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NIOSH CONTROL TECHNOLOGY ASSESSMENT
at
Uniroyal Tire Company
Ardmore, Oklahoma

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This in-depth plant survey report documents air contaminant controls for selected operations at Uniroyal Tire Company's Ardmore, Oklahoma tire plant. This survey was conducted during the period April 14 - 24, 1980. The controls for the following unit operations were evaluated: materials handling, hopper bin, compounding, mixing, milling, tread cementing, calendering, curing, repairing, and cementing.

This report includes detailed information regarding industrial hygiene sampling and the results of that sampling; detailed ventilation data for the engineering controls studied; and detailed observations of work practices which were in use during the survey.

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PURPOSE OF STUDY

The purpose for this study was to evaluate and document effective controls for air contaminants in the tire manufacturing industry (SIC 3011).

ABSTRACT

This in-depth plant survey report documents air contaminant controls for selected operations at Uniroyal Tire Company's Ardmore, Oklahoma tire plant. This survey was conducted during the period April 14 - 24, 1980. The controls for the following unit operations were evaluated: materials handling, hopper bin, compounding, mixing, milling, tread cementing, calendering, curing, repairing, and cementing.

This report includes detailed information regarding industrial hygiene sampling and the results of that sampling; detailed ventilation data for the engineering controls studied; and detailed observations of work practices which were in use during the survey.

CONTENTS

INTRODUCTION

During April 14-24, 1980, the National Institute for Occupational Safety and Health (NIOSH), conducted an evaluation of selected controls for air contaminants at the Uniroyal Tire Company tire plant in Ardmore, Oklahoma. The following controls for particulate air contaminants were evaluated: materials handling system for large volume materials, hopper/bin, automatic compounding system, mixer ventilation, mill line ventilation systems, automated end tread cementer, calendering ventilation system, general dilution canopy hood system for a curing room, defect repair table hood, and cement house ventilation system.

This plant was studied as part of a larger study of controls for air contaminants in tire plants. This plant was selected for study on the basis of a preliminary visit. During the preliminary visit, the controls in this plant appeared to be among the better controls for air contaminants in this industry.

GENERAL DESCRIPTION OF THE FACILITY

During the NIOSH study the plant was operating under normal conditions. Typically this plant employs 2,000 workers on three shifts and can produce 30,000 tires per day. The original structure built in 1970 and with numerous modifications and additions, now occupies approximately 1 million square feet of covered space. The hours of the shifts were 7:00 a.m. to 3:00 p.m. (day), 3:00 p.m. to 11:00 p.m. (evening), and 11:00 p.m. to 7:00 a.m. (night).

Occupational safety and health services are directed by Charles Shannon. At the time of the study, there was no formal training concerning the effect of air contaminants upon worker health.

OVERVIEW OF THE OCCUPATIONAL EXPOSURES FROM TIRE MANUFACTURING PROCESS

Tire manufacturing involves a series of operations which have the potential for creating worker exposures to a variety of air contaminants. The process is summarized in Figure 1. The occupational title groups developed by Williams[10] provide a standard description of tire manufacturing operations. These are listed in Appendix I. In addition to the classifications listed by Williams, a classification called "precompounding" has been added. Precompounding refers to the emptying of chemicals into bags, bins, or totes. In the mixing areas of the tire plant, rubber, carbon black, process oils, and chemicals are mixed in energy intensive mixers, such as Banbury mixers, and milled to produce rubber stocks. These operations produce air contaminants referred to as "compounding dusts" and "rubber fumes".

Rubber stocks are either calendered or extruded to produce various parts of the tire, e.g., the tire treadstock or the plystock. These operations increase elasticity by applying a shear-stress to the rubber. This results in friction, heat, and the generation of a fume.

A cement dissolved in a petroleum distillate is applied to the tread ends and the bottom of the tread. The workers near this operation and the workers in

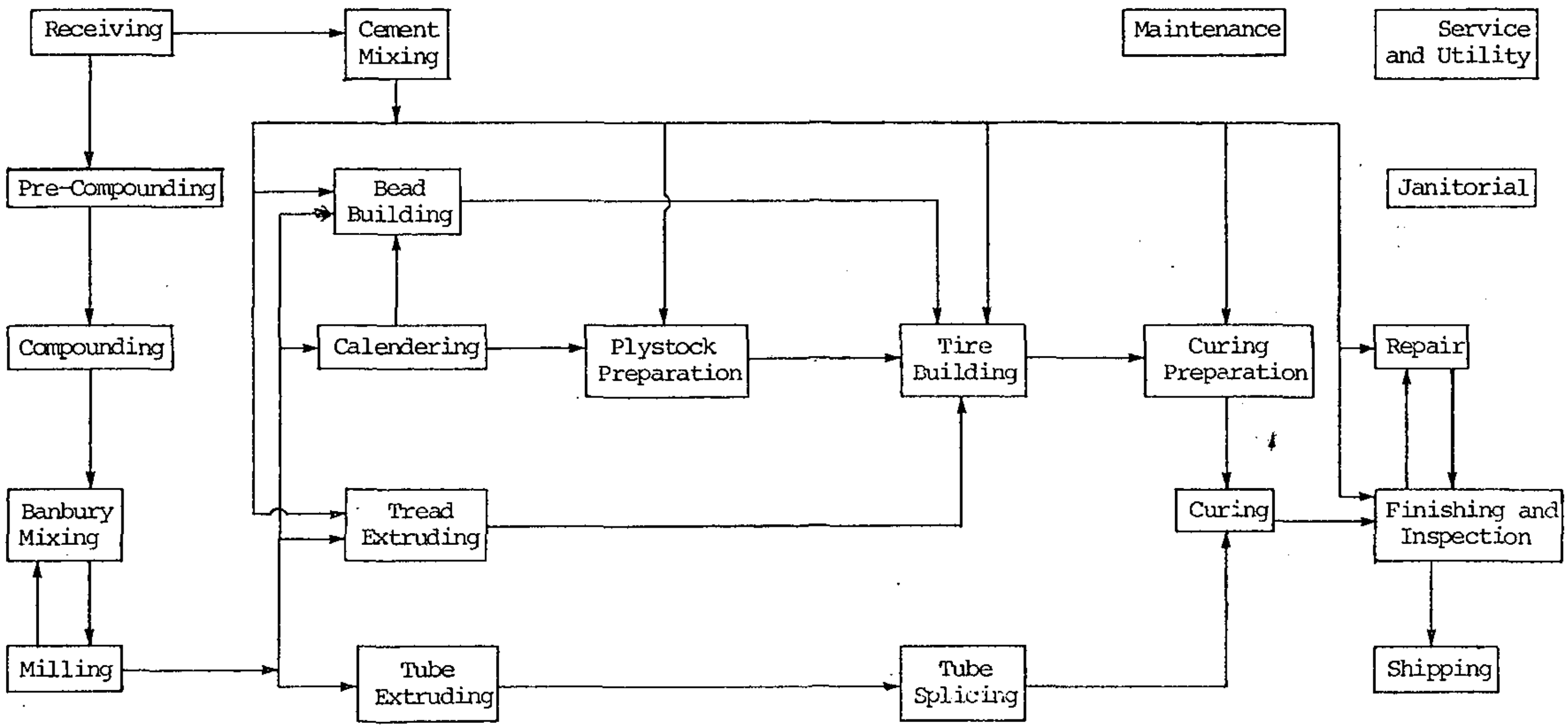

Figure 1. Production Stages in the Manufacture of Tires and Tubes.

the cement house where the cement is made are exposed to petroleum distillate. This petroleum distillate is essentially naphtha with a trace of benzene contamination.

After the individual tire parts are made, the tire is assembled on a drum. While assembling tires, workers occasionally use petroleum distillate to tackify the rubber parts.

After assembly, the tires are sent to the curing room where they are loaded into the curing presses. When the tires are released from the curing press, the tire is in its familiar shape. Freshly cured tires release a fume commonly called "curing fume".

After curing, the tires are sent to a final finish department for inspection and repair, and then to the warehouse.

DESCRIPTION OF EVALUATION METHODS

The selected controls were studied by collecting air samples, by making ventilation system measurements, and observation of process and work practices. Air samples and observations collected during four day and four evening shifts.

Air samples for total particulate and respirable particulate were collected in accordance with the NIOSH Sampling Data Sheet 29.02.[11] The sampling rates were 1.5 and 1.7 liters per minute (Lpm) for total and respirable particulate respectively. MSA-FWSB filters were also used to collect particulate air samples. These filters were corrected for a mean blank filter loss of 0.05 milligram (mg). The standard deviation of the mean weight loss was 0.02 mg. Air samples were collected with MSA model G pumps and DuPont P4000 pumps.

Air samples for the petroleum distillate used in this plant were collected on standard charcoal tubes. These samples were analyzed according to NIOSH method P&CAM 127.[12] Sample volumes of 20 to 30 L were collected at known sampling rates between 50 and 150 mL per minute with DuPont P125 pumps. These samples were quantitatively analyzed for m-xylene, acetone, toluene, and petroleum distillate by desorption in 1 mL of carbon disulfide and subsequent analysis in a gas chromatograph equipped with a flame ionization detector. The detection limit for these analysis is given in Table 1.

Table 1. Detection limits for solvent samples.

Analyte	Detection Limit mg/sample	Detection Limit Based Upon 20 L Sample, Volume (mg/m^3)
Benzene	0.03	0.15
Petroleum distillate	0.10	5.0
Toluene	0.01	0.50
m-Xylene	0.01	0.50

A bulk sample of the petroleum distillate was used to prepare standards for the petroleum distillate analysis.

Ventilation measurements were made using instruments listed in Appendix II. The exact measurements made for each control system are noted in the detailed evaluation for that control. Flow rates in ducts are calculated from average duct velocities. A pitot tube with an inclined manometer was used to make velocity pressure measurements which were converted to velocity. The pitot traverse points are based upon criteria presented by the American Conference of Governmental Industrial Hygienists (ACGIH).[13] If possible, the traverse location in the duct was about 7.5 duct diameters downstream of disturbances, otherwise, it was made as close to 7.5 duct diameters as possible. Capture and face velocity measurements were made using hot wire anemometers.

When air samples were collected at three or more locations at a given control, Analysis of Variance (ANOVA) and Duncan's Multiple Range Test[14] were used to determine whether shift and location affected concentration. The ANOVA is used to compute the mean square error used in Duncan's test. Before proceeding with this analysis, the data was transformed by taking the common logarithm of individual concentrations. Duncan's test was conducted at an overall level of confidence of 95 percent. This type of analysis was used to determine whether samples collected near the worker, the control, the emission sources, and in the general area are different. This analysis is used to judge control effectiveness.

DETAILED EVALUATIONS

This section contains the results of the detailed evaluation for the selected controls. These are presented in the form of case studies. These case studies will be used to prepare a final report.

MATERIALS HANDLING SYSTEM FOR LARGE VOLUME MATERIALS (1)

AREA: PRECOMPOUNDING

DESCRIPTION

Materials such as carbon black and zinc oxide are used in large amounts in the tire manufacturing process. This plant solved the problems of handling these materials by using a Sealdbin(R) system.

Sealdbins(R) are air-tight, collapsible, rubber containers manufactured by Uniroyal, Inc., Engineered Systems Department, Mishawaka, Indiana. The Sealdbins(R), in general, are made of puncture resistant plies of tire cord fabric coated with Neoprene and are used for dry, flowable materials. Although they come in a variety of sizes, this plant uses the 70 and 300 cubic feet sizes for the zinc oxide and carbon black, respectively. The maximum weight capability for these sizes are 60 and 40 pounds per cubic feet, respectively, but weights noted on the bins at the plant were about 1-1/2 and 3-1/2 tons, respectively. Several views of the Sealdbins(R) are shown in Figures 1-1, 1-2, and 1-3.

Normally, the Sealdbins(R) are filled by the manufacturers of the material and are shipped to the plant by railroad car, barge, and truck. Loading and unloading of the bins is by overhead crane or specially equipped fork lifts. The bins are stored outdoors since they do not require special storage.

The equipment required on the plant's dispensing floor for the Sealdbins(R) are an overhead lift (either trolley crane or tractors), a pneumatic cradle as shown in Figure 1-1, and a sleeve connection to the material surge hopper. At the plant, an overhead trolley crane system is used. It includes trolley-tracks leading to each dispensing station and to a reserve storage area. Also, at each stand, there is a pneumatic drop for the trolley to permit collapsing

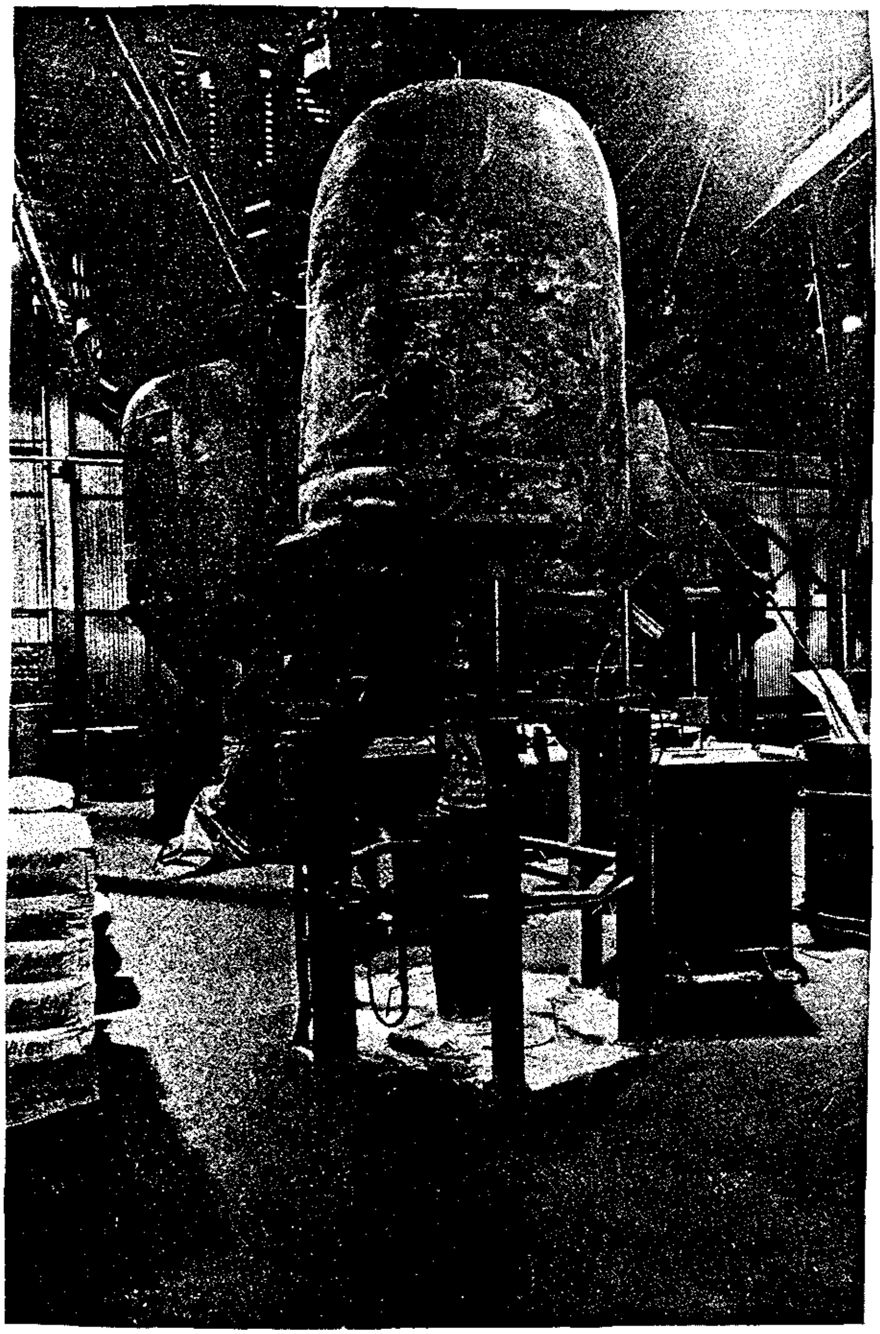

Figure 1-1. Sealdbins(R) and dispensing stations showing tilt stands.

Figure 1-2. Sealdbins(R) and dispensing stations.
Note positions of tilt stand tables and trolleys.

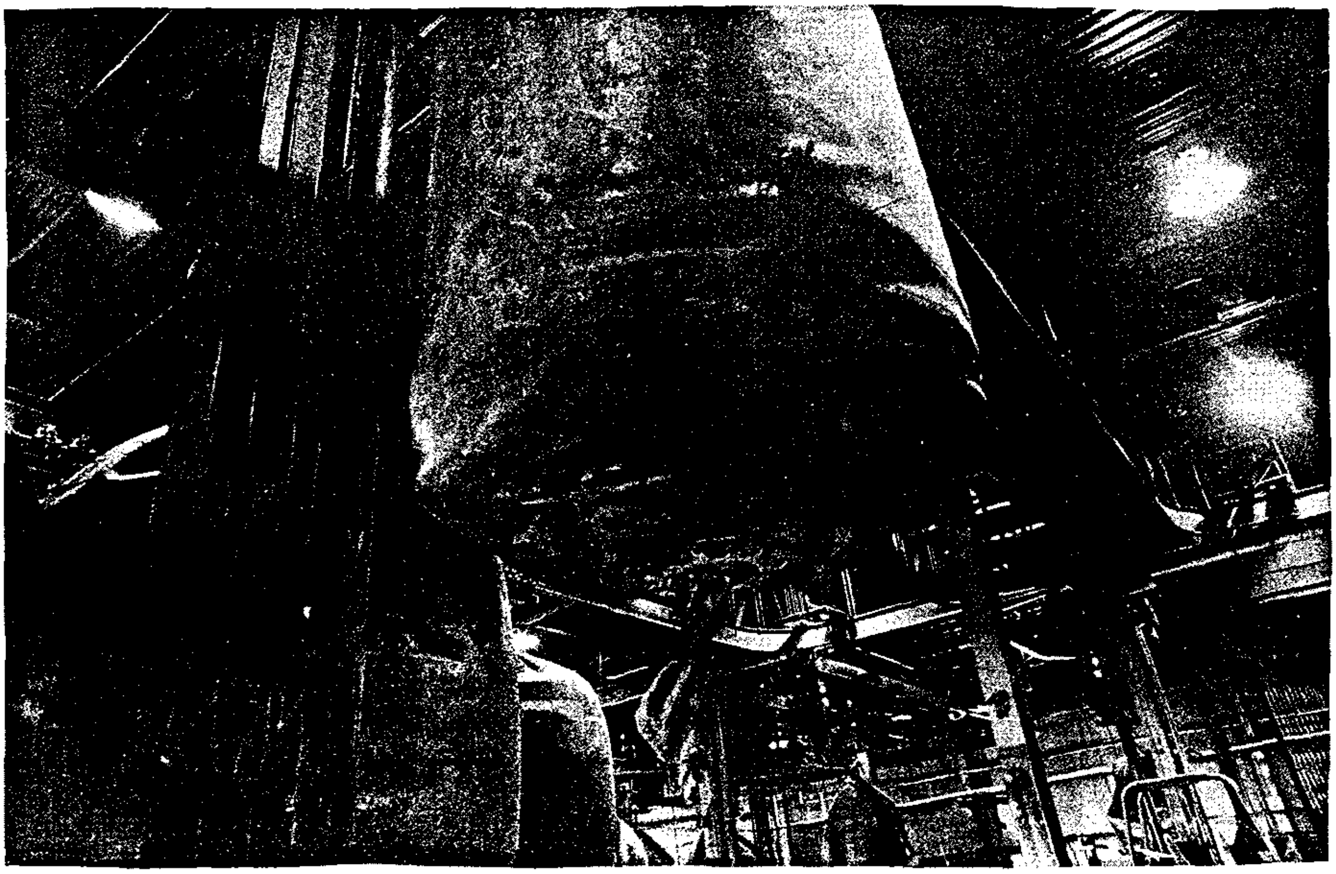

Figure 1-3. Sealdbin(R) showing bottom stock.
Also shown is the overhead conveying system.

of the bag. As a precaution, the plant has installed auxilliary manual loading hoppers next to the stands.

To allow for their overhead trolley system, the plant allowed 16 feet between the dispensing floor grade and the bottom of the trolley rail. According to the product literature, the dimensions of the suspended, full Sealdbin(R) are 88-inches-high by 48-inches diameter for the 70-cubic-foot bin, and 107-inches-high by 90-inches diameter for the 300-cubic-foot bin. The pneumatic cradle height at the plant was about 4-1/2 feet.

The pneumatic cradle, shown in Figures 1-1 and 1-2, is a table with a top which forms a funnel-shape when penumatic cylinders are actuated. The middle of the table is open to allow placement of the Sealdbin.(R) This ring is also the pivot point for the table arms. The cradle is also equipped with vibrators to shake the bins when needed.

The bags are returned to the material supplier either folded up or inflated to 3 psi. This plant's procedure is to inflate the bags and check them for leaks with a soap solution before shipping them to the supplier. In this way, leaks in the bag could be detected prior to shipping. Leaks in the bags are either cold-patched or patch-vulcanized, depending on their severity.

WORKER'S DUTIES

After a bag is emptied and moved to its storage area, the worker follows these steps to put a new Sealdbin(R) into operation:

1. A new Sealdbin(R) is positioned over the pneumatic cradle and lowered into position. The bin is lowered until its total weight is resting on the cradle, but the hoist is not detached from the bin.

2. The bottom cover plate is removed and the bottom sock is pulled from the emptying enclosure.

3. The bottom sock is fitted over the feed sleeve and sealed by a clamp.

4. The sock is untied and the cradle vibrators are activated. When the material is seen flowing through the sock, the vibrators are turned off.

5. Depending on the worker, the cradle air cylinders are actuated to move the arms into their raised position either when the bag is full or nearly empty.

Even with the vibrators, the material in the Sealdbin$^{(R)}$ will sometimes bridge and refuse to flow. In this case, the worker wedges a bar between the cradle ring and the bin and lifts against the bin to try and break the bridge. This was frequently observed with zinc oxide. Once the material starts flowing, however, there does not seem to be any other problems.

When the bag is empty, the reverse of the above procedures is used to remove the bin.

AIR SAMPLING DATA

Air samples were not collected as part of the study of this system. However, air samples were collected on the worker as part of a study of the hopper/bins.

VENTILATION DATA

There was no ventilation used to control dust emissions from the Sealdbin$^{(R)}$ system. A ventilation system was used on the auxiliary hoppers for the Sealdbin$^{(R)}$ system and ventilation measurements were made on that system. Because of the similarity between the auxiliary hoppers and the hopper/bins on the mixer charging system bins, the ventilation data for the auxillary hoppers is included in the detailed study for the latter.

EMISSION SOURCES OBSERVATIONS

The sources of dust emissions from the Sealdbin(R) system is the powdered materials in the Sealdbins(R). Dust generation into the air is by:

1. Dusts dispersed into air from spills or leaks in the system.

2. Dusts adhering to the bags or their socks being dispersed into the air.

3. Dusts entrained in air displaced when the sock is collapsed and pushed back into the emptying enclosure.

WORK PRACTICES OBSERVATIONS

The worker had responsibility for handling and hooking-up the Seald- bins(R) and some dust emissions can be the direct result of the way their job was performed. Therefore, work practices can have an effect on dust generation.

The procedure for handling and hooking-up the Sealdbins(R) as specified by the company appears to effectively prevent dust generation. In the observed operations, little visible dust was generated when the procedure was followed. Overall, the workers conscientiously followed the procedures.

Some work practices were observed which could increase dust generation. They were:

1. Spilling material. The reason for the spill was not investigated.

2. Not cleaning up spilled material beneath the stands.

3. Moving Sealdbins(R) with the bottom sock extended and the bottom cover plate off.

ENGINEERING CONTROLS OBSERVATIONS

Outside of materials bridging in the Sealdbins(R) and an occasional leak in a bag, there did not seem to be any problems with the operation of the system. No dust was observed being generated during hook-up of the Sealdbins(R) or while they were operating. Handling of materials by this system appeared more enclosed than other types of large volume handling systems.

One safety problem was observed with the system. When the cylinders that raised the arms of the pneumatic cradle were shut-off, the arms dropped rapidly without warning. The worker operating the cradle controls is responsible for assuring the area around the cradle is clear. But, the Sealdbins(R) can block his sight of part of the cradle. Severe injury appeared possible should any of the cradle arms hit someone.

MONITOR OBSERVATIONS

No monitoring equipment for specific contaminants or ventilation performance was noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

Dust generated from hooking up and unloading the Sealdbins(R) and from leaks can directly enter the worker's breathing zone. Dusts generated from leaks in the system or from spills can enter the general room air and elevate background contaminant concentrations which can also elevate the worker's exposure. How- ever, the total time spent by the worker in hooking up or unhooking the Seald-bins(R) (about 10 minutes) was relatively small. Also, leaks from tears in the Sealdbins(R) are reported to occur only two or three times a week and are easily repaired. Therefore, the greatest contribution to the worker's overall exposure is felt to be from spills.

Dust generation appeared to be a direct result of the way the worker performed his job. No ventilation systems were installed to capture dust generated by Sealdbin(R) operations. Therefore, work practices are very important in preventing dust generation.

The procedures outlined by the plant and followed by the workers appeared effectively in eliminate dust generation from hooking and unhooking the Sealdbins(R) from the system. No dust generation was observed during these operations.

The Sealdbin(R) system appeared to provide more enclosure for handling the large volumes of bulk materials than other systems. Inherently, the more such systems are enclosed, the less dust is generated.

HOPPER/BIN (2)

AREA: PRECOMPOUNDING

DESCRIPTION

The hopper/bin is part of an automatic weighing system - chemicals from the bin are automatically weighed and charged into the mixer. Each mixer is fed by two clusters of six bins each, although all bins need not be used at one time.

The hood used on the hopper/bins depends on whether the material was an explosion threat or not. The hoods for one cluster of bins are tied to a common manifold, but the system is designed to handle only one hood at a time. Each hood on the bins containing nonexplosive materials have doors made airtight by foam rubber around the edges. On bins containing explosive material, the evident intention is to have the compound seal the hood opening when the bin is full. When all hoods are sealed, air is proportioned into the system manifold by a counter weight damper. In addition a grate at the top of the bin, prevents foreign objects from falling into it. The hopper/bins and their ventilation system are shown in Figures 2-1 through 2-5.

The hopper/bin ventilation was designed and installed integral with the plant construction. Construction took place in the early seventies. At that time, judging from the welding seams on the explosive material hoppers, all of the hopper/bins were of the nonexplosive material design. However, at some time since and for reasons not ascertained, the explosive material design was implemented.

WORKER'S DUTIES

The worker's primary duty at the hopper/bins is to empty chemicals from containers, either paper bags or plastic bags within fiber drums, into the hopper. This job is performed on an as-needed basis. To empty paper-bagged chemicals:

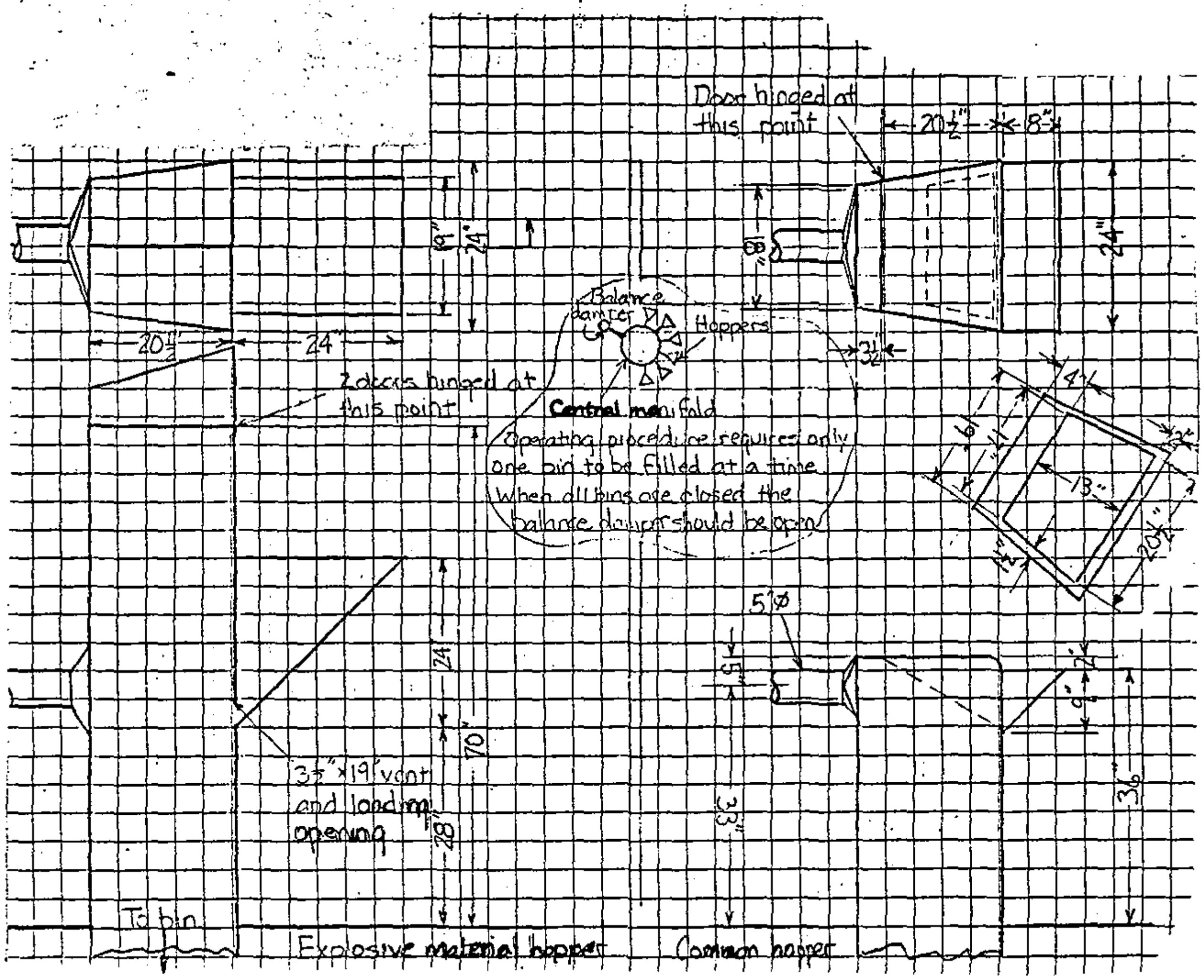

Figure 2-1. Hopper bin hood details.

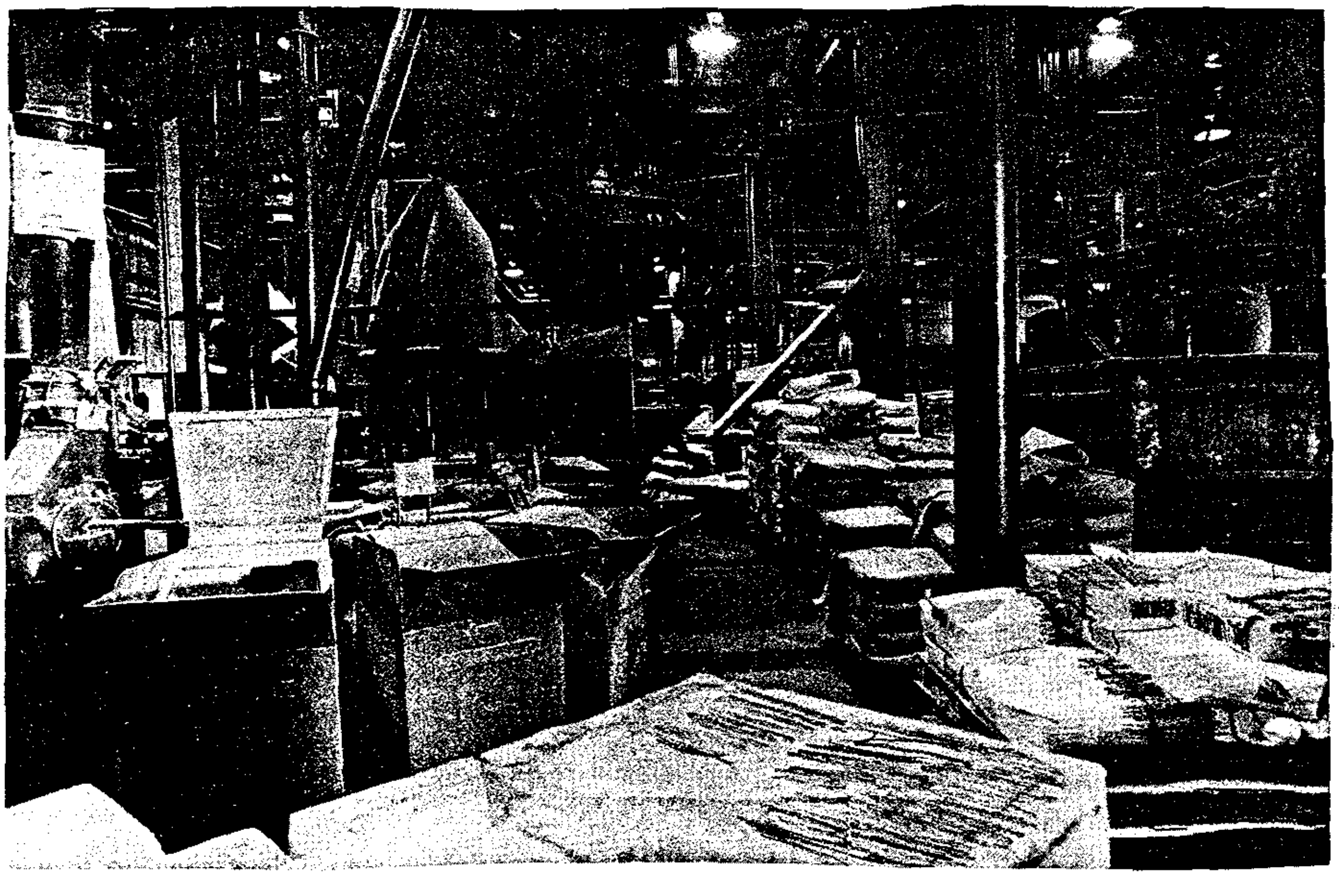

Figure 2-2. Hopper/bin loading station.

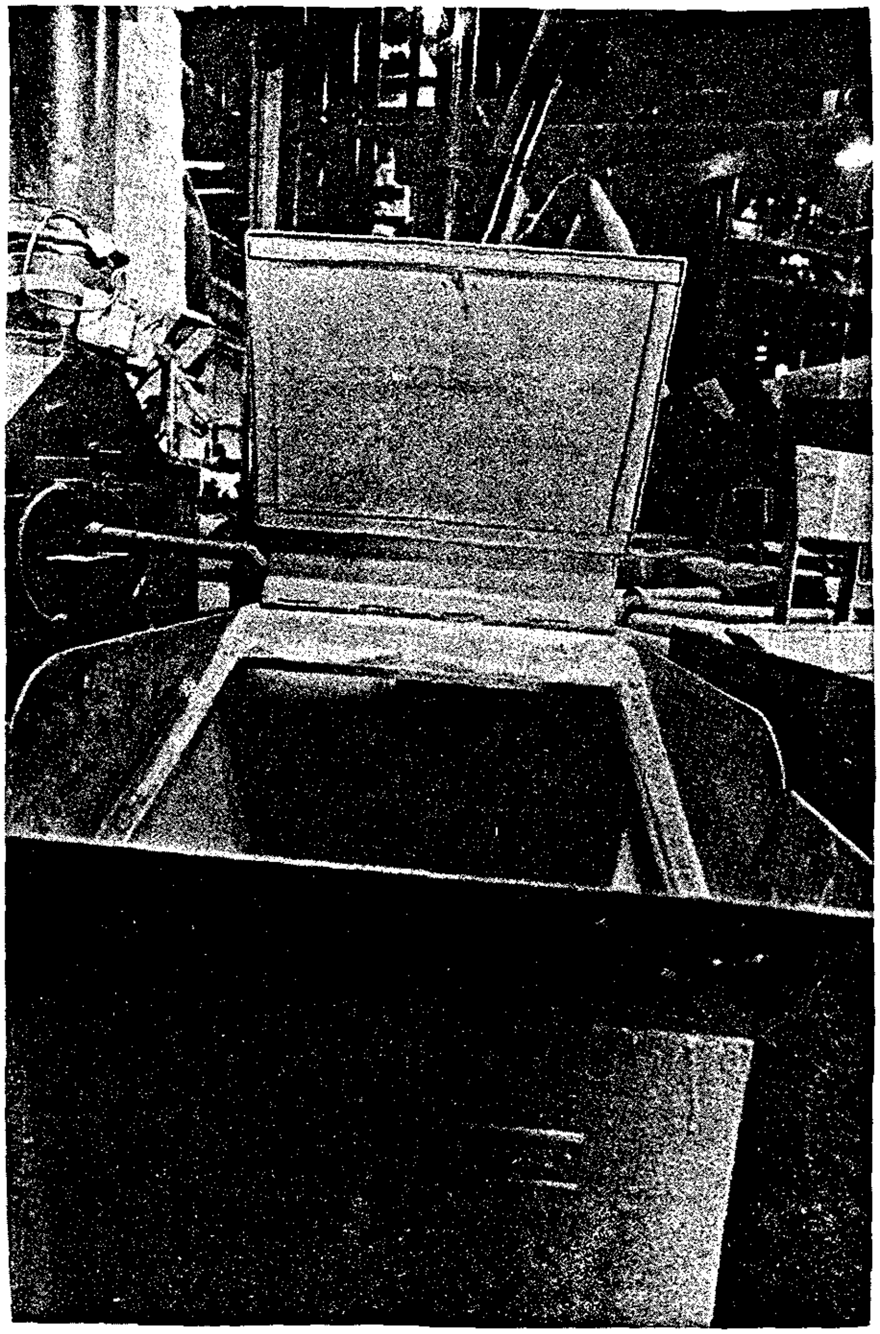

Figure 2-3. Hopper/bin hood for nonexplosive materials.

