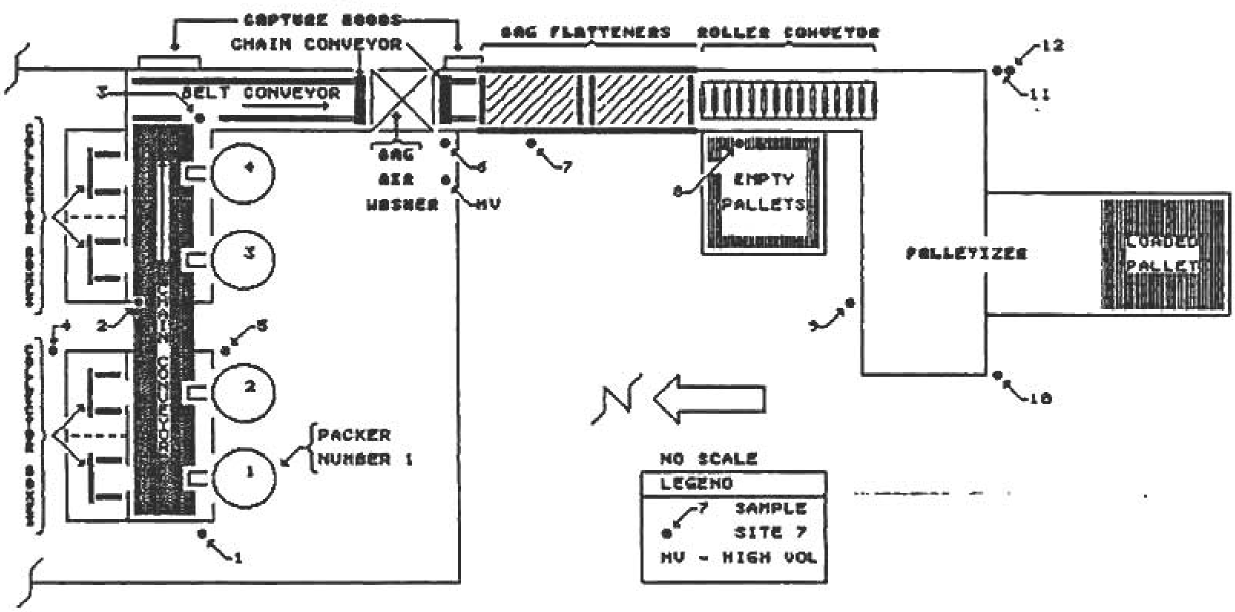


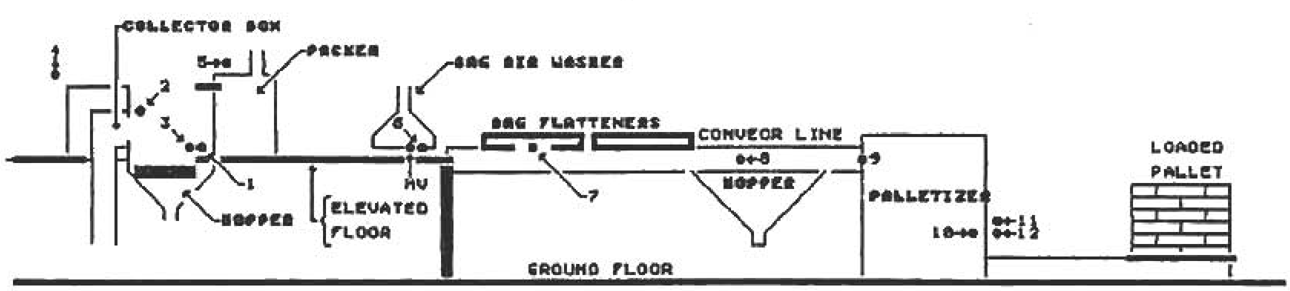
Figure 3: Packer Station 5



Bag Filling Station

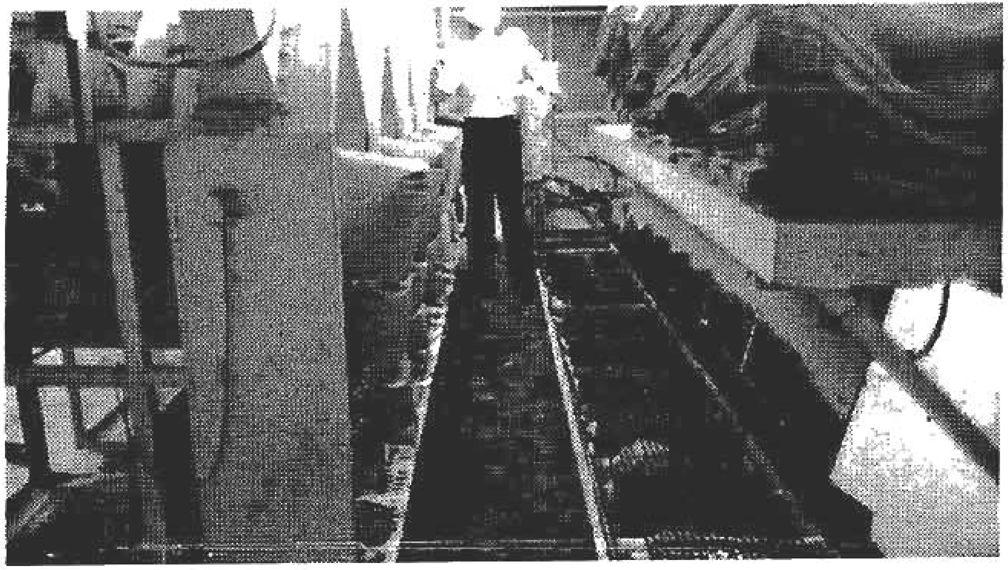


PLAN VIEW

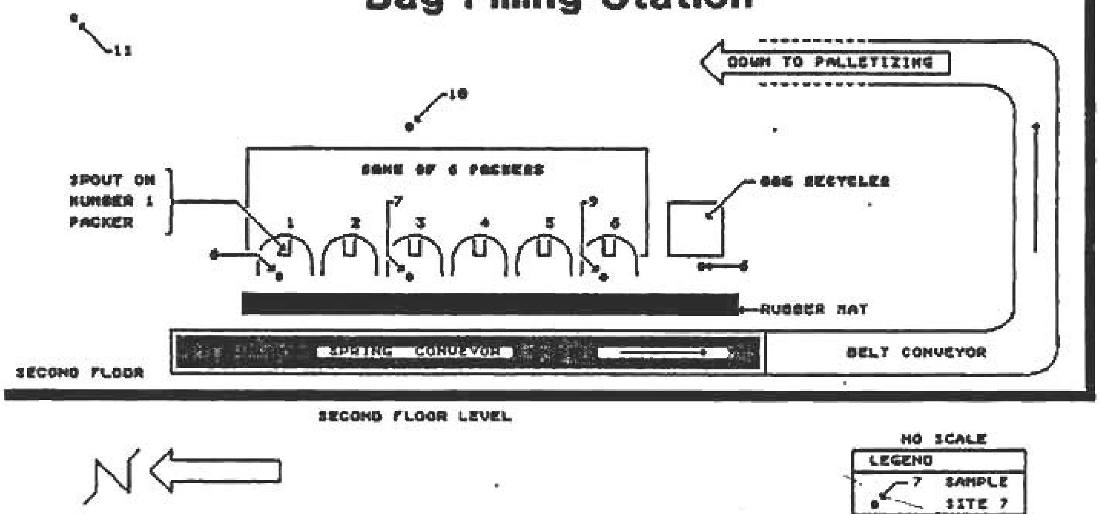


X-SECTION

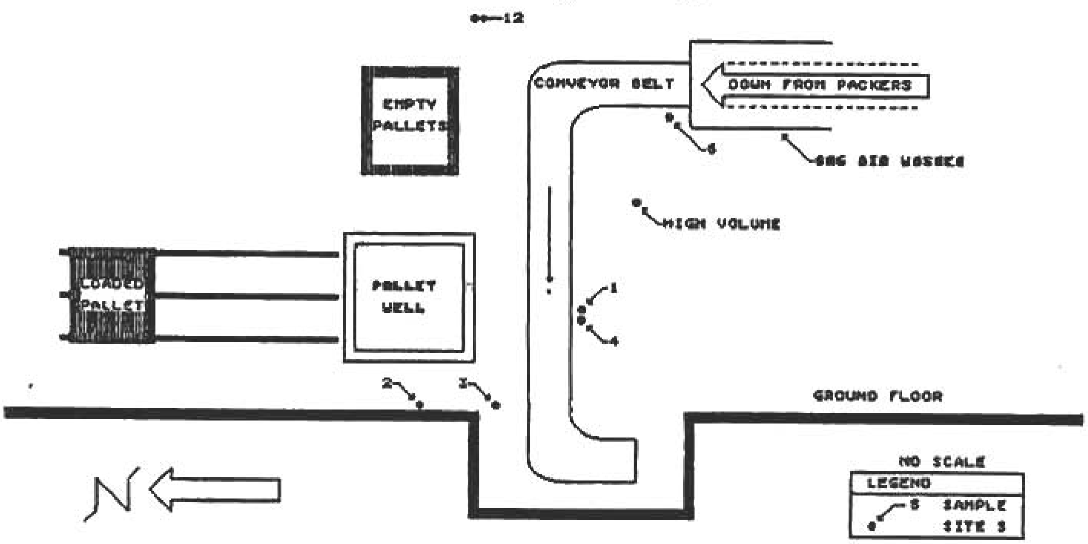
Figure 4: Packer Station 6



Bag Filling Station



Bag Filling Area



Palletizing Area

Figure 5: Packer Station 7

and near the palletizing stations. Area sample sites were located to determine the background levels at these stations for comparison with potential source concentrations.

Ventilation Measurements - Ventilation measurements were taken in exhaust ducts using a pitot tube and manometer to determine airflow from specific exhaust hoods. Air velocity measurements using a hot wire anemometer were taken at hood openings where emissions of respirable dust into the ambient air were likely. The in-duct measurements were compared, where possible, between the designed values (Figures 6 and 7) and the actual performance. Personal, source, and area sampling for respirable dust were performed along with the ventilation measurements to determine, if the "free" crystalline silica dust was being controlled to sufficiently low levels.

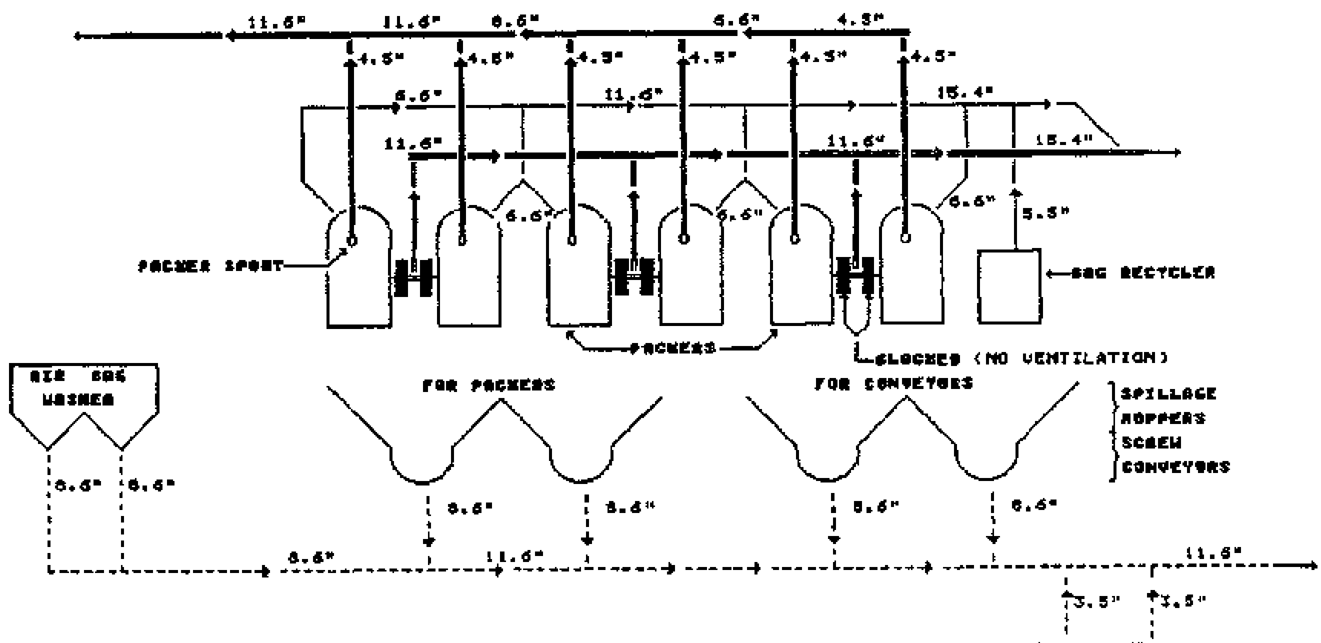


Figure 6: Designed Ventilation Ducting – Station 5

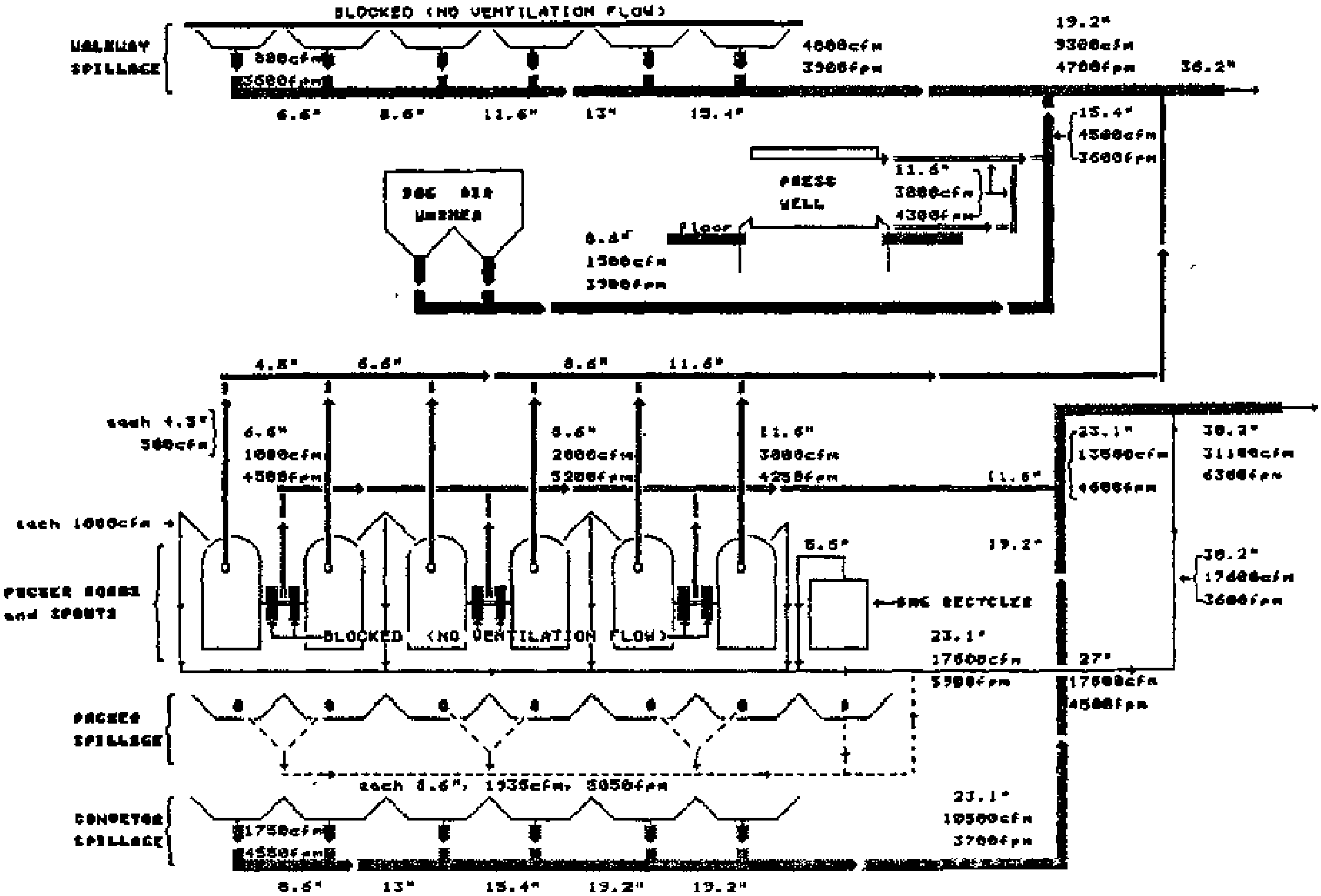


Figure 7: Designed Ventilation Ducting and Flow – Station 7

Smoke tube traverses were made of the air flow patterns in each bagging room, at the openings to the various enclosures, and at the packer hood faces. Also noted were weather conditions and operating abnormalities.