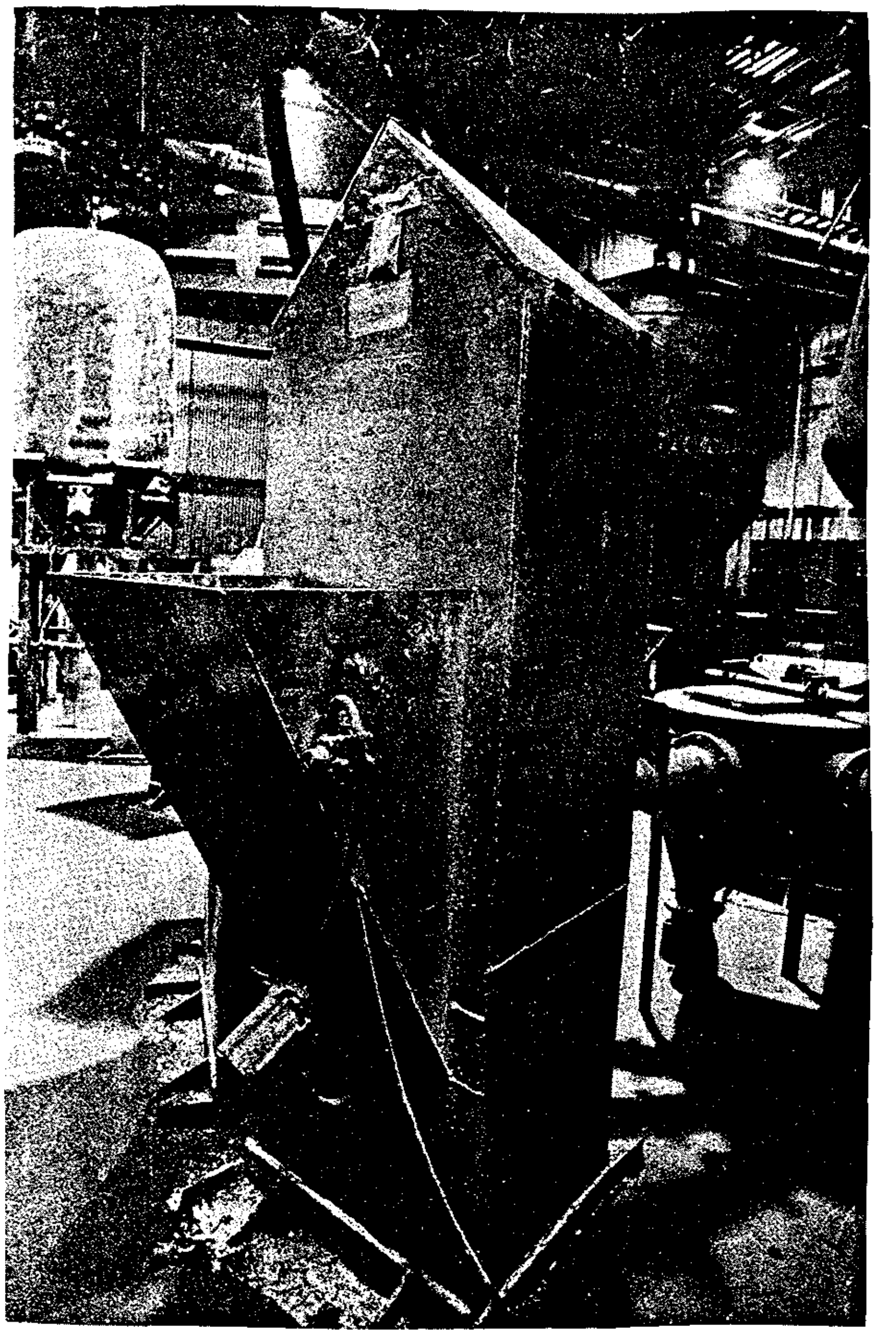

Figure 2-4. Hopper/bin hood for explosive materials.

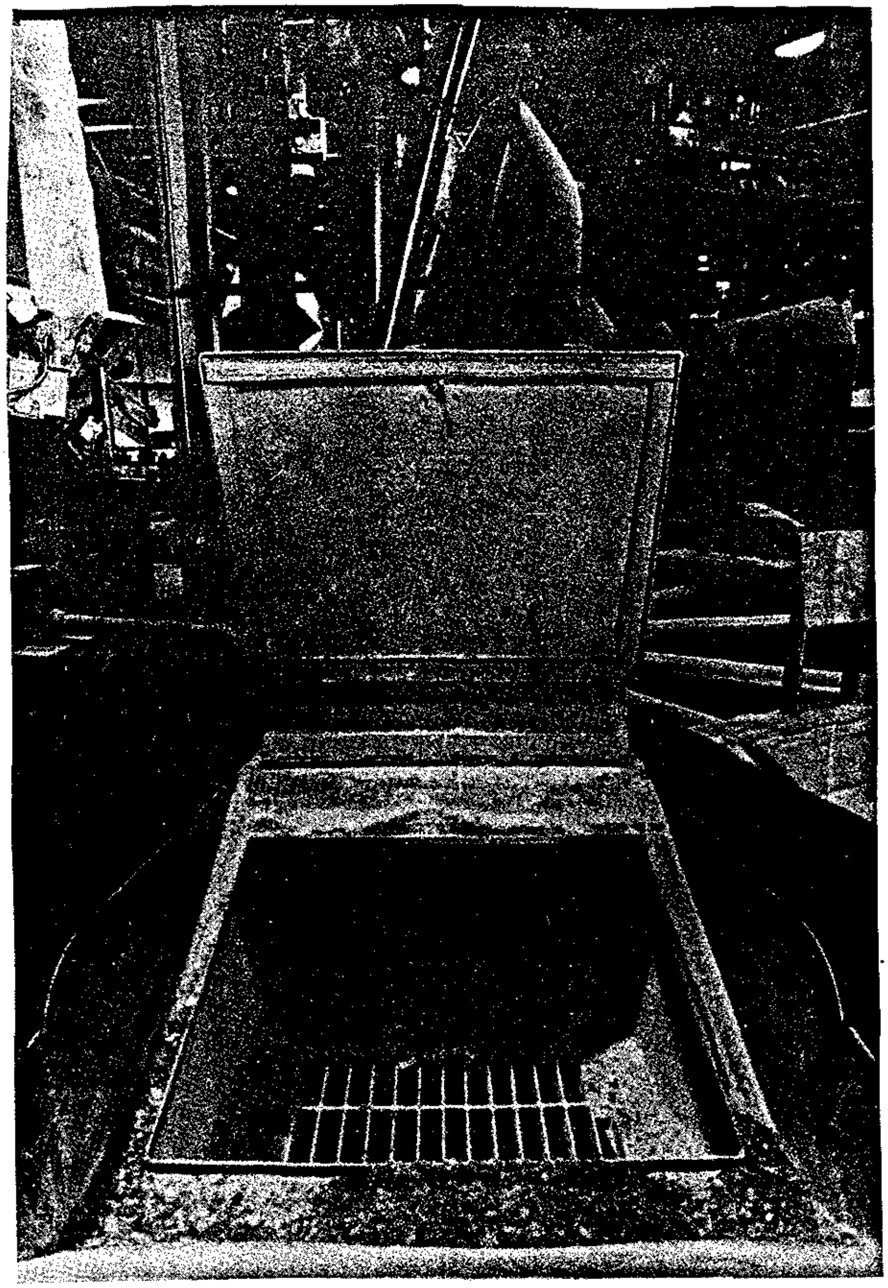

Figure 2-5. Hopper/bin hood for non-explosive materials
showing protective grate and duct entrance.
Also note material accumulated on the edges of the hood face.

1. A bag is picked-up from the pallet and placed broadface down on the forward position of the hopper/bin.

2. The bag is slit across the middle of the upper broad face and sides, but the bottom side is left intact.

3. The bag is flipped away from the worker so the cut face is turned down into the hopper/bin.

4. To empty the bag, it is pulled up by its ends and any chemical residues are gently shaken out.

5. The bag is placed in a garbage container.

To empty materials in plastic bags within drums:

1. The drum is turned on its side between the forks of a forklift.

2. The drum is transported to the appropriate hopper/bin and positioned so that the front edge of the drum is over the bin opening in the hopper/bin.

3. The drum lid and the plastic bag inside are opened successively.

4. To empty the bag, the end of the drum is lifted to tilt the drum and let the material flow out of the bag.

The worker's other duties relative to the hopper/bins are moving pallets of chemicals to the hopper/bins and removing empty pallets, keeping hood doors closed, repairing broken bags, cleaning up spills and keeping others from tracking through spills, and doing general housekeeping by vacuuming or wet mopping. Overall, the plant estimated the worker spent 2-hours per shift loading bins. The rest of the worker's time is spent performing duties in other areas of the plant.

AIR SAMPLING DATA

One cluster of hopper/bins was selected for air sampling based on its use and general condtion. Total particulate area samples were collected at the locations shown in Figure 2-6. Total and respirable particulate samples were collected on the worker. The results of the samples are summarized in Table 2-1. Personal samples were not removed from the worker when he was not loading bins. However, his greatest source of exposure was judged to be from hopper/bin loading and most of the hopper/bins where he worked had similar controls. Also, hopper/bin loading was performed intermittently throughout the entire shift.

Statistical analysis of the total particulate sampling results using analysis of variance and Duncan's Test is summarized in Table 2-1. Analysis of variance showed that location and shift significantly affected concentration. The results of the analysis are found from the Duncan's Test column and explanations at the bottom of the table.

Table 2-1. Full shift particulate concentrations for a hopper/bin.

Location (No. from Fig. 1-1)	Shift	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)	Duncan's Test[c]
Total Particulate:							
Column (4)	1	4	0.09	1.6	0.10	0.07-0.17	A
Column (4)	2	4	0.11	1.6	0.12	0.05-0.18	A,B
Hopper/bin hood manifold (1)	1	4	0.23	1.5	0.24	0.15-0.36	B,C
Hopper/bin hood manifold (1)	2	4	0.27	1.6	0.29	0.17-0.42	C
Worker (2)	1	4	0.50	1.8	0.55	0.21-0.87	C,D
Worker (2)	2	4	0.92	2.3	1.20	0.69-2.40	D
Respirable Particulate:							
Worker (3)	1 & 2	8	0.17	1.9	0.20	0.08-0.27	not-included

a. Locations with the same letter are not significantly different.

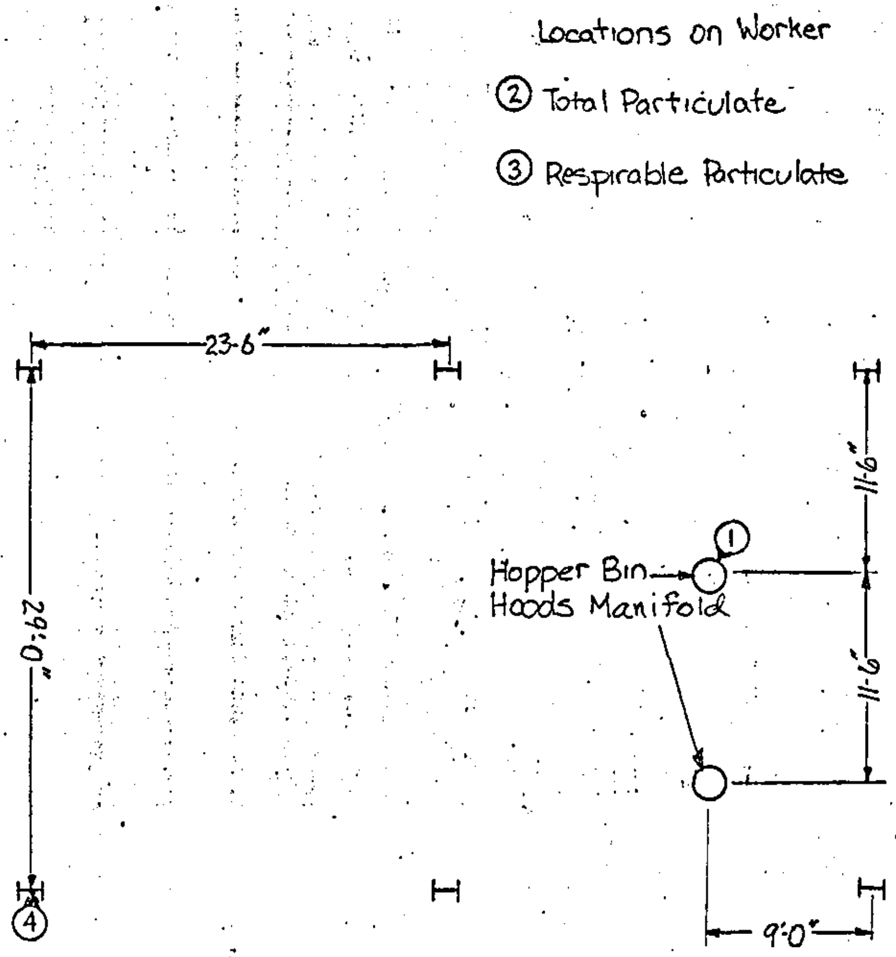

Figure 2-6. Hopper/bin sample locations.

VENTILATION DATA

Ventilation measurements were performed on one hood selected from the cluster where air samples were collected. For comparison, measurements were also performed on the hood of an auxilliary loading hopper. This hopper was of similar design to the former except it was directly connected to the ventilation system instead of a manifold like the former. The ventilation measurements are summarized in Table 2-2 and shown in Figures 2-7 and 2-8 in Appendix IV. Special conditions under which the measurements were made are indicated in the figures

Table 2-2. Hopper bin hood ventilation data.

Measurement	Quantity Measured	Design
Hopper/Bin Hood on Manifold		
Calculated average duct velocity[a]	3660 fpm	3665 fpm
Calculated duct flow	500 scfm	500 cfm
Estimated duct static pressure	6.0 in. H_2O	Unknown
Avgerage face velocity	60 fpm	295 fpm[b]
Auxiliary Hopper Hood		
Average duct velocity	4580 fpm	3665 fpm
Calculated duct flow	625 scfm	500 cfm
Duct static pressure	2.8 in. H_2O	Unknown
Average face velocity	310 fpm	295 fpm[b]

a. Measured at location after manifold.
b. Calculated from design drawing dimensions and airflow rates.

EMISSION SOURCES OBSERVATIONS

The source of the emitted dust at the bin loading operation was dusts from the powdered compounds. These specific sources were noted:

1. Dusts forced into air or entrained in air displaced when bags were emptied into the hoppers.

2. Dusts entrained in air displaced from collapsing empty bags.

3. Dusts from spilled compounds being dispersed into air.

4. Dusts slung into the air by empty bag handling.

WORK PRACTICE OBSERVATIONS

The worker generally had close contact with the material being poured in the hopper/bins and the generation of dusts was the direct result of the way the operation was performed. Also, proper operation of the ventilation system depended on work practices. Therefore, work practices appeared to have an important effect on the worker's exposure and ventilation system performance.

Work practices which could reduce dust generation were:

1. Splitting bags in the method specified by the plant. This method seemed well adapted for the hopper/bin hood. It permitted the hood face to remain open during slitting.

2. Specifying repair for split bags.

3. Carefully handling and disposing of empty bags.

4. Using wet mopping, wet mechanical sweepers, and vacuuming to clean up spills.

5. Sealing bags on dust collector returns. Bags were taped directly to the return.

Work practices which could increase dust generation or affect ventilation system performance were:

1. Not repairing split bags.

2. Dry sweeping spilled materials.

3. Sweeping spilled materials under structures.

4. Not using the vacuum system. Although the system was reportedly not working, the plant maintenance department was not informed.

5. Leaving hood doors open.

6. Not keeping door seal area clear. Material was spilled on the lower part of the hood face which prevented the door from closing. Also, sample bags of the material in each respective bin were hung on the hood door. When the door was closed, the bags prevented it from sealing.

7. Beating on hood ducts to clear them. Some ducts had been severely dented.

8. Not maintaining the ventilation system.

9. Not adequately protecting plastic bags for dust collector returns. The bags were set on the floor and in the open.

ENGINEERING CONTROLS OBSERVATIONS

On both the explosive and nonexplosive-type hoods, dust escaped the hood during bin filling. Also, the design of both hoods could permit blockage of a large portion of the hood face area by the bag being emptied into it. This was particularly true for the explosive material hoods. At these hoods, the material being poured into the bin entered it through the same area as the air was being pulled into the hood. The material could easily block the entrance so air could not be pulled into the hood. Therefore, dust generated from emptying bags could not be captured.

The design of the explosive material hood also appears to defeat the original design parameters of the ventilation system. Those parameters specify operation of only one hood at a time. The construction of the explosive material hoods permit air to be continuously drawn into them.

The airflow into the hopper/bin hood on the manifold, calculated from the hood face area and face velocity measurements, is about 100 cfm. Yet the airflow measured in the duct for the entire cluster of hoods was about 500 cfm. The difference in the measurements suggests leaks into the ventilation system. These leaks are probably through the damper or the hood door seals.

MONITOR OBSERVATIONS

No monitoring equipment for ventilation performance or specific contaminants was noted.

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

Workers used NIOSH approved nuisance dust respirators and Playtex(R) gloves. Workers felt the gloves were very durable and provided much ease of movement. Workers were also provided laundered coveralls.

DATA INTERPRETATION

Dusts generated from bag slitting, bin filling, and bag disposal can directly enter the worker's breathing zone. Dusts generated from housekeeping practices and spilled material can enter the general room air and elevate the background contaminant levels. Judging from the background contaminant levels as shown by the air samples collected on the column remote from the area, the worker's greatest exposure appears to come from dusts generated during bin filling.

The hopper/bin hood upon which ventilation measurements were made was found to be operating at only 20 percent of its design. Therefore, judgement of its effectiveness in controlling the dust generated from bag slitting and bin filling cannot be made. A true indication of the ventilation parameters was obtained from a hood which was operating at its design.

Some aspects of the hopper/bin hood design are undesirable. They are specifically presented in the "Engineering Controls Observations" section. Overall, the problems are blockage of the hood face by the bag during bin filling, operation of more than one hood at a time, leakage of air and the waste of chemicals.

The workers' exposures are significantly higher than background (sample location 4 in Figure 1-1), but not significantly different than the manifold sample levels. The increased worker exposure may be from dust observed escaping the hopper/bin hoods during bin filling. The worker's work practices are felt to control dust generation away from the hopper/bin hoods, as evidenced by the low background concentrations. Workers also appeared conscientious in their bin filling operations.

The worker's work practices can affect the operation of the ventilation system. Not keeping door seal areas clear and leaving hood doors open causes leaks in the ventilation system. Overfilling bins with the present design permits material to enter and plug hood ducts.

Maintenance work practices are felt to be the cause of the decrement in the hood's performance. The damper on the manifold did not appear to work because it was covered with material. Also, some ducts were partially plugged.

AUTOMATIC COMPOUNDING SYSTEM (3)

AREA: COMPOUNDING

DESCRIPTION

This compounding system is used to weigh masterbatch or final batch compounds and dispense them into the mixer. The basic components of the system are schematically shown in Figure 3-1.

The compounding system is computer operated and remotely controlled from an isolated room away from the mixing area. The system occupies three floors. On the third floor, compounds are poured into the system. The weighing equipment is on the second floor and the charging equipment is on the first floor.

The transition of a compound through the system is:

1. The compound is poured into the storage bin.

2. As needed, the compound is transferred from the storage bin to the weigh hopper by either an enclosed vibratory or screw conveyor (depending on feed rates and other factors).

3. After the proper weight of compound is attained, it is dropped into a surge hopper.

4. When the mixer is ready, the compound is discharged from the surge hopper into the mixer via transition chutes.

To facilitate movement of the compound through the system, vibrators are located on the weigh and surge hoppers, and on the lower transition chute. Also for this purpose, breakers are located in the throat of several of the storage bins.

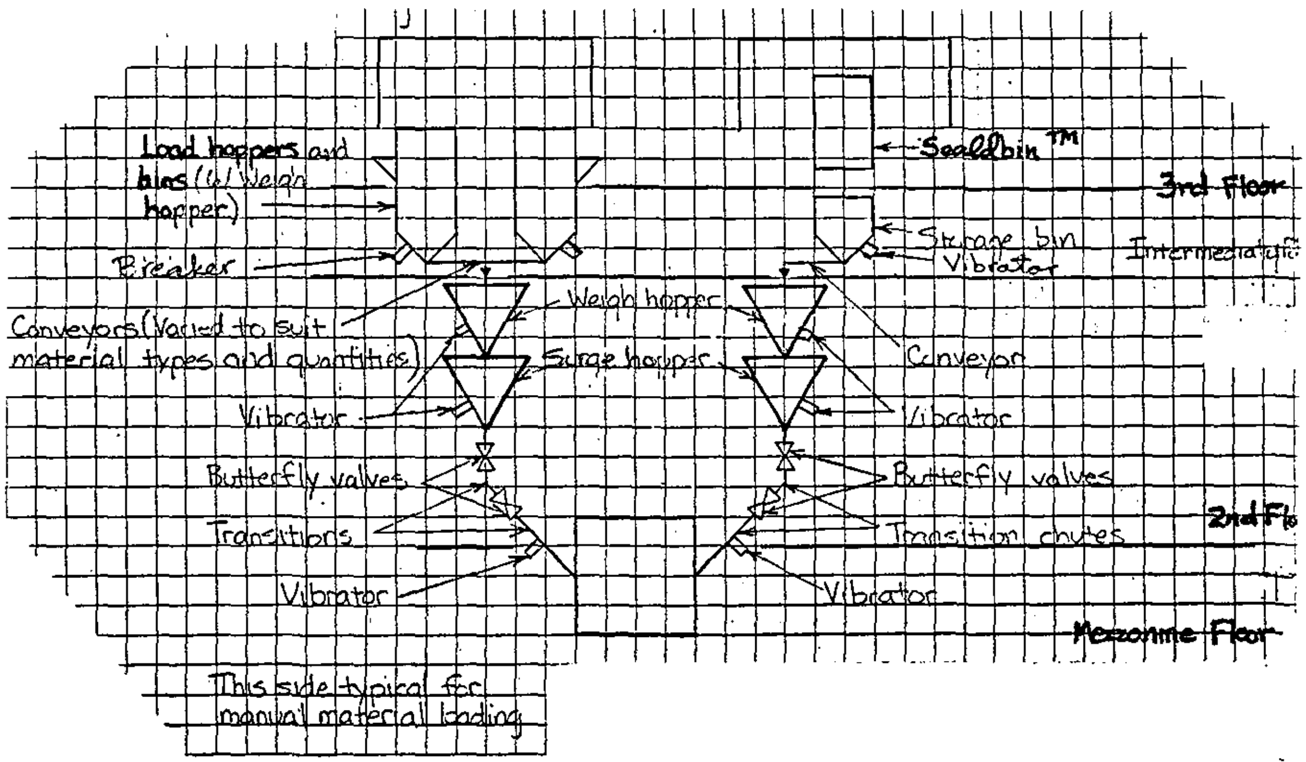

Figure 3-1. Automatic compounding system schematic.

The weighing mechanism on the system and its controls were designed by Toledo Scale (Div. of Reliance Electric). The company's reported accuracy on the weighing mechanism is 0.01 pounds. Toledo Scale claims the repeatability is 0.0002 pounds. To maintain the equipment's accuracy, it is checked periodically with a standard weight - adjustments are made every 3 to 6 months.

The only ventilation used on the system is a ventilated enclosure over the weigh hopper. This enclosure also covers the discharge end of the bin conveyors feeding the weigh hoppers and the inlet of the surge hoppers.

WORKER'S DUTIES

The area covered by this case study is the materials handling equipment in the system. Although a worker is involved with loading materials into the system and one is involved with operating the mixer, they are outside the scope of this study. For the system itself, no production workers are required, since it is controlled by computer. Only maintenance and quality assurance personnel are involved with this system and that involvement is infrequent.

AIR SAMPLING DATA

No air samples were collected around the compounding machinery. However, samples were collected on a mixer below the automatic compounding system as part of a study of that mixer. Past experience has shown that materials leaking from materials handling systems above the mixers generally causes an increase in the background concentrations around the mixer (if there is no additional contributors in the area). Therefore, indications of the system effectiveness may be shown by the samples collected at the mixer.

VENTILATION DATA

The ventilation measurements made on one weigh hopper enclosure are summarized in Table 3-1. Design airflow parameters were not available.

Table 3-1. Weigh hopper enclosure ventilation data.

Measurement	Quantity Measured
Average duct velocity	1905 fpm
Calculated duct flow	260 scfm
Duct static pressure	0.91 in. H_2O

EMISSIONS SOURCES OBSERVATIONS

The source of emissions from the automatic compounding system appears to be dust from the materials in the hopper. The possible emission sources observed were:

1. Dusts dispersed into the air by material movement on the conveyors.

2. Dusts dispersed into air from material falling into the weigh hoppers.

3. Dusts dispersed into air from leaks and cracks in the system.

WORK PRACTICES OBSERVATIONS

Little routine, direct contact is made between the workers and the materials in the charging system. So, production work practices appear to have little effect on dust generation. However, maintenance work practices can affect dust generation. In one case, some covers and seals on the conveyor enclosures were not replaced causing significant dust generation when the conveyor was started. Workers had tried to prevent the dust emissions by wrapping the conveyors in plastic.

During the study, cracks developed in the sides of two surge hoppers on one mixer. When informed of the problem, the plant promptly repaired the cracks.

ENGINEERING CONTROL OBSERVATIONS

Dust was not observed escaping from the automatic charging system except from open conveyors and cracks in the hoppers as mentioned previously.

The weighing system on the charging system was reported to operate with few problems. However, the material did cause sticking and bridging problems in the system hoppers. The sticking appeared to result from the hygroscopic nature of most of the materials. To combat the problem, the plant uses large vibrators. The plant also tried blowing dried compressed air through a perforated pipe inserted in the hopper. This was not successful because the material rapidly plugged the holes. The plant is still trying to solve this problem.

The vibrators on the system apparently helped move the material through the system, but they are noisy and caused metal fatigue on the structures to which they were attached. To combat the noise problem on some mixers, the plant switched some of its vibrators from hammer types to rotary types. Also, to combat the metal fatigue problem on some mixers, the plant has mounted the vibrators on metal channels welded on the sides of the hoppers and has used isolators between the lower transition chute and the mixer. For the former, metal fatigue still occurs, but it takes longer to occur. The re-occurrence of the fatigue, however, could be due to previous stress cracks in the metal or localized hardening of the steel because of welding used to seal cracks.

Overall, most parts of the automatic compounding system were well lighted and highly visible. This permitted easy visual inspection of the system for leakage.

MONITORS OBSERVATIONS

No monitoring equipment for specific contaminants or on ventilation system performance was noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

Use of an automatic system for compounding operations replaces the need for workers to perform that job and eliminates the exposure associated with manual compounding. As demonstrated by the installation in this plant, an automatic compounding system permits better enclosure and control of dust generating parts of the operation. This further reduces dust generation into the general plant air, and thus, decreases the back-ground concentrations.

The automatic compounding system does have materials handling problems. The materials sticking in the hoppers is an unresolved problem The weighing operations for the material, though, appear to be fully operational and functional with few problems.

The only work practices which could affect dust generation from the system appear to be those which defeat enclosure of the system, such as not replacing seals or conveyor covers. Conscientious efforts were being made by this plant to maintain its system.

MIXER VENTILATION SYSTEM (4)

AREA: MIXING

DESCRIPTION

The mixer is a size K-7 Intermix and is used to mix final batch stock. On this mixer, process oils and most of the powdered compounds are automatically fed directly into the mixing chamber. Preprocessed sheet rubber is fed into the chamber by conveyor belt via the charge door and mixer hopper. Low volume compounds for certain batches are also fed in with this rubber stock. These compounds are measured by volume, not by weight.

The operations of the mixer are automatically controlled by a computer located away from the area. The worker at the mixer weighs-out the rubber sheet stock on a conveeyor. His location is about 20 to 30 feet from the mixer. Under normal conditions, the worker need not go near the mixer. A layout of the mixer charging area is shown in Figure 4-1.

The ventilation system on this mixer consists of a charge door hood, internal mixer vent exhaust, and discharge door hood. The charge door hood is shown in Figures 4-2 and 4-3. It is a box-like construction with a number of exhaust slots and duct entrances located at several points around the hood. Dual exhaust slots are also located over the closed charge door position. Hinged access doors are located on both sides of the hood. The doors are equipped with latches.

The internal mixer vent exhaust consists of four separate exhaust ducts connected to openings into the mixer hopper. Two of these were installed originally on the mixer and are located on both sides of the lower part of the mixer hopper. The other two were installed to service the tell-tale rods, but, since tell-tale rods were never used on the mixer, the vents should only

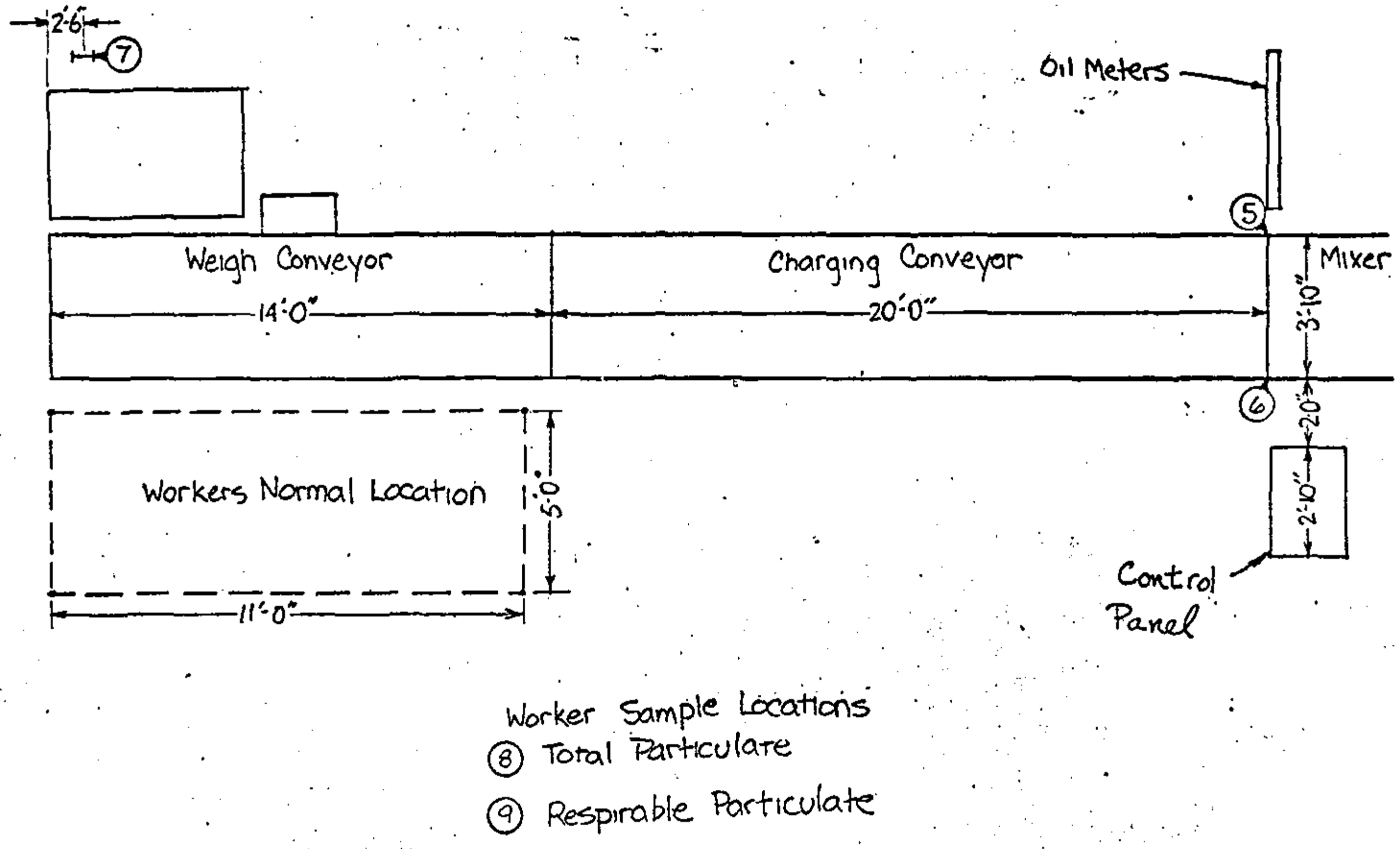

Figure 4-1. Mixer charging area layout and sample locations.

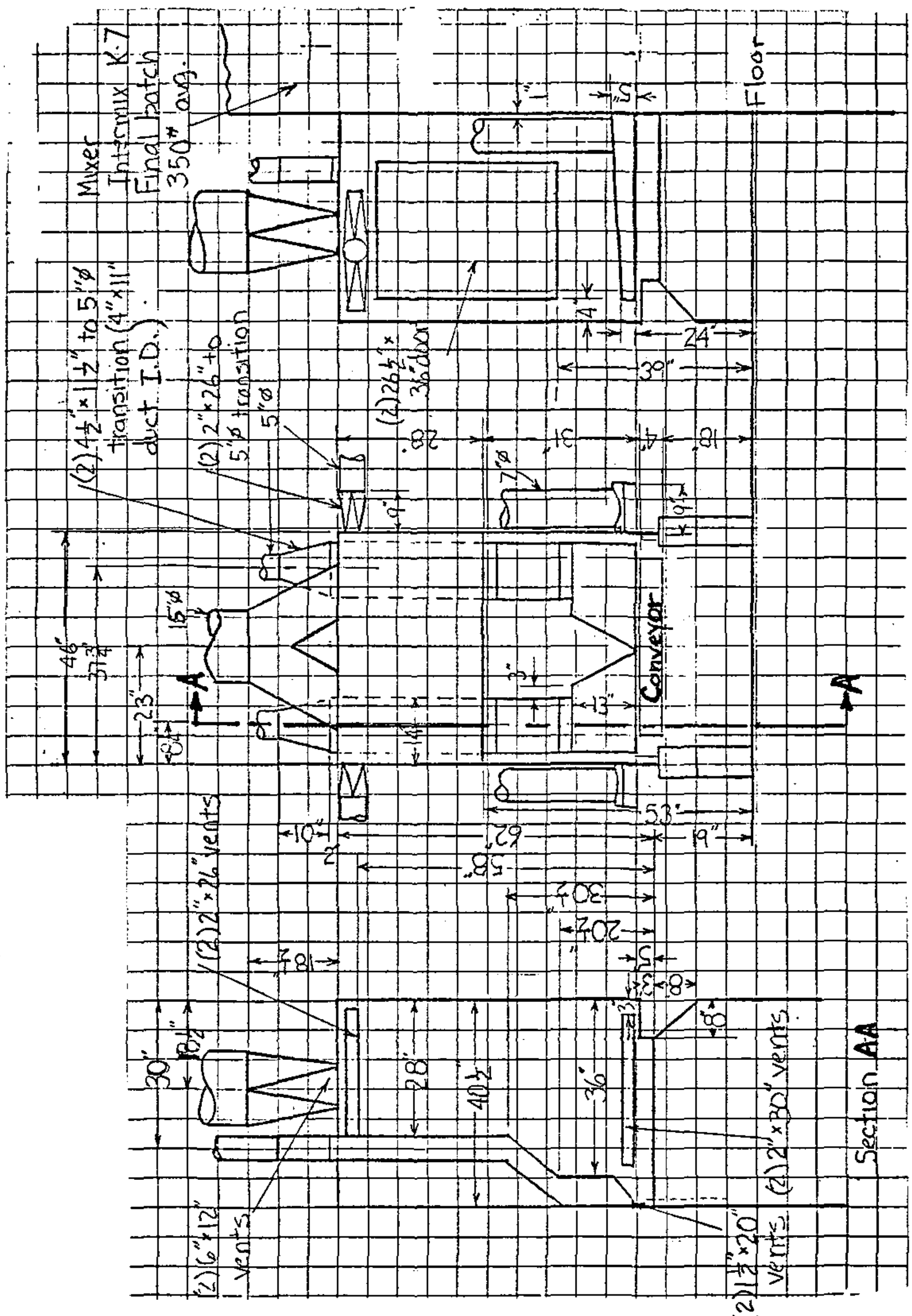

Figure 4-2. Mixer charge door hood detail.

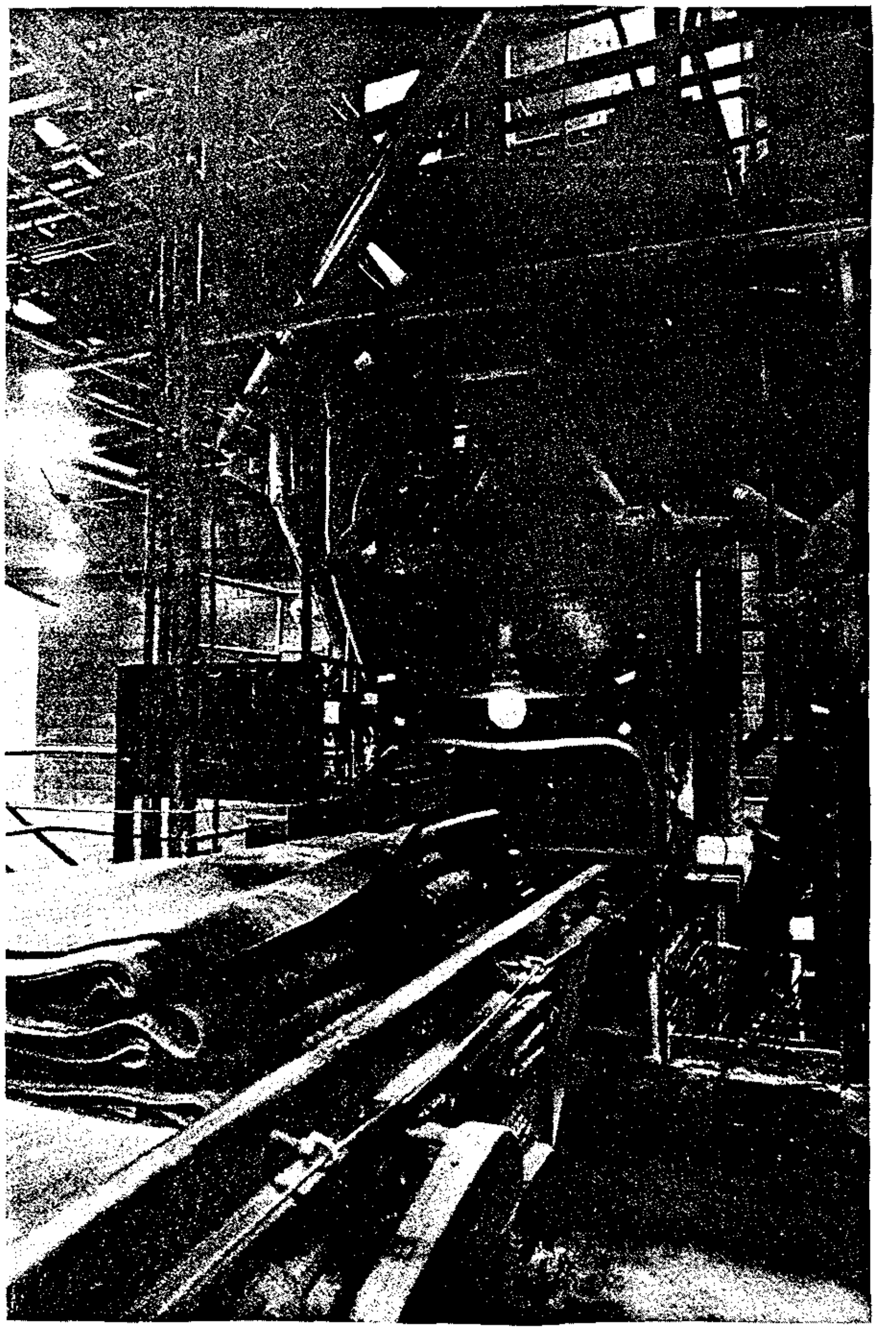

Figure 4-3. Mixer charge door hood.

vent the inside of the mixer. Both of these vents are located on the upper part of one side of the mixer hopper. Additional changes are noted below.

The discharge door hood was constructed by enclosing the front and back areas between the mixer legs and adding four exhaust duct entrances. The exhaust air into the hood evidently was designed to be drawn into the enclosure through the area under the dust rings. Doors are located in both sides of the enclosure. A typical side of the enclosure is shown in Figure 4-4.

The original ventilation system was designed for installation with the mixer machinery, but over the years some changes have been made:

1. The original design called for dust ring hoods on the mixer, but these had been removed and appear to have been used for the items in (2).

2. The drawings do not call out two of the internal mixer vent exhausts (not the "tell-tale hood" vents) and two slots on the charge door hoods (slots C and F in Figure 4-5 in Appendix IV). The exhaust supply for one or both of these sets appears to have come from the hoods mentioned in (1).

3. The tell-tale hoods were added after original installation of the ventilation system as mentioned above.

4. Cleanout doors were added to the lower slot duct entrances on the charge door hood (slots B and G in Figure 4-5) shortly after the original installation.

5. The plant converted the sliding gate on the mixer discharge to a drop door. To do this, the plant attached a shaft eccentrically to one side of the existing slide gate and added mechanisms to rotate the door like a drop door.

WORKER'S DUTIES

Virtually, the only job the worker performs is weighing rubber sheet stock.

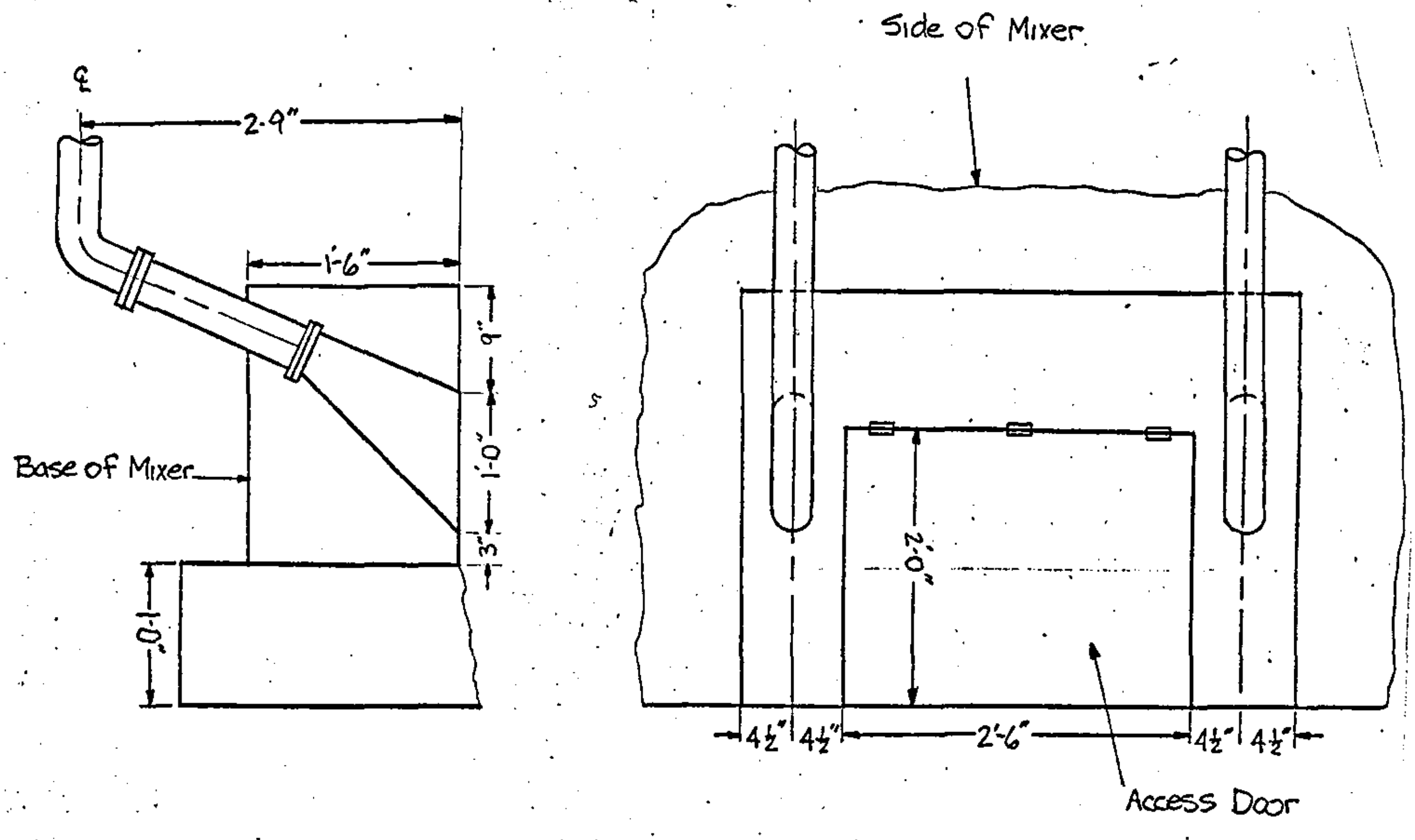

Figure 4-4. Mixer discharge door hood detail.

To do this, the rubber is pulled off a pallet and onto the weigh conveyor by a machine. When the proper weight of rubber is attained, the sheet is cut off by knife. If required, small amounts of powdered compounds are measured out in a styrofoam cup and poured on the rubber. Workers normally performed this job for about two hours, twice a day at this mixer. The rest of the time is spent performing duties at another mixer.

Workers perform some housekeeping as needed. Normally mechanical sweepers make regular rounds in the area.

AIR SAMPLING DATA

Total particulate area samples were collected at the locations shown in Figure 4-1. Total and respirable particulate samples were collected on the worker. These samples were transferred between the workers as they relieved each other. Sample results are summarized in Table 4-1 and detailed in Appendix III.

Statistical analysis of the total particulate sampling results using analysis of variance and Duncan's test is summarized in Table 4-1. Analysis of variance showed that location significantly affected concentration. The results of the analysis are found from the Duncan's test column and explanations at the bottom of the table.

Table 4-1. Full shift particulate results for a mixer.

Location (No. from Fig. 4-1)	N	GM (mg/m³)	GSD	AM (mg/m³)	Range (mg/m³)	Duncan's Test[c]
Total Particulate:						
Worker (8)	8	0.08	2.5	0.11	0.01-0.14	A
Charge door hood, left (5)	8	0.19	1.5	0.20	0.15-0.30	B
Column (7)	8	0.21	1.5	0.23	0.10-0.45	B
Charge door hood, right (6)	8	0.26	1.5	0.29	0.14-0.60	B
Respirable Particulate:						
Worker (9)	8	0.06	2.6	0.08	0.01-0.14	not included

a. Location with the same letter are not significantly different.

VENTILATION DATA

The ventilation measurements are summarized in Table 4-2 and shown in Figures 4-5 and 4-6 in Appendix IV . Special conditions under which the measurements were made are indicated in the table and figures, and labeling of the slots and duct entrances are shown in Figure 4-5. Design airflow parameters are given where available.

Table 4-2. Mixer ventilation data.

Measurement	Quantity Measured	Design
Charge Door Hood		
Average duct velocity[a]	2600 fpm	Unknown
Calculated duct flow[b]	3985 scfm	4000 cfm[c]
Duct static pressure	3.0 in. H_2O	Unknown
Average face velocity	295 fpm	Unknown
Slot A		
Average velocity	615 fpm	2000 fpm
Calculated flow	130 cfm	420 cfm
Slot H		
Average velocity	1525 fpm	2000 fpm
Calculated flow	320 cfm	420 cfm
Slot B		
Average velocity	1460 fpm	2240 fpm
Calculated flow	615 cfm	940 cfm
Slot G		
Average velocity	1280 fpm	2240 fpm
Calculated flow	535 cfm	940 cfm
Slot C		
Average velocity	425 fpm	Unknown
Calculated flow	155 cfm	Unknown
Slot F		
Average velocity	415 fpm	Unknown
Calculated flow	150 cfm	Unknown
Duct Entrance D		
Average velocity	2075 fpm	Unknown
Calculated flow	775 cfm	640 cfm
Duct Entrance E		
Average velocity	3505 fpm	Unknown
Calculated flow	1305 cfm	640 cfm

Table 4-2 (cont'd)

<u>Internal Mixer Vent Exhausts</u>		
Left side, upper front (tell tale hood):		
Average duct velocity[d]	1410 fpm[e]	3440 fpm
Calculated duct flow	125 scfm	300 cfm
Duct static pressure	2.75 in. H_2O*	Unknown
	3.5 in. H_2O**	Unknown
Left Side, Upper Back (tell tale hood):		
Average duct velocity[d]	2100 fpm[e]	3440 fpm
Calculated duct flow	185 scfm	300 cfm
Duct static pressure	3.0 in. H_2O*	Unknown
	3.7 in. H_2O**	Unknown
Left Side, Lower:		
Average duct velocity[f,g]	500 fpm[e]	Unknown
Calculated duct flow	45 scfm	Unknown
Duct static pressure	0.84 in. H_2O**	Unknown
Right Side:		
Average duct velocity[f,h]	815 fpm	Unknown
Calculated duct flow	70 scfm	Unknown
Duct static pressure	1.4 in. H_2O**	Unknown
<u>Discharge Door Hood</u>		
Front, Right Duct:		
Average duct velocity[i]	760 fpm	4770 fpm
Calculated duct flow	65 scfm	415 cfm
Duct static pressure	0.33 in. H_2O	Unknown
Front, Left Duct:		
Average duct velocity	1275 fpm	4710 fpm
Calculated duct flow	110 scfm	410 cfm
Duct static pressure	3.3 in. H_2O	Unknown
Back, Right Duct:		
Average duct velocity	1850 fpm	4710 fpm
Calculated duct flow	160 scfm	410 cfm
Duct static pressure	3.1 in. H_2O	Unknown
Back, Left Duct:		
Average duct velocity	1185 fpm	4770 fpm
Calculated duct flow	105 scfm	415 cfm
Duct static pressure	3.2 in. H_2O	Unknown

Table 4-2 (cont'd)

a. One-half-inch accumulation of material on duct walls. Duct diameter adjusted for calculation.
b. Airflow from internal mixer vent exhausts subtracted from flow calculated using average velocity and adjusted duct area.
c. Slots C and F design airflow not included - these slots were not shown in original design or any subsequent engineering changes.
d. Ten point measurement traverse used.
e. Measured with door closed. Random measurements showed the duct velocity increased by about 400 fpm with the door open.
f. Three point traverse made in flexible duct. Solid wall ducts were not accessible for making measurements. Calculation of the flow was not possible using indirect measurements.
g. Calculated possible instrument error of $\pm$ 19 percent.
h. Calculated possible instrument error of $\pm$ 6.5 percent.
i. Calculated possible instrument error of $\pm$ 7.5 percent.

* Door open.

**Door closed.

EMISSIONS SOURCES OBSERVATIONS

The sources of emissions around the mixer appeared to be the dusts from powder compounds used in by-products from the rubber mix. These specific sources were noted:

1. Dust displaced when the charge door opens. This dust clings to the internal parts of the mixer or floats in the air inside the mixer. When the charge door opens, air rushing into the mixer to replace displaced air forces contaminated air out of the hopper.

2. Dusts dispersed into air from leaks in the mixer's material handling system. Specifically, cracks in the mixer's surge hoppers leaked compound.

3. Dusts dispersed into air from the material on the floor.

4. Fumes emitted from the rubber being discharged from the mixer and from the inside of the mixer hopper.

WORK PRACTICES OBSERVATIONS

The worker at the mixer had little direct contact with the majority of powder compound ingredients. Their contact was restricted to the small cup of material added to the rubber. In addition, workers did not have to perform operations that could generate a large amount of dust or that were near dust generation areas. Therefore, work practices did not appear to effect their exposure. However, work practices could affect the operation of the mixer ventilation system.

Some notable work practices which appeared to reduce dust generation were:

1. Placing the manually-added powder compounds within the folds of the rubber sheets. This would prevent accidental spills and air movement from entraining compound dusts.

2. Keeping the area around the worker clean.

Observed work practices which could cause dust generation or could affect operation of the ventilation system are:

1. Dry sweeping spilled materials. This did not occur too often and the amount of material was small.

2. Not maintaining the ventilation system. Several slots and duct entrances had material accumulated in them.

3. Not maintaining complete records on changes to the ventilation system. Extra slots were added to the charge door hood and the dust ring hoods were removed without any noted changes to the design drawings.

4. Leaving the doors on the charge door hood open and not latching them when closed.

5. Deleting parts of the ventilation system without covering the entrance to the system. One branch of the ventilation system had been removed, but the entrance to the main was left open.

6. Not cleaning up material accumulated on structures. Material accumulations were noted on the charge door hood.

ENGINEERING CONTROL OBSERVATIONS

Dusts were not observed escaping the charge door hood. But, fumes were observed escaping from the discharge door hood. Also, no visible emissions were observed escaping from the dust ring seals.

Some material accumulation was noted in slots D and E on the charge door hood. Heavy material accumulation, a powder-oil mixture, was in the duct entrances of the discharge door hood. The duct velocity measurements on one of the ducts from this hood also showed low static and velocity pressures indicating a blockage downstream of the measurement location. In the main from the hood, a sulfurous compound build-up was noted on the duct walls.

Several items in the ventilation system could cause unnecessary static pressure losses. Some of these are:

1. Heavy use of flexible ducting.

2. Right angle entrances into ducts from duct entrances.

3. Multiple diametrically opposed entrances into main.

The face area of the charge door hood appeared to be minimized as much as possible. However, the area below the conveyor edge was left open.

MONITOR OBSERVATIONS

No monitoring equipment for specific contaminants or ventilation system performance was noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

Because the worker has minimal contact with the powdered compounds and because he is located so far from other sources, he does not have dust generated directly into his breathing zone. Uncontrolled dusts generated from the mixing and charging of the rubber could enter the general plant air and elevate the background particulate concentrations. Sample results, however, show that the workers at the mixer received exposures less than background as determined by the general area sample on the column (Figure 4-1, location 7).

The charge door hood appeared to control dust generated from the charge door. This is supported by the area sample results because samples collected on the hood were not significantly different than the general area samples.

The internal mixer vent exhausts may effectively control emissions generated by the internal pressure in the mixer since emissions were not blowing through seals when the mixer charge door was closed. However, the airflow into these hoods was very low, as was their transport velocities.

Based on observations, the discharge door hood did not work properly. The reason appeared to be plugging of the duct entrances by an oil/powder mixture. The source of the oil is unknown, but may be process oil from the mix or the dust ring. The powder evidently comes from the rubber ingredients.

The ventilation system has numerous improper design features. Although these features do not appear to affect its performance, they certainly reduce its efficiency.

By redesigning the mixer slide gate into a drop door, the plant may have proposed a solution to slide gate problems observed at other plants. The slide gates have problems with seals wearing out. Once worn, powdered compounds and rubber are blown out laterally between the gate and its seals. This material is difficult to control because of its velocity and the size of the area affected. Drop doors do not have these problems. So, substitution of a drop door for a slide gate appears to be a feasible solution.

The sampling data indicate the effectiveness of using oiled compounds. Cracks in hoppers supplying the mixer were observed to leak. These leaks should have increased the dust concentrations in the oven below the charge door hood but they did not. Air samples collected at the charge door and on a column over 30' away were not significantly different. In addition, dust from this operation did not appear to be carried to other areas of the plant.

Work practices did not appear to affect dust generation. But, practices such as leaving charge door hood doors open, could affect ventilation system performance. Recording ventilation system changes could affect future redesign and diagnostics of the system and keep plant engineers from repeating past mistakes.

MILL LINE (5)

AREA: MIXING

DESCRIPTION

After mixing in the mixers, masterbatch rubber is further mixed and processed into sheets by a mill line. In the order of material progression through the mill line, it consists of a 21-inch Transfermix (T-mix), a transfer conveyor, a 21-inch diameter roller sheeter mill, a batch-off conveyor, a dip tank, and a festoon. A layout of the mill line is shown in Figure 5-1.

Rubber from the mixer is discharged directly into the airtight hopper of the T-mix. From the T-mix hopper the rubber is pushed into the T-mix screw by two rams, a feed ram and a cross ram. The rams assure a continuous flow of rubber into the screw. The rubber, after passing through the T-mix, is extruded and cut into chunks. The chunks drop onto a covered conveyor and are carried to the sheeter mill.

The conveyor drops the rubber on the top of the mill rollers. The mill then squeezes the rubber into a sheet which is removed from the mill onto a batch-off conveyor and transported to a dip tank. At the dip tank, the rubber is dipped in a soap solution and finally transported to a festoon for drying and cooling.

The ventilation system for the T-mix was installed with the machinery in the early seventies. It includes an outlet hood, a rear shaft seal hood, ram hoods, and a hopper vent hood. The outlet hood is connected to the ventilation system on the rest of the mill line, but the other hoods on the T-mix are connected to a different system. The outlet hood is a ventilated enclosure with front access doors, as shown in Figures 5-2 and 5-3. A part of one side of the enclosure was open on the study hood, but a similar hood on another T-mix was totally enclosed, as shown in Figure 5-3.

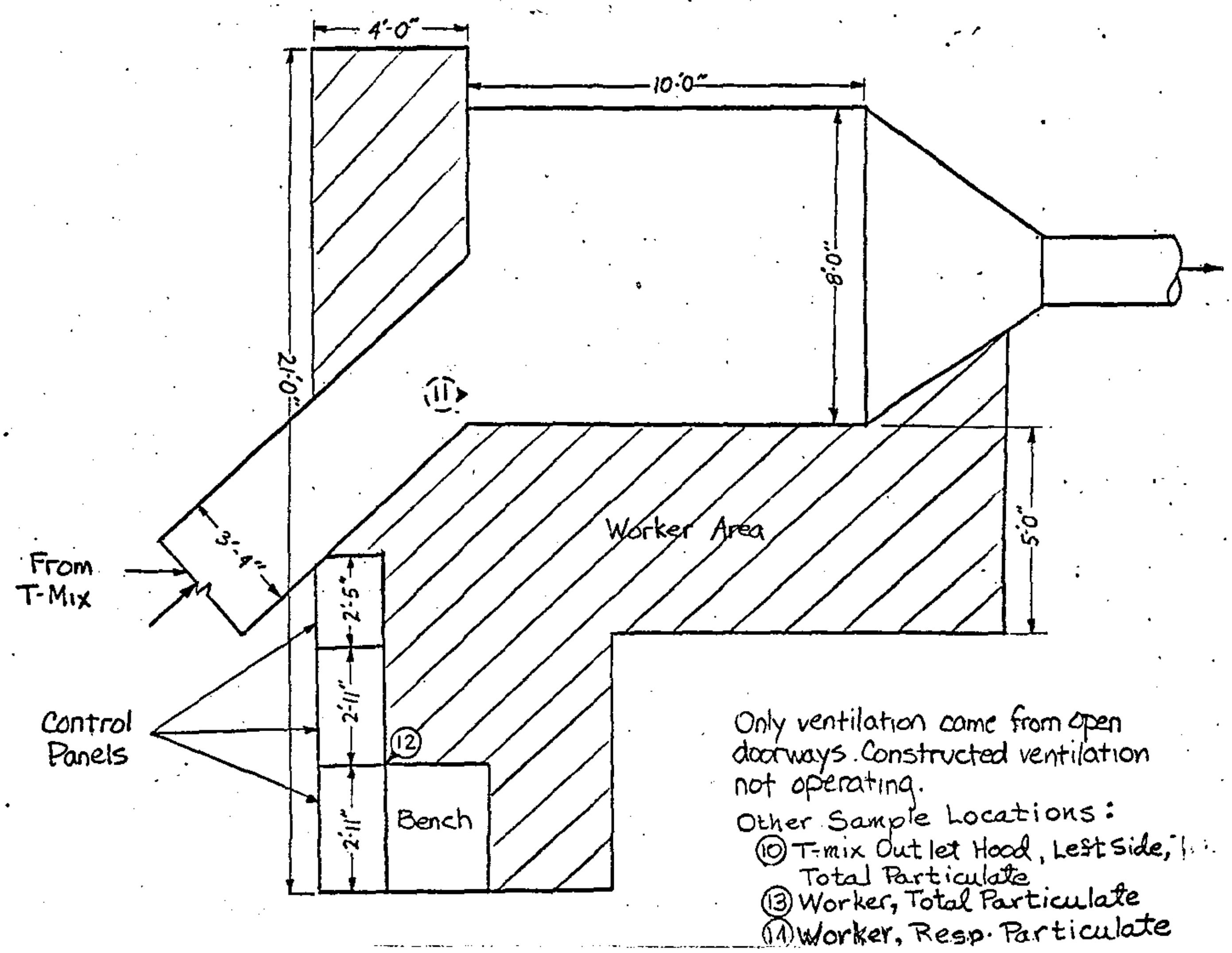

Figure 5-1. Mill line layout and sample locations.

End Report

Figure 5-2. Mill line T-mix outlet hood.

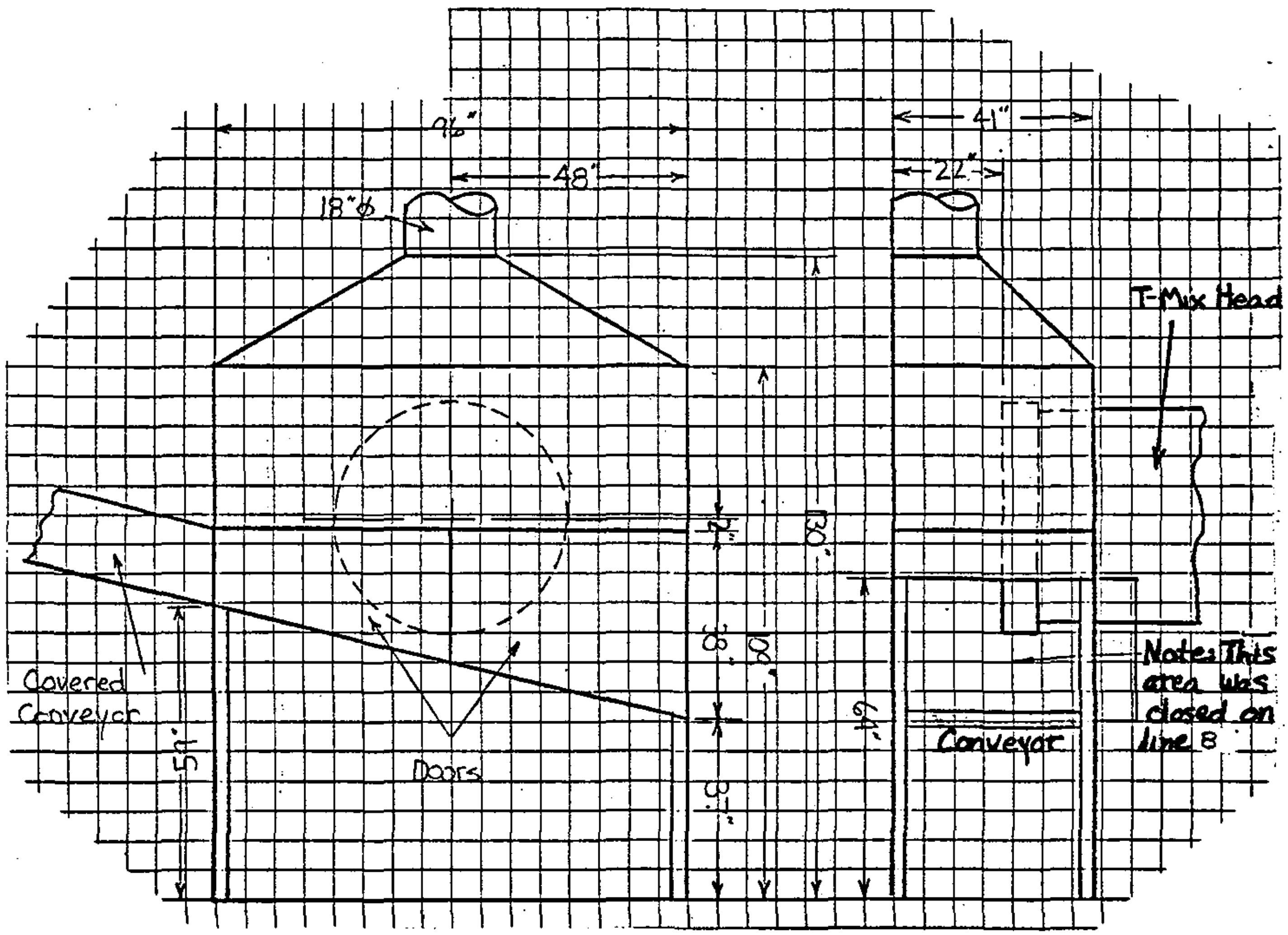

Figure 5-3. Mill line T-mix outlet hood detail.

The rear shaft seal is located where the drive shaft enters the T-mix. The U-shaped hood (Figure 5-4) on this seal covers about half of the shaft. The bottom of the hood is open permitting heavier materials to fall through to the floor and not clog the hood entrance. Fumes and lighter dusts are pulled into the hood. The hood is on a moveable mount providing access to the rear seal.

The hoods designed for the rams are of the push/pull type (Figures 5-5 and 5-6). The exhaust is located at the ram inlet to the T-mix and the supply is located at the ram full-withdrawn position. In essence, the air would blow down the ram and be pulled in by the exhaust hood. Also, any leaks around the ram inlet seal would be controlled by the exhaust hoods. In addition to the original ram hoods, two side draft hoods were added near each ram. These hoods were supposed to provide general exhaust for the ram area but were judged to be of little value.

The hopper vent hood is a bell hood located over the hopper vent pipe (Figure 5-7).

The transport conveyor hood is continuous with the T-mix and mill hoods. It is a ventilated enclosure over the top of the conveyor and is shown in part in Figure 5-2 and 5-8. Access doors are provided at intervals in the enclosure.

The mill hood is a box-shaped canopy hood. It is shown in Figures 5-8, 5-9, and 5-10. A similar mill hood on another line had the duct entrance at the back of the mill instead of on the side like the study hood.

The batch-off conveyor and dip tank are within a single ventilated enclosure shown in Figure 5-11. This enclosure is box-shaped and fits completely over the conveyor and tank and is continuous with the mill hood. It has doors in one side which allows workers access to the rubber sheet or the tank.

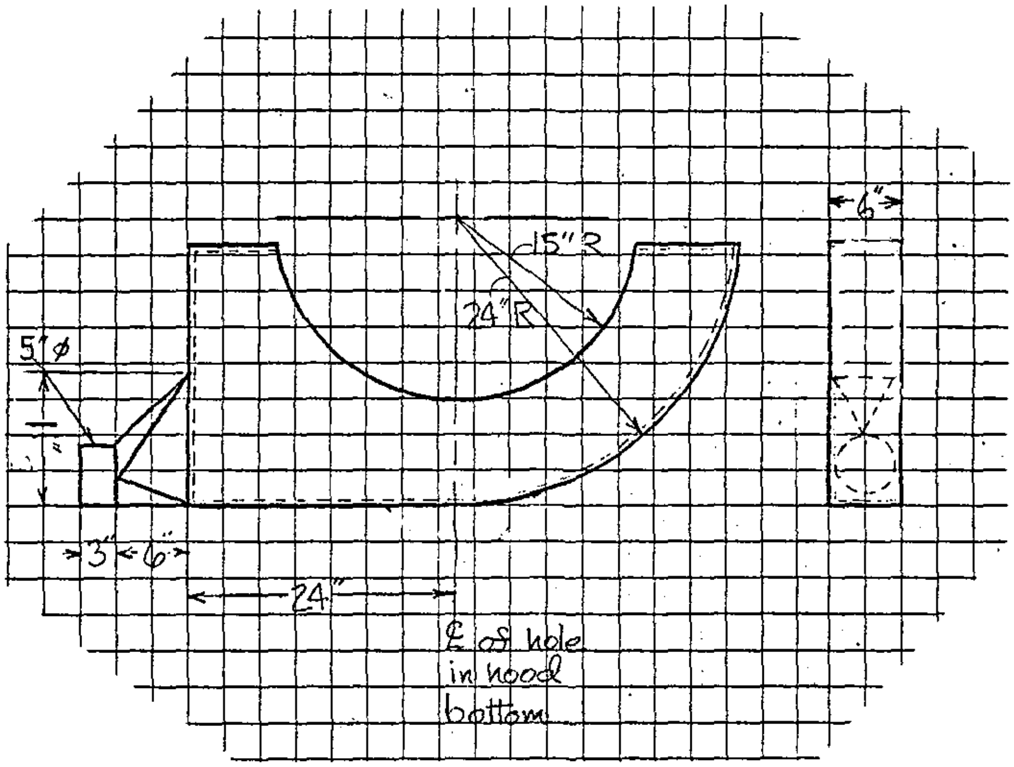

Figure 5-4. Mill line T-mix rear seal hood.

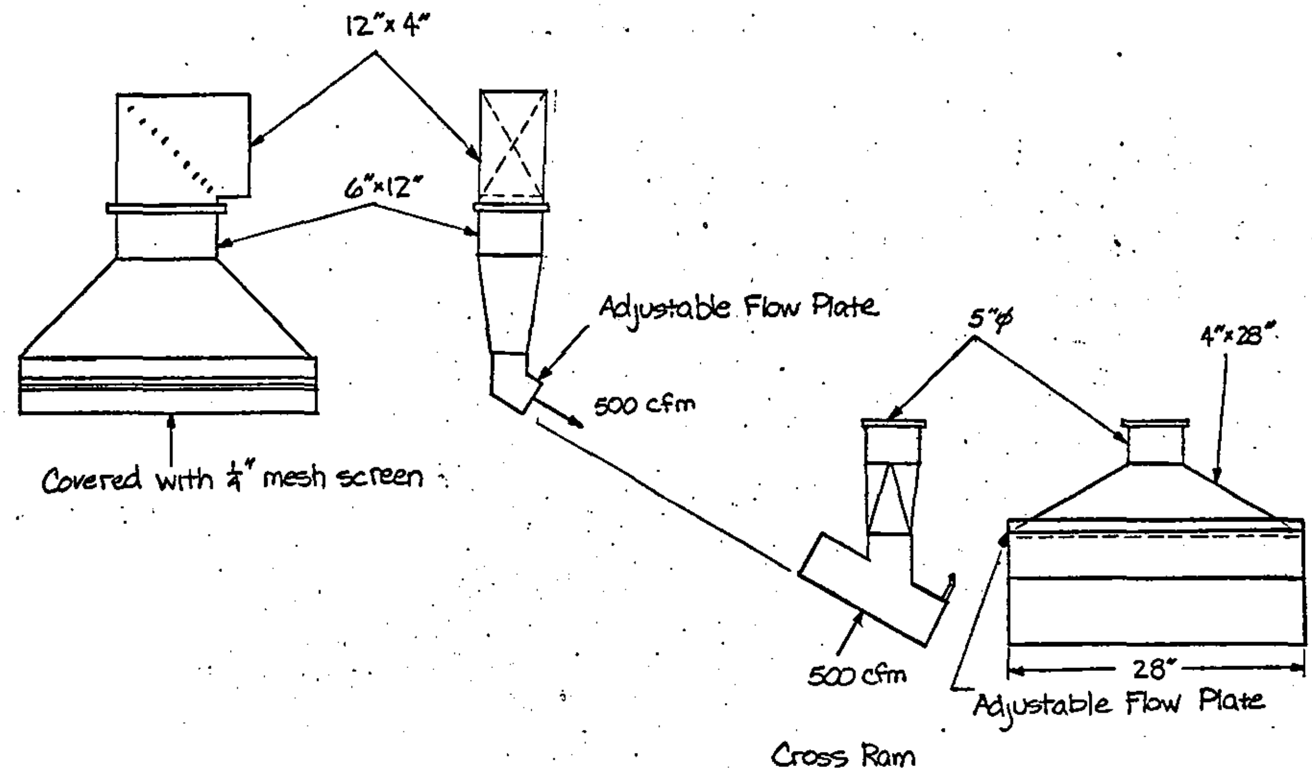

Figure 5-5. Mill line T-mix cross ram hood.

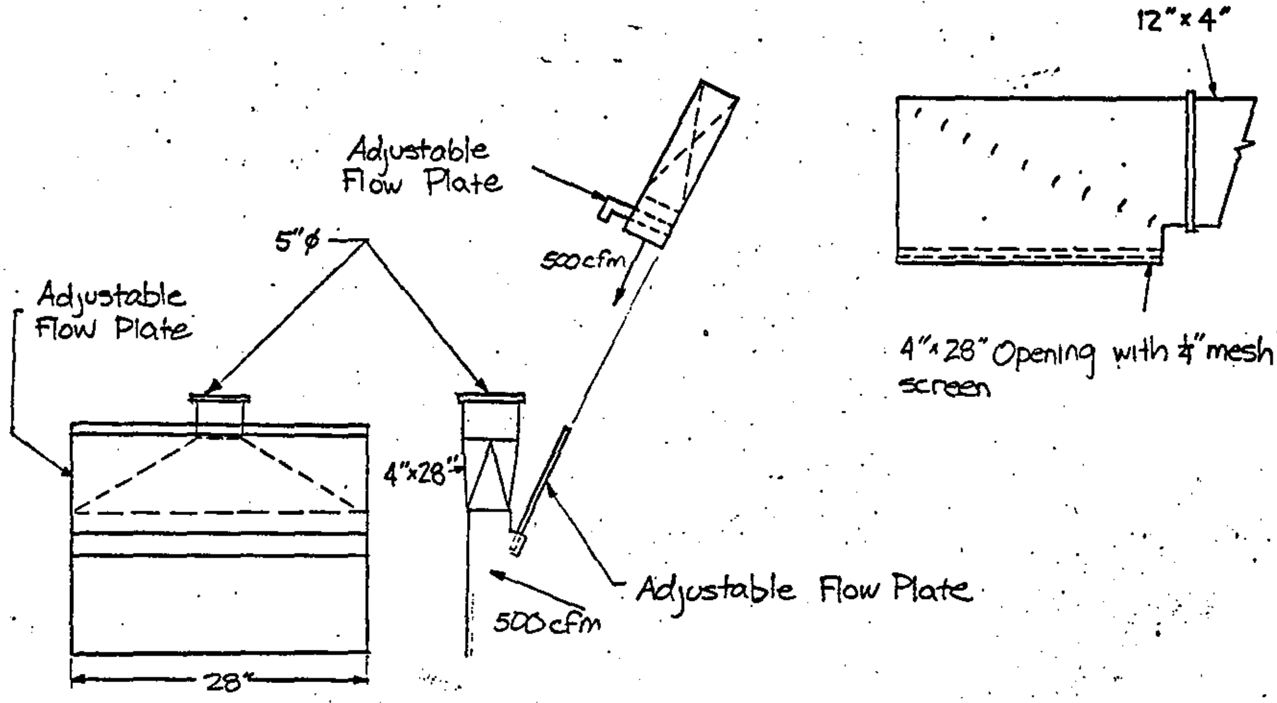

Figure 5-6. Mill line T-mix feed ram hood.

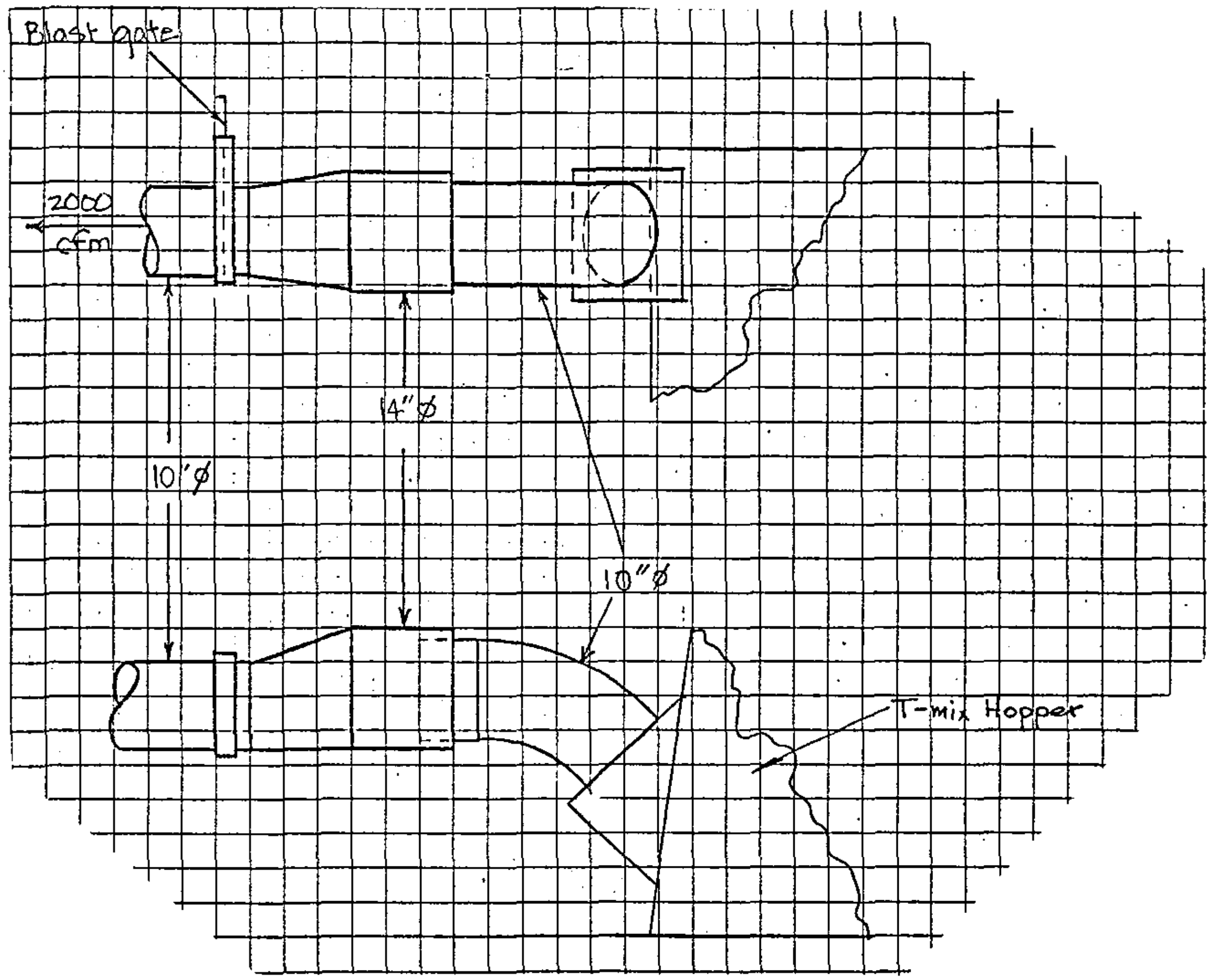

Figure 5-7. Mill line T-mix hopper hood.