SAMPLING PROCEDURES

A total of 84 source, 51 area, and 14 personal air samples for respirable silica and respirable total dust were collected over four consecutive days. Standard samples (flow rate of 1.7 liters/minute) were collected at 34 fixed locations and on 5 personnel (packaging operators). Also, three additional high volume sample (flow rate of 9.0 liters/minute) were collected at at each packaging station being studied to determine the composition of the airborne dust. Two months following this study, 4 bulk samples of product, similar to the product being packaged during the study, were obtained from the Company for analysis. All air samples were collected during normal packaging operations on second and third shift.

The results for the respirable fractions of the bulk samples are shown in Table 7. The results for the respirable air filter samples are shown in Tables 8A, B, and C. One respirable airborne dust sample (sampling rate of 1.7 liter/min.) was particle sized and chemically analyzed by the NIOSH Measurements Research Support Branch (MRSB), Appendix B-B.

IV. CONTROL TECHNOLOGY

INTRODUCTION - PRINCIPLES OF CONTROL

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, personal protection, administrative measures, and monitoring. These principles may be applied at or near the hazard source, to the general workplace environment, or at the point of occupational exposure to individuals. Controls applied at the source of the hazard, including engineering measures (process/equipment modification, isolation or automation, local ventilation) and work practices, are generally the preferred and most effective means of control both in terms of occupational and environmental concerns. Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping. Control measures may also be applied near individual workers, including the use of remote control rooms, isolation booths, supplied-air cabs, work practices, and personal protective equipment.

In general, a system comprised of all of the above control measures is required to provide worker protection under normal operating conditions as well as under conditions of process upset, failure and/or maintenance. Process and workplace monitoring devices, personal exposure monitoring, and medical monitoring are important mechanisms for providing feedback concerning effectiveness of the controls in use. Ongoing (scheduled) monitoring and maintenance of controls to insure proper use and operating conditions, and the education and commitment of both workers and management to occupational health are also important ingredients of a complete, effective control system. These principles of control apply to all situations, but their optimum application varies from case-to-case. The application of these principles at Manville Products Corporation for bag filling and palletizing operations is discussed throughout this section.

EVALUATION OF CONTROLS

A. Use of Capture Hoods, Ventilated and Non-ventilated, during Packaging Operations:

Ventilation is an engineering control procedure used to reduce airborne dust emissions into the worker's environment. Also used to reduce airborne dust emissions are hoppers to collect and remove spillage that occurs during packaging operations. Most of these hoppers are non-ventilated. At the three packaging stations evaluated (Stations 5, 6, and 7), a combination of controls and equipment design are used during bag filling, handling, conveying, and palletizing operations. These measures included the use of ventilated hoods at packers, bag recyclers, conveyor transfer points, bag air-washers, bag flatteners, packer/operator expanded metal walkways, and press wells (palletizing), and other ventilated capture hoods; and ventilated and non-ventilated hoods to capture packer and conveyor spillage.

1. Packer Hoods, Stations 5 and 7: At these two manual packaging stations, there are 6 in-line packer units per station, each unit being equipped with a hood, Figures 8 and 9. The packer hoods at Stations 5 and 7 are similar in design, approximately 18 inches deep by 20 inches wide by 67 inches high. For the typical (24"x36") bag being filled, over three fourths of the bag is within the hood enclosure. Air is exhausted from the hood in four directions; toward the back through the packer spout capture slot, up through the hood top, through one side of the hood, and down through the floor of the hood. The total air designed to be exhausted from each hood enclosure is approximately 4000 cfm (averaging over 450 fpm per square foot of open area), Figure 7.

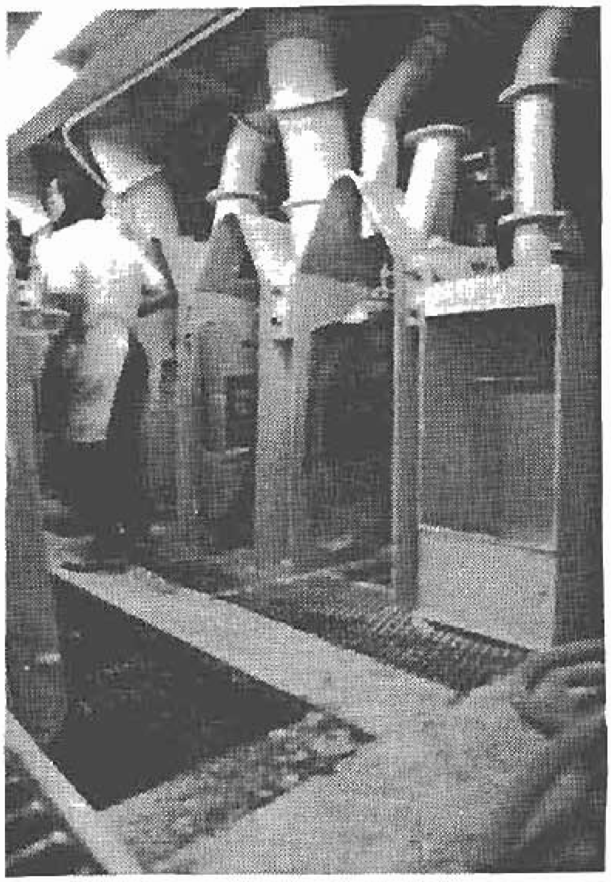
a. Packer Spout, Stations 5, 6, and 7: A narrow slot around the packer spout is connected to a 4.5 inch duct. The designed air flow entering this slot is 500 cfm (approximately 4500 fpm). The purpose of ventilation at the spout is to capture the airborne dust escaping from the bag's valve during bag filling.

b. Hood Top, Stations 5 and 7: On one side of the sloping top of each hood, there is a (6"x6") opening connected to a 6.6" O.D. duct designed to exhaust at 1000 cfm (4000 fpm at the opening). The opening is located above the packer spout, Figure 8. Its primary purpose is to capture airborne dust leaking form the bag's top seam during filling and dust knocked from the bag's valve during hand tucking (closing) operation.

c. Hood Side, Stations 5 and 7: In the middle and on one side of the hood is a (6"x12") opening connected to a 6.6" O.D. duct, Figures 8 and 9. It is designed to exhaust 1000 cfm (2000 fpm at the opening). The opening, located just below the packer spout, is designed to remove airborne dust generated within the hood during bag filling and bag valve closing operations. (At the stations being evaluated, this part of the system was not in use, having been blocked off. However, it was in use at other packer stations not being evaulated.)

d. Hood Floor - Ventilated, Station 7: The floor of each hood is expanded metal overlying a hopper, Figures 10 and 11. Each hopper is designed to exhaust nearly 2000 cfm, through each packer hood floor. The purpose of this part of the system is to capture spillage from the packer spout, product knocked from the bag's valve during closing, and spilled product in case of bag burst while in the hood.

2. Packer Spillage, Stations 5 and 7: The floor under each packer station is expanded metal overlying 2 non-ventilated hoppers. At Station 5, the expanded metal floor extends from 18" in front of the packer hoods, between and under the hoods (forming the packer hood floor) to the back of the hoods, Figures 8 and 9. At Station 7, the



Packer Hoods

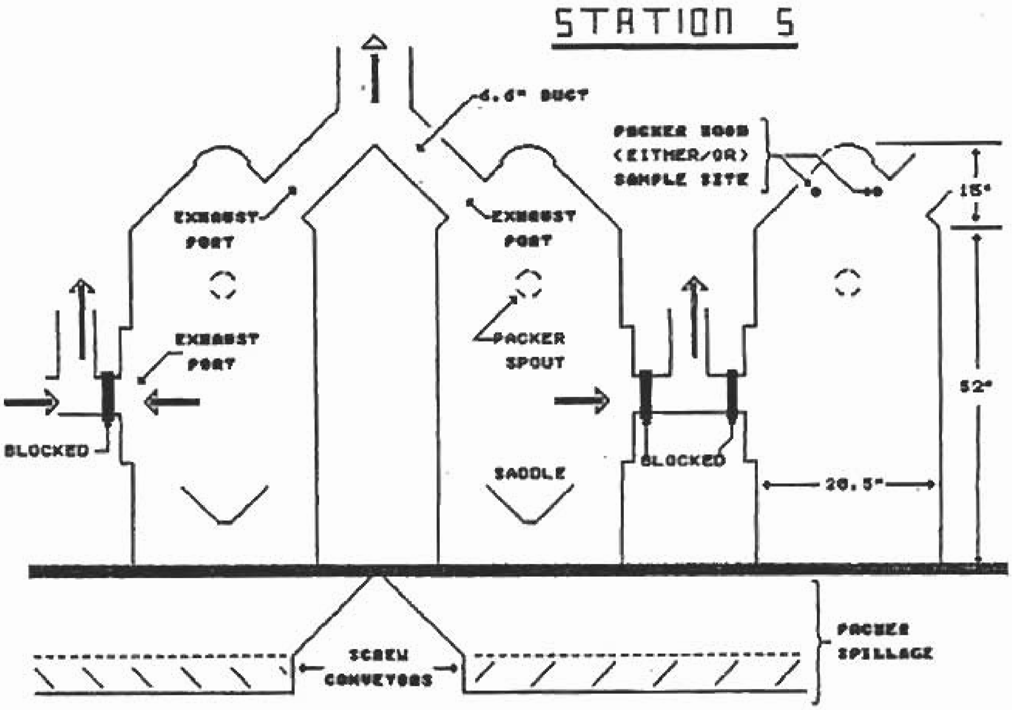


Figure 8: Packer Hoods and Spillage Hoppers - Station 5

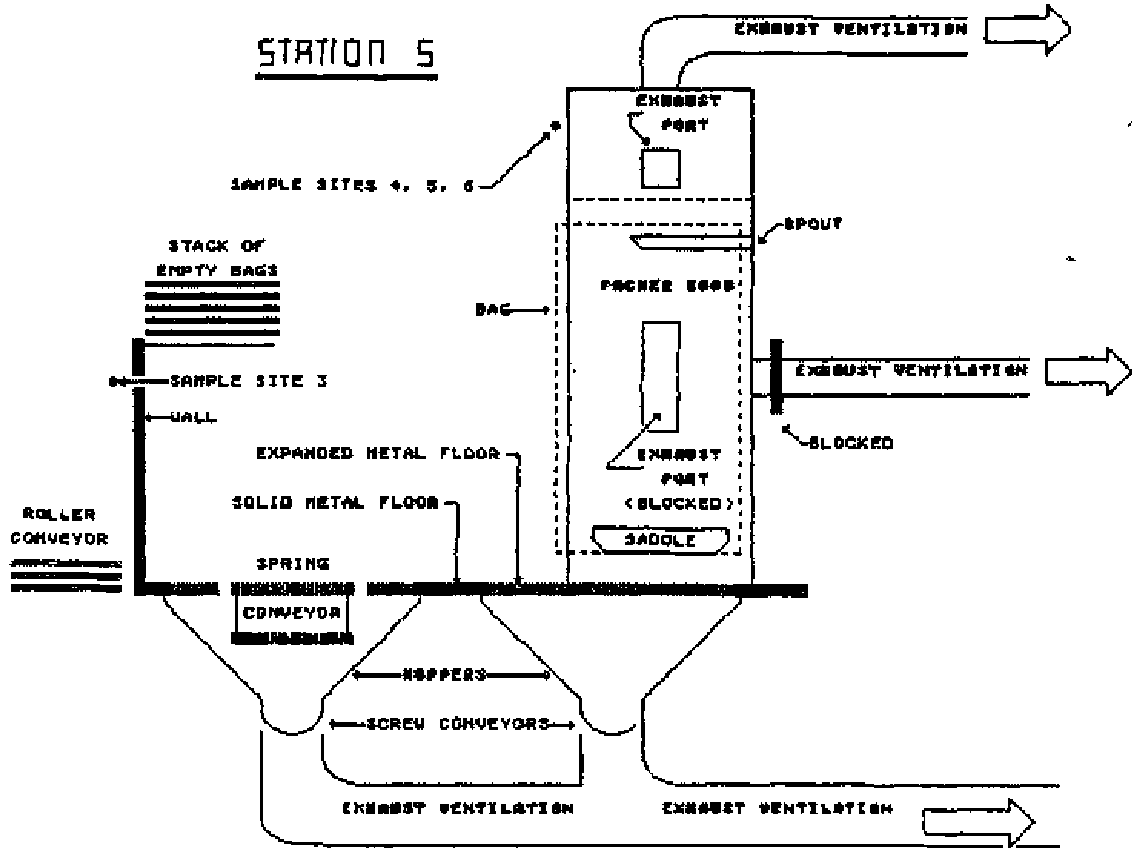


Figure 9: Packer Hoods and Spillage Hoppers (end view) – Station 5

expanded metal floor extends 6" in front of the packer hoods, between the hoods, and approximately two feet behind the hoods, Figures 10 and 11. Each hopper discharges the captured product by screw conveyor into the ventilation system. The purpose of this part of the system is to capture spillage from the packer spouts, bags, and leakage in the area of the packer units.

Packer Hoods

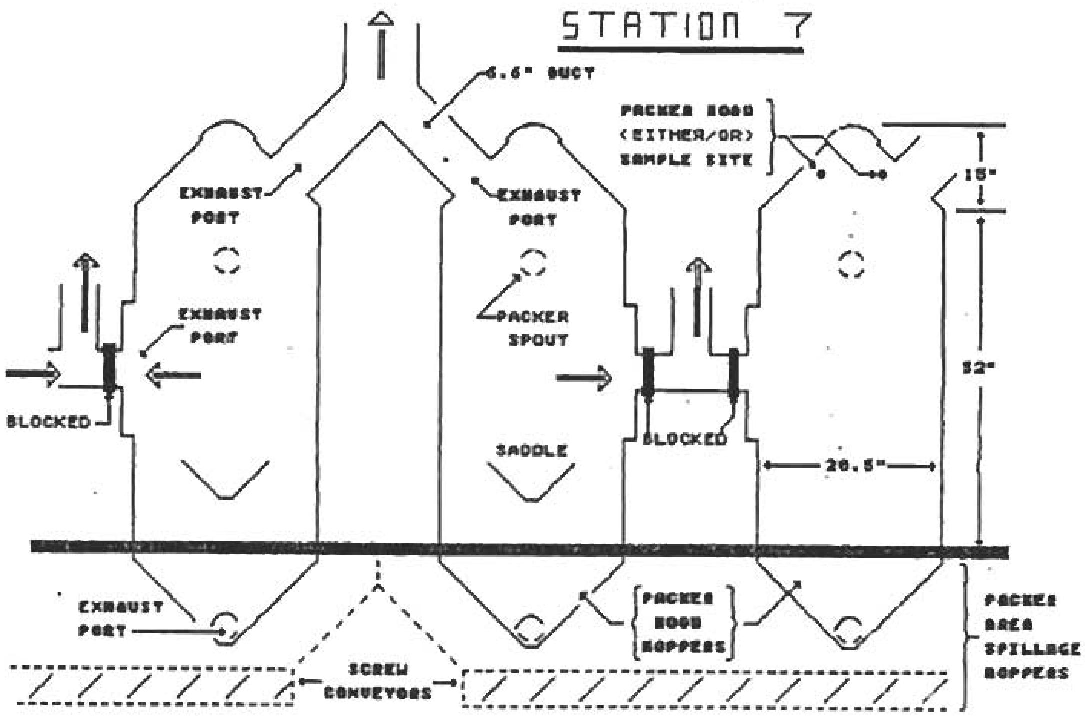


Figure 10: Packer Hoods and Spillage Hoppers – Station 7

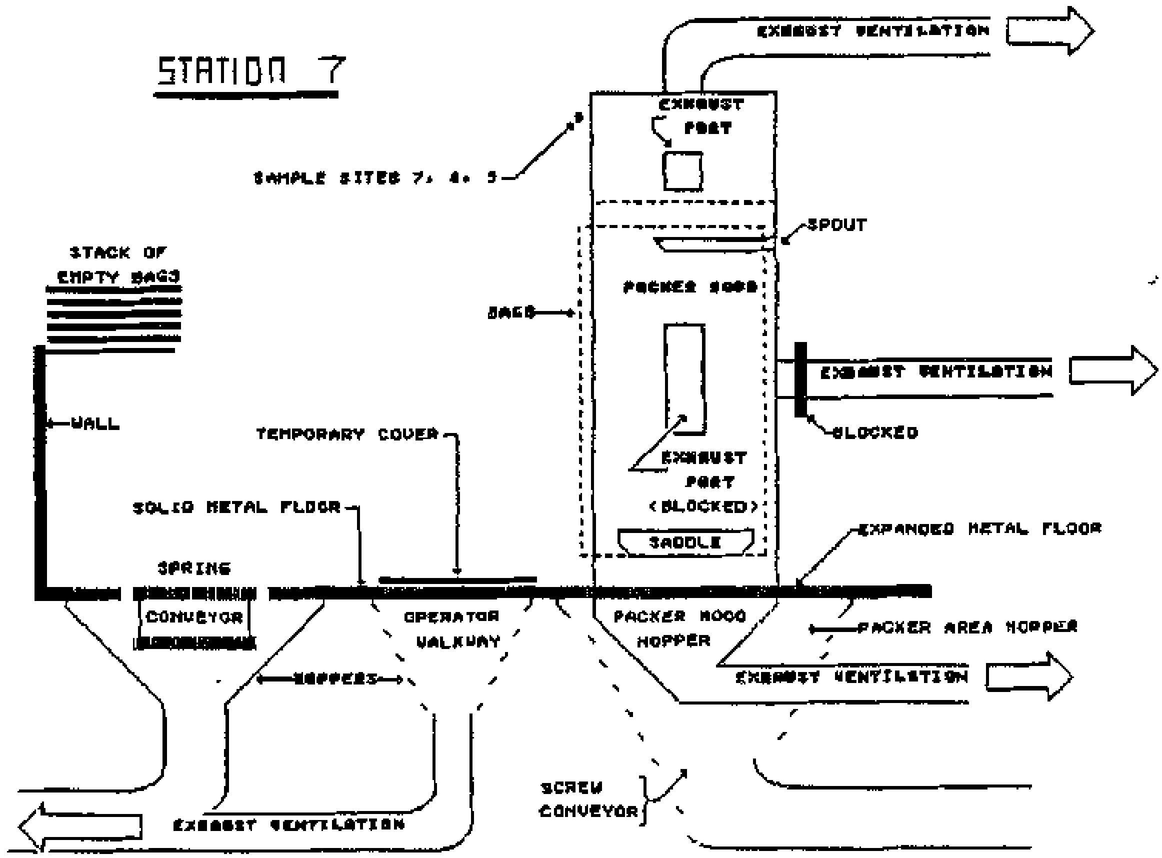
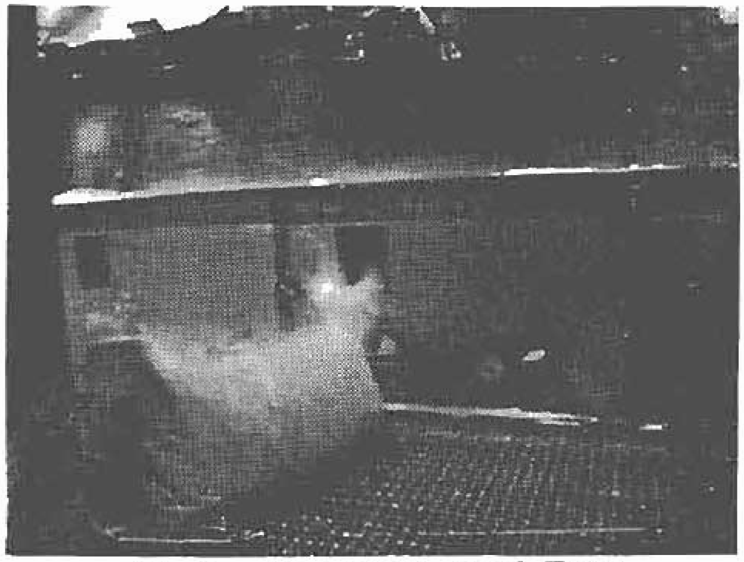


Figure 11: Packer Hoods and Spillage Hoppers (end view) – Station 7

3. Conveyor Spillage, Stations 5, 6, and 7: An open-type conveyor line (spring-type at stations 5 and 7 and chain-type at station 6) is opposite the packer units. These open-type conveyors, at floor level, discharge onto belt-type conveyors. Beneath these open-type conveyors, there are 2 to 6 hoppers equipped with exhaust ventilation, similar to that for packer spillage. At station 7, each of the 6 hoppers are designed to exhaust 1750 cfm, Figure 11. There is no exhaust from the two hoppers at Stations 5 and 6, the product being removed by a screw conveyor, Figures 9 and 12. The purpose of this system is to capture leakage from the bag when the bag is dropped onto and travels along the open-type conveyor.



Collector Box and Bag

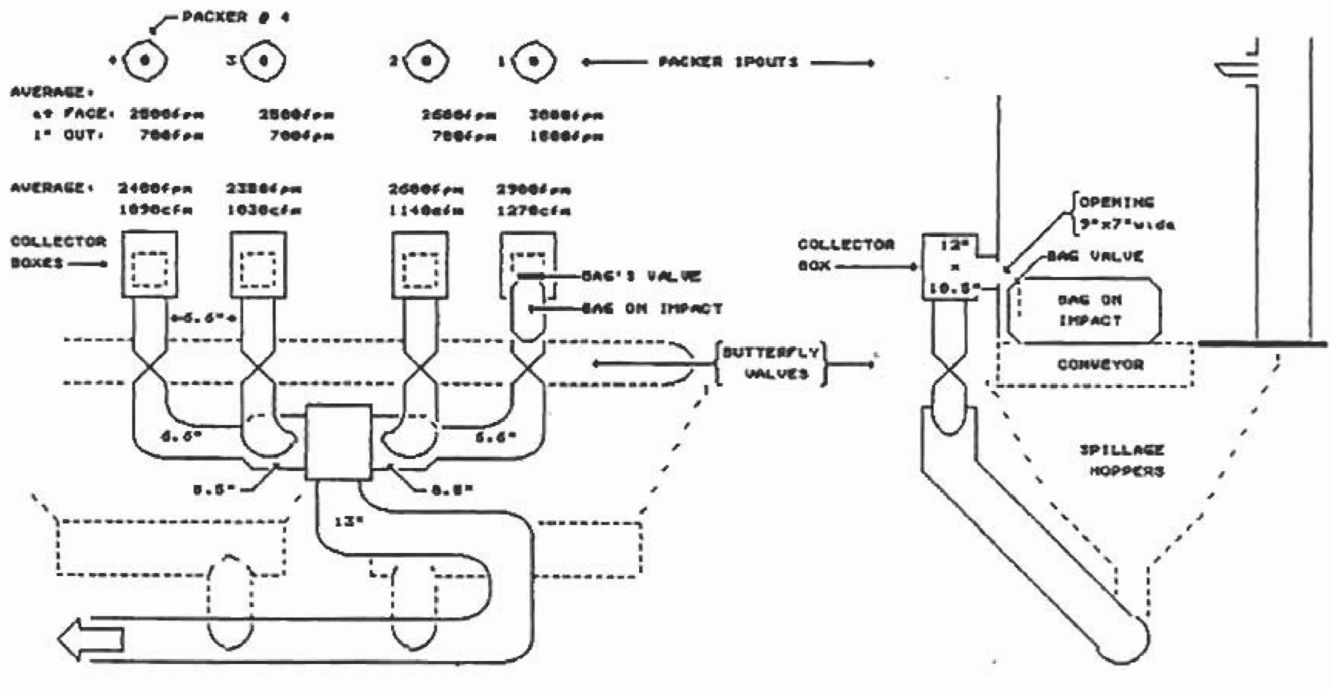
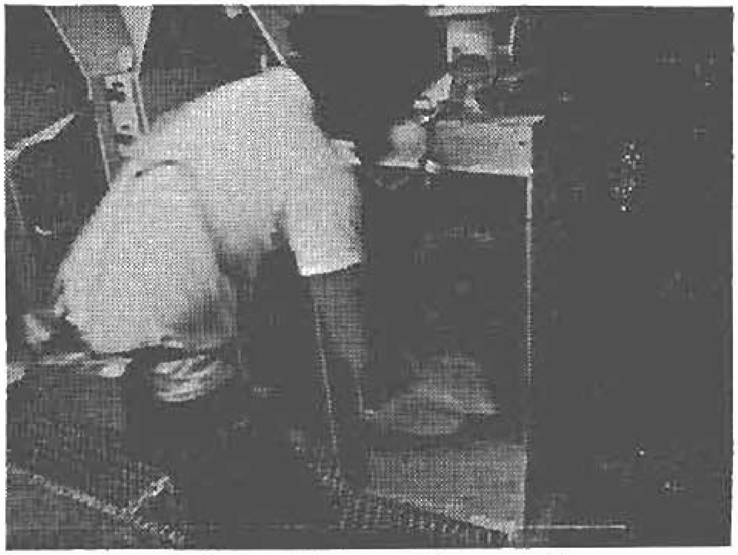


Figure 12: Measured Ventilation – Station 6

4. Bag Recyclers, Stations 5 and 7: The bag recycler is used to recycle individually damaged bags, Figure 13. These stations consists of a 29" by 19.5" wide hood with a grizzly (bars across the floor to prevent the paper bags from dropping through) for the floor. The bags are manually emptied into the hood, the product dropping through the grizzly into a hopper (part of the same hopper system used for packer spillage), and the empty bags are set aside for disposal. Air is exhausted (designed at 600 cfm) from the top of the hoods through a 5.5" duct. There is no ventilation through the floor at either station. The purpose of the recycler is to return the product to the packer bins and prevent airborne dust from escaping into the worker's environment.

5. Conveyor Transfer Point, Station 6: The filled bags travel east on the chain conveyor, then south on a belt conveyor, Figure 3. At the transfer point, the bags (lying on their front, bag valve facing west) are flipped 180° onto their back (bag valve now facing east), dropping one foot onto the belt conveyor. Along the east side of the belt conveyor at this transfer point is a slotted hood (9"x30" wide) having four rows of slots (3 rows of 1"x5" slots and one row of 1"x7" slots). Its purpose is to capture airborne dust escaping from the bag's valve when the bag is flipped over and impacts on the belt conveyor.

6. Bag Air-Washer, Stations 5, 6, and 7: As the filled bags move along the conveyor between bag filling and palletizing, they pass onto a chain-type conveyor and through and air-washer enclosure. At stations 5 and 7, the enclosure exits have rubber stripped curtains. At station 6, there are no curtains over the openings. The entry and exit to the enclosure are a third larger than the narrowest filled bag dimensions. When the bag is within the enclosure, air blows over the bag's surfaces to remove loose dust. Exhaust hoods, above and below the enclosure, captures the airborne dust. The designed total exhaust rate of the hoods is 1500 cfm.



Individual Bag Recycler

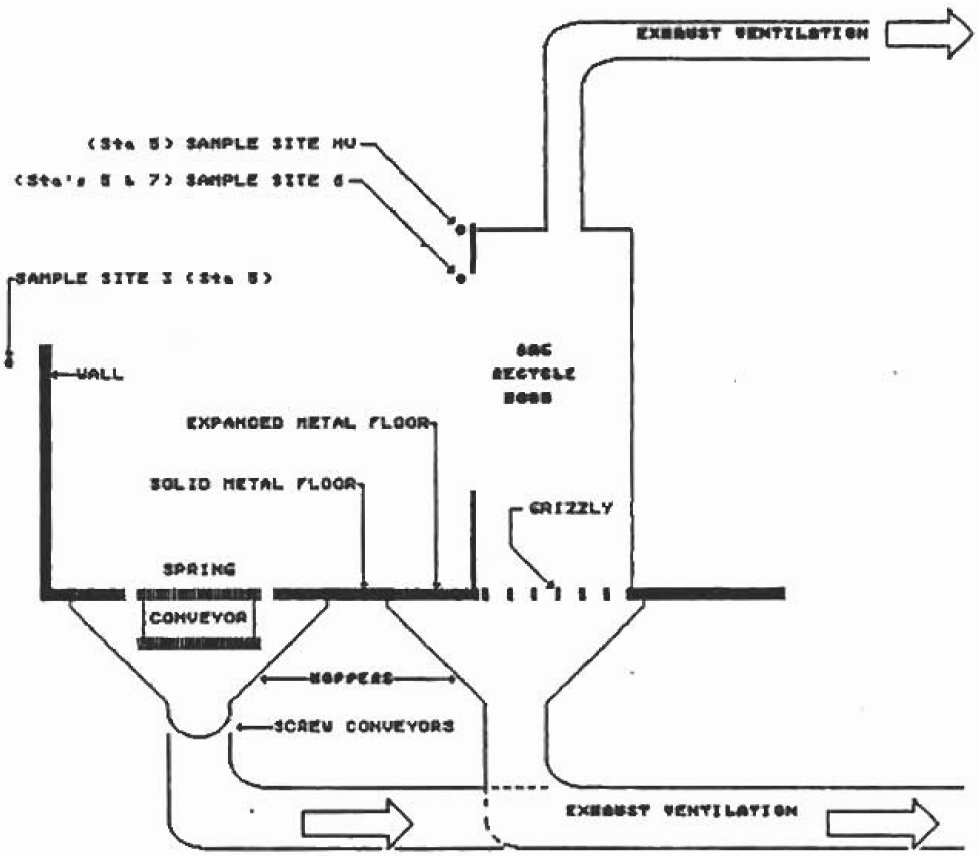


Figure 13: Bag Recycler

7. Bag Flatteners, Stations 5, 6, and 7: At station 6, after the bag exit the bag air-washer, they pass through a pair of bag flatteners. Along the east side (the same side the bag valve is facing) of the belt conveyor entering the first flattener, there is a capture hood. The purpose of this hood is to capture dust escaping form the bag's valve while the bags are being squeezed (deaerated). At stations 5 and 7, the bag flattener and the bag air-washer are within the same enclosure.