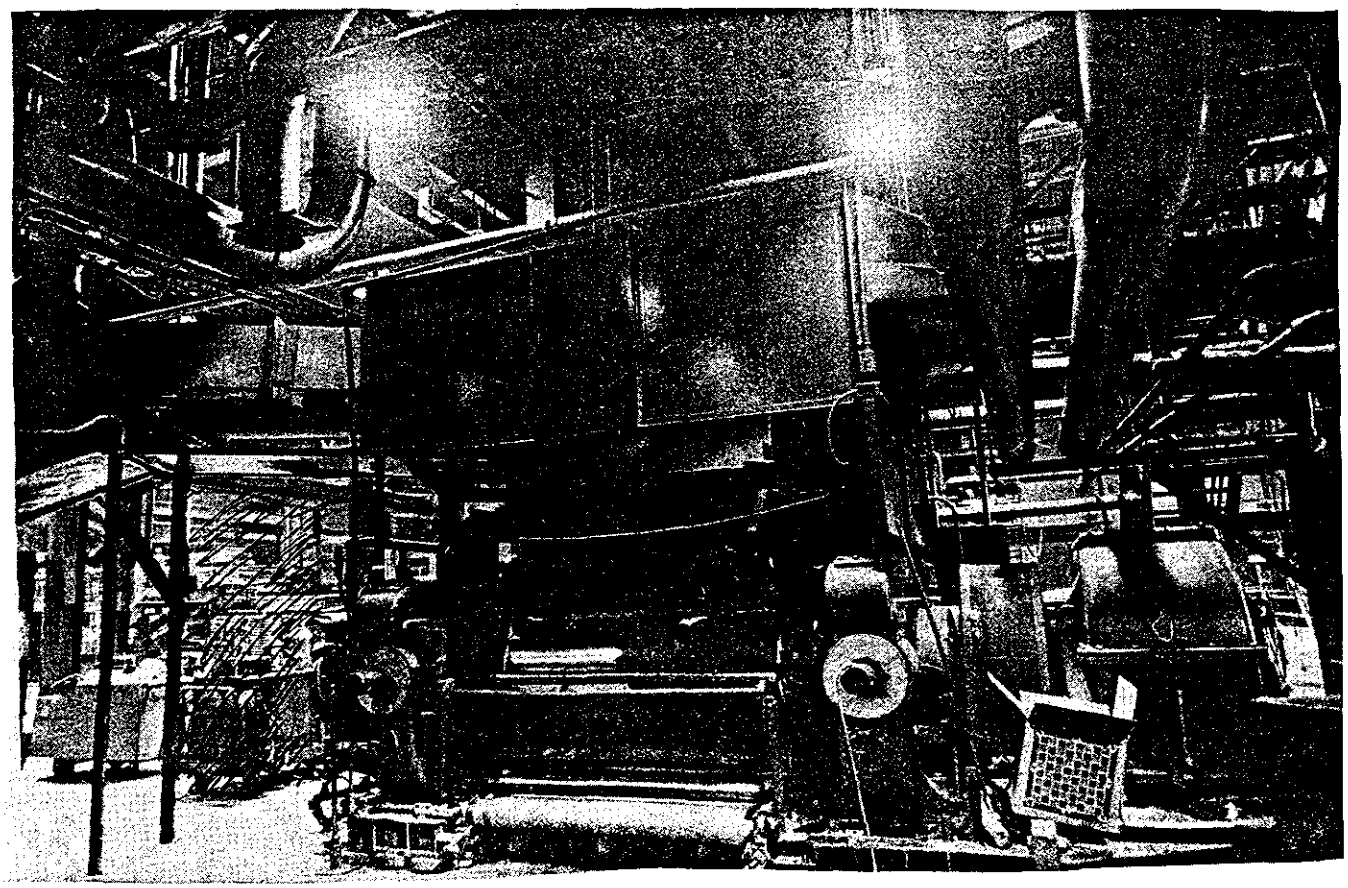

Figure 5-8. Mill line mill hood.

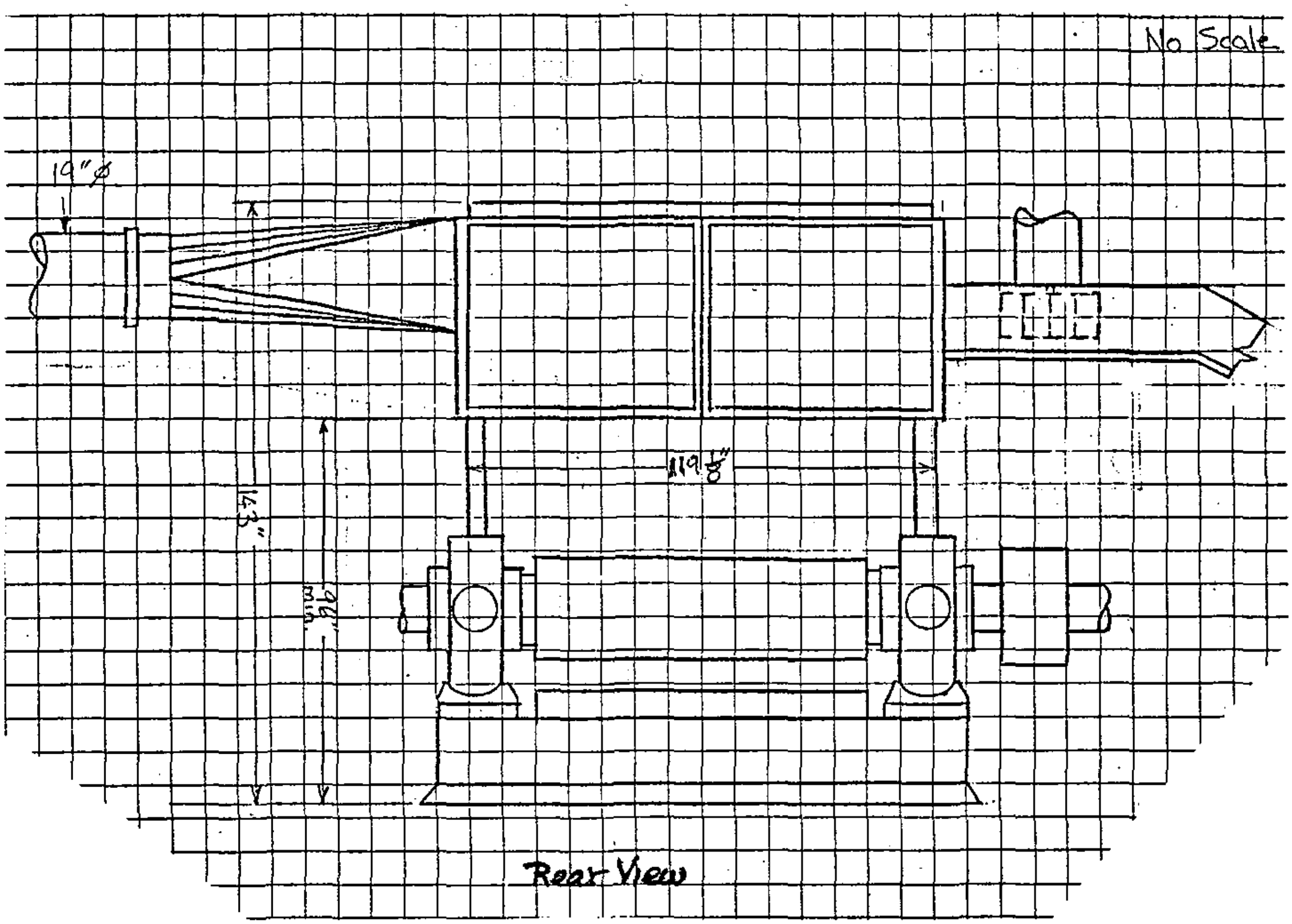

Figure 5-9. Mill line mill hood detail.

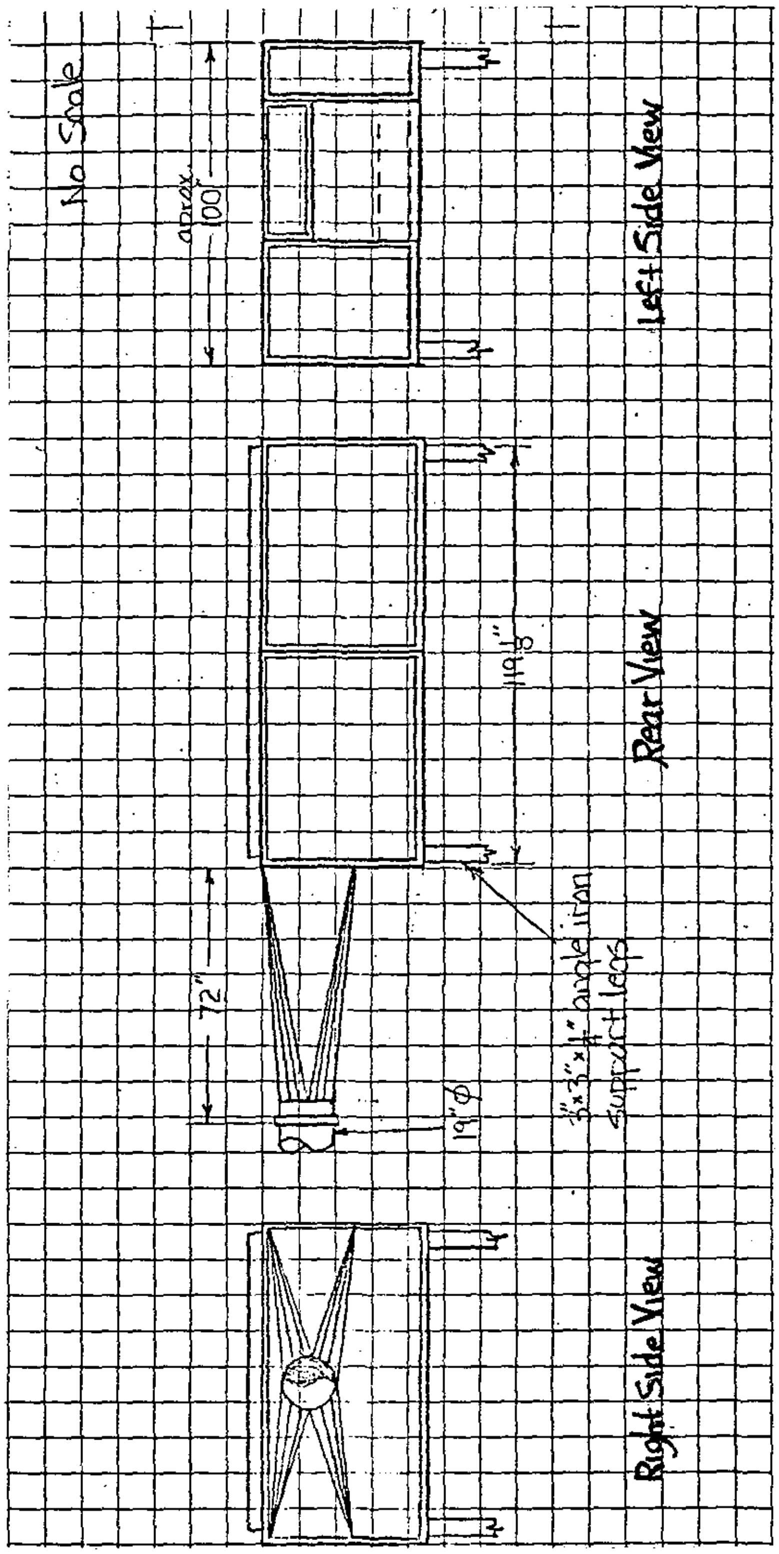

Figure 5-10. Mill line mill hood detail.

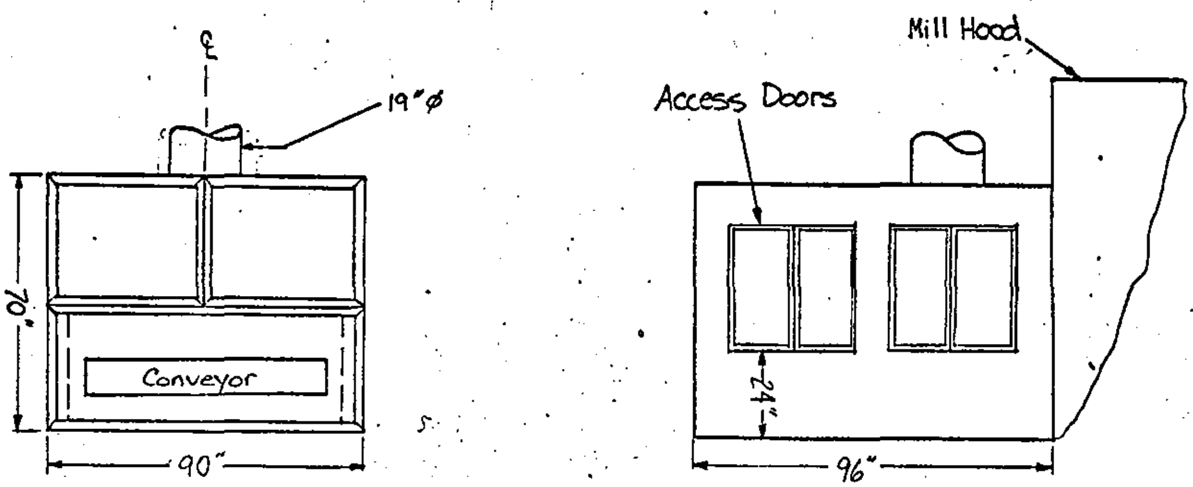

Figure 5-11. Mill line mill batch off conveyor and dip tank hood.

Since the hoods' installation, these changes have occurred:

1. The original design called for a canopy hood over the T-mix outlet. The distance from the floor to the bottom edge of the canopy was about eight feet. The plant redesigned this into the present enclosure.

2. The transport conveyor originally ran horizontally under the T-mix outlet and its hood was not connected to the T-mix hood. This was redesigned so the conveyor ran in a straight incline; it did not bend to the horizontal at the T-mix outlet. The conveyor hood was also made continuous with the outlet hoods. Part of the reason for this appears to be better emission control.

3. A drain pipe originally had been installed where the present hole is in the rear shaft seal hood. Judging from the material observed falling through the hood, the hood would have become filled with the material if it were not allowed to fall to the floor.

4. Several ducts on the transport conveyor hood were capped-off. On another line, with a similar hood, all the hoods were capped. No reason for this was obtained, but apparently they were not necessary; no emissions were seen escaping from the hoods on either line.

5. A longer, ventilated, enclosed conveyor formerly existed between the sheeter mills and dip tanks on the study mill line and a similar mill line. These conveyors were removed and shorter conveyors installed. The hoods on the dip tanks of both lines were also redesigned to connect to the mill hoods. The ducting formerly used for the conveyor enclosures were connected to the new hoods. No reason for these changes was ascertained.

6. The side and back of the study sheeter mill hood was enclosed, while the opposite side below the canopy edge was open as shown in Figure 5-8. The enclosure was not included in the design drawings.

7. The original drawing called for mushroom weathercaps on the fan outlets of the mill line ventilation systems, but these had been removed.

WORKER'S DUTIES

Only one worker is stationed at the mill line. Operation of the mill line is virtually automatic so the worker's only responsibility is assuring proper operation. At the T-mix, the worker's primary duty is inspecting the operation of the machinery. The worker's duties at the mill and the dip tank are primarily overseeing the equipment operation, but he may adjust the rubber thickness on the mill, thread through new batches on the batch off conveyor's dip tank, or cut off slabs of rubber for laboratory analysis. The workers are also responsible for overseeing the festooner operation and performing some housekeeping. The greatest amount of the worker's time is spent directly in front of the sheeter mill observing the process.

AIR SAMPLING DATA

Total particulate area samples were collected at the locations shown in Figure 5-1. Total and respirable samples were also collected on the worker. The sample results are summarized in Table 5-1 and detailed in Appendix II. Analysis of variance showed that neither shift nor location significantly affected concentration.

Table 5-1. Full shift particulate concentrations for a mill line.

Location (No. from Fig. 5-1)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
T-mix (10)	8	0.15	1.9	0.18	0.07-0.37
Sheeter mill, left side (11)	8	0.18	1.9	0.22	0.14-0.41
Desk (12)	8	0.10	1.8	0.12	0.05-0.20
Worker (13)	6	0.23	2.5	0.33	0.09-0.99
Respirable Particulate:					
Worker (14)	8	0.08	1.7	0.08	0.04-0.12

VENTILATION DATA

The sheeter mill hood did not appear to work and all the other hoods were enclosures, therefore, velocity measurements were restricted to duct velocities. The sheeter mill hood on another line appeared to control fume generation, so duct velocity measurements were made on its hoods for comparison. For clarity, the mill line studied will be designated mill line A and the other mill line B.

The measurements are summarized in Table 5-2 and special conditions under which the measurements were made are noted. Design airflow parameters are presented where available.

Table 5-2. Mixer ventilation data.

Measurement	Quantity Measured	Design
T-mix A Hoods		
Rear seal hood:		
Calculated avg. duct velocity	Not measured	3670 fpm
Duct flow	Not measured	500 cfm
Feed ram hood:		
Calculated avg. duct velocity	Not measured	3670 fpm
Duct flow	Not measured	500 cfm
Make-up airflow	Not measured	500 cfm
Cross ram hood:		
Calculated avg. duct velocity	Not measured	3670 fpm
Duct flow	Not measured	500 cfm
Make-up airflow	Not measured	500 cfm
Hopper vent hood:		
Calculated avg. duct velocity	Not measured	3670 fpm
Duct flow	Not measured	500 cfm
Outlet hood:		
Average duct velocity[a]	1440 fpm	2265 fpm
Calculated duct flow[b,c]	2420 scfm	4000 cfm
Duct static pressure	1.3 in. H_2O	Unknown
T-Mix B Hoods		
Outlet hood:		
Average duct velocity	4860 fpm	Unknown
Calculated duct flow	10,603 scfm	Unknown
Duct static pressure	2.7 in. H_2O	Unknown
No other hoods were noted on T-mix B.		
Transport Conveyor Hood A		
Calculated avg. duct velocity	1650 fpm	1590 fpm
Calculated duct flow	1295 cfm (1 duct)	1250 cfm*
Duct static pressure	Not measured	Unknown
Transport Conveyor Hood B		
No ducts from the ventilation system were connected to the hood.		

Table 5-2 (cont'd)

Sheeter Mill Hood A		
Average duct velocity[a]	1985 fpm	2285 fpm
Calculated duct flow[b,d]	3465 scfm	4500 cfm
Duct static pressure	1.6 in. H_2O	Unknown
Sheeter Mill Hood B		
Average duct velocity[a]	4105 fpm	Unknown
Calculated duct flow[b,e]	8350 scfm	Unknown
Duct static pressure	2.0 in. H_2O	Unknown
Batch-off Conveyor and Dip Tank Hood A		
Average duct velocity[a]	1285 fpm	2115 fpm
Calculated duct flow[b,f]	735 scfm	1950 cfm
Duct static pressure	1.3 in. H_2O	Unknown
Batch-off Conveyor and Dip Tank Hood B		
Average duct velocity[a]	1840 fpm	Unknown
Calculated duct flow[b,f]	2260 scfm	Unknown
Duct static pressure	1.6 in. H_2O	Unknown

*Each of 3 ducts.
a. Measurement location less than 7.5 duct diameters from disturbance.
b. Because of material accumulation in duct, duct diameter was adjusted for airflow calculations.
c. Material accumulation in duct: 1/4 in. on top and sides.
d. Material accumulation in duct: 1 in. on top; 1-1/4 in. on bottom.
e. Material accumulation in duct: 3/8 in. on top; 1/4 in. on bottom.
f. Material accumulation in duct: 1 in. on top and sides; 2.5 in. on bottom.

EMISSION SOURCES OBSERVATIONS

The primary sources of emissions from the milling process is fume from the mixed rubber. The rubber fumes throughout the process from the time it is dropped from the mixer until it enters the dip tanks. This fume, along with unmixed batch ingredients, such as carbon black, was also emitted from the rear seal of the T-mix.

The only other sources were contaminant generated from the dipping process. Emissions were generated from the dip tank and the dipped rubber sheet as it dries.

WORK PRACTICE OBSERVATIONS

The worker at the mill line has little contact with the process materials. Also, his work practices do not appear to affect the generation of contaminants. An increase in his exposure appeared possible if he stayed in the contaminant-generation areas too long. However, the worker spent most of his time observing the process from a distance. During a stock change-over he spends less than a minute at the face of the mill.

Some of the work practices which can cause contaminant generation or affect the ventilation system performance are:

1. Cleaning up dust spills with water from a high pressure nozzle. Instead of wetting down the dust, it blew it into the air.

2. Not cleaning up materials falling to the floor from the T-mix rear seal.

3. Not moving the T-mix rear seal hood back into position after it has been moved to perform an operation.

4. Leaving the T-mix outlet and transport conveyor hood doors open.

5. Not monitoring and maintaining the ventilation system.

6. Not keeping records on changes to the ventilation system. This could be troublesome in diagnosis of system problems or could lead to repetition of past mistakes.

ENGINEERING CONTROLS OBSERVATIONS

These observations concern the T-mix ventilation:

1. No fumes escaped any of the T-mix hoods.

2. Two large tapered side draft hoods located on either side of the T-mix hopper appeared unnecessary. The plant also questioned the need for these hoods. None of the drawings included these hoods and no engineering changes mentioned them, so the reason for their existence was unknown.

3. The plant also questioned the need for the rams' ventilation because fumes had never been observed escaping from that seal. The dimensional tolerances of these seals is very close, so only a very minute gap would exist between the ram and its seal. This gap could easily be sealed with rubber being scraped off the ram by the seal. Further, there should be little pressure inside the T-mix at that location to force fumes or rubber through the gap.

4. The plant reported that the rear seal on the T-mix was easily destroyed due to the internal pressures in the T-mix, and the viscosity and abrasiveness of some of the rubber components. Also, they reported that replacement of the seal was very difficult.

5. The outlet hood on line A could have been more enclosed like the outlet hood on line B, but this lack of enclosure did not seem to impair the hood's control capability.

These observations concern the transport conveyor hoods:

1. No fumes escaped the hoods on either line A or B. On line A, fumes did not escape even when the hood access doors were left open.

2. The effect of line B's conveyor hood not being connected directly to the ventilation system is unknown. However, a build-up of fume inside the hood seems possible. This could subsequently result in fumes leaking into the room air though openings in the hood or open access doors. Workers could also be exposed to this fume should they stick their head inside the hood enclosure.

These observations concern the sheeter mill hoods:

1. Fumes escaped line A's mill hood, but not line B's. However, when a make-up air fan located in an outside wall near the mills was turned on, fumes were blown out of both hoods. The air stream from the fan travelled parallel to the mill faces from right to left so fume was blown laterally out of the left side of the mill hoods.

2. The mill hoods were fairly well-enclosed. Only a portion of the left and front sides of the hoods were open. Possibly, the left side could also have been enclosed. The height of the bottom edge of the hood's front face appeared to be designed so the worker could stand away from the mill face and still see the transport conveyor. This can be seen in Figure 5-8.

3. The rear placement of the duct entrance of mill B's hood appeared better than the side placement of mill A's. The rear location would

permit the duct entrance to be closer to the fume source at the top of the mill. This would further create a lower airflow requirement to get the desired capture velocity.

4. Both mill hoods had well-designed tapered duct entrances. This helps reduce static pressure losses to the ventilation system.

These observations concern the batch-off conveyor/dip tank hoods:

1. No emissions escaped these hoods.

2. The enclosure of the batch-off conveyor and dip tank appeared to be a good design for containing emissions while providing easy access to the equipment. But, some refinements in the current design could provide better protection for the worker inside the enclosure and reduce static pressure losses. To provide better protection for the worker, the duct entrance could have been placed in the top or side of the hood enclosures opposite the access doors. This would pull fumes away from the worker's breathing zone while he is in the enclosure--the current design could pull the fumes through his breathing zone. Using a tapered duct entrance could reduce static pressure losses to the system.

These observations concern the overall ventilation system:

1. The airflow calculated for both mill lines (not including most of the T-mix hoods) was well below the design airflow (37,800 cfm). The manufacturer for the fan provided these fan performance characteristics: (1) at 0 inches H_2O static pressure, the fan's rated capacity is 41,000 cfm; (2) at 2 inches it is 32,810 cfm; and (3) at 4 inches it is 14,090 cfm. The static pressure measured in the main duct for mill line B's ventilation system just upstream of the fan was 2.6 inches H_2O. Therefore, it appears that the airflow deficit in both mill rows resulted from an improperly sized fan.

2. Ventilation measurements made on mill line A hoods (does not include most of the T-mix hoods) were found to be operating below design. The hoods on line B, if they have the same design airflow requirements as line A, would be above design. Yet, velocity measurements made at the fan outlet for both mill lines, but not included in this study report for accuracy reasons, indicated the airflow for both lines was nearly the same. The reason for line B's hoods to be operating above design is that line B has fewer hoods attached to the ventilation system than line A and the festoon hoods on line B were nearly closed while line A's were only 60% closed.

3. Heavy accumulations of material were found in the ducts of the hoods on mill line A, while little or none was found in line B's ducts. Conse- quently, the duct velocities for line B's hoods were higher than line A's hoods. Therefore, the accumulation may to result from an in- adequate transport velocity in line A's ducts.

MONITORS OBSERVATIONS

No monitoring equipment for specific contaminants or on ventilation system performance were noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

While observing the operation of the machinery or adjusting the mill rollers, the worker does not receive emissions directly into his breathing zone. While performing operations inside the enclosures on the machinery, the worker could receive emissions directly into his breathing zone. However, only a minor amount of the worker's time is spent in the enclosures. Uncontrolled emissions from the process can enter the general room air and elevate the background contaminant levels, or be carried to other parts of the plant by drafts. Emissions created by housekeeping can also elevate background contaminant levels.

Based on observations, all the hoods on line A, except the sheeter mill hood, controlled fumes from the rubber. Based on observations, mill line B's hoods controlled fumes. However, a make-up air fan near sheeter mill B blew some fume out of the sheeter mill hood.

The sampling data for the mill line do not show any significant difference between sample locations. This normally indicates containment of the sources by the controls. Yet, as mentioned, fumes were observed escaping the sheeter mill A's hood. This points out a case where the sample was located outside the contaminant stream, so it would collect little of the fumes escaping the hood. Instead, the escaping fume did not affect the total particulate concentration at the worker's location at the sheeter mill, but it was observed to contaminate other work areas.

In concept, the engineering controls on the mill line provide a sound basis for developing other controls which would operate properly. With the addition of a properly sized fan and some additional minor design changes, this system may perform well. Any new designs, however, must compensate for disturbances by the make-up air, or the make-up air must be redesigned to prevent disruption of the hoods.

The automation of the mill line reduces the contact of the worker with the process materials and their emissions. Thus, his exposure is reduced. It also reduces the effect of work practices on emission generation, since there are a minimum of work practices involved with the process. The effect of this can be seen in the sampling results where the worker's exposure was not significantly different than the background contaminant levels.

Work practices can affect the performance of the ventilation system. Leaving enclosure doors open can allow escape of emissions. Not maintaining systems can cause decrements in ventilation performance. Not recording changes to the ventilation system leaves open the chance of replicated bad designs and makes system problem diagnosis difficult.

AUTOMATED END TREAD CEMENTER (6)

AREA: TUBER LINE

DESCRIPTION

The purpose of this operation is to spread cement, a solvent-rubber mixture, on the ends of extruded and cut stock. The cement tackifies the rubber stock for later operations in tire building.

The cement is applied to the rubber by an automated sprayer. The sprayer sprays cement from a pressurized line on the stock as it runs beneath it. Upstream of the sprayer, a mechanical device positions the stock for spraying.

The ventilation system for the cementer is a downdraft ventilated enclosure placed beneath the spraying area. Inside the enclosure, directly beneath the sprayer, is a drip pan for excess cement. The front of the enclosure consists of two access doors. The enclosure ventilation is shown in Figures 6-1.

The enclosure for the sprayer was designed and installed with the original equipment. The ventilation to the enclosure was designed and installed by the contractor for the plant construction. Since its original installation no changes have been made.

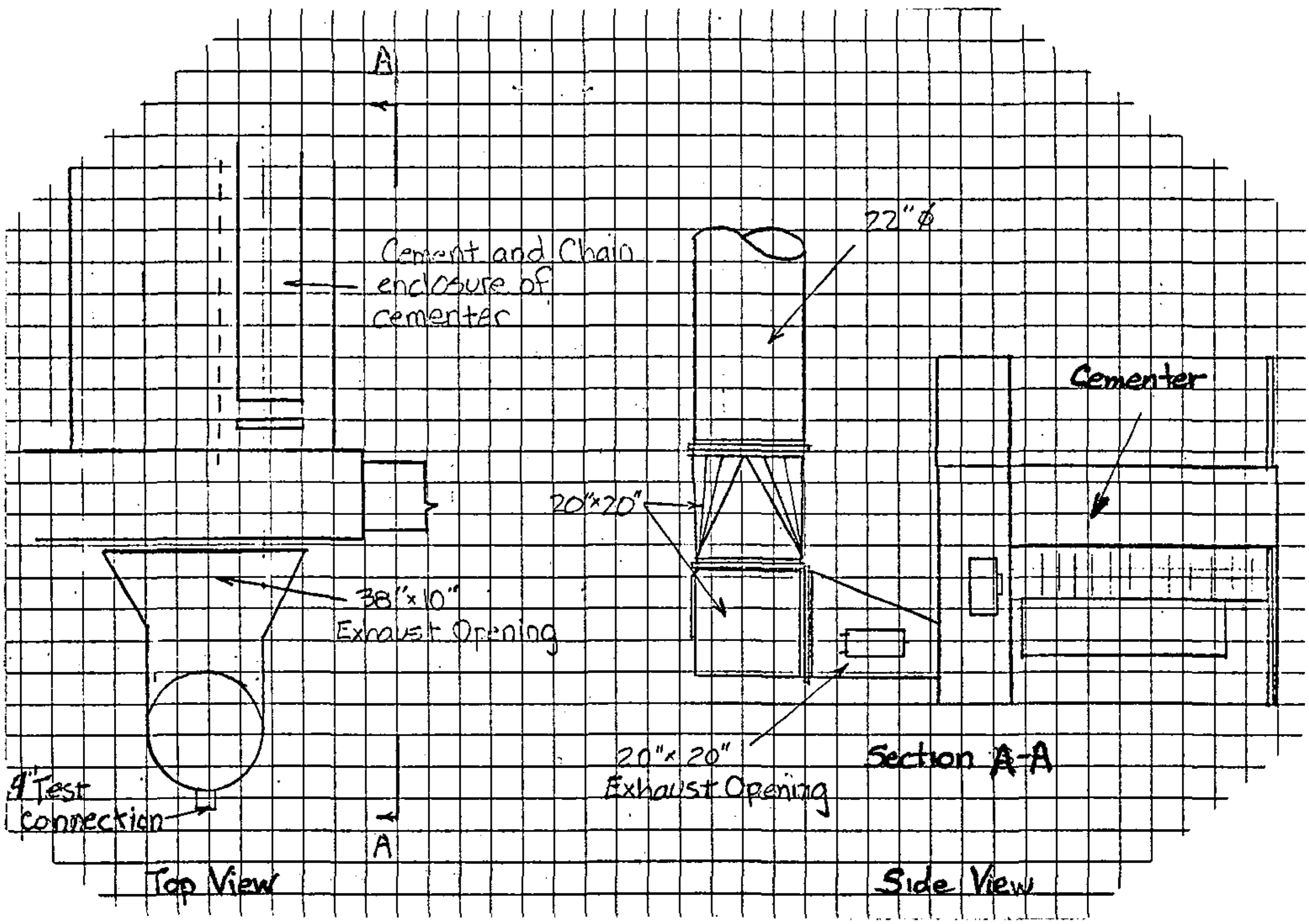

Figure 6-1. Automatic end tread cementer hood layout.

WORKER'S DUTIES

There are no workers permanently stationed at the end tread cementer. Instead, the only time workers need to be around the cementer is for maintenance and housekeeping operations, or to correct malfunctions or adjust the sprayer.

The only routine operation observed at the cementer is the cleaning out of the drip pan about every third shift. This operation required two workers. The pan was emptied by baling it out with a bucket and dumping the waste in a drum. The total time for the job is about 10 minutes.

There are two workers stationed near the cementer whose job is booking. They remove the cemented stock and places it on a cart for transport to tire building.

AIR SAMPLING DATA

Two area charcoal tube samples were collected at the end tread cementer - one next to the cementer and one on an electrical box a few feet from the cementer. A charcoal tube sample also was collected on one of the bookers to evaluate his exposure. The samples were analyzed for total petroleum distillate, benzene, m-xylene, and toluene. Results from the analysis are summarized in Table 6-1 and detailed in Appendix III.

Statistical analysis of the total petroleum distillate sampling results using analysis of variance and Duncan's test is summarized in Table 6-1. Analysis of variance showed that location significantly affected concentration. The results of the analysis are found from the Duncan's test column and explanations at the bottom of the table.

Short-term samples were also collected on the two workers emptying the drip pan. The sampling rate was 500 cc/min. These samples were analyzed for total petroleum distillate. The results of these samples are shown in Table 6-2.

Table 6-1. Full shift sample results from an automated end tread cementer.

Location	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)	Duncan's Test[c]
Total Petroleum Distillate:						
End tread cementer	8	66	1.3	71	40-105	A
Electrical box	8	56	1.4	60	35- 90	A
Worker (booker)	7	43	1.4	45	27- 64	B
Benzene:						
End tread cementer	8	0.4	1.5	0.40	0.11-0.71	
Electrical box	8	0.2	2.2	0.20	0.10-0.70	
Worker (booker)	7	0.3	2.0	0.30	0.20-0.50	
Toluene:						
End tread cementer	8	3.5	1.4	3.8	1.0-4.5	
Electrical box	8	3.9	1.4	4.1	1.2-5.0	
Worker (booker)	7	2.2	1.7	2.7	0.5-5.0	
m-Xylene:						
End tread cementer	8	3.2	1.4	4.4	1.5-3.9	
Electrical box	8	3.5	1.6	4.4	2.0-14.0	
Worker (booker)	7	2.1	1.4	2.2	0.5-5.0	

a. Locations with the same letter are not significantly different.

Table 6-2. Short-term personal sample results for cleaning out cementer drip pan.

Location	Time (min)	Petroleum Distillate Conc. (mg/m^3)
Worker hold drip pan	10	120
Worker baling drip pan	10	130

VENTILATION DATA

No ventilation measurements were made on the end tread cementer because of time constraints. However, some design airflow parameters were available and are presented in Table 6-3.

Table 6-3. Automated end tread cementer ventilation data.

Measurement	Design
Calculated average duct velocity	2800 fpm
Specified duct flow	7400 cfm

EMISSIONS SOURCES OBSERVATIONS

The emissions at the end tread cementer are the solvent vapors evaporating from the cement. These specific sources were noted:

1. Solvents evaporating from cements sprayed on the stock.

2. Solvents dispersed into the air from the cement spray.

3. Solvents evaporating from the cement in the drip tray.

4. Solvent evaporating from spilled or splattered cement and cement adhering to machine parts.

WORK PRACTICES OBSERVATIONS

Since workers are not permanently stationed at the end tread cementer and the cementer is fully automated, work practices did not appear to significantly affect solvent emissions or worker exposure. However, failure to clean up spills or empty the drip pan on time could cause solvent generation.

Worker contact with the cement only occurred during infrequent maintenance and housekeeping operations. Significant worker exposure may occur, should a worker become careless with the cement.

Work practices can affect operation of the ventilation system. Not repairing and maintaining the enclosure so it is air tight allows leaks. Not keeping the doors of the enclosure tightly closed can also allow leaks.

ENGINEERING CONTROL OBSERVATIONS

Limited observations about the ventilation system were made. The doors at the front of the enclosure did not appear to be air tight, allowing air to leak into the ventilation system. Although this air may aid in removing solvents evaporating from the drip pan, it reduces air movement around the spray.

Spraying in the direction of the airflow appears to be a good method for ventilating the cementer. This would help reduce the capture velocity needed for the cement spray.

MONITORING OBSERVATIONS

No monitoring equipment for specific contaminants or on the ventilation system were noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

This plant's cementer replaces the worker performing the end tread cementing, thus eliminating the worker exposure.

The ventilation system on the end tread cementer appeared to work very well. The designed direction of airflow into the hood was the same as the spray allowing for a lower capture velocity. Yet, the access doors on the cementer allowed air to leak into the ventilation system.

The sampling results, however, indicate that the ventilation system may have had problems controlling solvent vapors from the cementer. Sample results for the samples nearest the cementer were not significantly different than those for samples located several feet away. Since the cementer was the only major source of solvent vapors in the area, this indicates some solvent vapors escaping the cementer hood. Whether this is caused by other sources (e.g., the solvent which evaporates from the freshly cemented tread), or the result of a problem with the ventilation system cannot be confirmed without ventilation measurements. However, the petroleum distillate concentrations are well below the NIOSH recommended standard of 350 mg/m^3.

Because of the short-term, infrequent contact of workers with the cement at the cementer, work practices did not significantly affect worker exposure. Work practices, such as improper housekeeping and maintenance, could cause solvent vapor generation from spills which may not be controlled by the ventilation system. Work practices, such as leaving enclosure doors open, could cause a decrement in ventilation system performance.

Sample results from the booker worker show that he is exposed to solvents evaporating from the cemented stock. His exposure is well below NIOSH recomendations.[16]

CALENDER (7)

AREA: CALENDER LINE

DESCRIPTION

This plant used a 4-roll calender. The purpose of the 4-roll calender is to squeeze a thin sheet of rubber onto steel wire cord. The 4-roll calender coats both sides of the wire or fabric at one time. The coated steel is used to make the belts in the tire. A layout of the calender area is shown in Figure 7-1.

Rubber stock is plasticized on a series of mills before being conveyed to the 4-roll calender. The rubber supplied to the calender is fed onto the top and bottom two rollers. From here it is squeezed into a thin sheet and squeezed onto the steel between the middle rollers as shown schematically in Figure 7-2.

The worker's normal location is shown in Figure 7-1. From this location, he can watch both the calender and the mills. Process instrumentation is located next to this area.

The ventilation system on the mills and calender consists of box-shaped canopy hoods over two of the mills and calender. In addition, conveyors between the mills, and between the mills and the calender are covered by ventilated enclosures. Typical mill and conveyor hoods and the calender hood are shown in Figures 7-3, 7-4, 7-5, and 7-6.

The ventilation system was installed in the early seventies. No notable changes were found between the design drawings and the installation.

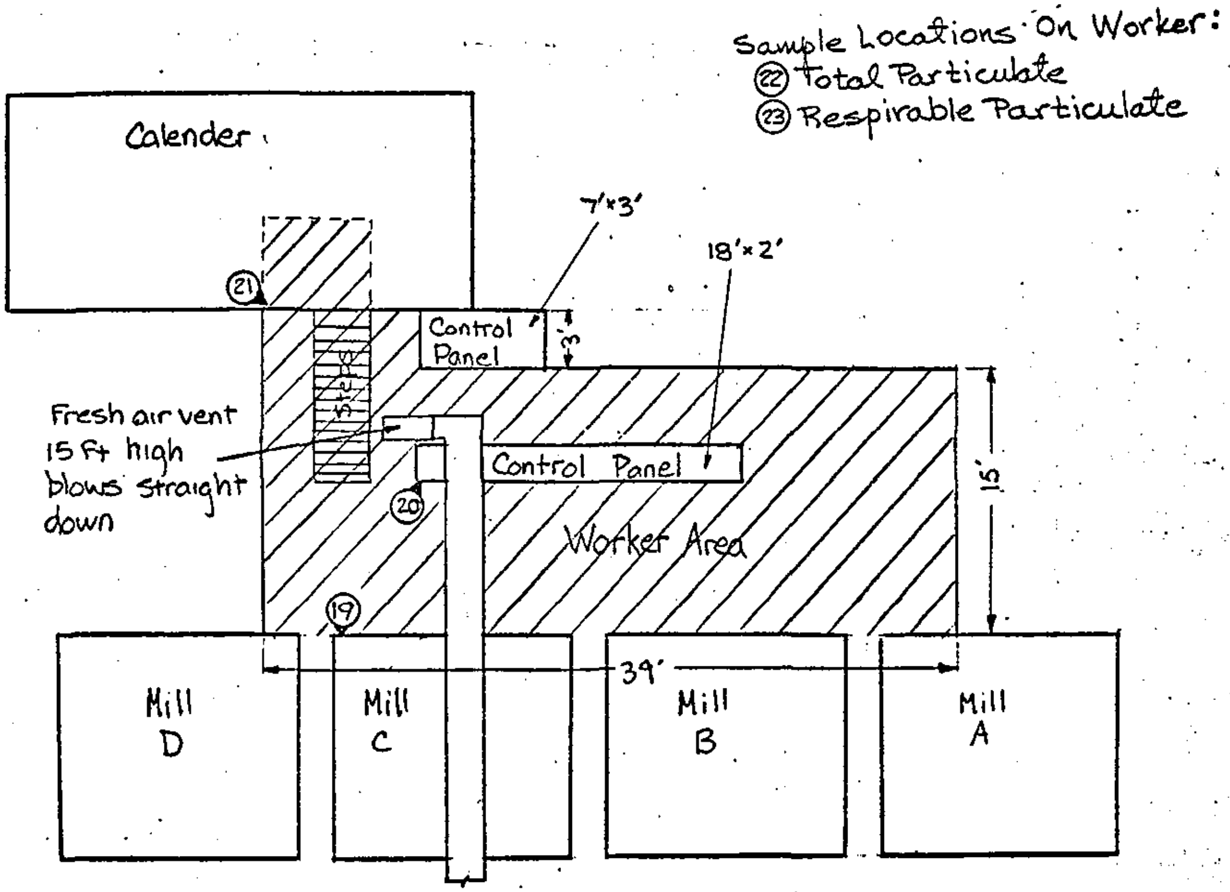

Figure 7-1. Calender area layout and sample locations.

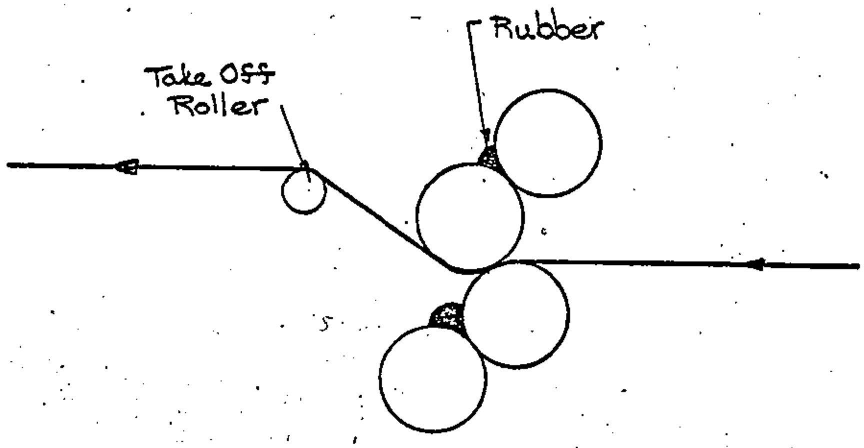

Figure 7-2. Calender material flow.

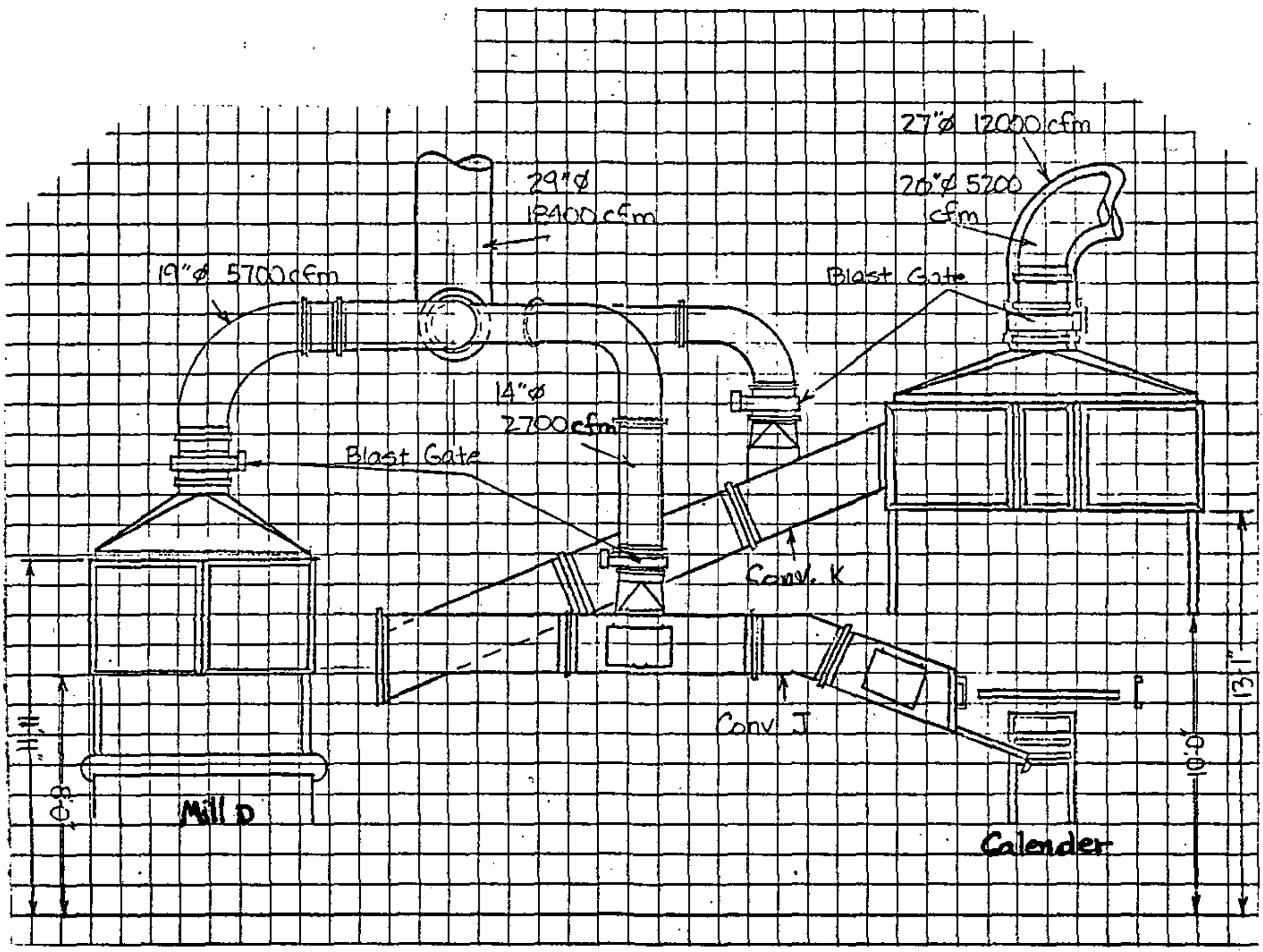

Figure 7-3. Calender line ventilation system layout.

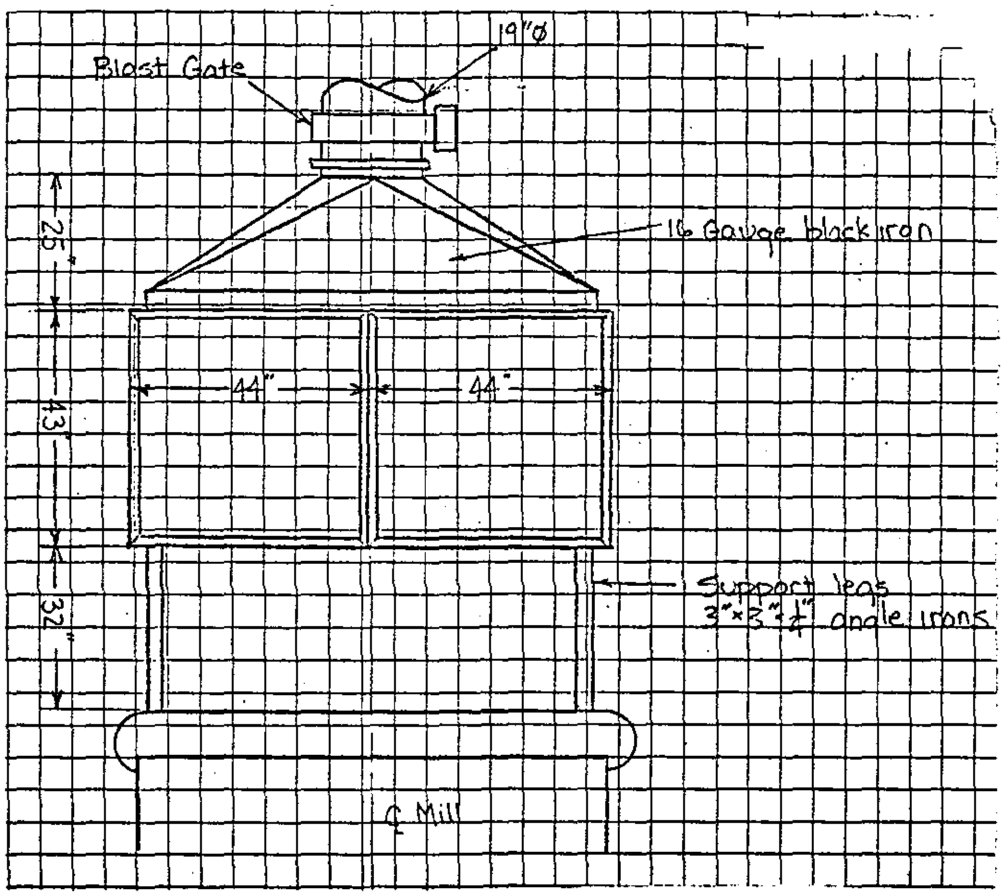

Figure 7-4. Calender line mill hood detail.

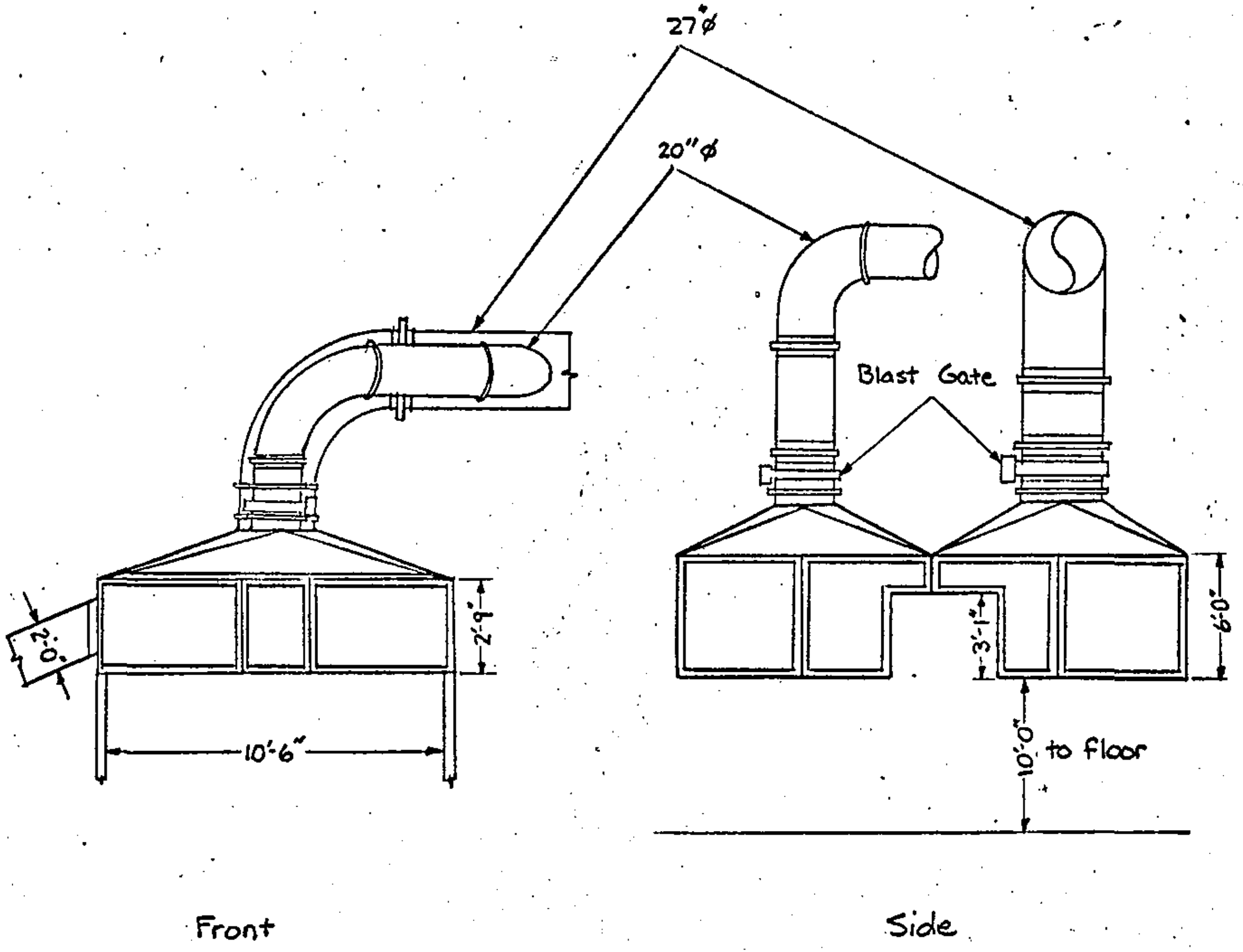

Figure 7-5. Calender line calender hood detail.

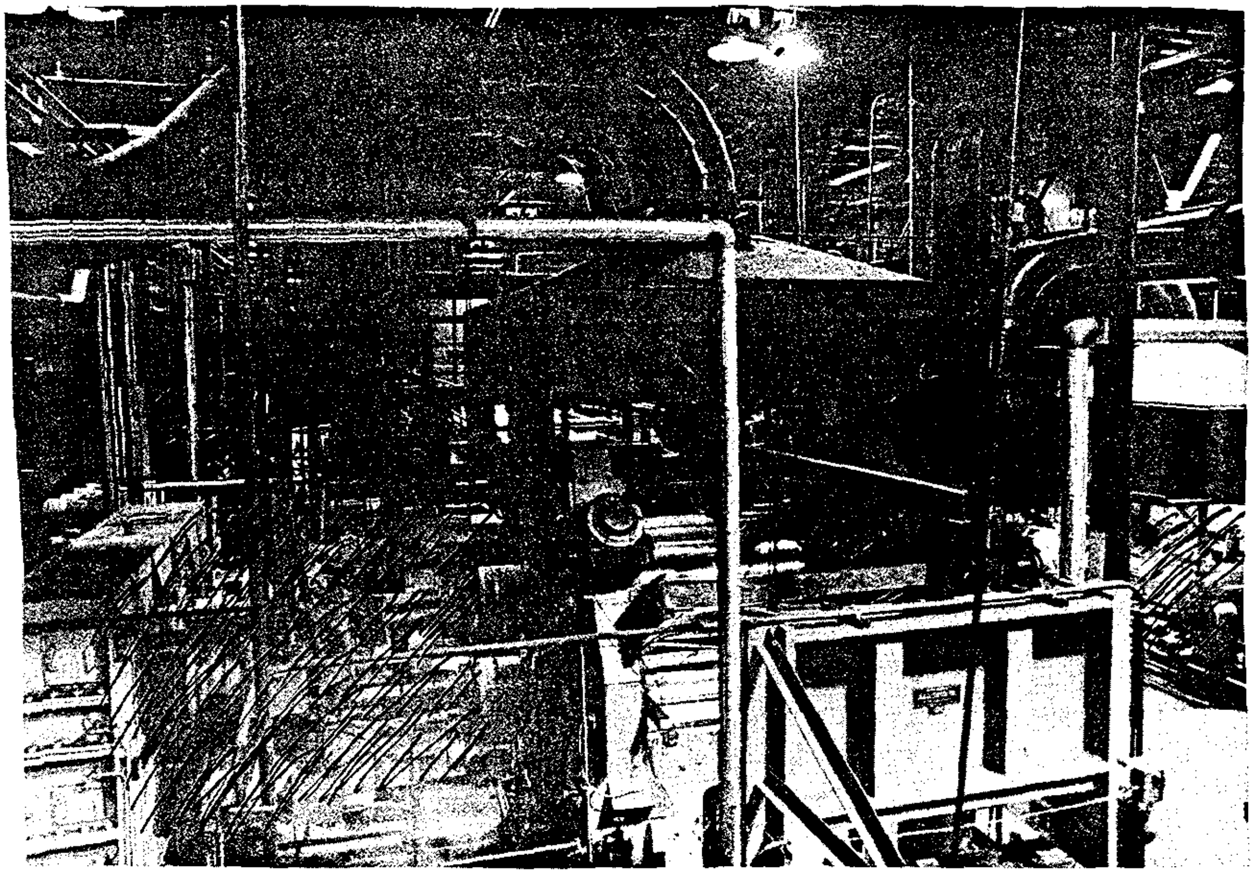

Figure 7-6. Calender line calender hood.

WORKER'S DUTIES

The calender worker's primary duty is monitoring the calender's operation by instrumentation and observation. When needed, he adjusts the rubber sheet thickness, the amount of rubber fed to the calender, and assists in start-ups. However, the majority of his time is spent standing in the location shown in Figure 7-1 observing the process.

AIR SAMPLING DATA

Total particulate area samples were collected at the locations shown in Figure 7-1. Total and respirable particulate samples were also collected on the worker. Sample results are summarized in Table 7-1. Samples were only collected on the day shift because the calender only operated on that shift.

Analysis of variance showed that location did not significantly affect concentration.

Table 7-1. Full shift particulate concentrations for calender.

Location (No. from Fig. 7-1)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Total Particulate:					
Warm-up mill (19)	4	0.11	1.6	0.12	0.07-0.20
Control panel (20)	4	0.09	1.7	0.10	0.04-0.14
Calender, lower area (21)	4	0.12	1.5	0.13	0.07-0.15
Worker (22)	4	0.10	1.4	0.11	0.06-0.14
Respirable Particulate:					
Worker (23)	3	0.12	1.3	0.12	0.09-0.14

VENTILATION DATA

Ventilation measurements were not made at the calender line because smoke tube traces indicated very low face velocities and the ventilation system ductwork was inaccessible for measurements. But some design airflow parameters were avail- able and are presented in Table 7-2.

Table 7-2. Calender line design ventilation requirements.

Measurement	Design
Mill Hoods (each)	
Calculated average duct velocity	2895 fpm
Design duct flow	5700 cfm
Conveyor Hood (connecting mills--2 ducts to hood)	
Duct A:	
Calculated average duct velocity	2245 fpm
Design duct flow	600 cfm
Duct B:	
Calculated average duct velocity	2865 fpm
Design duct flow	1000 cfm
Conveyor Hood (connecting mills & calender) (each)	
Calculated average duct velocity	2525 fpm
Design duct flow	2700 cfm
Calender Hoods	
Main Hood (over calender rollers):	
Calculated average duct velocity	3020 fpm
Design duct flow	12000 cfm
Secondary Hood (over worker platform):	
Calculated average duct velocity	2385 fpm
Design duct flow	5200 cfm

EMISSION SOURCES OBSERVATIONS

All visible emission sources are associated with the rubber as it moves through the process. These emissions begin as the rubber is being plasticized on the calender mill line and stop when the rubber coating on the stock is cooled. The emissions were observed coming from the rubber on all of the mills, the conveyors, and the calender.

WORK PRACTICES OBSERVATIONS

The work practices of the process worker do not appear to greatly affect his exposure since he does not often manually handle the rubber.

The general housekeeping of the floors around the calendering area was good. Floors were clean and uncluttered.

ENGINEERING CONTROL OBSERVATIONS

These observations were made about the fume emissions and from smoke tube traces:

1. Fume was observed being generated on all four mills, but only two mills had hoods.

2. A make-up air unit located near mill B blew fume from the mill toward the worker's location at the mill face.

3. Fume from unenclosed rubber moving between the mills and the conveyor escaped both the mill and the conveyor hoods. Further- more, the moving rubber appeared to pull fumes out of the mill hoods.

4. Fume generated from the upper area of the calender rose into the hood. However, when make-up air was blown from a diffuser next to the hood, some fume was pushed out of the hood.

5. Most of the fume generated from the lower area of the calender, beneath the worker platform, escaped the hood over the calender. However, when the make-up air diffuser mentioned in Item 4 was working, all the fume escaped the hood.

6. Fume generated at the steel wire entrance to the calender rose into the calender hood.

The mill and calender could be further enclosed without obstructing the process operations. Such enclosure would probably require additional lighting.

Currently, the worker platform on top of the calender is beneath and somewhat enclosed by the calender hood. While the calender is operating, limited time should be spent on the platform because of the heavy fume concentration.

Mushroom rain caps were installed on the exhaust fan outlets. Use of these caps on exhaust outlets is not recommended because of their high static pressure losses. Furthermore, they turn the contaminated air toward the plant roof where it can be taken up by make-up air units and recirculated.

MONITORS OBSERVATIONS

No monitoring equipment for ventilation system performance or specific agents was noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

The worker's exposure comes from the rubber fume as the rubber moves though the process. Normally, the worker has little direct contact with the rubber or spends little time in the immediate vicinity of the rubber. Thus, he usually does not receive fume emissions directly into his breathing zone. But, should he be required to perform operations at the top calender rollers or beneath the platform at the calendered stock exit, he may receive emissions directly into his breathing zone.

Fumes not captured by the ventilation system could enter the general room air. This fume could elevate the background contaminant levels and, thus, the worker's exposure.

Fume generated from rubber on mills A and B and their respective conveyors was not controlled. Visible fume from rubber on mills C and D appeared to be controlled by the hoods on these mills. However, rubber moving from the mills to the conveyors was observed to pull fume from the hoods. Also, fume from the portions of this rubber not enclosed in either the mill or conveyor hoods was not captured.

In general, all of the hoods were fairly open. This could allow drafts to blow fumes from the hoods. Fume generated from rubber at the top of the calender was mostly controlled by the calender hood. But, make-up air from a diffuser near the hood blew fumes through the hood. Also, the worker platform was located inside the hood so workers on the platform could be exposed to fume as it rises into the hood. Fume generated from rubber at the lower part of the calender was virtually uncontrolled.

The sampling data show that the particulate concentrations throughout the calendering area are fairly uniform and very low. Since the rubber being processed by the calender line appeared to be the only source of particulate in the area, the total particulate concentration should be from fume escaping the calender line controls. But, the samples may not be a true measure of the fume escaping the hoods because the samples were not placed directly in the contaminant stream.

The worker's work practices did not appear to affect the workers because their job was primarily observing the process--They had little direct contact with the process materials.

CURING PRESS ROWS (8)

AREA: CURING

DESCRIPTION

Two adjacent press rows were selected from several for this study. The selected press rows do not necessarily cure the same size tire. Also, only one of the press rows had a canopy hood. Make-up air is distributed thoughout the curing room.

A layout of the hooded press row is shown in Figure 8-1. The unhooded study press row is similar in layout. Each press row contains 18 curing presses of unknown size.

The hooded press row has a canopy hood fabricated from metal "curtains" hung from the curing room ceiling. The curtains extend down to 10 feet above the curing room floor. A projection of the hood perimeter is shown in Figure 8-1. Exhaust air is pulled from the hood by seven roof ventilators located in the positions shown in Figure 8-1. Numerous other ventilators exhaust general air from the curing room outside the hood. Some of these are shown in Figure 8-1.

Make-up air is supplied to the press row by diffusers located along the sides of the hood. The heights of these diffusers from the curing room floor are 14 feet for D-1 to D-34 and 20 feet for D-35 to D-46. The locations of the diffusers are shown in Figure 8-1 and the diffusers are shown in Figures 8-2 and 8-3. In addition, air coming from D-1 to D-34 is conditioned, while air from D-35 to D-46 is unconditioned outside air.

The exhaust and make-up air fans were installed as original equipment in the early to mid-seventies. Since that time the curtains were added.

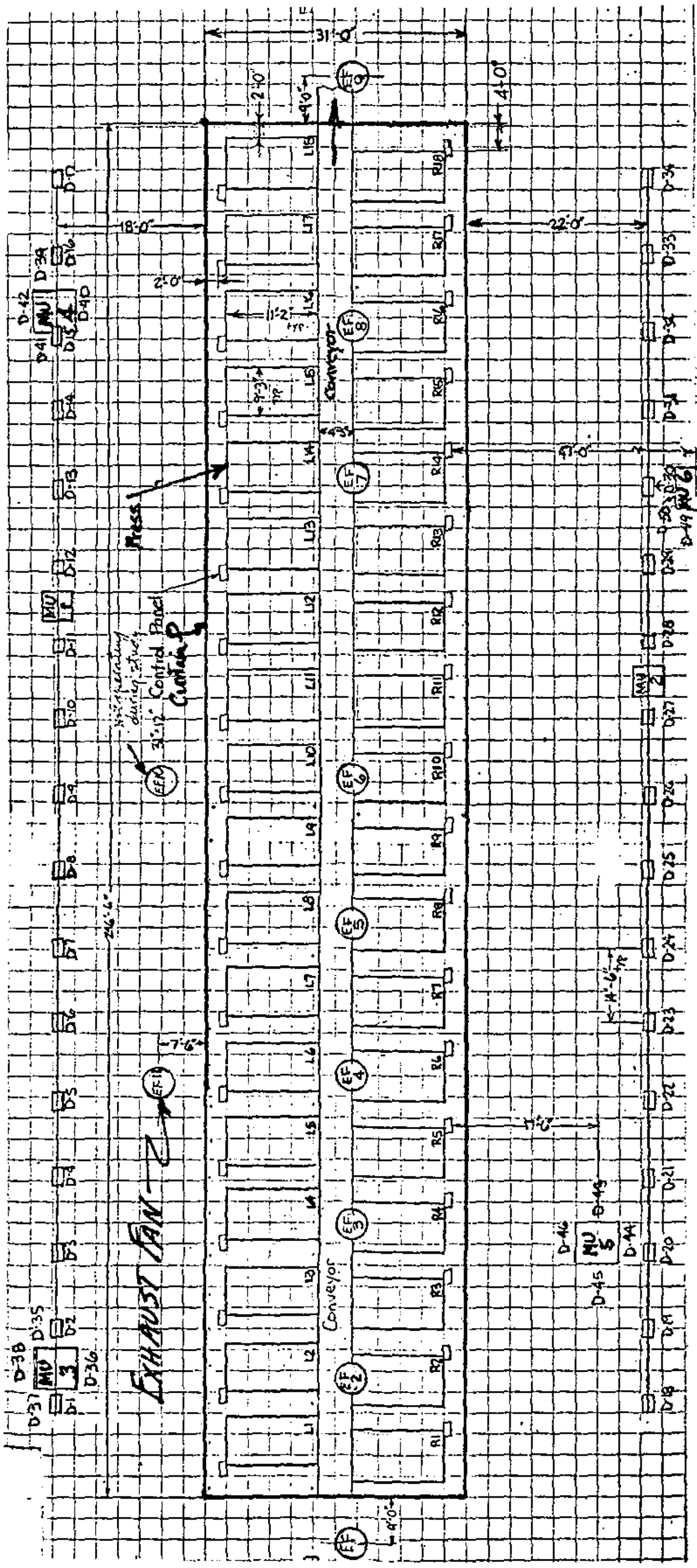

Figure 8-1. Curing press row B layout.

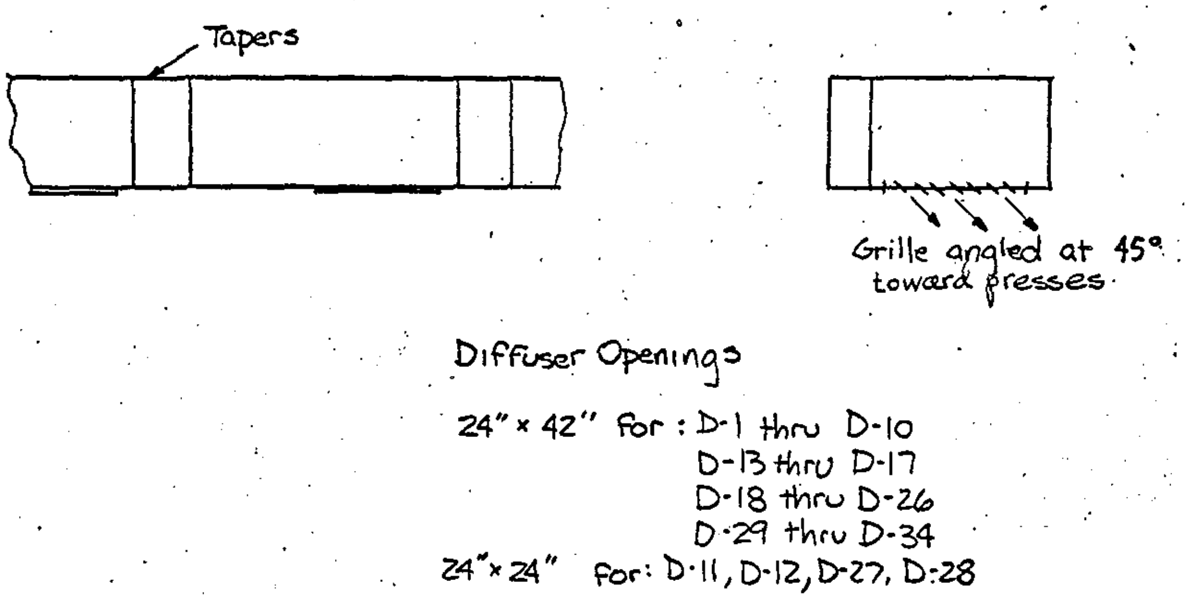

Figure 8-2. Curing press row B make-up air diffuser detail.

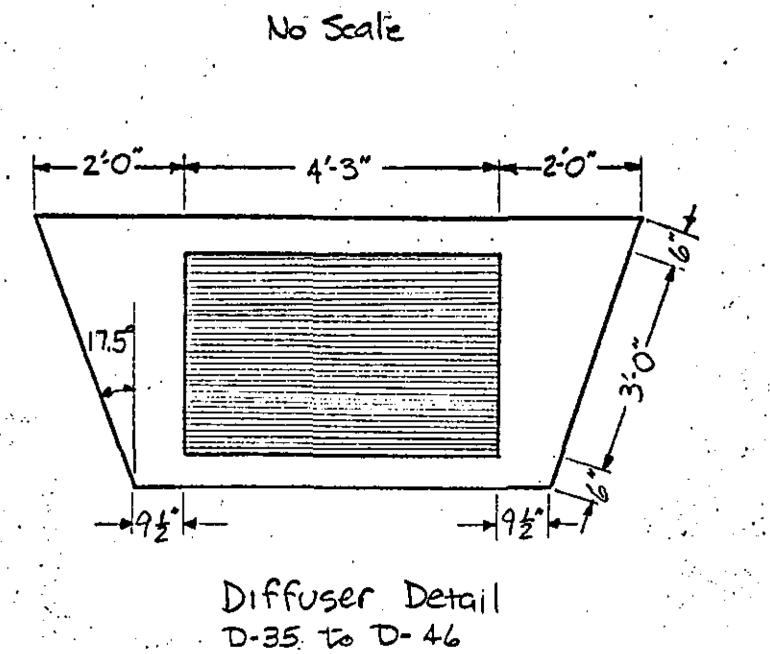

Figure 8-3. Curing press row B make-up air diffuser detail.

WORKER'S DUTIES

One worker operates each of the study press rows. The worker removes tires from a rack and places them on the curing press precure rack and corrects malfunctions in the flow of tires, such as jams. He also assures proper operation of the equipment and changes press bladders. The normal location for the worker
is beneath the hood edge on the hooded press row and an equal distance from the presses on the unhooded row. Correcting tire jams requires the worker to go to the conveyor at the back of the presses.

AIR SAMPLING DATA

Total particulate area samples were collected at the locations shown in Figure 8-4. Total and respirable particulate samples were also collected on one worker from each press row. Sample results are summarized in Table 8-1 and detailed in Appendix II.

Table 8-1. Full shift particulate concentration for curing press row.

Location (No. from Fig. 8-4)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Total Particulate:					
Column D (27)	8	0.08	1.6	0.08	0.03-0.13
Row B					
Press R9, front (28)	8	0.08	1.6	0.09	0.05-0.13
Press R9, back (29)	8	0.09	2.0	0.10	0.02-0.16
Press L98, front (30)	8	0.09	1.4	0.10	0.06-0.15
Worker (31)	8	0.22	1.3	0.22	0.13-0.28
Column E (33)	8	0.12	1.4	0.12	0.08-0.13
Row A					
Press R9, front (34)	8	0.11	1.4	0.12	0.09-0.18
Press L9, back (35)	8	0.15	1.5	0.17	0.09-0.24
Press L9, front (36)	8	0.14	1.3	0.15	0.10-0.17
Worker (38)	8	0.23	1.4	0.23	0.13-0.34
Column F (37)	8	0.13	1.4	0.13	0.09-0.18
Respirable Particulate:					
Row B					
Worker (32)	8	0.12	1.6	0.13	0.09-0.19
Row A					
Worker (39)	8	0.13	1.6	0.14	0.08-0.23

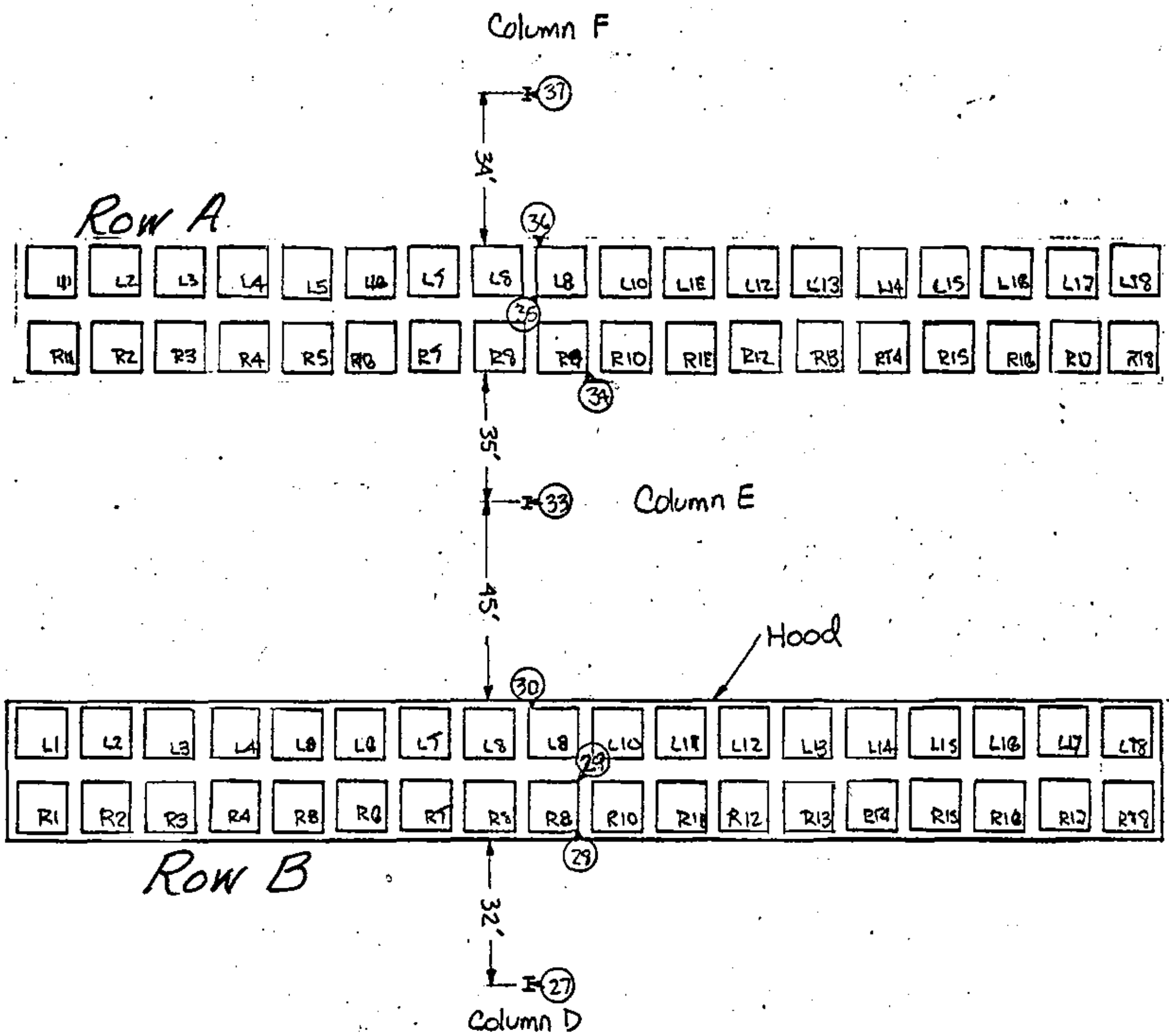

Figure 8-4. Curing press rows A and B sample locations.