8. Packer Operator Walkways, Station 7: In the area between the packers and the conveyor, there is a 1' by 20' section of expanded metal flooring, Figure 11. Beneath this floor, there are 6 hoppers fitted with exhaust ventilation with each hopper designed to exhaust 800 cfm. Its purpose is to reduce the accumulation of spilled product from the bag as the bag is manually transfered from the packer unit to the conveyor. Due to the chilling effect of the air movement on the operator, this portion of the system was blocked off.

9. Press Wells (Palletizing), Stations 5 and 7: The press wells at these two stations are similar in design, both being semi-automatic operations, Figure 2. (At station 6, palletizing is completely automatic.) The tops of the wells are a foot above the floor level and there cross-sectional areas are a couple inches greater than the pallet's cross section. The well extends over 5 feet below the floor level. The floor of the well is electrically raised and lowered by the operator. (As the operator fills the pallet by manually tossing the bags into the well, he lowers the floor until the pallet is full.) Within a foot of the top of the well's interior walls, there are a series of horizontal slots for exhaust ventilation. Their purpose is to capture the airborne dust generated during palletizing.

   Approximately eight feet above the press well, there is an immovable cap, a flat plate framed by a 10" pipe. The cross-sectional area of the plate is the same as for the well. On the interior side of this pipe are a series of horizontal slots for exhaust ventilation. (At station 5, there is one row of slots on all 4 sides. At station 7, there are two rows of slots on the sides, one row of slots nearest the operator, and no slots on the side farthest from the operator.) At Station 5, a rubber curtain extends 6" down from the south and east side of the 10" pipe to contain some of the dust generated during compressing. When the pallet is filled, the operator raises the load, pressing it into this cap. The purpose of this part of the system is to capture the airborne dust generated while the pallet load is being compressed.

10. Capture Hoods at Bag Drop, Station 6: When the filled bag (automatically ejected from the packer) impacts on the chain conveyor, product is expelled from the bag's valve. To capture this airborne material, a 9" by 7" hood (collector box) is positioned near the bag valve's impact position, Figure 12. (When the bag is ejected, it lands on its side with the bag valve on the up side of the bag. Conveyor motion then causes the bag to roll onto its front.) The center of these openings are 19" above the conveyor and less than 2" from the bag's valve at bag impact on the conveyor.

11. Additional Capture Hood, Station 5: North of the packer operator's work area, there is a slotted (eleven horizontal 1" by 5" slots) capture hood, Figure 3. Its purpose is to capture airborne dust generated from the conveyor line exiting the bag filling area.

The ventilated dust controls at stations 5, 6, and 7 are summarized in Tables 5A, B, and C.

B. Use of Automation to Reduce Worker Exposure to Airborne Contamination and Physical Injury:

Automation reduces the potential of exposure to contaminated air and physical injuries such as back strain and tendinitis. Station 6 is completely automated from the filling of the bags to palletizing. One operator monitors the equipment and restocks the bag feeders to the packers.

C. Use of Shrink Wrap and Stretch Wrap to Control Bag Leakage and Strengthen Pallet Load Structures:

Presently, both shrink and stretch wrap are used upon the customer's request. Stretch wrap is preferred, giving a better package units. Shrink wrap, which requires more energy to emplace, is being phased out by the company. Several advantages to using wrapped pallets include: reduced airborne dust contamination and greater pallet load stability.

D. Work Practices:

Housekeeping consists mainly of vacuum sweeping within the buildings and wet washing and sweeping outside in the areas surrounding the buildings. During the day shift, a "Day Crew" continually cleans in and around the buildings, floors, equipment and where ever else needed. A special crew, "High Level Cleaners", clean the rafter beams, towers, and other overhead areas. Prompt cleanup of spills is emphasized.

When a packer at the various packaging stations is not in use, an empty bag is left on the packer spout. Its purpose is to contain any leakage that may escape from the packer spout while the unit is not in operation yet still under pressure.

E. Control Monitoring - Environmental and Medical:

Environmental monitoring of atmospheric dust and of ventilation systems serves at least four purposes; ventilation control evaulations, contaminated source identification, work area monitoring, and personal exposure monitoring. Effective medical monitoring systems can detect the earlier stages of long term adverse effects due to such exposures, making it possible to take corrective measures, usually before irreversible or extensive damage has occurred.

1. Environmental Monitoring: Environmental monitoring is performed by Manville's Health, Safety, and Environment Department (HSED) staff. They perform both industrial hygiene and safety and housekeeping inspections. The HSED staff for the Lompoc Operation and other

Manville West Coast operations annually visit each plant within their area. Other HSED staffs cover other geographical areas involving Manville's operations.

The West Coast HSED staff monitor environmental hazards such as respirable dust, fibers (asbestos and fiberglass), fumes, vapors, noise, and microwaves from ovens. Most of the samples collected are analyzed by each department locally. Some samples are sent to the Corporate Industrial Hygiene Lab in Denver, Colorado, an AIHA (American Industrial Hygiene Association) accredited lab for analyses.

2. Medical Monitoring: Twice-a-week, a doctor from the Santa Barbara Medical Foundation Clinic visits the plant site to perform annual physicals on all employees; white collar, supervisory, laborer, and clerical. The physicals include 14" by 17" chest x-rays, audiograms, visual screening, pulmonary function test, hearing, urine analysis, and complete blood counts. Permanent health records are maintained and stored on all employees, present and past including deceased.

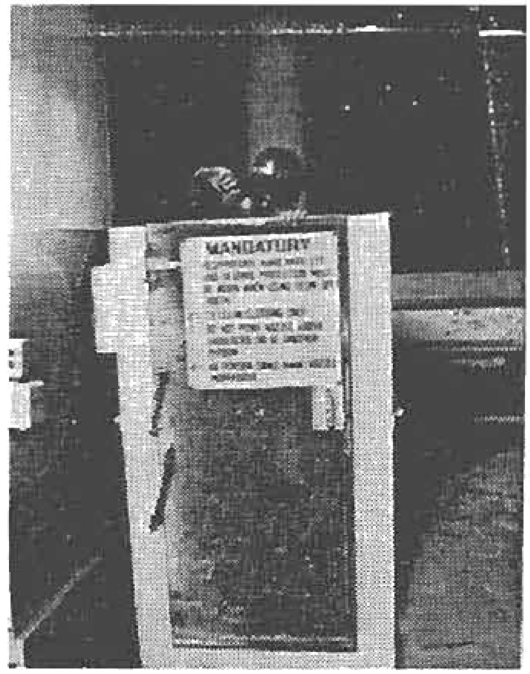
F. Personal Protective Equipment:

A combination of personal protective equipment is required in different areas of the plant. This equipment includes respirators (MSA Dust Foe 66 and as a backup, MSA Comfo II), safety glasses, hearing protection (EAR disposables) safety hats, and safety shoes. The wearing of respirators is required in the packaging areas. Aprons are also provided the packaging crews.

G. Blow-Off Booth:

Located outside of Building 1148, there is a Blow-off Booth, Photo 3. An air hose, equipped with a diffuser-type nozzle, uses shop air to blow dust particles from the clothing. (The booth is a vertical, open-top cylinder, three feet in diameter and five feet high. Ventilation is drawn down through the expanded metal flooring.) The employee enters the booth and closes the door before using it. Instructions on the proper use of the booth are clearly posted on the booth's door. (The company has recently obtained a variance permitting the use of this blow-off booth arrangement with a protected nozzle.)

Inside Blow-off Booth



Blow-off Booth in Operation

V. SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS:

The conclusions and recommendations are based on the respirable dust concentrations measured by NIOSH, Tables 4A, B, and C and Figures 14 and 15. Tables 9A, B, and C are Manville's side-by-side sample results for total respirable dust. (According to a statistical analysis of the duplicate sampling data, there is no statistically significant difference between the measured data collected by Manville and the data collected by NIOSH, Table 6.) The ventilation measurements at the three packaging stations and the Press Well at Station 7 are in Figures 12, 16, and 17.

A. Management has well established and effective medical and environmental monitoring programs.

B. Dust control in all areas requires a combination of good engineering controls, such as exhaust ventilation, and good work practices, including product handling and housekeeping procedures. As dust emissions from point sources were reduced, it normally follows that the level of personal exposures to atmospheric dust were also reduced proportionately.

C. Good local exhaust ventilation is essential at the various packaging operations to remove airborne dust. Proper ventilation design requires sufficient air movement; the development of effective flow patterns; and effective maintenance of the ventilation system.

The effectiveness of the ventilation systems at several capture hoods was evaluated by measuring dust concentrations during normal packaging operations primarily on second shift. At the three packaging stations, the respirable silica dust concentrations (cristobalite) was less than 0.03 mg/M^3. (From the high volume samples, the cristobalite content of the respirable dust was 19% or less, 16% at Station 6). From the 1.7 liters per minute airborne samples, all source and background samples were below the lower limit of quantitation (less than 0.03 mg) for both quartz and cristobalite.) Since most of the samples collected for cristobalite and quartz respirable dust were below the lower limit of quantitation, the relative effectiveness of the various dust controls were determined from the total respirable dust concentrations which were estimated to contain approximately 15% to 20% cristobalite. The PEL for these samples would be from 0.32 mg/M^3 to 0.24 mg/M^3

For packaging Stations 5, 6, and 7, the daily average total respirable dust concentrations are shown in Figure 14, Tables 4A, B, and C. A comparison of the calculated cristobalite and measured total respirable dust concentrations for these three stations are shown in Figure 15.