Analysis of variance of the total particulate sample results showed that press row, day, and type of sample (area or personal) significantly affected concentration. Because of the significant interaction between press row and sample type, Duncan's test was applied to the geometric means of same sample types from each press row. These results are summarized in Table 8-2. To examine the effect of day on the sample results, Duncan's test was applied to samples collected on the same day. These results are presented in Table 8-3.

Table 8-2. Statistical Analysis results for geometric mean concentration of sample type and press row.

Press Row	Sample Type	GM (mg/m^3)	Duncan's Test[a]
Row B (w/hood)	Area	0.08	A
Row A (w/o hood)	Area	0.13	B
Row B (w/hood)	Personal	0.22	C
Row A (w/o hood)	Personal	0.22	C

a. Results with the same letter are not significantly different.

Table 8-3. Statistical analysis results from geometric mean concentrations for days.

Day	GM (mg/m3)	Duncan's Testa
4-21-81	0.13	A, B
4-22-81	0.14	A
4-23-81	0.11	B, C
4-24-81	0.10	C

a. Results with the same letter are not significantly different.

VENTILATION DATA

The ventilation measurements are summarized in Table 8-4 and shown in Figures 8-5 through 8-12 in Appendix IV. Figures 8-10 through 8-12 show the velocity measurements around the perimeter of the hood at heights of 3, 5, and 7 feet. Normally, the measurements from these three heights are averaged and presented in one figure. But at this plant, the airflow at the 3 and 5 feet heights was into the hood, while at 7 feet it was out of the hood and an average was not appropriate.

Table 8-4. Curing press row ventilation data.

Measurement	Quantity Measured	Design
Exhaust Airflow		
Hooded press row:		
EF-2	34,975 cfm	unknown
EF-4	35,270 cfm	"
EF-6	34,650 cfm	"
EF-8	37,495 cfm	"
Average	35,600 cfm	"
Total hood exhaust	249,200 cfm	"
Unhooded press row:		
EF-120	26,355 cfm	26,000 cfm
EF-128	24,410 cfm	26,000 cfm
EF-127	21,115 cfm	26,000 cfm
Average	23,960 cfm	26,000 cfm
Total exchange for fan hoods in curing room	Not measured	442,000 cfm
Total exchange for fans not in curing room	Not measured	702,000 cfm
Make-up Airflow		
D-1 to D-34:		
Avg. 24" x 44" diffuser flow (except D-1 and D-18)	a	3,435 cfm
Avg. D-1 and D-18 flow	a	3,445 cfm
Avg. 24" x 44" diffuser flow	a	1,720 cfm
Total flow	a	109,950 cfm
D-35 to D-46:		
Average diffuser flow	a	13,000 cfm
Total flow	a	156,000 cfm
Dimensions		
Distance from control panel face to hood face		2'-0"
Height of hood edge from floor		10'-0"
Calculated hood volume		128,596 ft^3

Table 8-4 (cont'd)

a. Calculation of the flow based on diffuser air velocity measurements was felt to be inaccurate. Estimate of actual diffuser flow cannot be made because amounts of diffuser area occupied by the grilles is unknown. However, calculation of the flow using estimates of the actual open diffuser area based on grille dimensions from diffuser product literature indicates that the make-up air is at design.

EMMISSIONS SOURCES OBSERVATIONS

All the visible emission sources were associated with the cured tire as it moved through the process. The greatest emissions occurred when the mold opened after the cure cycle and as the tire underwent post cure inflation (PCI).

WORK PRACTICES OBSERVATIONS

The work practices in the room appear to have minimal effect on the worker's exposure because the worker rarely handles freshly cured fuming tires. The worker may increase his exposure by staying near a fuming tire too long or being too near an opening press. However, these practices were not observed.

ENGINEERING CONTROL OBSERVATIONS

Fumes escaped the hood when a press opened after a cure. Smoke tube traces showed air movement out of the hood at and above a height of seven feet throughout the hood perimeter.

The entire curing room ventilation was designed to operate under either summer or winter airflow conditions. These conditions are shown in Table 8-5. The study at the plant was performed under the summer conditions.

A series of temperature measurements were made in the curing room, outside the plant, and at the exhaust fan outlet. These measurements are shown in Table 8-6.

Table 8-5. Seasonal ventilation conditions for a curing room.

Season	Exhaust Airflow	Make-Up Airflow
Summer	858,000 cfm	520,000 cfm
Winter	1,144,000 cfm	1,092,000 cfm

Table 8-6. Temperature measurements for curing press rows.

Location	Temperature (°F)
Ambient air temp. at make-up air inlets:	82
Hooded press row (row B):	
In front of press row L-2	84
In front of press row R-2	82
In front of press row L-6	85
In front of press row R-6	81
In front of press row L-10	84
In front of press row R-10	80
In front of press row L-16	81
In front of press row R-16	81
Average	82
Unhooded press row (Row A):	
In front of press L-3	90
In front of press R-3	85
In front of press L-9	88
In front of press R-9	87
In front of press L-16	86
In front of press R-16	84
Average	87

Table 8-6 (cont'd)

Hooded press row (Row B)	
EF-2 outlet	94
EF-3 outlet	95
EF-4 outlet	93
EF-5 outlet	95
EF-6 outlet	94
EF-7 outlet	95
EF-8 outlet	92
Average	94
Unhooded press row (Row A):	
EF-120 outlet	90
EF-127 outlet	89
EF-128 outlet	92
Average	90
Other exhaust fans not directly over presses:	
EF-1	80
EF-9	88
EF-11	82
EF-119	91
EF-111	87

The energy lost from the curing room through Row B was calculated using the following equation:

$$q = dQc_p\ (T_{out} - T_{in})$$

where
q = total energy gain by the air
d = density of air at 70^oF (0.0748 $lbs/ft)^3$)
Q = airflow rate (249,200 cfm)
c_p = specific heat of air (0.24 $BTU/lb/ft^3$)
T_{out} = average temperature of air leaving row B's hood (94^oF)
T_{in} = average temperature of air entering row B's face (82^oF)

This assumes that all the energy gained by the air is generated within the press row B. However, some energy is probably lost into the rest of the curing room. The calculation shows 56,270 Btu/min exit the plant through the hooded press row alone. A similar calculation for the unhooded press row using an airflow of 71,880 cfm and an outlet temperature of 90°F yielded 10,765 Btu/min. This assumes that the air entering the unhooded press row was totally supplied by the make-up air units at 82°F.

For comparison, if the exhaust flow for the unhooded row were increased to that of the hooded row, then the energy gain, q, would be 35,790 Btu/min. This shows that for equal flows from the two press rows, the air from the hooded press row has a higher energy gain. This further could translate into lower temperatures around the presses and a lower cooling demand for the worker. The temperatures at the press faces show this to be true with the temperatures at the press face for the hooded row being lower (82°F) than those for the unhooded row (87°F).

MONITORS OBSERVATIONS

No monitoring equipment for ventilation performance or specific contaminants were noted.

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

No personal protective equipment was noted.

DATA INTERPRETATION

Fume can pass directly through the workers breathing zone while handling freshly cured tires; however, workers do not frequently handle the freshly cured tired. Fume which is not controlled by the ventilation system can raise background contaminant levels and thus the worker's exposure. Workers can also receive additional exposure by entering areas where background contaminant levels are elevated, such as the area beneath the hood.

Fume was observed escaping the hood over the hooded press row. In addition, smoke tube traces showed a flow of air out of the hood at and above seven feet around the perimeter of the hood.

Sampling data for the curing room showed that contaminant levels for the hooded press row were significantly lower than the unhooded press row. Yet, the number and flow rate of the roof exhausters over the unhooded press row were lower than those for the hooded press row. But, the total exhaust airflow outside of the hoods was greater than that in the hoods. Therefore, if the assumption is made that fume generated by the unhooded press row is accessible to all the exhaust fans outside of the hoods, then this suggests that the hooded row is more efficient at controlling the fume than the unhooded row. The sample data also show the worker's samples are significantly greater than all the area samples.

The sample data also show a significant difference between days. Again, the reason for this is unknown, but, this could be the effect of production rates varying between days, curing different types of tires, or varying environmental conditions.

Temperature measurements about the curing room showed that exhaust outlet temperatures for the hooded press row were higher than the unhooded press row. But, these measurements also showed lower temperatures at the faces of presses on the hooded row than the unhooded row. From calculations, this showed a greater equivalent gain in energy for the hooded press row than the unhooded press row. This further indicates better control of the energy generated from the curing presses for the hooded row over the hooded row.

Work practices are not felt to affect the worker exposure.

TIRE REPAIR TABLE HOOD (9)

AREA: FINAL FINISH

DESCRIPTION

The repair table studied is used to repair minor defects on the tire sidewall and bead and was selected from several tables. The repair table and hood are shown in Figure 9-1. The hand tools used at the station are primarily an electric buffer and grinder. Both operated at 3450 revolutions per minute, but the grinder used a 3-inch grinding wheel and the buffer a 6-inch wheel. A solvent/paint mixture was also used at the station. Branding occurs solely at another table separate from the repair tables.

The repair table consists of rollers on a donut-shaped table. The tire is set on the rollers for repair. The table can be adjusted to various tilts.

The hoods for the tables are all similar. There is a duct entrance attached to the middle of the table. In essence, the table and tire on the table become the flange of the hood. The duct entrance of some of the hoods was covered with screening. The study table was of this type.

The table was designed and installed in the early seventies. Originally, the ducting specified for the table was an 8-inch diameter, flexible duct, and a 9-inch diameter branch duct. On the installation, these were 8 inches and 12 inches diameter, respectively. The reason for the change is unknown.

WORKER'S DUTIES

The worker removes tires from a conveyor belt and places them on the repair table. The normal procedure for repairing the tire is to:

1. Grind the defect on the tire.

2. If needed, buff off the defect spot.

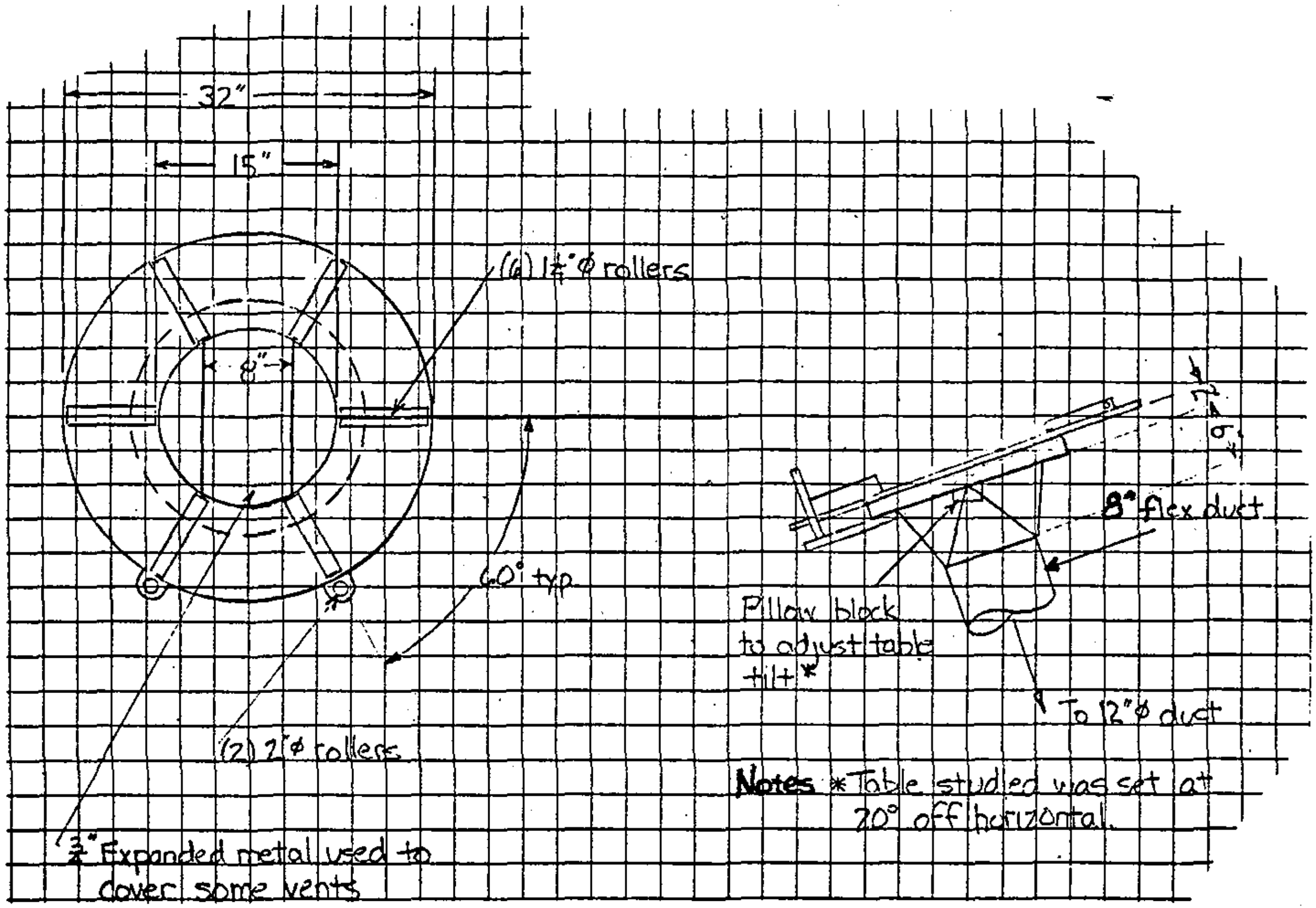

Figure 9-1. Tire repair table hood detail.

3. Blow-off the spot with an air hose and paint the blackwall with the solvent/rubber mixture.

4. Chalk-mark the repair spot.

5. Place the tire on a return conveyor.

AIR SAMPLING DATA

Total particulate samples were collected on the worker. Sample results are sum- marized in Table 9-1 and detailed in Appendix II. A student's t-test showed no significant differences between workers' particulate exposures.

Table 9-1. Full shift particulate concentrations for a tire repair worker.

Location (mg/m^3)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range
Worker	7[a]	0.17	1.6	0.19	0.1-0.40

a. One sample was 3.3 mg/m^3 and was not included in the table.

VENTILATION DATA

The ventilation measurements are summarized in Table 9-2 and shown in Figures 9-2 and 9-3 in Appendix IV. Design airflow parameters are presented where available.

Table 9-2. Defect repair table hood ventilation data.

Measurement	Quantity Measured	Design
Average duct velocity	2290 fpm	4390 fpm[a]
Calculated duct flow	1800 scfm	1940 cfm
Duct static pressure	6.0 in. H_2O	Unknown
Average face velocity	2155 fpm	2455 fpm[b]

a. Based on original 9-inch diameter duct specification.
b. Calculated from calculated hood face area and design airflow.

EMISSION SOURCES OBSERVATIONS

The source of emissions are the petroleum distillate in the paint and the particulate and fume from the grinding operations. The sources of the petroleum distillate emissions are:

1. Evaporation from open containers of the paint.

2. Evaporation from the surfaces where they are applied.

3. Evaporation from utensils used with the paint.

4. Evaporation from spills of the paint.

The sources of the particulate emissions are:

1. Spray from the grinding and buffing operations.

2. Particulates blown off tires by compressed air.

3. Grindings on the floor and structures.

WORK PRACTICE OBSERVATIONS

Improper work practices can contribute to the worker's exposure because of his integral involvement with the process. In essence, the operations of the worker generates the emissions. Moreover, the heavy use of portable hand tools also keeps him near the emission source. Work practices could also affect ventilation system performance. Some of the work practices observed which could contribute to particulate generation or decreased ventilation performance were:

1. Aiming the grinder so particulate shot out of the hood instead of toward the duct entrance. However, in some cases, aiming the grinder to do this would be extremely difficult for the worker with the current arrangement.

2. Blowing off tires with air hoses. This generates dust emissions which the hood cannot capture.

3. Removing screens from the hood duct entrances. This allows large materials, such as cigarette wrappers, to enter the ventilation system.

4. Not keeping screens on hoods clean. Several hoods were totally blocked.

5. Throwing trash, such as gum and cigarette wrappers, into the hood. The ventilation system may not have the capacity to handle these items, possibly causing duct blockage.

ENGINEERING CONTROLS OBSERVATIONS

Depending on the size of tire being repaired and the oreintation of the grinder, particulate was captured by the hood. However, particulate could also escape the hood. The times when it escaped the hood primarily occurred when the grinder spray was aimed away from the duct entrance and when small rim-size tires were repaired. In the latter case, these tires partially obstructed the hood face, as shown in Figure 9-3.

Most grinding was done on the lower portion of the table. Yet, the greatest capture velocities occurred at the upper portion of the tire, as shown in Figure 9-3. Part of the reason for this appears to be that the lower area of the tire is farther away from the hood face than the upper area. In some cases, the upper part of the tire is positioned directly over the hood face. Such was the case for the tire used to measure the capture velocities.

On many of the repair tables, the flexible duct was so long it lay on the floor. This caused several extra bends in the ducts which causes additional static pressure losses in the system. It also provides an impaction surface for particulate--a layer of particulate coated the ducts of the hoods.

Some grinding particulate lying on the floor appeared to cause a sticky foot switch for a grinder.

Long, thin strips of cured rubber were accumulated on the screens of some hoods and on the repair area floor. The plant reported that these pieces of rubber are called "rims" and that they result from the way the white sidewall in the tires is ground. Certain types of grinding wheels or the grinding wheel adjustment on the white sidewall grinder were reported to cause the rims. Furthermore, the rims can be as long as two feet.

The build-up of the rims on the screen became so bad in some instances that the screen became blocked. Apparently this lead to the removal of the screens on some hoods.

The plant reported frequent occurrences of fires in the ducts from the white sidewall grinders and the repair tables. A duct to the repair tables appeared to previously have had a fire because it was rusty and unpainted. A possible correlation between the rims and an inadequate transport velocity, and the fires could exist. A sampling of the rims from the wet collector return for the repair table ventilation system found the longest rim to be 12-inches long. If the rims are not being broken apart in the ventilation system, then the longer rims may be falling out in the main duct. Reportedly, these rims can roll together on the bottom of the duct in a snowball effect. Eventually, these "rim balls" can block the duct or provide fuel for a duct fire.

MONITORS OBSERVATIONS

No monitoring equipment for the ventilation system and for specific contaminants was noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

Minor exposures are expected from the particulate from the grinding operations because of its relatively large size, and the velocity and direction with which it is thrown away from the worker. However, a greater exposure to the grinding particulate may be possible when it is blown off the tires with an air hose.

Worker exposures to solvent vapors is possible because of the evapora- tion from open paint cans, painting accessories, and spills. But, the surface area and quantities are small, so little contribution to the worker exposure is expected. Petroleum distillate exposures at tire repair operations were below 20 mg/m^3. This is well below the NIOSH recommended standard of 350 mg/m^3 for petroleum distillate.

The table hood does capture grinding particulate if the grinding spray is aimed toward the hood face and the hood face is not obstructed by the tire being repaired. Under these conditions, some grinding particulate can escape the hood.

The particulate which escaped the hood is not felt to be hygienically significant as shown by the worker's air sampling data. But, this particulate was observed to be a housekeeping and maintenance nuisance.

Work practices could affect the generation of particulate by aiming grinding particulate so it is not captured by the hood. Work practices can also affect the hood performance by allowing materials to block the hood face or throwing large objects into the hood which the ventilation system cannot handle.

CEMENT HOUSE

AREA: CEMENT HOUSE

DESCRIPTION

The cement house is used to store, mix, and/or dispense liquids, such as undertread and endtread cements, mold release agents, and solvents used in tire building. These materials are stored by several means:

1. Flammable liquids used in large volume, such as naphthas, are stored in underground tanks outside the plant and pumped into the cement house to outlets or directly to mixing tanks.

2. Other liquid materials, such as degreasers or minor ingredients, are stored in 55-gallon drums laid on a rack along one wall of the room.

3. Some heavily used mixtures, such as cements, are blended in mixing tanks, piped into plummer tanks (small capacity, enclosed), and transported into the plant. Plummer tanks not taken directly into the plant are placed on agitators in the cement house.

The locations of some of the fixed storage structures are shown in the cement house layout in Figure 10-1.

Distribution of materials from the cement house is by several modes depending on the material. Two modes are plummer tanks and solvent cans. The solvent cans usually contain naphtha for use in tire building.

The ventilation system in the cement house is general exhaust with make up air as shown in Figure 10-1. The general exhaust is provided by exhaust vents located about the cement house. Each vent is open toward the floor to pull air off the floor. No grilles cover the vents. The vent locations are shown in Figure 10-1.

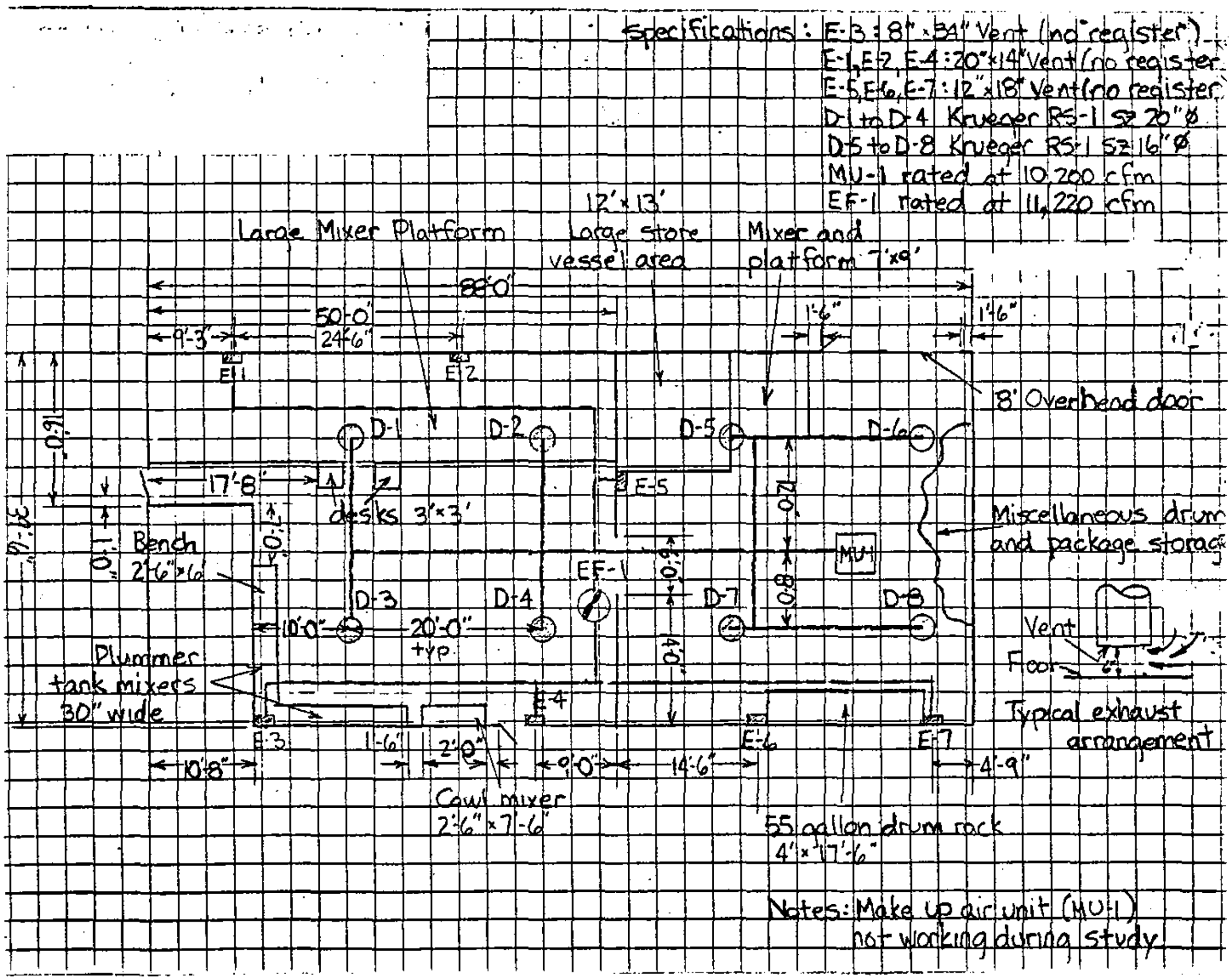

Figure 10-1. Cement house layout.

Make up air was supplied to the cement house by circulated cone diffusers located about 17 feet above the floor. Their locations are shown in Figure 10-1. During the study the make-up air system was not operating.

The ventilation system was installed when the cement house was built in the early seventies. Notable differences between the company drawings and the actual installation were recorded.

WORKER'S DUTIES

Only one worker per shift performs duties in the cement house, but other personnel have access to the area. During the study, the cement house worker spent 50 to 75 percent of his time performing duties in the cement house. The other time was spent outside the cement house delivering materials to other areas and preparing rubber stock for the cement.

The worker's primary duties in the cement house are mixing materials in accordance with recipes specified on recipe cards and filling containers with materials stored in the cement house. The former is performed either in the large enclosed mixers, shown in Figure 10-2, or with the cowl mixers, shown in Figure 10-3.

The mixing in the large, enclosed tank is accomplished as follows:

1. The tank is about half-filled with solvent.

2. The mixing blade is started.

3. Solid ingredients, such as uncured rubber, are added through the door on top of the mixer. The time required for this operation was about 5 minutes.

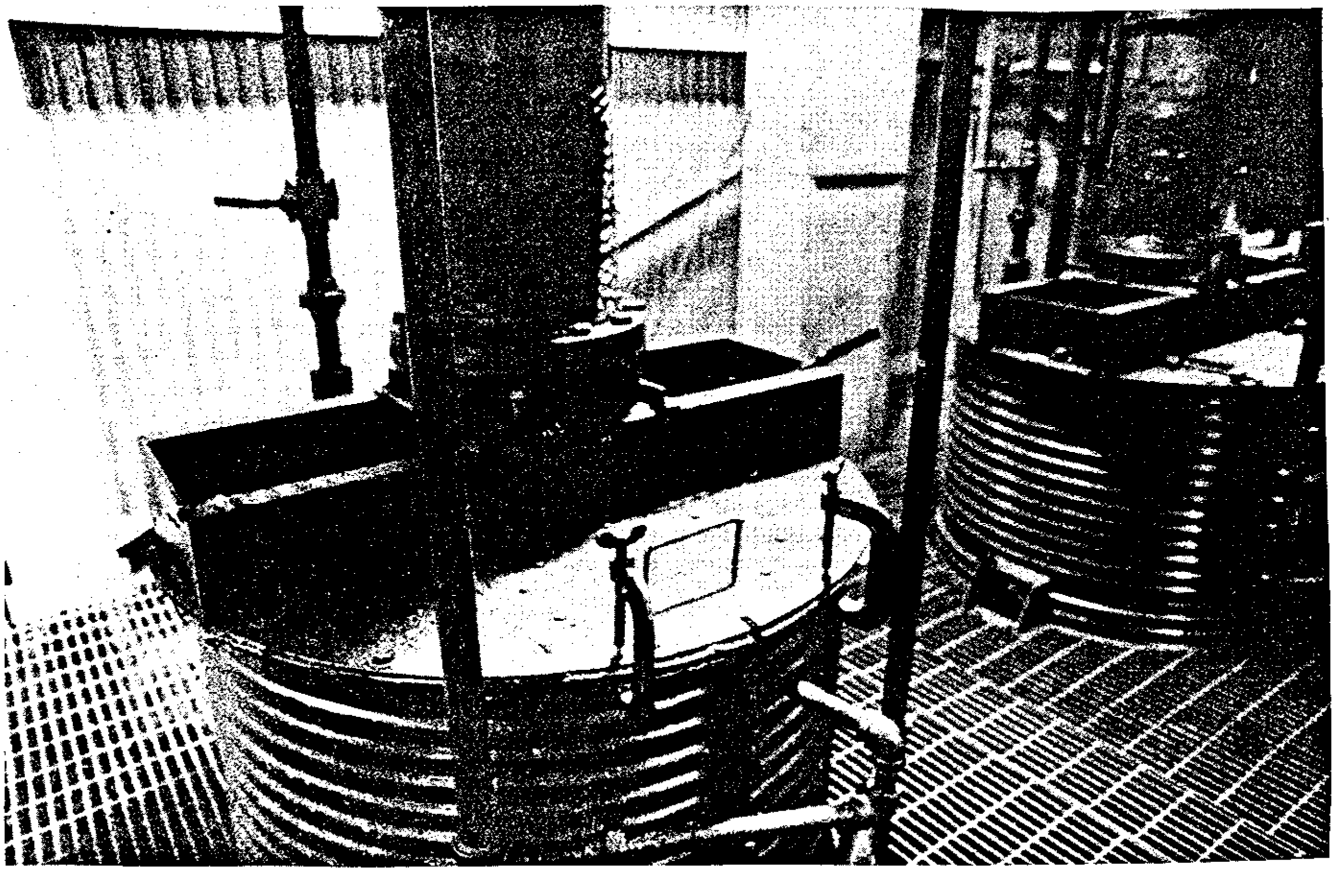

Figure 10-2. Cement house large mixing tank.

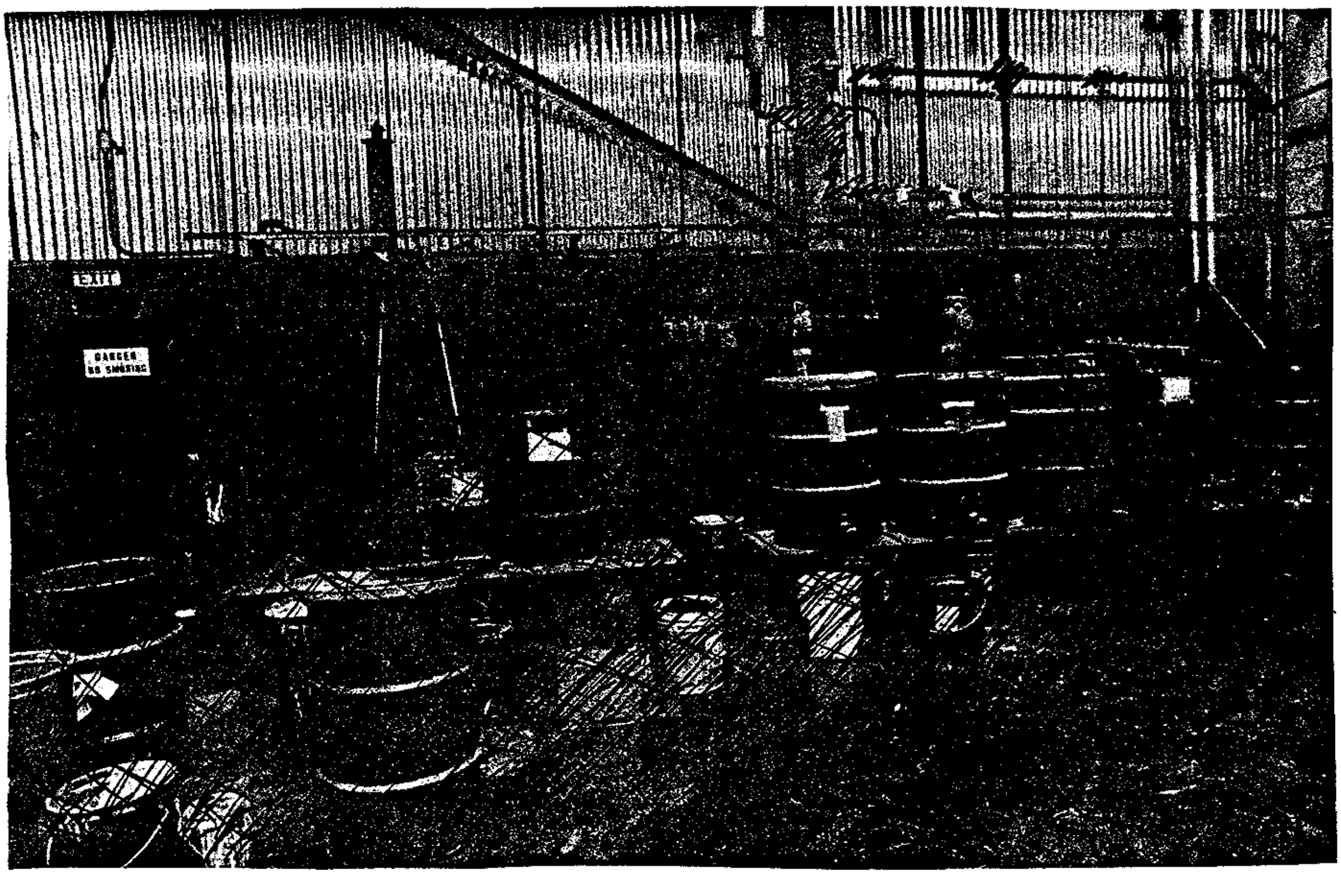

Figure 10-3. Cement house cowl mixer and agitators.

4. When all solid ingredients are added, the tank door is closed and the rest of the specified solvent is added.

5. The mixture is allowed to churn for the time specified on the recipe card and is then piped into plummer tanks.

Mixing with the cowl mixers is accomplished as follows:

1. The appropriate container is placed into position under the cowl mixer.

2. The cowl mixer is lowered into position.

3. The mixer is started. Additional ingredients can be added to the material in the container.

4. When finished, the cowl mixer is raised and the mixing blade cleaned with rags.

5. The drum is removed.

Inks are mixed infrequently, but to do the job naphtha and rubber and powdered chemicals are mixed in open 55-gallon drums. The naphtha is added to the drums from a gasoline-type nozzle.

Filling of containers from 55-gallon drums is done by opening a valve on the drums and allowing the liquid to flow into the container. This operation takes about 30 minutes.

The only other main duty of the worker inside the cement house is housekeeping.

AIR SAMPLING DATA

Area charcoal tube samples were collected at the locations shown in Figure 10-4. Also, charcoal tube samples were collected on the cement house worker.

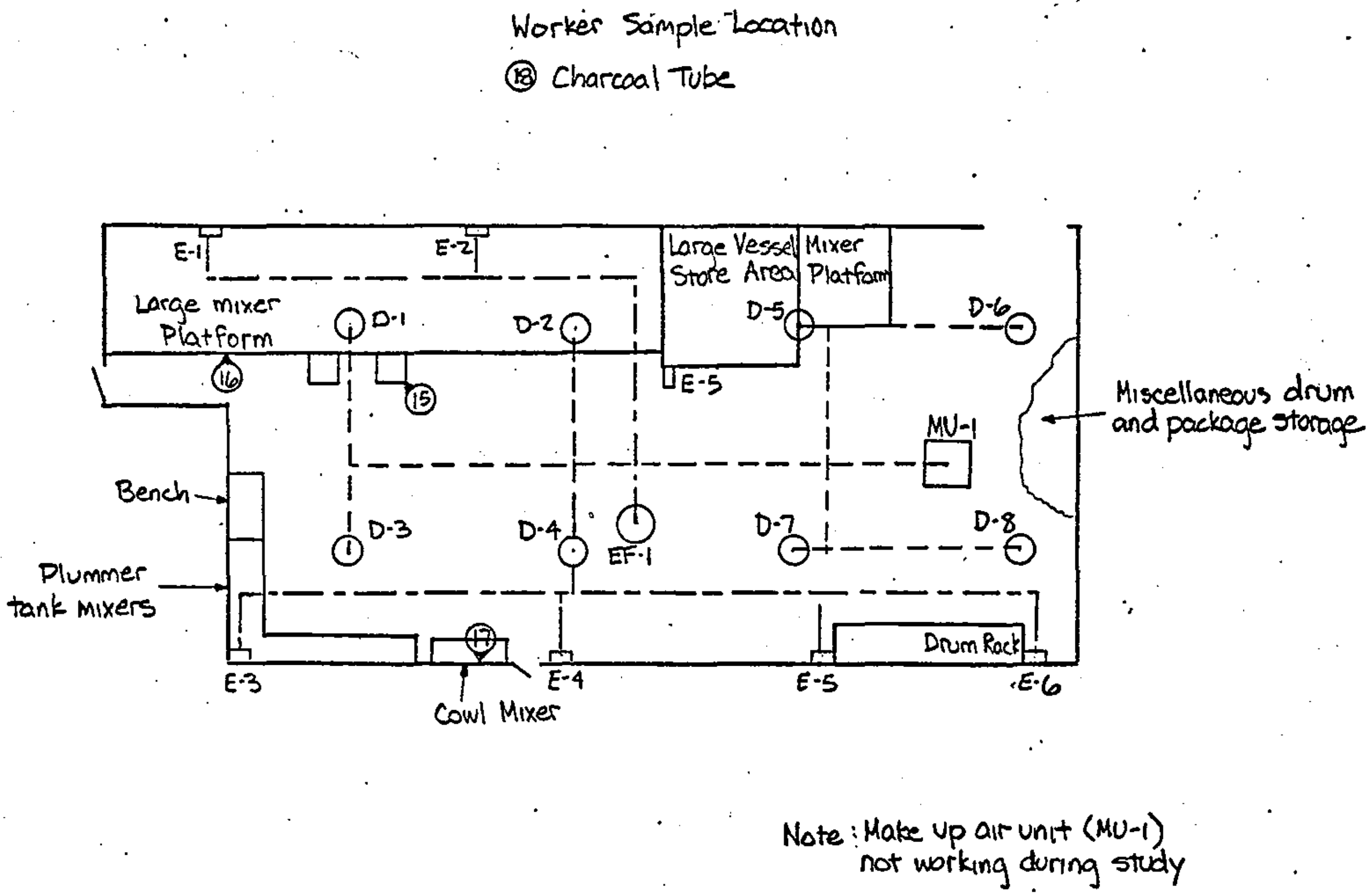

Figure 10-4. Cement house sample locations.