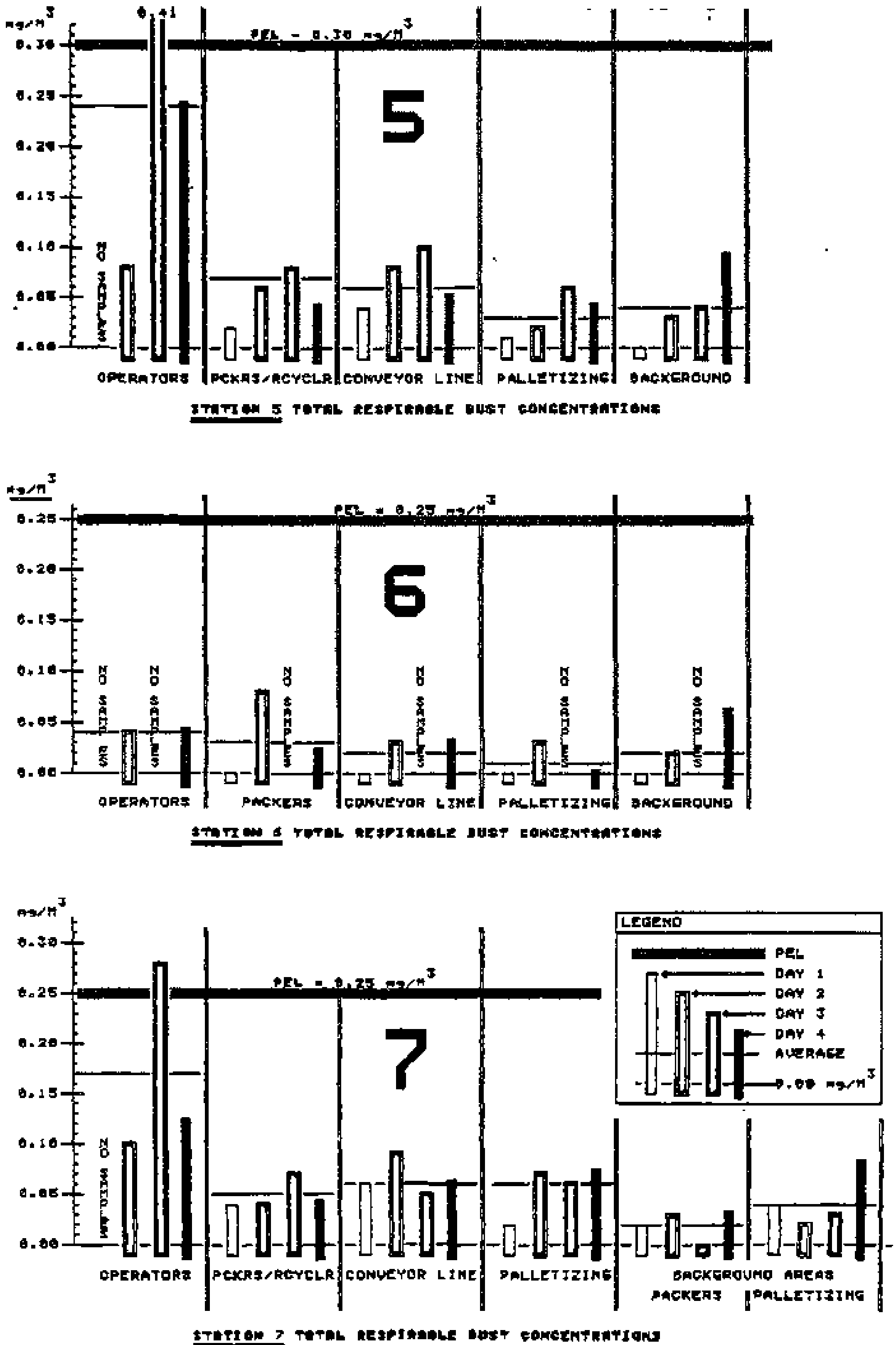


Figure 14: Average Respirable Dust Concentrations – Stations 5, 6, and 7

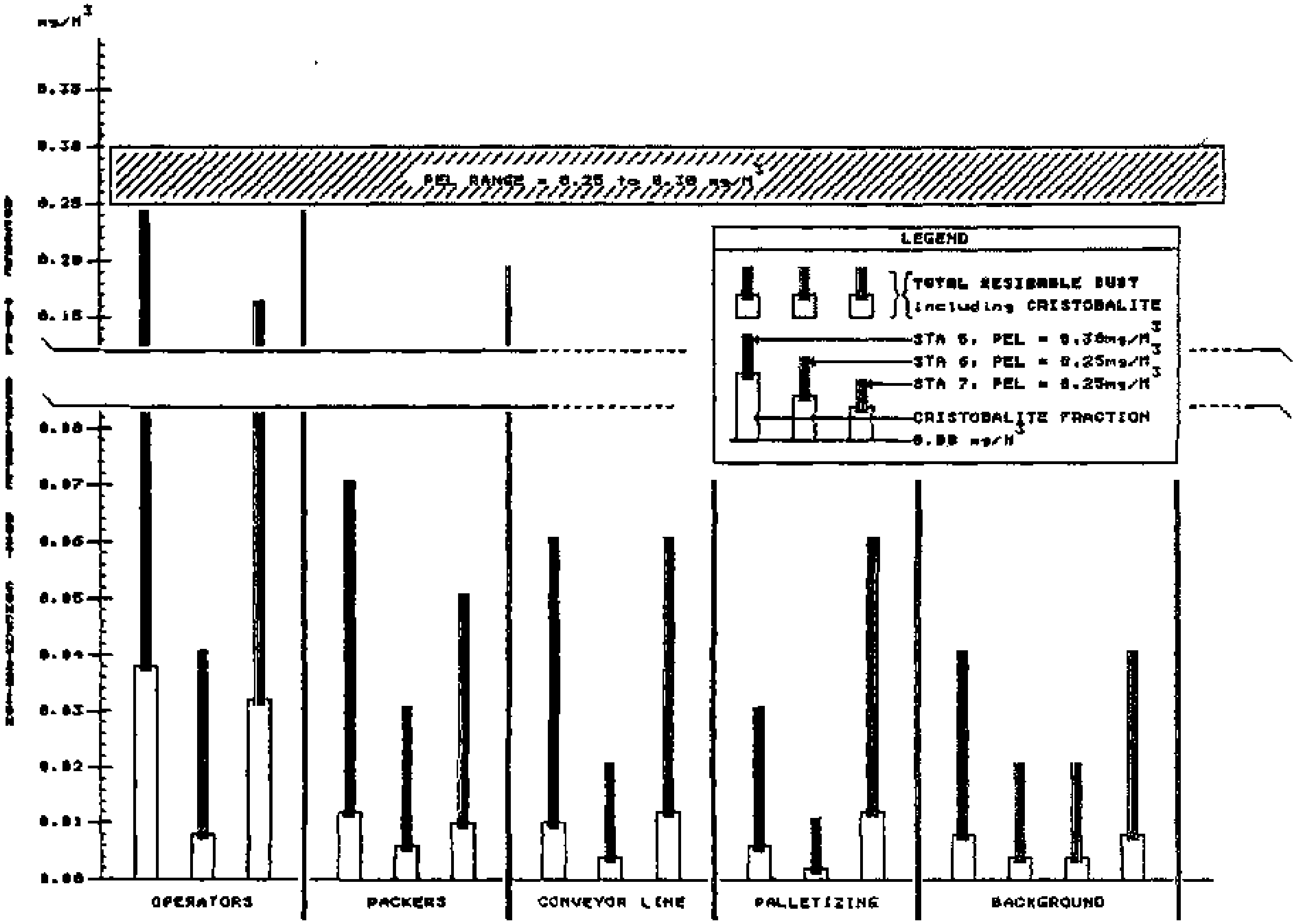


Figure 15: Average Respirable Dust Concentration Comparisons

1. Bag Filling Area (Packers) - Of the three packaging stations, Station 6 dust controls resulted in the lowest average total respirable dust concentration of 0.03 mg/M^3 (background, 0.02 mg/M^3 and PEL, 0.25 mg/M^3). Station 7 has the next lowest average total respirable dust concentration of 0.05 mg/M^3 (background, 0.03 mg/M^3 and PEL, 0.30 mg/M^3). Station 5 dust concentrations were 0.08 mg/M^3 (background, 0.05 mg/M^3 and PEL, 0.25 mg/M^3). At all three stations, the total respirable dust and crystalline silica levels were below the PELs. The main reason for the lower dust concentration at Station 6 was the higher face velocities (2650 fpm at the spout and 2580 fpm at the collector boxes) at the capture hoods and the strategic positioning of the collector boxes. At Stations 5 and 7, the face velocities at the packer hoods were less than 25% (510 fpm at Station 5 and 640 fpm at Station 7) of those at Station 6, Figures 12 and 16.

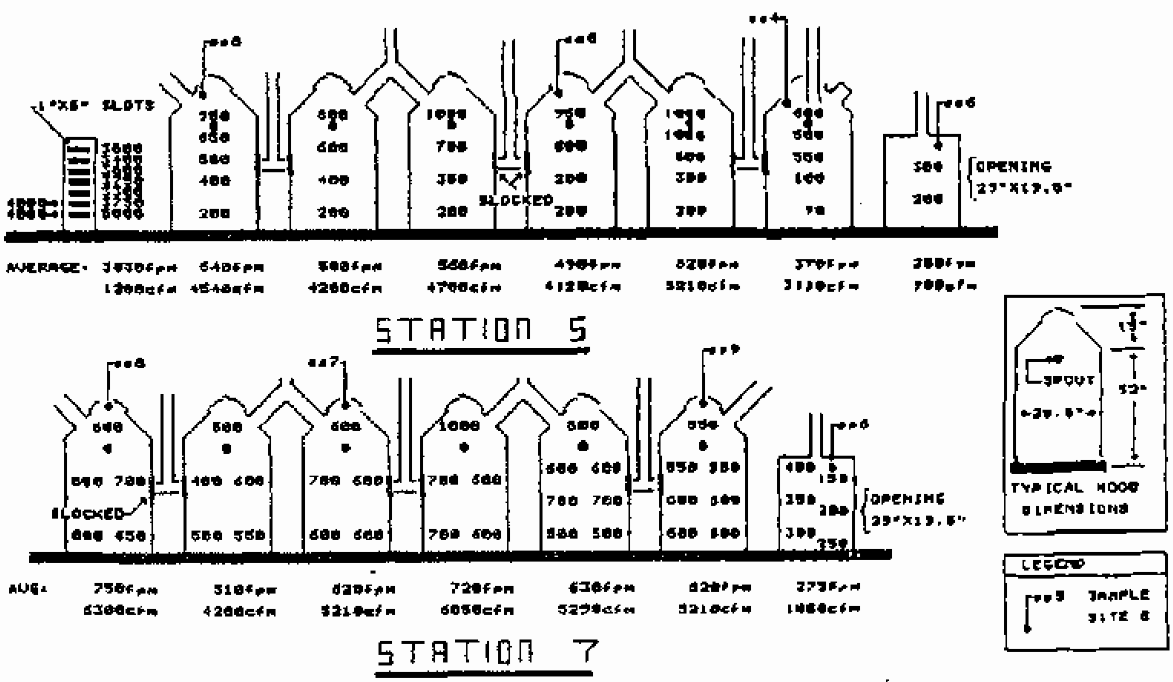


Figure 16: Measured Ventilation at Hoods - Stations 5 and 7

2. Conveyor Line - The average total respirable dust concentration along the conveyor line at Station 6 was the lowest of the three stations, 0.02 mg/M^3, (background, 0.02 mg/M^3). Station 7 dust level averaged 0.06 mg/M^3 (background, 0.04 mg/M^3) and Station 5 averaged 0.07 mg/M^3 (background, 0.04 mg/M^3). The reasons for the lower dust levels at Station 6 were the location of capture hoods at key points along the conveyor line and the cleanliness of the bag's surface during conveying. Whenever the bag impacts on the conveyor (bags ejected from the packer onto the chain conveyor and bag drop at the transfer point), the bag's valve is positioned within a couple inches of a capture hood.

   The use of ventilation beneath the spring conveyor (Station 5 is not ventilated) contains the conveyor spillage. This probably accounts for the lower levels at Station 7 than at Station 5.

3. Palletizing - The average total dust concentration in the palletizing area is the lowest at Station 6, 0.01 mg/M^3, which is below the background level of 0.02 mg/M^3. Station 5's average level was slightly lower, 0.03 mg/M^3 (background, 0.04 mg/M^3) than for Station 7, 0.06 mg/M^3 (background, 0.04 mg/M^3). In each case, the low levels are primarily due to the diluting effect of the make-up air (source from out side of the building) required by the various ventilation systems. At both Stations 5 and 7, dust can be seen escaping from the press well and the pallet load during the compacting operation. However, Station 5 is located in the building with several other packaging stations and their ventilation systems. This results in a greater volume of make-up air being moved through the area as general dilution ventilation. Station 7 is located on two floors in another building and is the only packaging station in the building. Most of the ventilation for Station 7 occurs on the upper (packer) level. As a result, there is less make-up air moving through the palletizing area of Station 7 than through the palletizing area of Station 5 to dilute the dust.

The dust ventilation systems at Stations 5 and 7 palletizing areas capture most of the dust generated before it enters the workers' environment. Figure 17 shows the measured ventilation rates at Station 7.

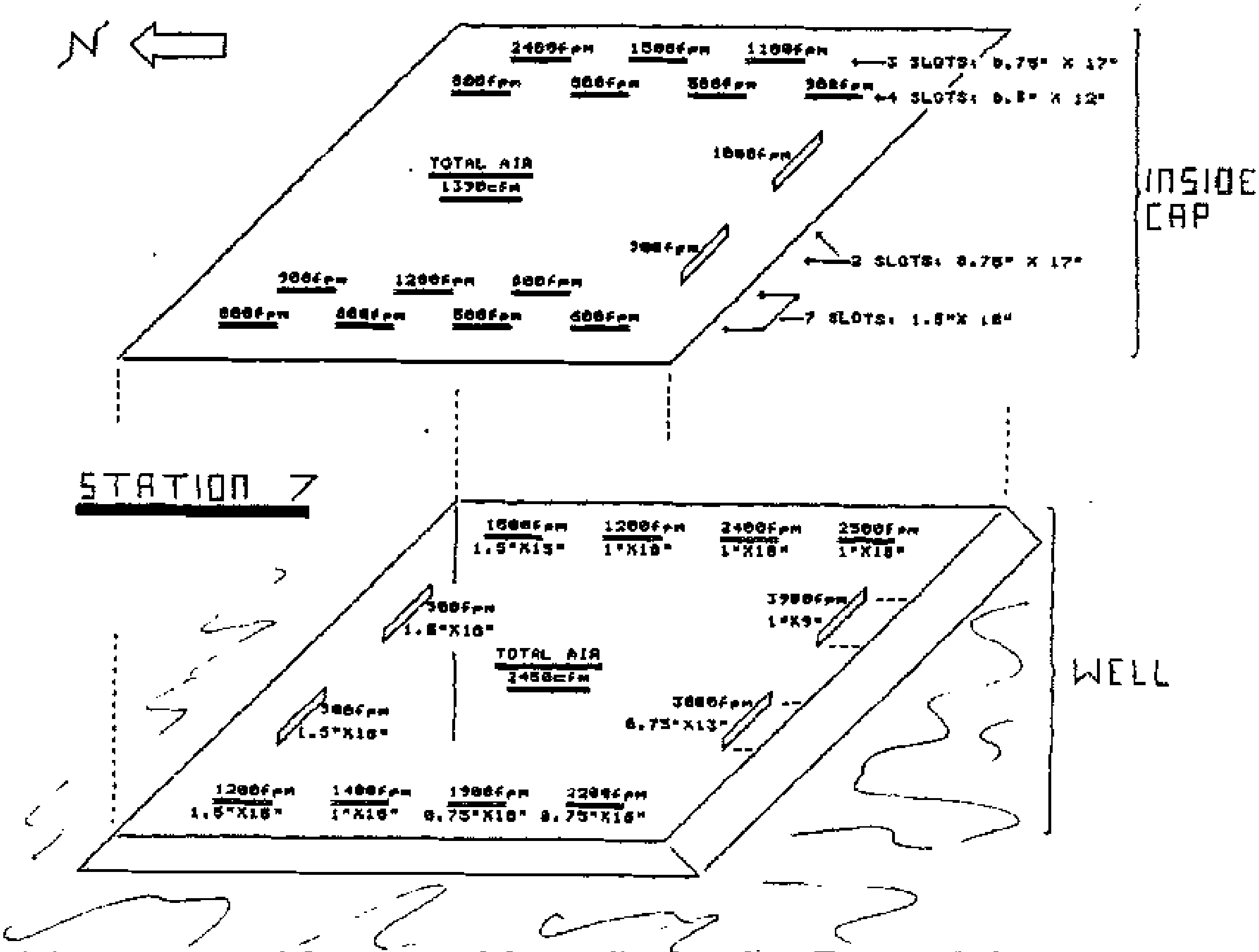


Figure 17: Measured Ventilation at Press Well - Station 7

4. Operator's Working Area and Automation - The operator's average total respirable dust exposure is lower at Station 6, 0.04 mg/M^3, than the exposure at Station 7, 0.17 mg/M^3, or Station 5, 0.24 mg/M^3. The main reason for this difference is due to the automation of Station 6. At the manual packaging stations, the operator spends most of his time at the two main dust generating areas, bag filling and palletizing. At Station 6, the operator may spend as little as 10% of his time in these areas. Also, the existing dust controls at Station 6 are effective in maintaining low dust concentrations in the general packaging area.

   Although exposures at both Stations 5 and 7 were below the calculated PELs, Station 7 operator's average dust exposures are lower, 0.17 mg/M^3 (68% of the PEL), than for Station 5 operator's, 0.24 mg/M^3 (96% of the PEL). The reason is due to the additional ventilation at Station 7 (packer hood floor and conveyor spillage). (At Station 5, the packer hood floor and conveyor spillage hoppers are not ventilated.) Another factor is the separation of the palletizing area and the packer area at Station 7. Dust generated at palletizing (Station 7) does not become part of the make-up air entering the bag filling area as it does at Station 5.

   On D-3, personal dust exposures were above the average measured at Stations 5 and 7. (There was no packaging at Station 6 on D-3.) At Station 5, these higher dust concentration were mainly due to the increased bag breakage rate for the filled product bags during the shift. At Station 7, the packaging rate was increased, two packer operators filling bags, for part of the shift. Both of these factors could account for the higher dust concentrations experienced on D-3.

D. Non-ventilated Spillage Hoppers - Non-ventilated hoppers are used to collect the dust in some areas such as under the packer units (Stations 5 and 7); under the open-type conveyors onto which the bags are dropped (Stations 5 and 6), and under the bag air-washer and part of the conveyor line (Station 6). As a result, product does not accumulate on the floor, later becoming airborne and entering the workers' environment.

E. Work Practices - Although an incentive pay program exists at this plant, several exemplary work practices were observed. These included leaving a bag on the packer spout to capture spout leakage when the packaging station is not in use. Special clean-up crews continually vacuum clean the floor and do other general clean-up in the area. A special crew vacuum cleans the rafters and other overhead structures. Such work practices result in lower background dust levels. Also, positive incentive bonuses, in the form of awards, are given to the employee for achieving an accident-free work record for a given time period.

F. Other Dust Controls - A blow-off booth removes loose dust particles from the employee's clothing. This removes dust from near the worker's breathing zone (shirt). Also, it reduces the potential dust exposure to the employee's family (wearing dusty clothes home) if the employee does not change clothes at the work site.

In conclusion, Manville has several effective dust controls, maintaining average total respirable dust levels below 0.06 mg/M^3 and crystalline silica dust levels below 0.02 mg/M^3. A well designed ventilation system, moving large volumes of air, captures most of the dust before it enters the worker's environment. The company also makes use of other controls such as spillage hoppers and bags left on idle packer spouts to help contain the dust, and wet sweeping of paved areas between the buildings on a routine basis.

TABLE 4A
ATMOSPHERIC DUST CONCENTRATIONS (mg/M^3)
MANVILLE, LOMPOC OPERATION

Station 5 (Figure 3)

Date	D-1	D-2	D-3	D-4	Av'g
Hrs Sampled	6.0	7.5	5.0	6.0	6.1
Hrs Pkg	4.0	5.8	4.5	3.4	4.4
Product	C512	C545	C545	C545	

Sample Site	TOTAL DUST (For 16% Cristobalite, PEL = 0.30)					CRISTOBALITE (For 100% Crist., PEL = 0.05)					RMKS
	D-1	D-2	D-3	D-4	Av'g	D-1	D-2	D-3	D-4	Av'g	1
A. Packers											2
4	0.03	0.04	0.11	0.08	0.06	a	a	c	c	b	
5	neg.	0.10	0.02	0.13	0.06	a	b	a	c	b	
8	0.02	0.06	0.04	0.11	0.06	a	b	a	c	b	
B. Bag Recycler											
6	0.02	0.03	0.16	0.17	0.10	a	a	c	c	b	
C. Conveyor Line											
3	0.05	0.09	0.13	0.10	0.09	a	b	c	c	c	
7	0.03	0.06	0.06	neg.	0.04	a	b	a	a	b	
D. Palletizing											
1	0.00	0.00	0.07	0.02	0.02	a	a	c	a	b	
2	0.03	0.01	0.04	0.03	0.03	a	a	a	a	a	
12	0.00	0.04	0.06	0.06	0.04	a	a	a	c	b	
E. Background											
9	neg.	0.04	0.06	0.12	0.06	a	a	a	c	b	
10	0.00	0.05	0.05	0.08	0.04	a	b	a	c	b	
11	neg.	0.01	0.02	0.08	0.03	a	a	a	b	b	
F. Operator											
P-1		0.10	0.28	0.45	0.28		b	c	0.07	0.02	3
P-2		0.07	(0.54)	0.03	(0.21)		b	(0.09)	a	(0.03)	4
G. High Volume (Bag Recycler Area)											
HV (6)		0.12			0.12		0.02			0.02	

RMKS Remarks
(1) 17% Cristobalite determined from high volume sample.
(2) More broken bags in area than normal on D-3.
(3) No personal samples taken on the D-1.
(4) Sampler worn in pocket for unknown time on d-2.

C512 Calcined product.
C545 Flux calcined product.
D-1 Sample day, first (D-1), second, third, and fourth.
HV (6) High volume sample site near site 6 for Station 5.
neg. Negative values assumed to be 0.005 mg/M^3 for determining averages.
a Less than 0.01 mg per cubic meter.
b Less than 0.02 mg per cubic meter.
c Less than 0.03 mg per cubic meter.
( ) Low reliability of sample.

TABLE 4B
ATMOSPHERIC DUST CONCENTRATIONS (mg/M³)
MANVILLE, LOMPOC OPERATION

Station 6 (Figure 4)

Date	D-1	D-2	D-3	D-4	Av'g
Hrs Sampled	5.5	7.5	0	7.5	6.8
Hrs Pkg	5.0	6.7	0	5.5	5.7
Product	HSC	HSC		HSC	

Sample Site	TOTAL DUST (For 19% Cristobalite, PEL = 0.25)					CRISTOBALITE (For 100% Crist., PEL = 0.05)					RMKS
	D-1	D-2	D-3	D-4	Av'g	D-1	D-2	D-3	D-4	Av'g	1
A. Packers											2
1	neg.	0.03		0.01	0.02	a	a		a	a	3
2	0.00	0.07		0.00	0.02	a	b		b	b	
3	0.00	0.03		0.02	0.02	a	a		a	a	
5	0.00	(0.14)		0.01	(0.05)	a	(0.07)		a	(0.03)	4
B. Bag Feeder Area											
4	neg.	0.13		0.04	0.06	a	b		a	b	
C. Conveyor Line											
3	0.00	0.03		0.02	0.02	a	a		a	a	
6	0.00	0.04		neg.	0.02	a	a		a	a	
7	neg.	0.04		0.02	0.02	a	a		a	a	
8	neg.	0.01		0.06	0.02	a	a		b	b	
D. Palletizing											
9	neg.	0.05		neg.	0.02	a	b		a	b	
10	neg.	0.01		neg.	0.01	a	a		a	a	
E. Background											
11	neg.	0.03		0.04	0.02	a	a		a	a	5
12	neg.	0.00		0.07	0.02	a	a		b	b	5
F. Operator											
P-1		0.04		0.04	0.04	a	a		a	a	6
G. High Volume (Conveyor Line Area)											
HV (6)				0.05	0.05				0.01	0.01	

RMKS Remarks

(1) 20% Cristobalite determined from high volume sample.
(2) No packaging or samples taken on D-3.
(3) Spill at no. 1 packer on D-1.
(4) Product spilled at no. 2 packer covering sampler on D-2.
(5) Duplicate, side-by-side samples at Station 6.
(6) No personal samples taken on 17th. Hose off pump for approximately 30 minutes on 18th.

HSC Flux calcined product.
D-1 Sample day; first (D-1), second (D-2), third (D-3), and fourth (D-4).
HV (6) High volume sample site near site 6 for Station 5.
neg. Negative values assumed to be 0.005 mg/M³ for determining averages.
a Less than 0.01 mg per cubic meter.
b Less than 0.02 mg per cubic meter.
( ) Low reliability of sample.

TABLE 4C
ATMOSPHERIC DUST CONCENTRATIONS (mg/M^3)
MANVILLE, LOMPOC OPERATION

Station 7 (Figure 5)

Date	D-1	D-2	D-3	D-4	Av'g
Hrs Sampled	6.0	5.0	7.5	7.5	6.5
Hrs Pkg	5.5	5.0	7.0	5.7	5.8
Product	HSC	HSC	HSC	HSC	

Sample Site	TOTAL DUST (For 19% Cristobalite, PEL ≈ 0.25) D-1	D-2	D-3	D-4	Av'g	CRISTOBALITE (For 100% Crist., PEL = 0.05) D-1	D-2	D-3	D-4	Av'g	RMKS 1
A. Packers											
7	0.02	0.04	0.08	0.04	0.04	a	a	b	a	b	2
8	neg.	0.00	0.05	0.05	0.03	a	a	b	b	b	
9	0.16	0.08	0.09	0.03	0.09	c	c	b	a	b	
B. Bag Recycler											
6	0.00	0.02	0.07	0.03	0.03	a	a	b	a	b	
C. Conveyor											
1	0.14	0.10	0.06	0.06	0.09	c	c	b	b	c	
4	0.03	0.08	0.00	0.08	0.05	a	c	a	b	b	
5	0.02	0.08	0.09	0.03	0.06	a	c	b	a	b	
D. Palletizing											
1 & 4	0.08	0.09	0.03	0.07	0.07	b	c	b	b	c	3
2	neg.	0.06		0.07	0.04	a	a		b	b	4
3	0.00	0.06	0.09	0.08	0.06	a	a	b	b	b	
E. Background in Bag Filling (Packer) Area											
10	neg.	0.04	neg.	0.01	0.02	a	a	a	b	b	
11	0.05	0.02	0.01	0.05	0.03	a	a	a	b	b	
E. Background in Palletizing Area											
12	0.04	0.02	0.03	0.08	0.04	a	a	a	b	b	
F. Operator											
P-1		0.09	0.13	0.17	0.13		c	b	b	c	5
P-2		0.10	0.43	0.08	0.20		c	b	b	c	5
G. High Volume (Conveyor Line Area)											
HV			0.13		0.13			0.02		0.02	6

RMKS Remarks

(1) 20% Cristobalite determined from high volume sample.
(2) Broken bag in area on D-1.
(3) Duplicate, side-by-side samples at Station 7 are averaged
(4) D-3 sample particle sized and chemically analyzed by NIOSH.
(5) No personal samples taken on D-1. On D-3, two operators filling bags during part of shift.
(6) High volume sample site located between sites 1 & 4 and 5 for Station 7 and treated as one in determining averages.

HSC Flux calcined product.
D-1 Sample day; first (D-1), second (D-2), third (D-3), and fourth (D-4).
HV (6) High volume sample site near site 6 for Station 5.
neg. Negative values assumed to be 0.005 mg/M^3 for determining averages.
a Less than 0.01 mg per cubic meter.
b Less than 0.02 mg per cubic meter.
c Less than 0.03 mg per cubic meter.

TABLE 5A

EFFECTIVENESS OF VENTILATION CONTROLS
STATION 5
(Bag Filling, Conveying, and Palletizing)

(AVERAGE CRISTOBALITE CONTENT OF 16%, PEL = 0.30 mg/M^3)

Location	Ventilation Description	Hood Air Movement		Respirable Dust Levels		Remarks
		Vel. (FPM)	Flow (CFM)	Total (mg/M^3)	Excess (mg/M^3)	
A. Bag Filling Area						
1. Packer 1 (ss-8)	1, 2, 3. Packer hood at each packer unit with following vent'n system, Figures 6 and 7; a) Packer Spout, narrow vent'd slot at spout. b) Hood Top - 6"x6" vent'd opening near and above packer spout. c) Hood Side -6"x18" vent'd slot on 1 side of hood. (Blocked off, not in use.) d) Hood Floor -expanded metal floor overlying non-vent'd hoppers (3 hoods per hopper).	540	4500	0.06	0.02	Good control; System maintains avg. tot. respir. dust conc'n at 0.06 mg/M^3 in the Bag Filling Area.
2. Packer 4 (ss-5)		490	4120	0.06	0.02	
3. Packer 6 (ss-4)		370	3110	0.06	0.02	
4. N. of Packer 1	4. Capture hood located near spring-belt conveyor discharge, Fig. 3. Vertical hood with a row of horizontal (1"x5") slots on W. side, plus 2 (1"x5") slots on bottom, N. side of hood.	3830	1200			
B. Bag Recycler						
1. Recycler (ss-6)	1. Hood with vent'n from top and open metal floor overlying a non-vent'd hopper. (Same hopper used to collect spillage from packer hoods.)	250	980	0.10	0.06	Good control. The slightly higher total dust conc'n (0.10 mg/M^3 versus 0.06 mg/M^3) may be due to dust from Press Well Area during palletizing operations.

TABLE 5A (STATION 5) continued, PEL = 0.30 mg/M^3

Location	Ventilation Description	Hood Air Movement Vel. (FPM)	Hood Air Movement Flow (CFM)	Respirable Dust Levels Total (mg/M^3)	Respirable Dust Levels Excess (mg/M^3)	Remarks
C. Palletizing						
1. E. of Well (ss-3)	1. Narrow horizon'l slots within 6" of top of well's 4 interior sides, Figure 2. Makeup air, for packer hoods, crosses W. to E. across Press Well into Bag Filling Area.	Approximately 1800	2000	0.09	0.05	Good control. However, dust can be seen escaping from the Press Well during palletizing and from bags during compacting, probably accounting for most of the higher dust concentrations at Bag Recycler and east of the Press Well, (ss-3).
2. N. of Well (ss-7)	2. Bags exiting Bag Air-Washer which is under vent'n. Makeup air does not cross Press Well, from west entering Bag Filling Area.					
3. N. of Cap (ss-1)	3, 4, 5. Narrow horizontal slots facing interior of cap, Fig. 2.	Approximately 900	1000	0.02	0.00	
4. E. of Cap (ss-12)	Flexible 6" long curtain hangs down from exterior on south and east side					
5. W. of Cap (ss-2)	of cap.					
D. Station 5 Summary				Operators		
1. Bag Filling Area	1. Combination of 8 vent'n hoods and 4 non-vent'd hoppers beneath packers and spring-belt conveyor.		Total 28,000	0.25	0.21	Good control, moving large volumes of air capture dust at the main dust sources. Expanded metal floors over non-vent'd hoppers are used in areas where spillage is most likely to occur, packers and spring-belt conveyors.
2. Palletizing Area	2. Exhaust from Press Well and overhead cap.		Total 3,000			

Excess = (Total respirable dust concentrations at sample site) less the (average background level of 0.04 mg/M^3).

ss Sample site.

TABLE 5B

EFFECTIVENESS OF VENTILATION CONTROLS
STATION 6
(Bag Filling, Conveying, and Palletizing)

(AVERAGE CRISTOBALITE CONTENT OF 19%, PEL = 0.25 mg/M^3)

Location	Ventilation Description	Hood Air Movement Vel. (FPM)	Hood Air Movement Flow (CFM)	Respirable Dust Levels Total (mg/M^3)	Respirable Dust Levels Excess (mg/M^3)	Remarks
A. Bag Filling Area						
1. Packer 1 (ss-1)	1, 2, 3, 4. Packer hood at each packer unit with the following ventilation system: a) Packer Spout - narrow vent'd slot around spout. b) Collector Box - 7"x9" opening located 19" above chain conveyor (at bag impact, bag's valve within 2" of the opening, Fig. 8).	3000=Spout	2900=C. Box	0.02	0.00	Good control. Collector boxes positioned to capture dust expelled from bag's valve when bag impacts on chain conveyor (after being filled and ejected from the packer spout).
2. Packer 2 (ss-5)		2600=Spout	2600=C. Box	(0.05)	(0.03)	
3. Packer 3 (ss-2)		2500=Spout	2500=C. Box	0.02	0.00	
4. Packer 4 (ss-3)		2500=Spout	2460=C. Box	0.02	0.00	
B. Bag Feeder Area						
1. Bag Stack (ss-4)	1. Makeup air flows from north to south across this area into the Bag Filling Area.			0.06	0.04	Diluting effect due to makeup air flow into Bag Filling Area.
C. Conveyor Line						
1. Transfer Point (ss-3)	1. 9"x30" capture hood with slotted openings (3 rows of four 1"x5" slots and 1 row of four 1"x7" slots) located at chain conveyor discharge.	880	520	0.02	0.00	Good controls. Well placed capture hoods and hoppers.
2. Air-Washer (ss-6)	2. Hooded enclosure with over head exhaust hoods and non-vent'd spillage hoppers located beneath the open-type conveyor.			0.02	0.00	
3. Flattener (ss-7)	3. Capture hood at entry to the bag flattener.			0.02	0.00	

TABLE 5B (STATION 6) continued, PEL = 0.25 mg/M^3

Location	Ventilation Description	Hood Air Movement		Respirable Dust Levels		Remarks
		Vel. (FPM)	Flow (CFM)	Total (mg/M^3)	Excess (mg/M^3)	
4. Roller Conveyor (ss-8)	4. Non-vent'd hopper beneath the conveyor.					.
D. Palletizing						
1. Top (ss-9)	1, 2. No ventilation.			0.02	0.00	Completely automated.
2. Bottom (ss-10)				0.01	0.00	
E. Station 6 Summary						
1. Station 6	1. Combination of vent'd hoods and non-vent'd hoppers beneath portions of the conveyor line.			Operator 0.04	0.02	Good control. Packaging station is completely automated, maintaining tot. respir. dust levels at or below 0.02 mg/M^3.

Excess = (Total respirable dust concentrations at sample sites) less the (average background level of 0.02 mg/M^3).

ss Sample site.

C. Box Collector Box.

( ) Low reliablity of sample.

TABLE 5C

EFFECTIVENESS OF VENTILATION CONTROLS
STATION 7
(Bag Filling, Conveying, and Palletizing)

(AVERAGE CRISTOBALITE CONTENT OF 19%, PEL = 0.25 mg/M^3)

Location	Ventilation Description	Hood Air Movement		Respirable Dust Levels		Remarks
		Vel. (FPM)	Flow (CFM)	Total (mg/M^3)	Excess (mg/M^3)	
A. Bag Filling Area						
1. Packer 1 (ss-8)	1, 2, 3. Packer hood at each packer unit with the following ventil'n system, Figures 6 and 7:	750	6300	0.03	0.01	Good control; Total air being exhausted by the six-packer hoods is app'ly approximately 32,000 cfm, Figure 14.
2. Packer 4 (ss-7)	a) Packer Spout - narrow vent'd slot around spout, designed spout vent'n (500 cfm.)	620	5210	0.04	0.02	
3. Packer 6 (ss-9)	b) Hood Top - 6"x6" vent'd opening near and above packer spout, designed vent'n (1000 cfm.) c) Hood Side - 6"x18" vent'd slot on one side of hood, designed vent'n (1000 cfm.) (Blocked off, not in use.) d) Hood Floor - expanded metal floor overlying vent'd hoppers beneath each packer hood, designed vent'n each hood (1935 cfm.)	620	5210	0.09	0.07	
4. Hoppers	4. Six vent'd hoppers beneath spring conveyor, designed vent'n (1750 cfm.) each. Another 6 vent'd hoppers beneath packer operators' walkway, designed vent'n (800 cfm.) each. (Blocked off, not in use.)					