The worker's sample was not removed when he left the cement house to perform duties in other areas of the plant.

The charcoal tube samples were analyzed for toluene, benzene, m-xylene, and total petroleum distillate. The results of the analysis are summarized in Table 10-1 and detailed in Appendix II. Based upon analysis of variance, overall shift affected petroleum distillate concentration. The analysis results are shown in Table 10-2.

Short-term charcoal tube samples were also collected while the worker performed operations which were felt to generate solvent emissions. These samples were analyzed for total petroleum distillate. The results are shown in Table 10-3.

Table 10-1. Full shift sample results for cement house.

Location	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Total Petroleum Distillate:					
Platform column (16)	8	169	2.7	294	10-2083
Worker's desk (15)	8	97	2.7	254	10-325
Cowl mixer (17)	8	201	2.5	285	43-1111
Worker (18)	7	169	2.3	236	40-740
Benzene:					
Platform column (16)	8	0.76	3.0	1.28	0.20-11.25
Worker's desk (15)	8	0.40	2.7	0.64	-* -2.83
Cowl mixer (17)	8	1.00	3.0	1.30	0.20-5.00
Worker (18)	7	0.80	2.3	1.20	0.30-4.00
Toluene:					
Platform column (16)	8	3.5	1.8	4.2	1.6-20.0
Worker's desk (15)	8	2.5	1.6	2.8	0.5-5.7
Cowl mixer (17)	8	5.0	1.9	6.0	1.0-15.0
Worker (18)	7	3.1	1.6	3.2	2.0-7.0
m-Xylene:					
Platform column (16)	8	1.87	1.6	2.1	1.05-4.20
Worker's desk (15)	8	1.40	1.5	1.6	0.80-2.70
Cowl mixer (17)	8	2.70	1.9	3.2	0.80-6.30
Worker (18)	7	1.10	1.6	1.2	0.60-3.70

*Below detection limit.

Table 10-2. Statistical analysis results for cement house overal petroleum sample results.

Sample	N	GM (mg/m^3)	Duncan's Test[a]
Day shift, all samples	15	100	A
Night shift, all samples	16	218	B

a. Samples with the same letter are not significantly different.

Table 10-3. Short-term petroleum distillate sample results for cement house operations.

Sample Description	Sample Time (min)	Concentration (mg/m^3)
Sample on worker adding rubber to large mixer	5	3717
Sample on top of mixer while worker added rubber	5	1115
Sample on worker filling 55 gallon drum from large mixer	31	645
Sample on worker cutting and adding rubber to large mixer[a]	10	800
Sample on large mixer while worker cut and added rubber to large mixer	10	400

a. Rubber added to large mixer from work platform--rubber was cut up on cement house floor.

VENTILATION DATA

Ventilation measurements were not made on the make up air system because it was not operating. The ventilation measurements are summarized in Table 10-4 and shown in Figure 10-5 in Appendix IV. Design airflow parameters are presented where possible.

Table 10-4. Cement house ventilation data.

Measurement	Quantity Measured	Design
<u>General Exhaust</u>		
Average Velocities:[a,b]		
E-1	630 fpm	960 fpm
E-2	480 fpm	960 fpm
E-3	595 fpm	960 fpm
E-4	570 fpm	960 fpm
E-5	405 fpm	880 fpm
E-6	475 fpm	880 fpm
E-7	405 fpm	880 fpm
Calculated flow:		
E-1	1225 cfm	1815 cfm
E-2	930 cfm	1815 cfm
E-3	1130 cfm	1815 cfm
E-4	1110 cfm	1815 cfm
E-5	605 cfm	1320 cfm
E-6	710 cfm	1320 cfm
E-7	605 cfm	1320 cfm
Total flow:	6315 cfm	11,220 cfm
<u>Make-up Air</u>		
Flow per each diffuser		
D-1 to D-4	Not measured	1650 cfm
D-5 to D-8	Not measured	900 cfm
Total flow		10,200 cfm

a. Duct velocity should be identical.
b. Corrected for instrument error.

EMISSION SOURCES OBSERVATIONS

The emissions sources in the cement house are the solvents used in the materials and dusts from powdered compounds. Specific sources noted were:

1. Evaporation of solvents in open containers, such as buckets.

2. Evaporation of solvents from leaks.

3. Evaporation of solvents through open doors on mixing tanks. The greatest evaporation seems to occur when materials are added to the tanks while they are mixing.

4. Evaporation of solvents from garbage in open trash cans.

5. Evaporation of solvents from spills.

6. Entrainment of solvents in air displaced by filling plummer and mixing tanks.

7. Evaporation of solvents from cement streams. This occurs when cement or other liquids are poured into containers.

WORK PRACTICES OBSERVATIONS

The generation of some solvent vapors into the cement house air appeared to be the direct results of how the worker performed his duties. Therefore, work practices did appear to affect solvent emissions. Some of the observed work practices which could generate solvent emissions or affect the worker's exposure were:

1. Mixing in open containers.

2. Pouring solvents into open containers.

3. Adding rubber to tanks in a manner which splashes cement out of the tanks.

4. Using open trash containers for solvents.

5. Not covering open buckets of solvent-based materials or residuals of solvent-based materials.

6. Not cleaning up spills and unusable items.

7. Cleaning hands with solvents.

8. Using loose fitting lids on tanks and drums.

Access to cement house was available to anyone. Several personnel besides the cement house worker entered the cement house. These extra individuals may unknowingly contribute to solvent emissions by not following procedures that control solvent emissions.

ENGINEERING CONTROL OBSERVATIONS

Smoke tube traces inside the cement house showed the general room air had little movement. Despite the doors being open at the time of the measurement. A combination of smoke tube traces and velocity measurements around some of the exhaust vents showed that velocities were only about 20 fpm three feet from the vent.

The design of the exhaust system was similar to that for a positive pressure ventilation system. This could cause unnecessary static pressure losses in the system. Also, from the drawings, the fan used in the system appears to be of the roof ventilation type. These fans suffer a large drop in airflow with increase in static pressure. The exhaust ventilation system was operating at only 56 percent of its design, possibly because of these design features.

The floors and lower walls of the cement house were a dark color. This coupled with low illumination made it difficult to see in some areas of the cement house. Spills of materials would be difficult to spot under such conditions.

The make up air system reportedly had been inoperative for an extended amount of time. The plant reported that this was because of a hard-to-get part. Lack of air movement in the cement house may have been due to the loss of this system.

To prevent solvents from leaking through cracks in lids on the large mixing tanks, the plant used C-clamps.

MONITORS OBSERVATION

No monitoring equipment for ventilation system performance or specific contaminants was noted.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

Solvents evaporate directly into the workers breathing zone when he fills tanks and adds ingredients to the tanks. Solvent vapors which evaporate from spills and leaks, or open tanks and containers can evaporate into the general room air and elevate the background concentrations, thus also increasing worker exposure. Based on observations, operations involving the filling or adding of ingredients to tanks are generally of short duration. However, the sample results show the resultant emissions to be a great deal higher than the background (area samples) concentrations. But over the full shift the effect of the short-term, high emission rate sources are minor, as shown by the worker's time-weighted-average samples not being significantly different than the area samples.

No conclusions can be drawn on the effectiveness of the cement house ventilation systems because the make up air system was not working and because of the large performance decrement in the exhaust ventilation system. However, the results of this study will be used as a comparison with other cement houses studied. The air sample results show a significant difference between the day and night shifts overall sample results. Although the exact reason for this is unknown, the difference may be from opening or closing the cement house doors. During the day when it was warm, the doors were left open. This could allow air to enter the cement house and dilute the solvent vapors. At night when it became cooler, the doors were shut. The opening and closing of the doors seems to correspond with the rise and fall in the sample results.

The greatest overall contributor to the solvent concentrations in the cement house appears to be the sources generated by work practices. These are such things as the open containers of solvent-base materials, housekeeping practices, and mixing in open containers.

COMPARISON TO EXISTING STANDARDS

In the portions of the tire plant studied, workers are exposed to air contaminants which are either particulates or vapors. In terms of occupational health standards, the particulates are either nuisance dusts or respirable nuisance dusts. If the dust passes through the 10 mm nylon cyclone[11], the dust is considered to be respirable.

During cementing operations, petroleum distillate evaporates into the air and becomes a vapor. The petroleum distillate is usually contaminated with benzene, toluene and other aromatic hydrocarbons. The American Conference of Governmental Industrial Hygienists (ACGIH) refers to this petroleum distillate as a rubber solvent.

The Occupational Safety and Health Administration (OSHA) standards and the National Institute for Occupational Safety and Health (NIOSH) and ACGIH have recommended limits for occupational exposure to the air contaminants found in this plant are:

8-Hour TWA concentrations (mg/m^3).

Air Contaminant	OSHA PEL[16]	NIOSH Recommended Standard[17]	ACGIH TLV[18]
Nuisance dust	15	--	10
Respirable nuisance dust	5	--	5
Petroleum distillates (naphtha) or Rubber solvent	2000	350	1600
Benzene	30	3	30*
Toluene	650	375	375
m-Xylene	424	434	434

*60 minute ceiling

With the exception of the petroleum distillate concentrations in the cement house, all particulate and vapor concentrations obtained in this study were below those specified in the above table. In the cement house, one area sample exceeded 2000 mg/m^3 for a 4-hour period. This could be due to a cement droplet landing in the sorbent. Short-term petroleum distillate results listed in Table 10-3 exceeded all of the petroleum distillate PEL for an 8-hour sampling period. In Table 10-3, the sampling periods were less than 30 minutes. Although this is not a violation of the OSHA standards, an appropriate respirator should be worn when doing the operations listed in Table 10-3.

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APPENDIX I

DESCRIPTION OF OCCUPATIONAL TITLE GROUPS IN TIRE AND TUBE MANUFACTURING[10]

Occupational Title Group	Description of Process
Compounding	Batch lots of rubber stock ingredients are weighed and prepared for subsequent mixing in Banburys; solvents and cements are prepared for process use.
Banbury Mixing	Raw ingredients (rubber, filler, extender oils, accelerators, antioxidants) are mixed together in a Banbury mixer. This internal mixer breaks down rubber for thorough and uniform dispersion of the other ingredients.
Milling	The batches from the Banbury are further mixed on a mill, cooled, and the sheets or slabs coated with talc so they are not tacky. The stock may return to the Banbury for additional ingredients, or go on to breakdown or feed mills prior to extrusion or calendering.
Extrusion	The softened rubber is forced through a die forming a long, continuous strip in the shape of tread or tube stock. This strip is cut in appropriate lengths, and the cut ends are cemented so as to be tacky.
Calendering	The softened rubber from the feed mill is applied to fabric forming continuous sheets of plystock by the calender (a mill with three or more vertical rolls and much greater accuracy and control of thickness).
Plystock Preparation	The plystock from the calender is cut and spliced to the correct size for tire building, and so the strands in the fabric have the proper orientation.
Bead Building	Parallel steel wire is insulated with rubber vulcanizable into a semi-hard condition and covered with a special rubberized fabric. The beads maintain the shape of the tire and hold it on the wheel rim in use.
Tire Building	The tire is built from several sheets of calendered plystock, treads and beads.
Curing Preparation	The assembled green or uncured tire is inspected, repaired, and coated with agents to keep it from sticking to the mold in vulcanization.
Tube Splicing	Assembly of tube stock; i.e., tube building
Curing	The green tire or tube is placed in a mold and vulcanized under heat and pressure.
Final Inspection and Repair	The cured tire is trimmed, inspected, and labeled; repairable tires or tubes which do not pass initial inspection are repaired.

APPENDIX II

AIR CONTAMINANT CONCENTRATION DATA

Table 1. Full shift particulate concentration.
Hopper/bin.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Hopper/bin hood manifold (Figure 2-6, location 1)				
4-14-80	2	437	656	0.17
4-15-80	1	358	537	0.27
4-15-80	2	434	651	0.45
4-16-80	1	448	672	0.36
4-16-80	2	439	659	0.37
4-17-80	1	429	644	0.19
4-17-80	2	445	668	0.17
4-18-80	1	445	668	0.15
Location: Worker (Figure 2-6, location 2)				
4-14-80	2	417	626	0.71
4-15-80	1	350	525	0.87
4-15-80	2	429	644	1.26
4-16-80	1	440	660	0.59
4-16-80	2	273	410	2.43
4-17-80	1	429	644	0.53
4-17-80	2	435	653	0.34
4-18-80	1	444	666	0.21
Location: Column F5-54 (Figure 2-6, location 4)				
4-14-80	2	438	657	0.14
4-15-80	1	400	600	0.17
4-15-80	2	436	654	0.14
4-16-80	1	450	675	0.06
4-16-80	2	450	675	0.12
4-17-80	1	428	642	0.07
4-17-80	2	446	669	0.05
4-18-80	1	443	665	0.08
Respirable Particulate				
Location: Worker				
4-14-80	2	418	627	0.23
4-15-80	1	350	525	0.23
4-15-80	2	429	644	0.27
4-16-80	1	440	660	0.18
4-16-80	2	273	510	0.35
4-17-80	1	429	644	0.19
4-17-80	2	435	653	0.05
4-18-80	1	442	663	0.08

Table 2. Full shift total particulate concentration.
Intermix: Mixer.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Charge door hood, left (Figure 4-1, location 5)				
4-14-80	2	447	671	0.18
4-15-80	1	253	380	0.17
4-15-80	2	410	615	0.15
4-16-80	1	210	315	0.18
4-16-80	2	455	683	0.30
4-17-80	1	450	675	0.18
4-17-80	2	428	642	0.17
4-18-80	1	445	668	0.27
Location: Charge door hood, right (Figure 4-1, location 6)				
4-14-80	2	444	666	0.14
4-15-80	1	250	375	0.25
4-15-80	2	410	615	0.18
4-16-80	1	225	338	0.18
4-16-80	2	455	683	0.21
4-17-80	1	450	675	0.60
4-17-80	2	428	642	0.25
4-18-80	1	445	668	0.53
Location: Column E5-54 (Figure 4-1, location 7)				
4-14-80	2	444	666	0.14
4-15-80	1	249	374	0.33
4-15-80	2	400	600	0.24
4-16-80	1	225	338	0.18
4-16-80	2	458	687	0.19
4-17-80	1	449	674	0.24
4-17-80	2	430	645	0.10
4-18-80	1	446	669	0.45
Location: Worker (Figure 4-1, location 8)				
4-14-80	2	443	665	0.14
4-15-80	1	184	276	0.12
4-15-80	2	406	609	0.18
4-16-80	1	195	293	0.12
4-16-80	2	455	683	0.13
4-17-80	1	449	674	0.03
4-17-80	2	424	636	0.11
4-18-80	1	445	668	0.01

Table 2 (cont'd)

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Respirable Particulate				
Location: Worker (Figure 4-1, location 9)				
4-14-80	2	443	665	0.08
4-15-80	1	184	276	0.12
4-15-80	2	406	609	0.09
4-16-80	1	195	293	0.12
4-16-80	2	455	683	0.13
4-17-80	1	449	674	0.08
4-17-80	2	424	636	0.01
4-18-80	1	445	668	0.03

Table 3. Full shift particulate concentration.
Mill line.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: T-mix (Figure 5-1, location 10)				
4-14-80	2	420	630	0.35
4-15-80	1	433	650	0.37
4-15-80	2	446	669	0.11
4-16-80	1	456	684	0.18
4-16-80	2	409	614	0.19
4-17-80	1	455	683	0.10
4-17-80	2	447	671	0.08
4-18-80	1	432	648	0.07
Location: Sheeter Mill, left side (Figure 5-1, location 11)				
4-14-80	2	448	672	0.39
4-15-80	1	464	696	0.26
4-15-80	2	431	647	0.25
4-16-80	1	456	684	0.17
4-16-80	2	469	704	0.03
4-17-80	1	440	660	0.41
4-17-80	2	446	669	0.14
4-18-80	1	427	641	0.14
Location: Desk (Figure 5-1, location 12)				
4-14-80	2	449	674	0.21
4-15-80	1	436	654	0.11
4-15-80	2	432	648	0.08
4-16-80	1	516	774	0.15
4-16-80	2	468	702	0.12
4-17-80	1	440	660	0.14
4-17-80	2	445	668	0.05
4-18-80	1	424	636	0.04
Location: Worker (Figure 5-1, Location 13)				
4-14-80	2	447	671	0.15
4-15-80	1	430	645	0.34
4-15-80	2	433	650	0.25
4-16-80	2	409	614	3.36
4-17-80	1	450	675	0.09
4-17-80	2	443	665	0.02
4-18-80	1	488	732	0.99

Table 3 (cont'd)

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Respirable Particulate				
Location: Worker (Figure 5-1, Location 14)				
4-14-80	2	417	709	0.12
4-15-80	1	430	731	0.06
4-15-80	2	433	736	0.17
4-16-80	1	516	877	0.07
4-16-80	2	409	695	0.09
4-17-80	1	444	755	0.03
4-17-80	2	443	753	0.05
4-18-80	1	488	830	0.06

Table 4. Full shift solvent concentrations.
Cement house.

Date	Shift	Sample Volume (L)	Pet. Dis. Conc. (mg/m^3)	Benzene Conc. (mg/m^3)	Tol. Conc. (mg/m^3)	Xylene Conc. (mg/m^3)
Location: Worker's desk (Figure 10-1, location 15)						
4-14-80	2	16	62.5	0.31	3.13	1.88
4-14-80	2	25	280.0	1.16	3.20	1.20
4-15-80	1	48	62.5	0.25	3.13	2.71
4-15-80	2	20	200.0	0.85	3.00	1.50
4-15-80	2	21	476.0	2.81	5.71	1.90
4-16-80	1	45	44.4	0.18	1.56	0.89
4-16-80	2	24	83.3	0.33	2.50	1.67
4-16-80	2	14	142.9	0.50	3.57	2.14
4-17-80	1	26	76.9	0.15	2.31	1.15
4-17-80	1	21	14.3	0.14	0.48	*
4-17-80	2	25	280.0	1.16	3.20	1.20
4-17-80	2	17	303.0	1.33	4.24	1.82
4-18-80	1	24	4.2	0.13	*	*
4-18-80	1	25	40.0	0.16	1.60	0.80
Location: Platform column (Figure 10-1, location 16)						
4-14-80	2	19	52.6	0.26	2.11	1.58
4-14-80	2	29	241.4	1.00	3.10	1.38
4-15-80	1	46	173.9	0.59	5.87	4.57
4-15-80	2	22	318.2	1.27	3.64	1.82
4-15-80	2	24	208.3	11.30	20.00	4.17
4-16-80	1	43	46.5	0.19	1.63	1.16
4-17-80	1	38	78.9	0.29	1.84	1.05
4-17-80	1	7	142.9	0.09	4.29	2.86
4-17-80	2	28	178.6	0.75	2.50	1.07
4-17-80	2	19	315.8	1.47	4.21	2.11
4-18-80	1	23	391.3	1.57	3.91	1.30
4-18-80	1	23	39.1	0.17	1.74	0.87
Location: Cowl mixer (Figure 10-1, location 17)						
4-14-80	2	17	58.8	0.29	2.94	1.76
4-14-80	2	23	173.9	0.78	4.35	2.61
4-15-80	1	49	81.6	0.29	2.65	1.84
4-15-80	2	36	1111.1	5.00	15.00	6.39
4-16-80	2	19	157.9	0.68	5.79	3.68
4-16-80	2	9	666.7	2.67	15.60	8.89
4-17-80	1	25	400.0	1.60	8.40	4.00
4-17-80	2	11	81.8	0.36	3.64	1.87
4-17-80	2	2	200.0	2.00	5.00	5.00
4-18-80	1	23	130.4	0.56	3.04	1.30
4-18-80	1	23	43.5	0.17	1.74	0.87

Table 4 (cont'd)

Date (mg/m^3)	Shift	Sample Volume (L)	Pet. Dis. Conc. (mg/m^3)	Benzene Conc. (mg/m^3)	Tol. Conc. (mg/m^3)	Xylene Conc.
Location: Cement Worker (Figure 10-1, Location 18)						
4-14-80	2	19	157.9	0.74	6.84	3.68
4-14-80	2	23	260.9	1.35	3.04	0.87
4-15-80	2	20	250.0	0.95	2.00	0.50
4-16-80	1	22	90.9	0.36	2.73	1.82
4-16-80	2	21	95.2	0.38	1.90	0.95
4-16-80	2	6	83.3	*	3.33	*
4-17-80	1	24	83.3	0.38	2.50	1.25
4-17-80	2	27	222.2	1.00	2.22	0.74
4-18-80	1	14	714.3	4.07	7.14	2.14

*Below detection limit.
Samples on same shift taken consecutively.

Table 5. Full shift solvent concentrations.
Control: Treadline 2.

Date	Shift	Sample Volume (L)	Pet. Dis. Conc. (mg/m^3)	Benzene Conc. (mg/m^3)	Tol. Conc. (mg/m^3)	Xylene Conc. (mg/m^3)
Location: Worker (booker)						
4-21-80	1	33	27.3	0.18	1.82	1.52
4-22-80	1	32	31.3	0.13	1.25	1.88
4-22-80	1	12	75.0	0.25	4.17	3.33
4-22-80	2	31	64.5	0.23	2.58	2.58
4-22-80	2	16	62.5	0.31	5.00	5.00
4-23-80	1	32	62.5	0.34	2.50	2.19
4-23-80	1	15	53.3	0.80	2.67	2.67
4-23-80	2	24	41.7	0.46	2.08	1.67
4-23-80	2	21	47.6	0.48	2.86	2.86
4-24-80	1	26	38.5	0.27	2.31	1.92
4-24-80	1	19	10.5	0.16	0.52	0.53
4-24-80	2	20	50.0	0.20	2.50	2.00
4-24-80	2	23	42.9	0.30	2.61	2.17
Location: End tread cementer						
4-21-80	1	24	41.7	0.29	4.58	2.92
4-21-80	1	18	55.6	0.33	3.33	3.33
4-21-80	2	45	44.4	0.13	1.56	1.56
4-22-80	1	29	68.7	0.28	4.48	3.10
4-22-80	1	12	83.3	0.58	5.83	4.17
4-22-80	2	28	71.4	0.25	3.93	3.93
4-22-80	2	16	62.5	0.31	4.38	3.73
4-23-80	1	29	68.7	0.34	4.14	3.45
4-23-80	1	13	76.9	0.31	4.62	3.85
4-23-80	2	24	83.3	0.67	3.75	3.33
4-23-80	2	19	263.2	14.20	25.30	5.26
4-24-80	1	24	83.3	0.29	3.33	2.50
4-24-80	1	18	51.4	0.74	2.29	1.71
4-24-80	2	19	105.3	0.32	3.68	3.68
4-24-80	2	21	95.2	0.38	4.76	4.76
Location: Electrical box						
4-21-80	1	24	41.7	0.29	4.58	2.92
4-21-80	1	19	52.6	0.37	3.68	3.16
4-21-80	2	28	35.7	0.11	3.93	14.30
4-22-80	1	29	69.0	0.24	3.79	2.41
4-22-80	1	12	75.0	0.50	5.00	3.33
4-22-80	2	15	66.7	0.20	4.00	3.33

Table 5 (con'd)

Date	Shift	Sample Volume (L)	Pet. Dis. Conc. (mg/m^3)	Benzene Conc. (mg/m^3)	Tol. Conc. (mg/m^3)	Xylene Conc. (mg/m^3)
4-23-80	1	29	70.2	0.35	3.51	3.16
4-23-80	1	24	71.4	0.29	3.57	2.86
4-23-80	2	3	33.3	*	3.33	3.33
4-23-80	2	4	100.0	0.75	5.00	2.50
4-24-80	1	25	40.0	0.28	2.80	2.00
4-24-80	1	17	29.4	0.18	1.18	0.59
4-24-80	2	11	85.7	0.29	3.81	3.81
4-24-80	2	11	100.0	3.00	10.00	10.00

* Below detection limit.
Samples on same shift taken consecutively.

Table 6. Full shift total particulate concentration. Calender.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Warm-up mill (Figure 7-1, location 19)				
4-21-80	1	442	663	0.06
4-22-80	1	428	642	0.19
4-23-80	1	438	657	0.08
4-24-80	1	430	645	0.11
Location: Control Panel (Figure 7-1, location 20)				
4-21-80	1	441	662	0.09
4-22-80	1	426	639	0.13
4-23-80	1	440	660	0.04
4-24-80	1	430	645	0.10
Location: Calender, lower area (Figure 7-1, location 21)				
4-21-80	1	439	659	0.14
4-22-80	1	425	638	0.10
4-23-80	1	440	660	0.07
4-24-80	1	430	645	0.18
Location: Worker (Figure 7-1, location 22)				
4-21-80	1	225	348	0.10
4-22-80	1	416	624	0.13
4-23-80	1	423	635	0.05
4-24-80	1	360	540	0.12
Respirable Particulate				
Location: Worker (Figure 7-1, location 23)				
4-21-80	1	225	348	0.13
4-22-80	1	416	624	0.13
4-24-80	1	360	540	0.08

Table 7. Full shift total particulate concentration.
Curing Press Rows.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Column D (Figure 8-4, location 27)				
4-21-80	1	422	633	0.03
4-21-80	2	440	660	0.07
4-22-80	1	426	539	0.10
4-22-80	2	397	596	0.12
4-23-80	1	465	698	0.05
4-23-80	2	431	647	0.10
4-24-80	1	440	660	0.10
4-24-80	2	423	635	0.07
Location: Row B, Press R9, front (Figure 8-4, location 28)				
4-21-80	1	421	632	0.05
4-21-80	2	440	660	0.07
4-22-80	1	429	644	0.11
4-22-80	2	398	597	0.12
4-23-80	1	465	698	0.05
4-23-80	2	431	647	0.06
4-24-80	1	440	660	0.11
4-24-80	2	429	644	0.05
Location: Row B, Press R9, back (Figure 8-4, location 29)				
4-21-80	1	421	632	0.13
4-21-80	1	441	662	0.08
4-22-80	1	429	644	0.10
4-22-80	2	398	597	0.16
4-23-80	1	465	698	0.06
4-23-80	2	429	644	0.12
4-24-80	1	437	655	0.16
4-24-80	2	429	644	0.02
Location: Press L9, front (Figure 8-4, location 30)				
4-21-80	1	420	640	0.07
4-21-80	2	439	659	0.10
4-22-80	1	438	657	0.14
4-22-80	2	398	597	0.11
4-23-80	1	465	698	0.06
4-23-80	2	418	627	0.09
4-24-80	1	436	654	0.14
4-24-80	2	423	635	0.06

Table 7 (cont'd)

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Location: Row B, worker (Figure 8-4, location 31)				
4-21-80	1	380	570	0.18
4-21-80	2	423	635	0.27
4-22-80	1	403	605	0.25
4-22-80	2	396	594	0.19
4-23-80	1	405	608	0.24
4-23-80	2	396	594	0.31
4-24-80	1	435	653	0.24
4-24-80	2	413	620	0.12
Location: Column E (Figure 8-4, location 33)				
4-21-80	1	407	611	0.09
4-21-80	2	434	651	0.08
4-22-80	1	440	660	0.13
4-22-80	2	407	611	0.10
4-23-80	1	459	689	0.09
4-23-80	2	408	612	0.18
4-24-80	1	434	651	0.21
4-24-80	2	422	633	0.08
Location: Row A, Press R9, front (Figure 8-4, location 34)				
4-21-80	1	423	635	0.11
4-21-80	2	434	651	0.17
4-22-80	1	436	654	0.16
4-22-80	2	405	608	0.09
4-23-80	1	466	699	0.08
4-23-80	2	410	615	0.09
4-24-80	1	430	645	0.14
4-24-80	2	418	625	0.09
Location: Row A, Press R9, back (Figure 8-4, location 35)				
4-21-80	1	426	639	0.24
4-21-80	2	432	648	0.22
4-22-80	1	449	674	0.20
4-22-80	2	405	608	0.11
4-23-80	1	470	705	0.11
4-23-80	2	450	675	0.23
4-24-80	1	430	645	0.14
4-24-80	2	442	663	0.09

Table 7 (cont'd)

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Location: Row A, Press L9, back (Figure 8-4, location 36)				
4-21-80	1	440	660	0.15
4-21-80	2	440	660	0.17
4-22-80	1	450	675	0.17
4-22-80	2	409	614	0.12
4-23-80	1	470	705	0.13
4-23-80	2	438	657	0.13
4-24-80	1	430	645	0.20
4-24-80	2	438	657	0.10
Location: Column F (Figure 8-4, location 37)				
4-21-80	1	420	630	0.18
4-21-80	2	440	660	0.20
4-22-80	1	450	675	0.17
4-22-80	2	409	614	0.12
4-23-80	1	467	701	0.11
4-23-80	2	413	620	0.11
4-24-80	1	430	645	0.08
4-24-80	2	440	660	0.09
Location: Row A, worker (Figure 8-4, location 38)				
4-21-80	1	403	605	0.33
4-21-80	2	445	668	0.34
4-22-80	1	417	626	0.23
4-22-80	2	401	602	0.26
4-23-80	1	410	615	0.19
4-23-80	2	407	611	0.18
4-24-80	1	429	644	0.23
4-24-80	2	397	596	0.13
Respirable Particulate				
Location: Row B, worker (Figure 8-4, location 32)				
4-21-80	1	380	646	0.13
4-21-80	2	423	719	0.18
4-22-80	1	403	685	0.19
4-22-80	2	396	673	0.04
4-23-80	1	405	689	0.12
4-23-80	2	396	673	0.17
4-24-80	1	435	740	0.11
4-24-80	2	413	707	0.08

Table 7 (con't)

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Location: Row A, worker (Figure 8-4, location 39)				
4-21-80	1	401	682	0.20
4-21-80	2	445	757	0.23
4-22-80	1	417	709	0.13
4-22-80	2	401	682	0.06
4-23-80	1	405	689	0.08
4-23-80	2	405	689	0.18
4-24-80	1	429	729	0.17
4-24-80	2	397	675	0.08

Table 8. Full shift total particulate concentration.
Tire repair table.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Location: Worker				
4-21-80	1	405	608	0.15
4-21-80	2	431	647	3.67*
4-22-80	1	415	623	0.25
4-22-80	2	399	599	0.11
4-23-80	1	375	563	0.12
4-23-80	2	428	642	0.41
4-24-80	1	425	638	0.15
4-24-80	2	403	605	0.18

*Not included in Table 9-1.

APPENDIX III

VENTILATION MEASUREMENT INSTRUMENTATION

Instrument	Controls
Dwyer inclined manometer w/pitot tube MN 400, Error ± 5% (Used for duct velocity)	All controls except curing press row and cement house ventilation
Kurz anemometer MN 441 SN 474-1 Error: + 4% 0- 300 fpm. +12% 0-1250 fpm. (Used for face velocity)	Intermix charge door hood
Kurz anemometer MN 441 SN 1396 Error: -6% 0-1250 fpm +1% 0-6000 fpm (Used for duct, face and capture velocities)	Curing room Repair table hood
TSI anemometer Gastec (Bendix) smoke tester kit w/$TiCl_4$ tubes (Used for smoke tube traces)	Hopper/bin All controls
MN 1650 SN 2144 Error: ± 2% F. S. (Used for duct entrance, face, and capture velocities)	Intermix charge door hood Cement house Repair table hood

APPENDIX IV

VENTILATION DATA

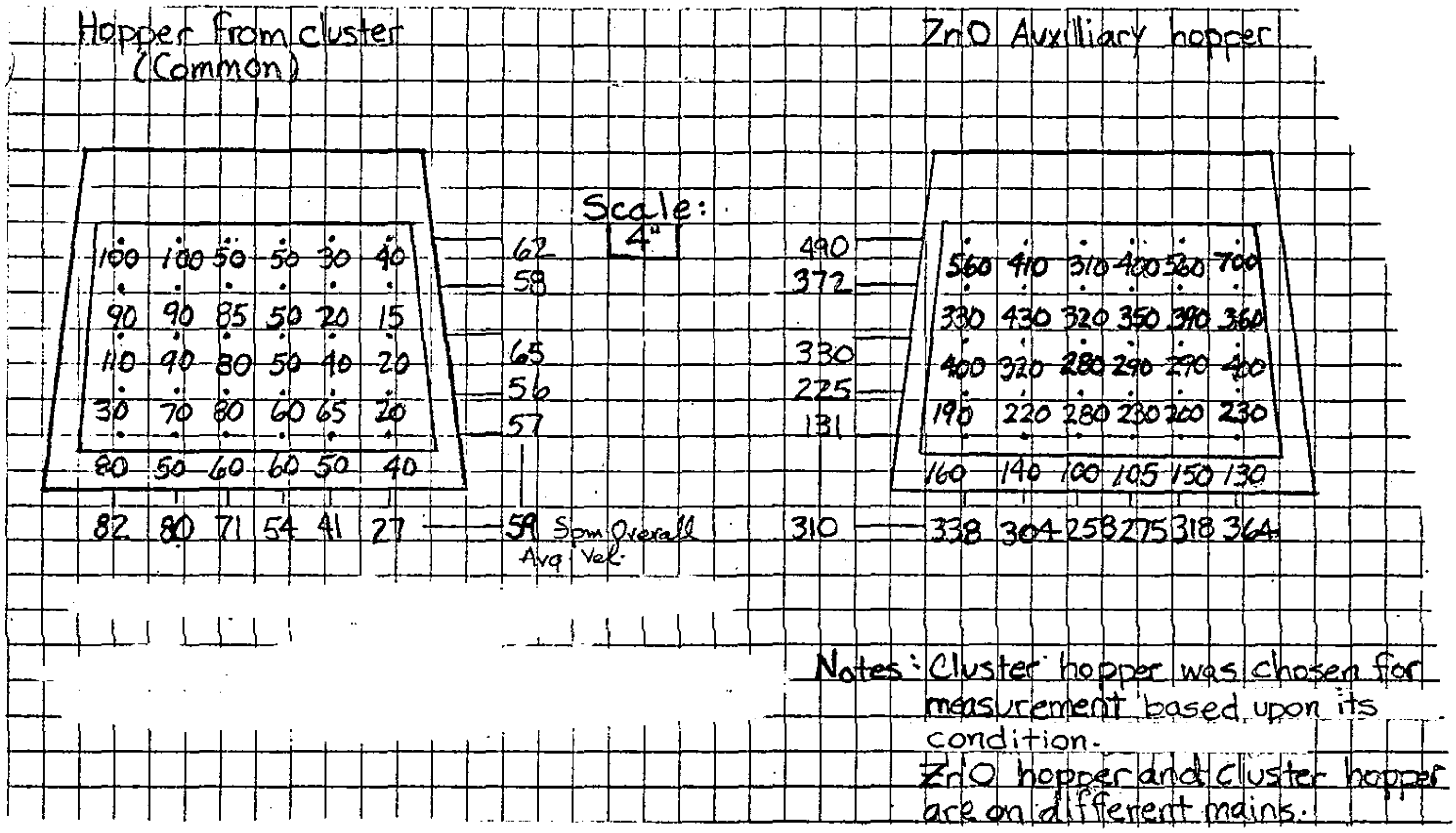

Figure 2-7. Hopper/bin hoods face velocities.

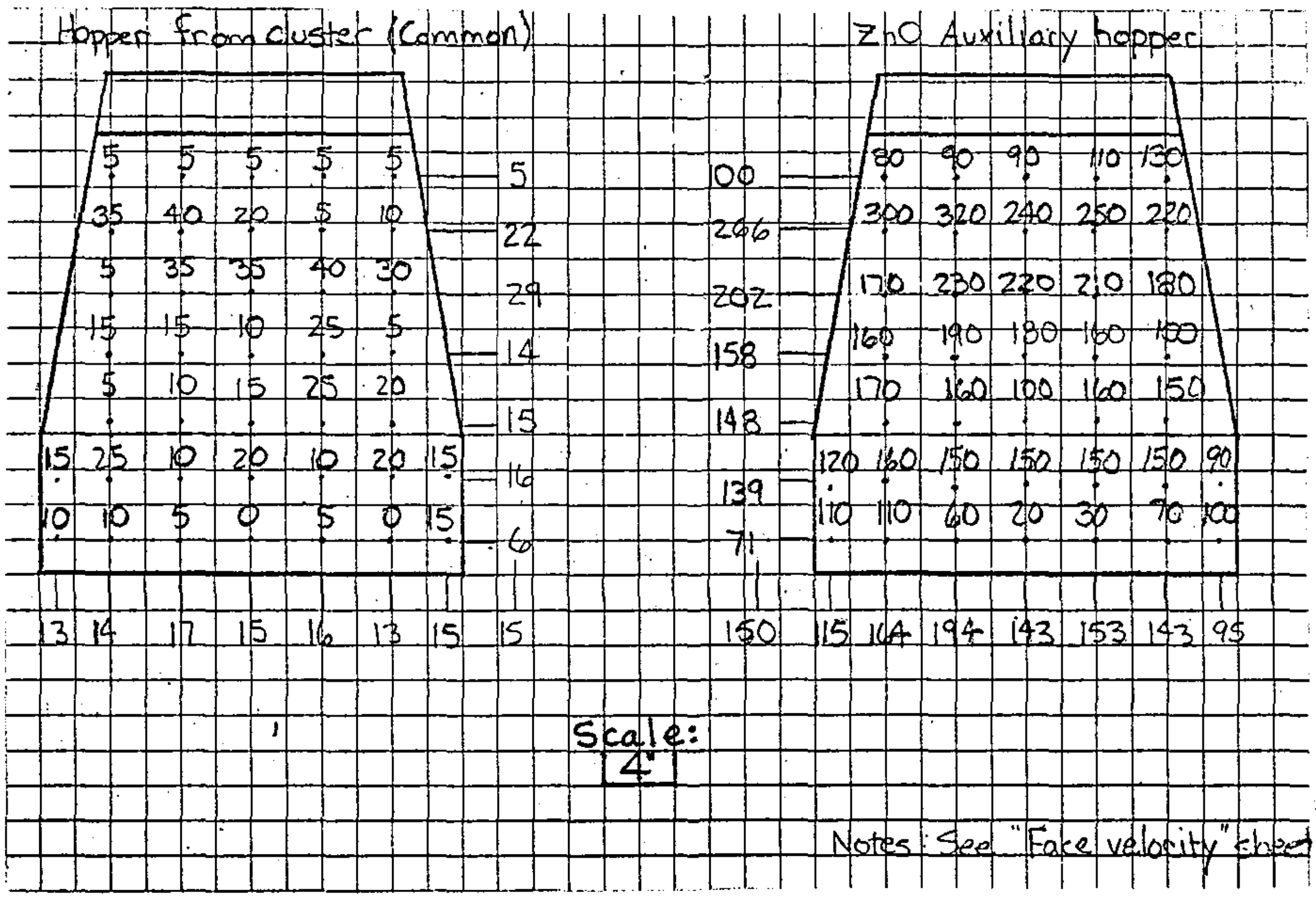

Figure 2-8. Hopper/bin hoods capture velocities.