TABLE 5C (STATION 7) continued, Pel = 0.25 mg/M^3

Location	Ventilation Description	Hood Air Movement		Respirable Dust Levels		Remarks
		Vel. (FPM)	Flow (CFM)	Total (mg/M^3)	Excess (mg/M^3)	
B. Bag Recycler						
1. Recycler (ss-6)	1. Hood with vent'n from top, and open metal floor overlying a non-vent'd hopper (same hopper for packer hoods).	275	1080	0.03	0.01	Good control; the slightly higher dust concentrations (0.06 mg/M^3 vs 0.03 mg/M^3) may be due to dust from the Press Well during palletizing operations.
C. Palletizing						
1. S. Side (ss-1, 4)	1, 2, 3. Well - Narrow horizontal slots within 6" of top of Well's 4 interior sides, Fig. 2. Cap - Narrow horizontal slotsfacing interior of cap, Figure 2. Flexible 6" long curtain hangs down from the exterior of the cap. Makeup air, for Bag Filling Area, crosses north to south across Press Well Area into Palletizer Operator Area.	Well 1900	Well 2450	0.07	0.03	Good control. However, dust can be seen escaping from the Well during palletizing and probably accounts for much of the higher dust concentrations in Palletizer Operators' Area, (ss-1, 4)
2. W. Side (ss-2)		Cap 970	Cap 1390	0.04	0.00	
3. SW. Corner (ss-3)				0.06	0.02	

TABLE 5C (STATION 7) continued, Pel = 0.25 mg/M^3

Location	Ventilation Description	Hood Air Movement		Respirable Dust Levels		Remarks
		Vel. (FPM)	Flow (CFM)	Total (mg/M^3)	Excess (mg/M^3)	
D. Station 7 Summary				Operators		
1. Bag Filling Area	1. Combination of ventilated packer hoods, bag recycler hood and hoppers, plus non-vent'd hoppers around the packer hoods.		Total 40,000	0.17	0.14	Good control, moving large volumes of air to capture dust at main dust sources. Use of expanded metal floors over non-vent'd hoppers the Bag Filling Areas are used where spillage is likely to occur, around the packer hoods. Also, Palletizing and Bag Filling Areas are separated. This reduces effects of dust escaping from Palletizing Operation.
2. Palletizing Area	2. Exhaust from Press Well and overhead cap.		Total 3,800			

Excess = (Total respirable dust concentrations at sample sites) less the (average background level).
(a) Average background level in Bag Filling Area = 0.02 mg/M^3.
(b) Average background level in Palletizing Area = 0.04 mg/M^3.

ss Sample site.

TABLE 6
STATISTICAL EVALUATION OF PAIRED DUST CONCENTRATIONS*

		Station 5	Station 6	Station 7
1. No. of Paired Samples	(N)	31	27	35
2. Avg. Value of Manville Data	($\overline{X}$)	119 ug/M^3	32 ug/M^3	71 ug/M^3
3. Avg. Value of NIOSH Data	($\overline{Y}$)	76 ug/M^3	26 ug/M^3	67 ug/M^3
A. Student t-Test[1]				
4. Calculated "t-Test" Value	(t)	1.43	0.63	0.30
5. Significant "t-Test" Value (at .05 level)		2.04	2.05	2.03
6. Statistical Evaluation:		a	a	a
B. Sandlers A Test[2]				
7. Calculated "A Test"	(A)	0.497	2.06	10.8
8. Significant "A Test" Value (at .05 level)		0.264	0.265	0.260
9. Statistical Evaluation:		a	a	a

* Test of significance of differences in level of paired Manville and NIOSH (Total Respirable) Dust Samples, Tables 9A, B, and C.

[1] Student t-Test:[17] - For the Student t-Test, if the calculated value for "t" is less than the table value, non-directional, at .05 level, the difference is not significant.

$$t = \frac{\overline{X} - \overline{Y}}{\sqrt{\dfrac{\Sigma D^2 - \dfrac{(\Sigma D)^2}{N}}{N(N-1)}}}$$

D = differences in value between each X and Y pair.
N = number of pairs of values.
$\overline{X}$ = average value of Manville data.
$\overline{Y}$ = average value of NIOSH data.

[2] Sandlers A Test:[17] - If the calculated svalue for "A" is greater than the table value, non-directional, at .05 level, the difference is not significant.

$$A = \frac{\Sigma D^2}{(\Sigma D)^2}$$

D = differences in value between each X and Y pair.

a - No significant difference in values.

APPENDIXES B - ANALYTICAL PROCEDURES

Of the 153 samples collected, including the 4 bulk samples; 151 were analyzed by Utah Biomedical Test Laboratory (UBTL), one analyzed by NIOSH, and one damaged and discarded.

A: UBTL Analysis

1. Bulk Samples:

UBTL first analyzed the four bulk samples for quartz and cristobalite using x-ray diffraction. Historically, tridymite does not appear to constitute a problem in this industry[22]. Samples were passed through a ten micrometer precision sieve to obtain respirable dust for analysis. NIOSH Method P&CAM 259 was used to analyze the samples with the following modifications: (1) Filters were dissolved in tetrahydrofuran rather than being ashed in a furnance. (2) Standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure. The lower limit of quantitation is 0.03 milligrams or 1.5% based on a two-milligram portion for both polymorphs of silica (quartz and cristobalite). The results are listed on Table 6.

2. Respirable Filter Samples:

UBTL used NIOSH Method P&CAM 259 to analyze the respirable airborne dust samples for free silica (quartz and cristobalite) with the following modifications: (1) Filters were dissolved in tetrahydrofuran rather than being ashed in a furnance. (2) Standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure. Only those samples with a total weight of 0.05 milligrams or greater were analyzed. The cut-off value was based on the percent silica found in the bulk samples (58%) and the lower limit of quantitation (0.03 mg). The results are listed in Table 7.

For the respirable airborne dust samples, UBTL determined the total weight of each sample by weighing the samples plus filters on an electrobalance and subtracting the previously determined tare weight of the filter. The tare and gross weighings were done in duplicate. The instrument precision of weighings done at one sitting is 0.01 mg. Due to variable factors such as overloading, hygroscopicity of samples, humidity, and the physical integrity of the filter itself, the actual precision can be considerably poorer and occassional slight net negative particulate weights are to be expected.

B. NIOSH Measurements Research Support Branch Analysis.

One respirable airborne dust sample was particle sized and chemically analyzed. The filter, containing the sample was not suitable for scanning electron microscopy analysis. Consequently, the filter was ashed in a low temperature asher using an oxygen plasma. The resulting ash was suspended in a 0.05% solution of Aerosol OT in filtered, deionized water, sonicated for 10 minutes in a small ultrasonic bath, and filtered through a 0.1 um pore size Nuclepore filter. The resulting filter was then attached to a carbon planchet and examined in the scanning electron microscope at a magnification of 1000X. All of the particles in 28 randomly selected fields of view were sized and analyzed for 31 elements using a Kevex 7000 energy dispersive x-ray spectrometer and a LeMont Scientific DA-10 image analyzer. The particles were sorted into chemical classes and subclasses by the image analyzer on the basis of their elemental composition. The large majority of particles from this analysis were classified as silica; i.e., only a major peak for silicon was seen in the x-ray spectra for these particales. The spectrum is typical of crystalline silica, diatom fragments. and amorphous silica particles.

TABLE 7

BULK PRODUCT SAMPLE RESULTS
(Samples collected by Company in 3/83)

Station	Product	% Quartz	% Cristobalite	PEL in ug/M^3
5	Super-Cel Calcined	1.5*	28	0.17
5	Flux Calcined	1.5*	58	0.08
6	Flux Calcined	2.0*	52	0.09
7	Flux Calcined	2.0*	57	0.08

* - Less than.

TABLE 8

RESULTS OF AIR SAMPLES FOR SILICA
MANVILLE
LOMPOC, CALIFORNIA

JANUARY, 1983

LOC. #	T	DATE	(1)	TOTAL WEIGHT (mg)	TOTAL WEIGHT mg/M^3	QUARTZ (mg)	QUARTZ mg/M^3	CRISTOBALITE (mg)	CRISTOBALITE mg/M^3
5-01	S	1/17	630.4	0.01	0.02	-	-	-	-
5-02	S	1/17	644.2	0.03	0.05	-	-	-	-
5-03	S	1/17	629.3	0.04	0.06	-	-	-	-
5-04	S	1/17	638.9	0.03	0.05	-	-	-	-
5-05	S	1/17	626.1	0.00	0.00	-	-	-	-
5-06	S	1/17	622.6	0.02	0.03	-	-	-	-
5-07	S	1/17	622.9	0.03	0.05	-	-	-	-
5-08	S	1/17	621.2	0.02	0.03	-	-	-	-
5-09	A	1/17	624.8	0.00	0.00	-	-	-	-
5-10	A	1/17	602.0	0.01	0.02	-	-	-	-
5-11	A	1/17	602.0	0.00	0.00	-	-	-	-
5-12	S	1/17	595.1	0.01	0.02	-	-	-	-
6-01	S	1/17	545.2	neg.	neg.	-	-	-	-
6-02	S	1/17	549.8	0.01	0.02	-	-	-	-
6-03	S	1/17	541.8	0.01	0.02	-	-	-	-
6-04	A	1/17	546.0	neg.	neg.	-	-	-	-
6-05	S	1/17	520.5	0.01	0.02	-	-	-	-
6-06	S	1/17	539.4	0.01	0.02	-	-	-	-
6-07	S	1/17	523.3	neg.	neg.	-	-	-	-
6-08	S	1/17	525.9	neg.	neg.	-	-	-	-
6-09	S	1/17	513.0	0.00	0.00	-	-	-	-
6-10	A	1/17	501.0	0.00	0.00	-	-	-	-
6-11	A	1/17	513.3	0.00	0.00	-	-	-	-
6-12	A	1/17	488.4	neg.	neg.	-	-	-	-

Comments:
6-01 | S - Spill at no. 1 packer unit at 1630 hours.

TABLE 8 continued

LOC. #	T	DATE	(l)	TOTAL WEIGHT (mg)	TOTAL WEIGHT mg/M³	QUARTZ (mg)	QUARTZ mg/M³	CRISTOBALITE (mg)	CRISTOBALITE mg/M³
7-01	A	1/17	583.1	0.09	0.15	0.03*	0.05*	0.03*	0.05*
7-02	S	1/17	588.2	neg.	neg.	-	-	-	-
7-03	A	1/17	586.3	0.01	0.02	-	-	-	-
7-04	A	1/17	575.9	0.03	0.05	-	-	-	-
7-05	S	1/17	579.0	0.02	0.03	-	-	-	-
7-06	S	1/17	582.3	0.01	0.02	-	-	-	-
7-07	S	1/17	559.3	0.02	0.04	-	-	-	-
7-08	S	1/17	569.2	neg.	neg.	-	-	-	-
7-09	S	1/17	554.0	0.10	0.18	0.03*	0.05*	0.03*	0.05*
7-10	A	1/17	563.5	0.00	0.00	-	-	-	-
7-11	A	1/17	558.5	0.04	0.07	-	-	-	-
7-12	A	1/17	551.3	0.03	0.05	-	-	-	-
Comments:									
7-06	S - Pump out of position, hanging loose. Corrected.								
7-07	S - Broken bag causing extra dust in area.								
B-01	B	1/17	-	0.00	-	-	-	-	-
B-02	B	1/17	-	neg.	-	-	-	-	-
B-03	B	1/17	-	0.06	-	-	0.03*	-	0.03*
B-04	B	1/17	-	neg.	-	-	-	-	-
5-01	S	1/18	787.7	0.01	0.01	-	-	-	-
5-02	S	1/18	765.4	0.02	0.03	-	-	-	-
5-03	S	1/18	779.7	0.08	0.10	0.03*	0.04*	0.03*	0.04*
5-04	S	1/18	768.8	0.04	0.05	-	-	-	-
5-05	S	1/18	783.0	0.09	0.11	0.03*	0.04*	0.03*	0.04*
5-06	S	1/18	778.5	0.03	0.04	-	-	-	-
5-07	S	1/18	790.3	0.06	0.08	0.03*	0.04*	0.03*	0.04*
5-08	S	1/18	774.3	0.06	0.08	0.03*	0.04*	0.03*	0.04*
5-09	A	1/18	770.8	0.04	0.05	-	-	-	-
5-10	A	1/18	775.7	0.05	0.06	0.03*	0.04*	0.03*	0.04*
5-11	A	1/18	761.0	0.02	0.03	-	-	-	-
5-12	S	1/18	762.9	0.04	0.05	-	-	-	-
5-CJ	P	1/18	722.4	0.08	0.11	0.03*	0.04*	0.03*	0.04*
5-GD	P	1/18	718.2	0.06	0.08	0.03*	0.04*	0.03*	0.04*
HV-5	H	1/18	2475.0	0.31	0.13	0.03*	0.01*	0.05	0.02
Comments:									
5-06	S - Sampler fell on floor at 0900. Repositioned.								
6-01	S	1/18	762.0	0.03	0.04	-	-	-	-
6-02	S	1/18	741.9	0.06	0.08	0.03*	0.04*	0.03*	0.04*
6-03	S	1/18	755.8	0.03	0.04	-	-	-	-
6-04	A	1/18	757.7	0.11	0.15	0.03*	0.04*	0.03*	0.04*
6-05	S	1/18	777.0	0.12	0.15	0.03*	0.04*	0.07	0.09
6-06	S	1/18	754.1	0.04	0.05	-	-	-	-
6-07	S	1/18	763.9	0.04	0.05	-	-	-	-
Comments:									
6-05	S - Broken bag at 1245. Product covered cyclone. Cleaned.								

TABLE 8 continued

LOC. #	T	DATE	(1)	TOTAL WEIGHT (mg)	mg/M3	QUARTZ (mg)	mg/M3	CRISTOBALITE (mg)	mg/M3
6-08	S	1/18	766.5	0.02	0.03	-	-	-	-
6-09	A	1/18	736.8	0.05	0.07	0.03*	0.04*	0.03*	0.04*
6-10	A	1/18	764.7	0.02	0.03	-	-	-	-
6-11	A	1/18	758.5	0.03	0.04	-	-	-	-
6-12	A	1/18	771.8	0.01	0.01	-	-	-	-
6-CM	P	1/18	748.2	0.04	0.05	-	-	-	-
Comments:									
6-CM	P - Hose off pump less than 30 minutes. Reconnected.								
7-01	A	1/18	484.5	0.06	0.12	0.03*	0.06*	0.03*	0.06*
7-02	S	1/18	494.2	0.04	0.08	-	-	-	-
7-03	A	1/18	492.4	0.04	0.08	-	-	-	-
7-04	A	1/18	493.1	0.05	0.10	0.03*	0.06*	0.03*	0.06*
7-05	S	1/18	487.9	0.05	0.10	0.03*	0.06*	0.03*	0.06*
7-06	S	1/18	490.3	0.02	0.04	-	-	-	-
7-07	S	1/18	475.4	0.03	0.06	-	-	-	-
7-08	S	1/18	482.7	0.01	0.02	-	-	-	-
7-09	S	1/18	486.5	0.05	0.10	0.03*	0.06*	0.03*	0.06*
7-10	A	1/18	491.8	0.03	0.06	-	-	-	-
7-11	A	1/18	491.8	0.02	0.04	-	-	-	-
7-12	A	1/18	498.1	0.02	0.04	-	-	-	-
7-LH	P	1/18	469.8	0.05	0.11	0.03*	0.06*	0.03*	0.06*
7-VV	P	1/18	477.5	0.06	0.13	0.03*	0.06*	0.03*	0.06*
B-01	B	1/18	-	0.01	-	-	-	-	-
B-02	B	1/18	-	0.02	-	-	-	-	-
B-03	B	1/18	-	0.02	-	-	-	-	-
B-04	B	1/18	-	0.04	-	-	-	-	-
5-01	S	1/19	546.0	0.05	0.09	0.03*	0.05*	0.03*	0.05*
5-02	S	1/19	532.1	0.03	0.06	-	-	-	-
5-03	S	1/19	533.5	0.08	0.15	0.03*	0.06*	0.03*	0.06*
5-04	S	1/19	542.9	0.07	0.13	0.03*	0.06*	0.03*	0.06*
5-05	S	1/19	528.7	0.02	0.04	-	-	-	-
5-06	S	1/19	505.2	0.09	0.18	0.03*	0.06*	0.03*	0.06*
5-07	S	1/19	544.6	0.04	0.07	-	-	-	-
5-08	S	1/19	529.0	0.03	0.06	-	-	-	-
5-09	A	1/19	541.5	0.04	0.07	-	-	-	-
5-10	A	1/19	557.1	0.04	0.07	-	-	-	-
5-11	A	1/19	538.4	0.02	0.04	-	-	-	-
5-12	S	1/19	541.5	0.04	0.07	-	-	-	-
5-GD	P	1/19	538.0	0.16	0.30	0.03*	0.06*	0.03*	0.06*
5-PV	P	1/19	536.3	0.30	0.56	0.03*	0.06*	0.05	0.09
Comments:									
Station 5 - More broken bags than normal.									
5-PV	P - Operator wearing impinger in pocket for unknown time.								

TABLE 8 continued

LOC. #	T	DATE	(1)	TOTAL WEIGHT (mg)	mg/M3	QUARTZ (mg)	mg/M3	CRISTOBALITE (mg)	mg/M3
7-01	A	1/19	775.3	0.06	0.08	0.03*	0.04*	0.03*	0.04*
7-02	S								
7-03	A	1/19	763.7	0.08	0.10	0.03*	0.04*	0.03*	0.04*
7-04	A	1/19	784.1	0.01	0.01	-	-	-	-
7-05	S	1/19	769.9	0.08	0.10	0.03*	0.04*	0.03*	0.04*
7-06	S	1/19	737.8	0.06	0.08	0.03*	0.04*	0.03*	0.04*
7-07	S	1/19	755.2	0.07	0.09	0.03*	0.04*	0.03*	0.04*
7-08	S	1/19	738.7	0.05	0.07	0.03*	0.04*	0.03*	0.04*
7-09	S	1/19	758.6	0.08	0.11	0.03*	0.04*	0.03*	0.04*
7-10	A	1/19	756.8	0.00	0.00	-	-	-	-
7-11	A	1/19	729.3	0.02	0.03	-	-	-	-
7-12	A	1/19	761.0	0.03	0.04	-	-	-	-
7-CV	P	1/19	719.3	0.10	0.14	0.03*	0.04*	0.03*	0.04*
7-FC	P	1/19	679.4	0.30	0.44	0.03*	0.04*	0.03*	0.04*
HV-7	H	1/19	6120.0	0.80	0.13	0.03*	0.00	0.15	0.02

Comments:
Station 7 - Two operators bag filling part of shift.
7-02 S - Sample analyzed by NIOSH, Appendix B-B.

LOC. #	T	DATE	(1)	TOTAL WEIGHT (mg)	mg/M3	QUARTZ (mg)	mg/M3	CRISTOBALITE (mg)	mg/M3
B-01	B	1/19	-	0.01	-	-	-	-	-
B-02	B	1/19	-	0.00	-	-	-	-	-
B-03	B	1/19	-	neg.	-	-	-	-	-
B-04	B	1/19	-	neg.	-	-	-	-	-
5-01	S	1/20	610.7	0.02	0.03	-	-	-	-
5-02	S	1/20	614.3	0.03	0.05	-	-	-	-
5-03	S	1/20	600.2	0.07	0.12	0.03*	0.05*	0.03*	0.05*
5-04	S	1/20	593.2	0.06	0.10	0.03*	0.05*	0.03*	0.05*
5-05	S	1/20	607.2	0.09	0.15	0.03*	0.05*	0.03*	0.05*
5-06	S	1/20	603.7	0.11	0.18	0.03*	0.05*	0.03*	0.05*
5-07	S	1/20	607.2	neg.	neg.	-	-	-	-
5-08	S	1/20	610.7	0.08	0.13	0.03*	0.05*	0.03*	0.05*
5-09	A	1/20	607.2	0.08	0.13	0.03*	0.05*	0.03*	0.05*
5-10	A	1/20	596.7	0.06	0.10	0.03*	0.05*	0.03*	0.05*
5-11	A	1/20	600.2	0.06	0.10	0.03*	0.05*	0.03*	0.05*
5-12	S	1/20	621.3	0.05	0.08	0.03*	0.05*	0.03*	0.05*
5- C	P	1/20	576.2	0.27	0.47	0.03*	0.05*	0.04	0.07
5-GD	P	1/20	586.3	0.03	0.05	-	-	-	-
6-01	S	1/20	810.1	0.02	0.02	-	-	-	-
6-02	S	1/20	829.0	0.01	0.01	-	-	-	-
6-03	S	1/20	813.1	0.03	0.04	-	-	-	-
6-04	A	1/20	792.6	0.04	0.05	-	-	-	-
6-05	S	1/20	808.4	0.02	0.02	-	-	-	-
6-06	S	1/20	826.0	0.00	0.00	-	-	-	-
6-07	S	1/20	815.3	0.03	0.04	-	-	-	-
6-08	S	1/20	820.0	0.06	0.07	0.03*	0.04*	0.03*	0.04*

Comments:
6-08 S - Sampler out of position, hanging loose. Corrected.

TABLE 8 continued

LOC. #	T	DATE	(1)	TOTAL WEIGHT (mg)	mg/M³	QUARTZ (mg)	mg/M³	CRISTOBALITE (mg)	mg/M³
6-09	A	1/20	797.7	0.00	0.00	-	-	-	-
6-10	A	1/20	823.0	0.00	0.00	-	-	-	-
6-11	A	1/20	808.4	0.04	0.05	-	-	-	-
6-12	A	1/20	824.3	0.07	0.08	0.03*	0.04*	0.03*	0.04*
6-CM	P	1/20	728.3	0.04	0.05	-	-	-	-
HV-6	H	1/20	3843.0	0.21	0.05	0.03*	0.01*	0.04	0.01
7-01	A	1/20	780.2	0.06	0.08	0.03*	0.04*	0.03*	0.04*
7-02	S	1/20	763.9	0.06	0.08	0.03*	0.04*	0.03*	0.04*
7-03	A	1/20	760.5	0.07	0.09	0.03*	0.04*	0.03*	0.04*
7-04	A	1/20	799.2	0.07	0.09	0.03*	0.04*	0.03*	0.04*
7-05	S	1/20	763.3	0.03	0.04	-	-	-	-
7-06	S	1/20	759.2	0.03	0.04	-	-	-	-
7-07	S	1/20	785.4	0.04	0.05	-	-	-	-
7-08	S	1/20	790.2	0.05	0.06	0.03*	0.04*	0.03*	0.04*
7-09	S	1/20	771.2	0.03	0.04	-	-	-	-
7-10	A	1/20	768.4	0.02	0.03	-	-	-	-
7-11	A	1/20	769.9	0.05	0.06	0.03*	0.04*	0.03*	0.04*
7-12	A	1/20	783.0	0.07	0.09	0.03*	0.04*	0.03*	0.04*
7-LH	P	1/20	725.0	0.13	0.18	0.03*	0.04*	0.03*	0.04*
7-VV	P	1/20	727.6	0.07	0.10	0.03*	0.04*	0.03*	0.04*
B-01	B	1/20	-	-	neg.	-	-	-	-
B-02	B	1/20	-	-	0.07	-	0.03*	-	0.03*
B-03	B	1/20	-	-	0.01	-	-	-	-
B-04	B	1/20	-	-	0.04	-	-	-	-
B-05	B	1/20	-	-	0.04	-	-	-	-

* Less Than
T Type of Sample
A Area Samples
S Source Samples
P Personal Samples
H High Volume Samples
B Blanks

TABLE 9A

RESPIRABLE AIRBORNE DUST CONCENTRATIONS (mg/M^3)

NIOSH AND MANVILLE SAMPLES

(NIOSH values blank corrected)

Station 5

Date	1-17	1-18	1-19	1-20	Av'g
Hrs Sampled	6.0	7.5	5.0	6.0	6.1
Hrs Pkg	4.0	5.8	4.5	3.4	4.4
Product	C512	C545	C545	C545	

Sample Site	1-17 Tm	1-17 Tn	1-18 Tm	1-18 Tn	1-19 Tm	1-19 Tn	1-20 Tm	1-20 Tn	Av'g Tm	Av'g Tn
A. High Volume										
HV (6)				0.12						0.12
B. Operator										
P-1			0.12	0.10	0.23	0.28	0.16	0.45	0.17	0.28
P-2			0.16	0.07	0.21	(0.54)	0.61	0.03	0.33	(0.21)
Av'g			0.14	0.08	0.22	(0.41)	0.38	0.24	0.25	(0.24)
C. Packers										
4	neg.	0.03	0.05	0.04	0.09	0.11		0.08	0.05	0.06
5	0.02	neg.	0.12	0.10	0.10	0.02	0.07	0.13	0.08	0.06
6		0.02		0.03		0.16		0.17		0.10
8	0.01	0.02		0.06		0.04	0.77	0.11	0.39	0.06
Av'g	0.01	0.02	0.08	0.06	0.10	0.08	0.42	0.12	0.14	0.07
D. Conveyor										
3	0.07	0.05	0.09	0.09	0.19	0.13	0.09	0.10	0.11	0.09
7	0.04	0.03	0.04	0.06	0.13	0.06		neg.	0.07	0.04
Av'g	0.06	0.04	0.06	0.08	0.16	0.10	0.09	0.05	0.09	0.06
E. Palletizing										
1	0.01	0.00		0.00		0.07		0.02	0 01	0.02
2	0.02	0.03	0.06	0.01	0.06	0.04		0.03	0.05	0.03
12		0.00		0.04		0.06	0.06	0.06	0.06	0.04
Av'g	0.02	0.01	0.06	0.02	0.06	0.06	0.06	0.04	0.04	0.03
F. Background										
9		neg.		0.04		0.06		0.12		0.06
10		0.00		0.05		0.05	0.08	0.08	0.08	0.04
11	0.05	neg.	0.06	0.01	0.10	0.02	0.03	0.08	0.06	0.03
Av'g	0.05	0.00	0.06	0.03	0.10	0.04	0.05	0.09	0.06	0.04

SC Super-Cel, calcined product.
FC Flux calcined product.
HV (6) High volume sample site near site 6 for Station 5.
Tm Manville results as Total Respirable Dust (mg/M^3).
Tn NIOSH results as Total Respirable Dust (mg/M^3).
( ) Low reliability of sample.
Av'g Negative values are treated as 0.005 mg/M^3.

TABLE 9B

RESPIRABLE AIRBORNE DUST CONCENTRATIONS (mg/M^3)

NIOSH AND MANVILLE SAMPLES

(NIOSH values blank corrected)

Station 6

Date	1-17		1-18		1-19		1-20		Av'g	
Hrs Sampled	5.5		7.5		0		7.5		5.1	
Hrs Pkg	5.0		6.7		0		5.5		4.3	
Product	HSC		HSC				HSC			
Sample Site	Tm	Tn	Tm	Tn	Tm	Tn	Tm	Tn	Tm	Tn
A. High Volume										
HV (6)								0.05		0.05
B. Operator										
P-1			0.03	0.04			0.07	0.04	0.05	0.04
C. Packers										
1	neg.	neg.	0.02	0.03			0.02	0.01	0.01	0.02
2	0.01	0.00	0.10	0.07			0.04	0.00	0.05	0.02
3	neg.	0.00	0.05	0.03			0.04	0.02	0.03	0.02
4	neg.	neg.	0.04	0.13			0.02	0.04	0.02	0.06
5		0.00		(0.14)				0.01		(0.05)
Av'g	0.00	0.00	0.05	(0.08)			0.03	0.02	0.03	0.03
D. Conveyor										
6	0.05	0.00	0.06	0.04			0.02	neg.	0.04	0.01
7	0.03	neg.	0.04	0.04			0.03	0.02	0.03	0.02
8		neg.		0.01				0.06		0.02
Av'g	0.04	0.00	0.05	0.03			0.02	0.03	0.04	0.02
E. Palletizing										
9	0.02	neg.	0.05	0.05			0.04	neg.	0 04	0.02
10	0.02	neg.	0.02	0.01			0.03	neg.	0.02	*
Av'g	0.02	*	0.04	0.03			0.04	*	0.03	0.01
F. Background										
11		neg.		0.03				0.04		0.02
12		neg.		0.00				0.07		0.02
Av'g		*		0.02				0.06		0.02

HSC	Flux calcined product.
HV (6)	High volume sample site near site 6 for Station 6.
Tm	Manville results as Total Respirable Dust (mg/M^3).
Tn	NIOSH results as Total Respirable Dust (mg/M^3).
*	Less than 0.01 mg/M^3.
( )	Low reliability of sample.
11,12	Duplicate, side-by-side samples at Station 6.
Av'g	Negative values are treated as 0.005 mg/M^3.

TABLE 9C

RESPIRABLE AIRBORNE DUST CONCENTRATIONS (mg/M^3)

(NIOSH values blank corrected)

Station 7

Date	1-17		1-18		1-19		1-20		Av'g	
Hrs Sampled	6.0		5.0		7.5		7.5		6.5	
Hrs Pkg	5.5		5.0		7.0		5.7		5.8	
Product	HSC		HSC		HSC		HSC			
Sample Site	Tm	Tn	Tm	Tn	Tm	Tn	Tm	Tn	Tm	Tn
A. High Volume										
HV (1,4,5)						0.13				0.13
B. Operator										
P-1			0.19	0.09	0.09	0.13	0.16	0.17	0.15	0.13
P-2			0.10	0.10	0.11	0.43	0.10	0.08	0.10	0.20
Av'g			0.15	0.10	0.10	0.28	0.13	0.12	0.12	0.17
C. Packers										
6		0.00		0.02		0.07		0.03		0.03
7	0.06	0.02	0.07	0.04	0.07	0.08	0.06	0.04	0.06	0.04
8	0.01	neg.		0.00		0.05	0.05	0.05	0.02	0.02
9		0.16		0.08		0.09		0.03		0.09
Av'g	0.03	0.04	0.07	0.04	0.07	0.07	0.06	0.04	0.05	0.05
D. Conveyor										
1	0.04	0.14		0.10		0.06		0.06	0.04	0.09
4	0.05	0.03	0.12	0.08	0.07	0.00	0.06	0.08	0.08	0.05
5	0.04	0.02	0.07	0.08	0.06	0.09	0.05	0.03	0.06	0.06
Av'g	0.04	0.06	0.10	0.09	0.06	0.05	0.06	0.06	0.06	0.06
E. Palletizing										
1 & 4	0.05	0.08	0.12	0.09	0.07	0.03	0.06	0.07	0 08	0.07
2	0.06	neg.	0.08	0.06	0.07		0.04	0.07	0.06	0.02
3		0.00		0.06		0.09		0.08		0.06
Av'g	0.06	0.02	0.10	0.07	0.07	0.06	0.05	0.07	0.07	0.06
F. Background in Packer Area										
10	0.08	neg.	0.06	0.04	0.04	neg.		0.01	0.06	0.01
11	0.08	0.05	0.04	0.02	0.03	0.01	0.03	0.05	0.04	0.03
Av'g	0.08	0.02	0.05	0.03	0.04	*	0.03	0.03	0.05	0.02
G. Background in Palletizing Area										
12		0.04		0.02		0.03		0.08		0.04

HSC Flux calcined product.
HV(1,4,5) High volume sample site located between sites 1-4 and 5 for Sta. 7.
Tm Manville results as Total Respirable Dust (mg/M^3).
Tn NIOSH results as Total Respirable Dust (mg/M^3).
1 & 4 Duplicate, side-by-side samples at Station 7 are averaged and treated as one in determining averages.
Av'g Negative values are treated as 0.005 mg/M^3.

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