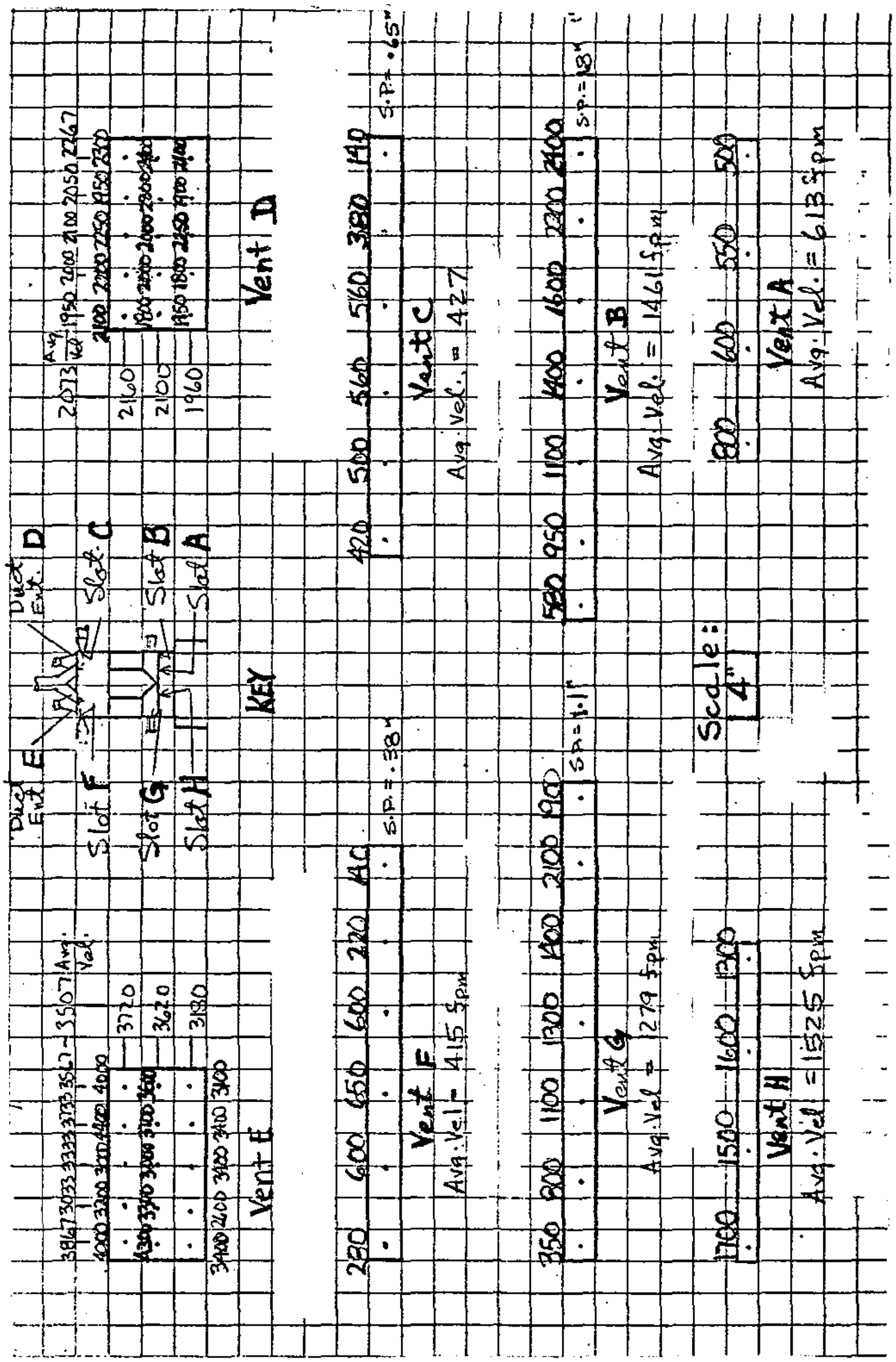

Figure 4-5. Mixer charge door hood slot velocities.

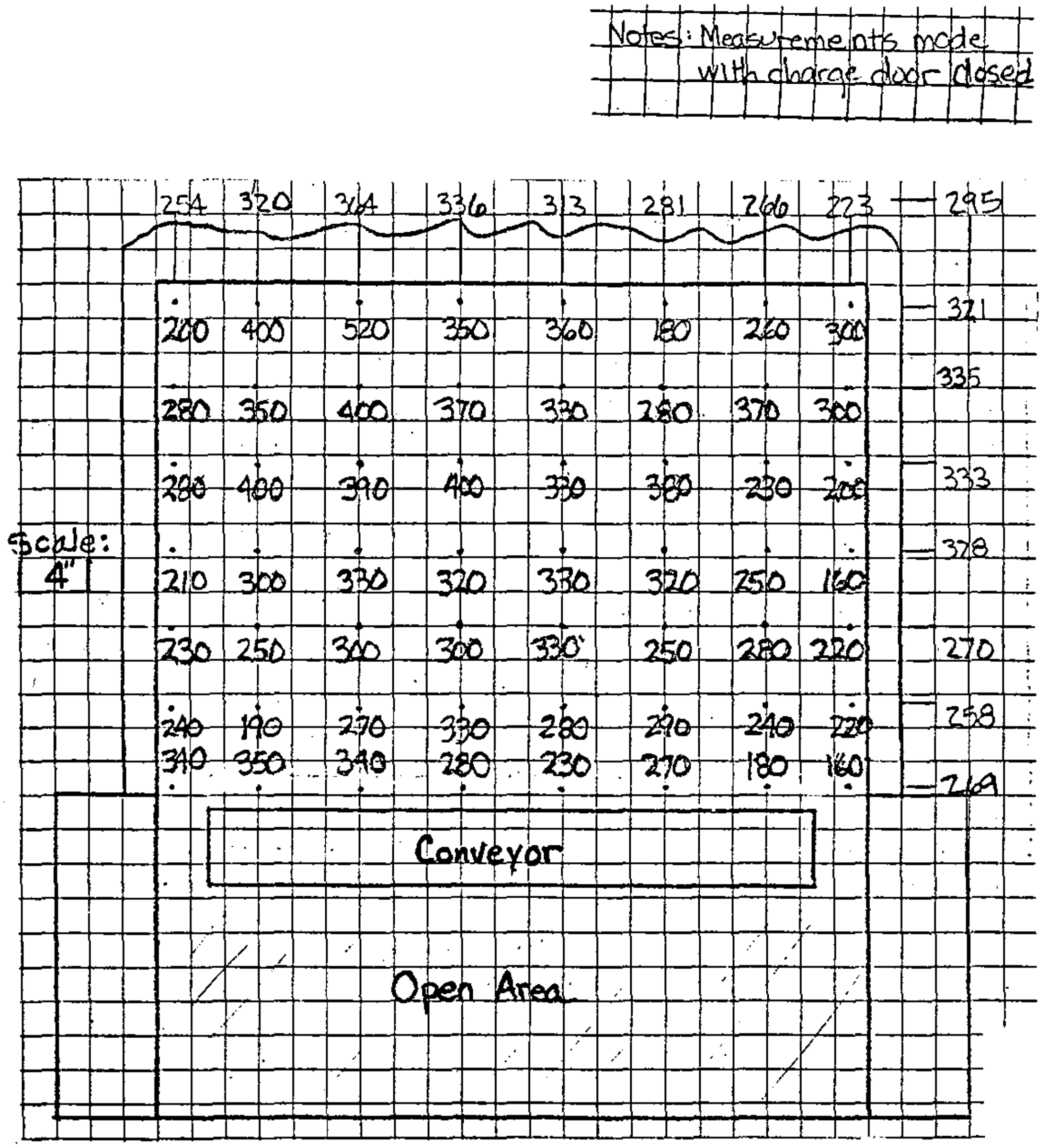

Figure 4-6. Mixer charge door hood face velocities.

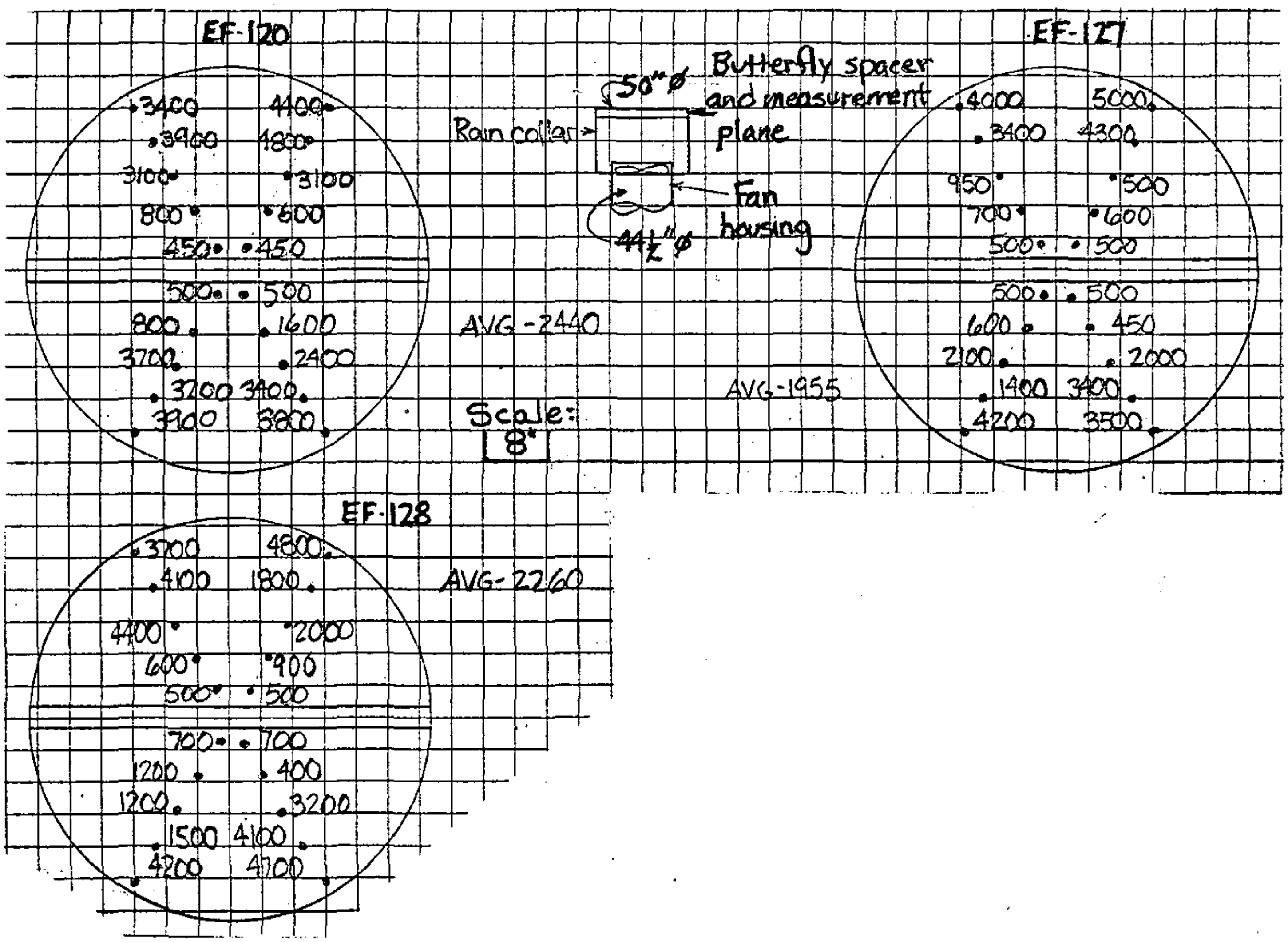

Figure 8-5. Curing press row A exhaust fan velocity measurements.

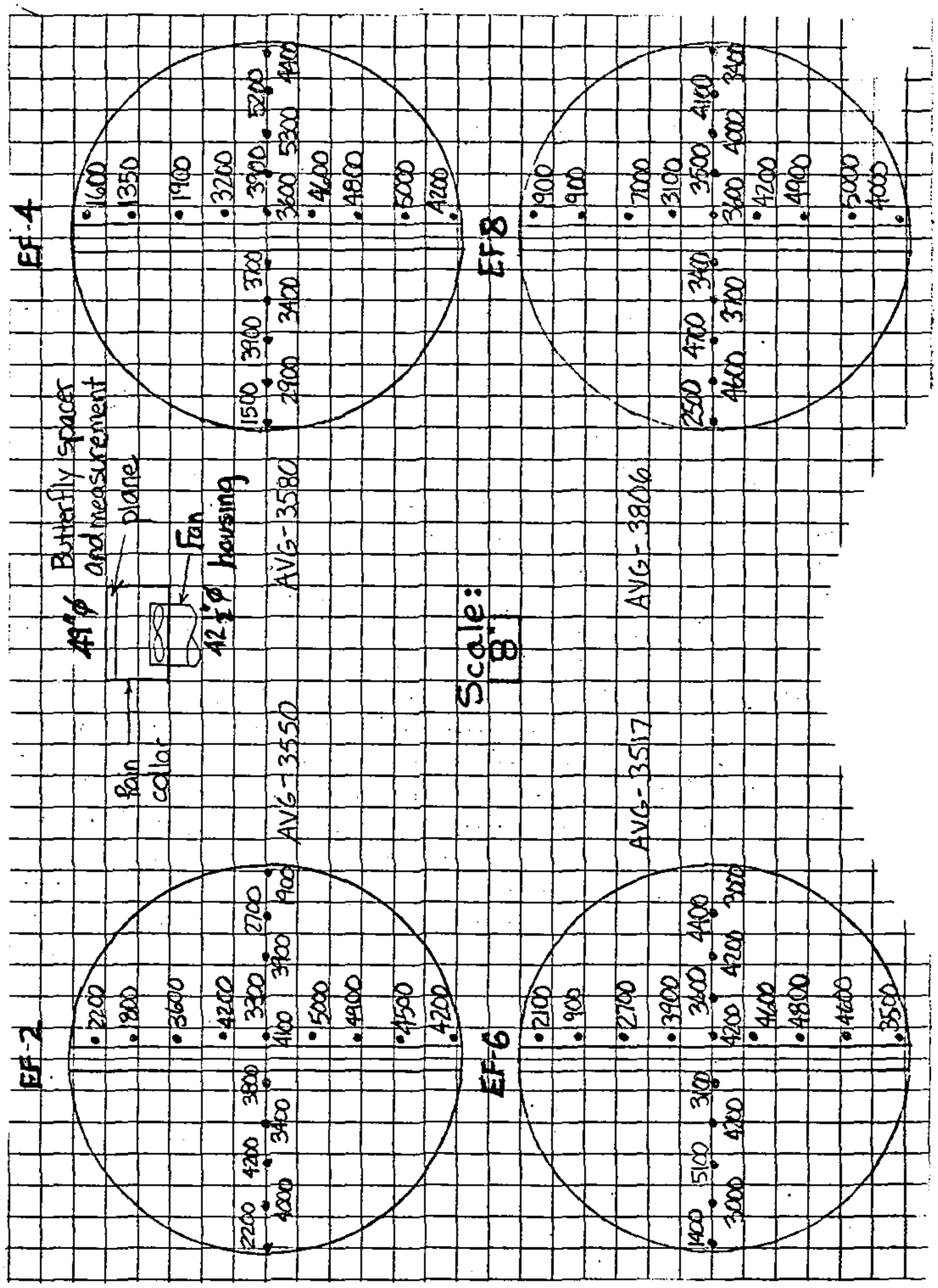

Figure 8-6. Curing press row B exhaust fan velocity measurements.

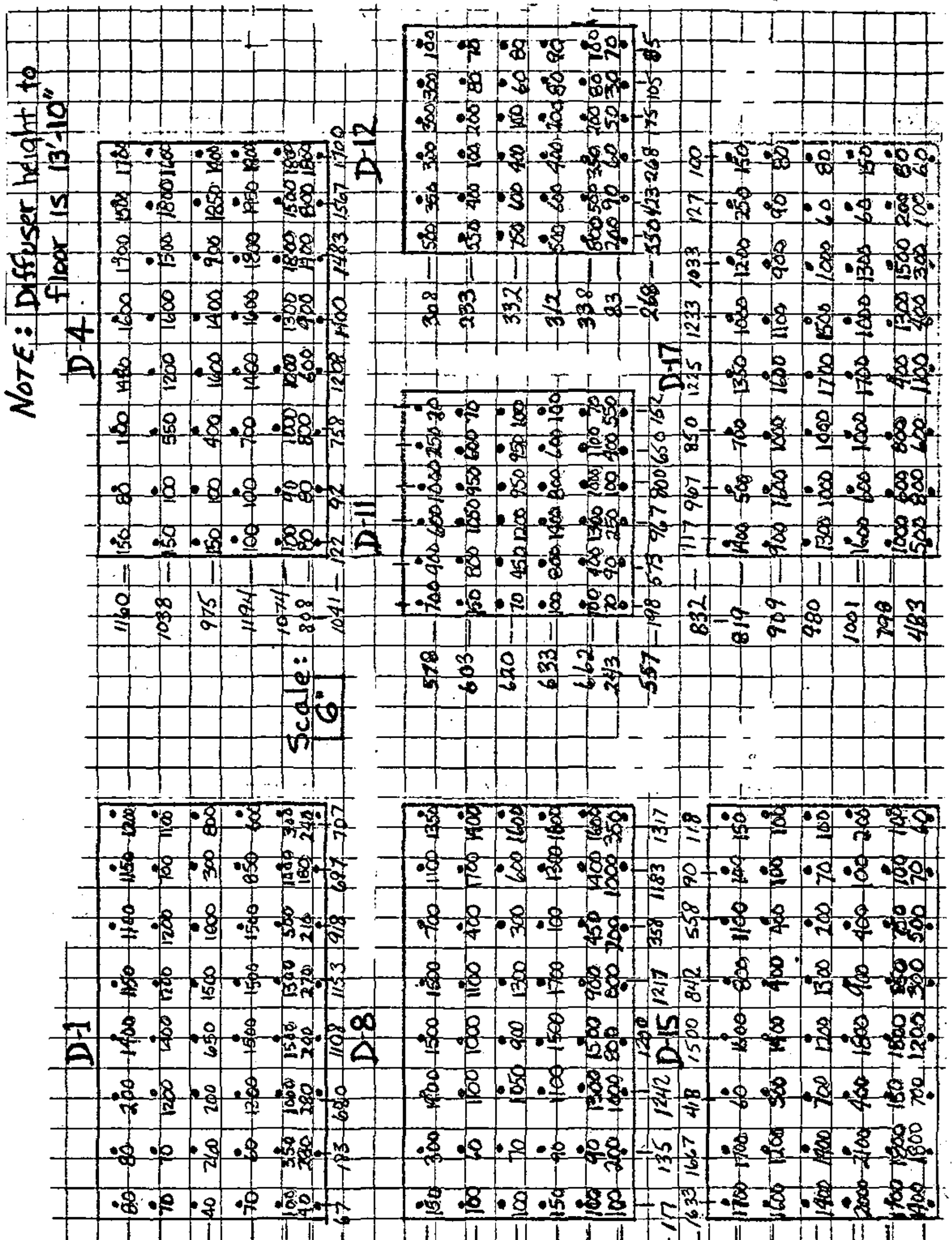

Figure 8-7. Curing press row B make up air diffuser velocity.

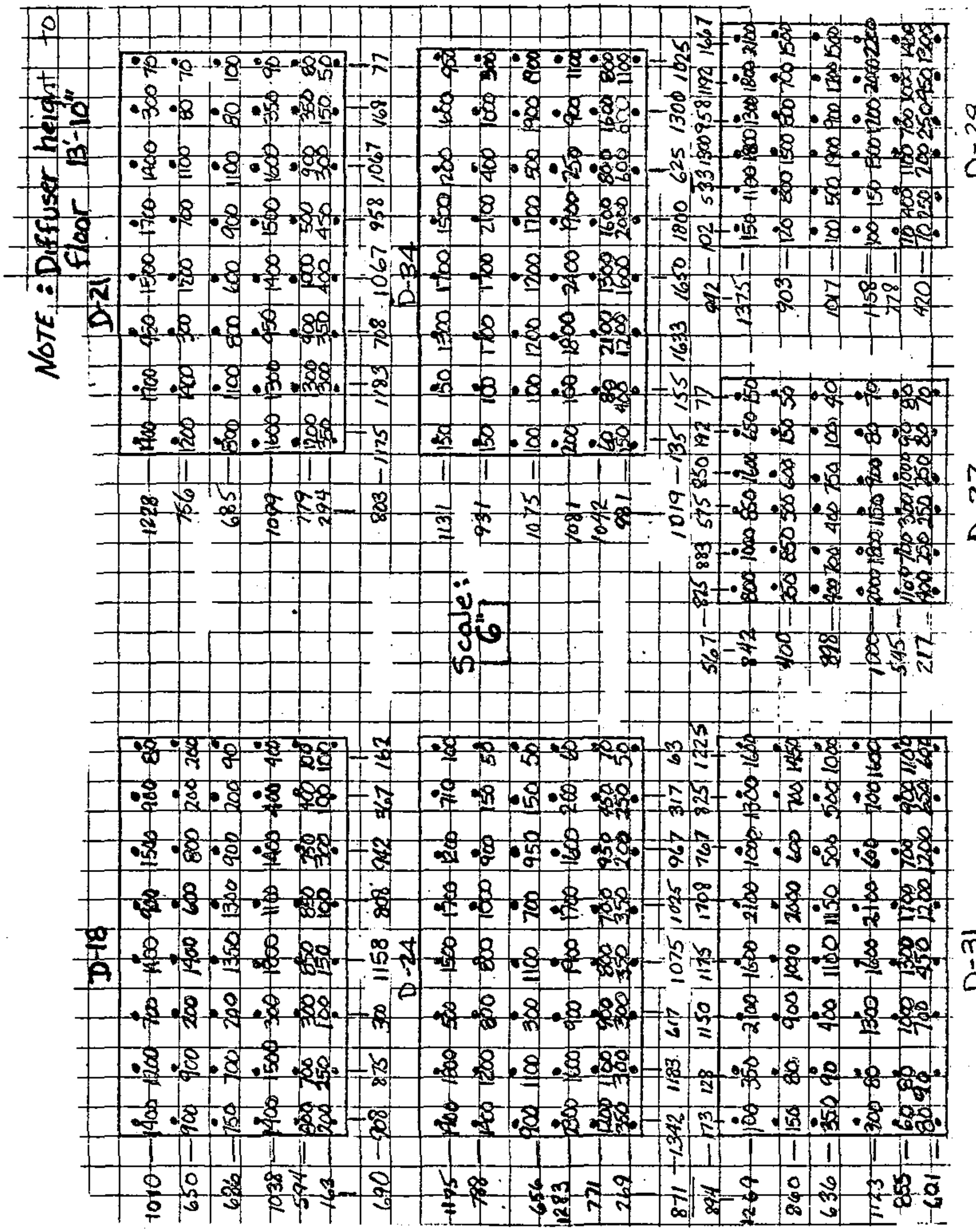

Figure 8-8. Curing press row B make up air diffuser velocity.

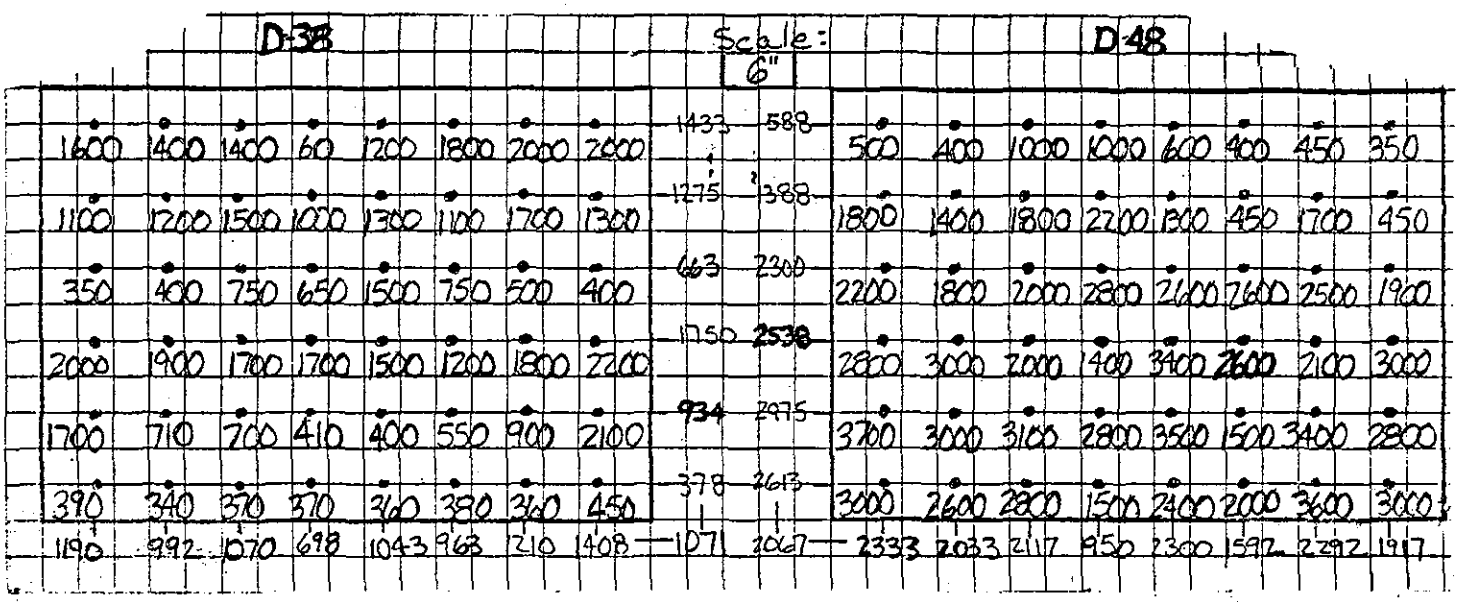

Figure 8-9. Curing press row B make-up air diffuser velocity.

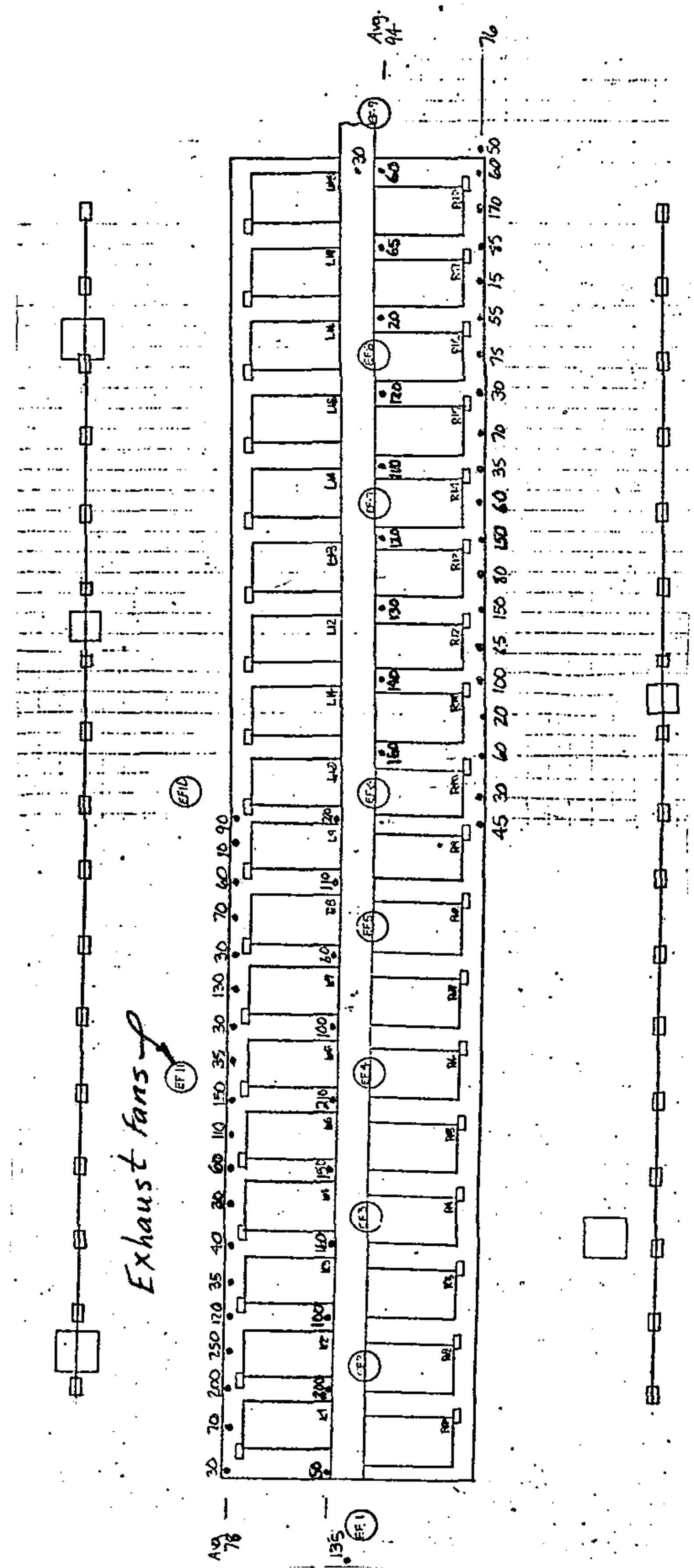

Figure 8-10. Curing press row B velocity measurements at 3 feet.

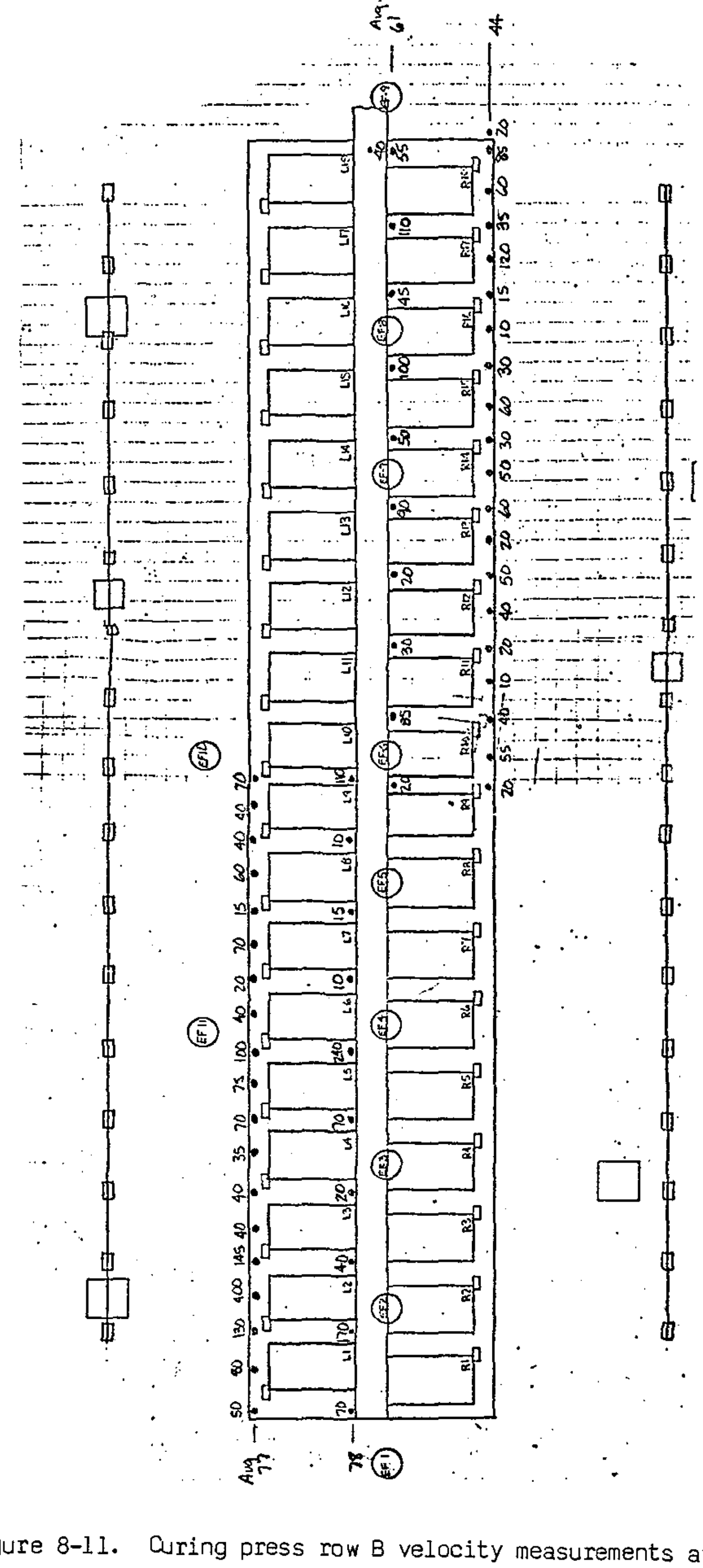

Figure 8-11. Curing press row B velocity measurements at 5 feet.

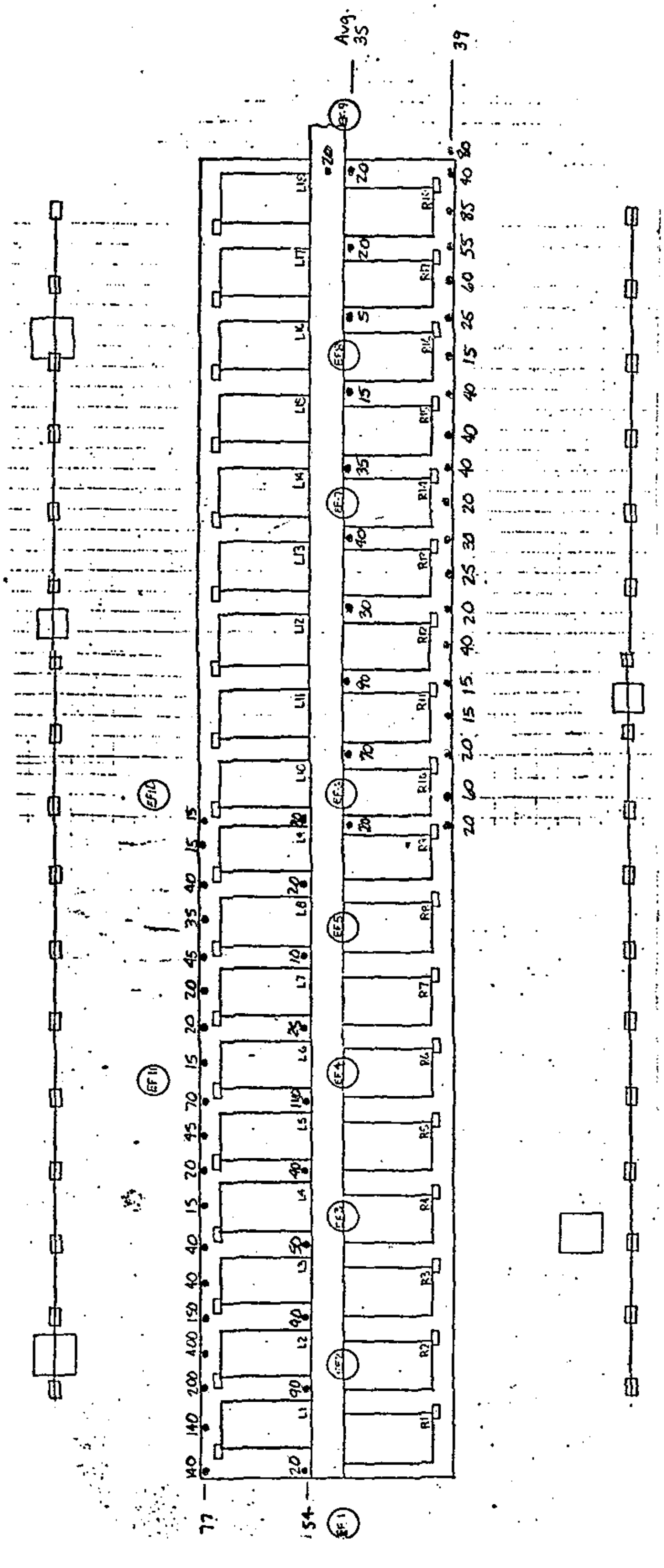

Figure 8-12. Curing press row B velocity measurements at 7 feet.

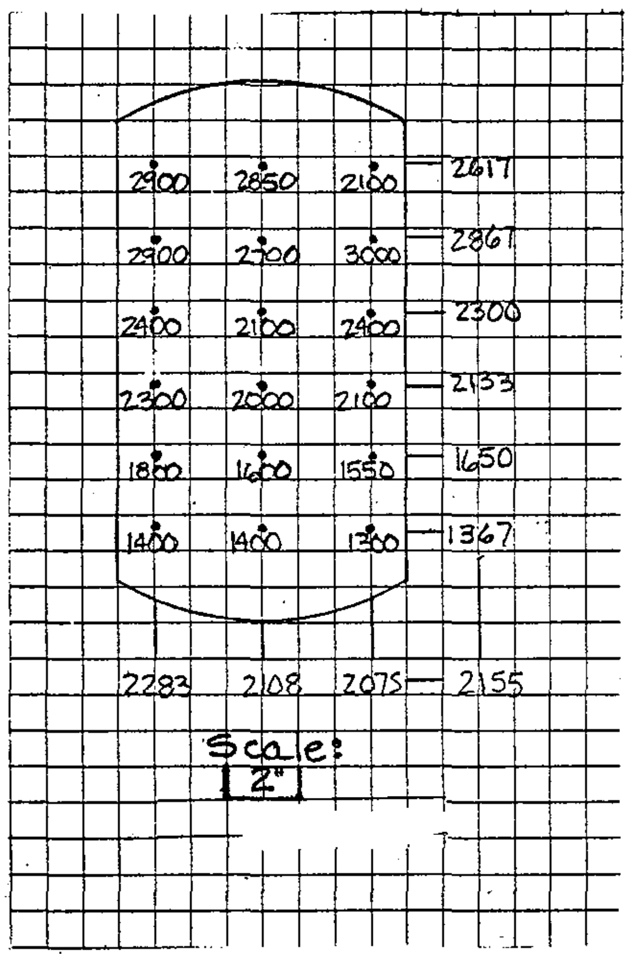

Figure 9-2. Tire repair table hood face velocities.

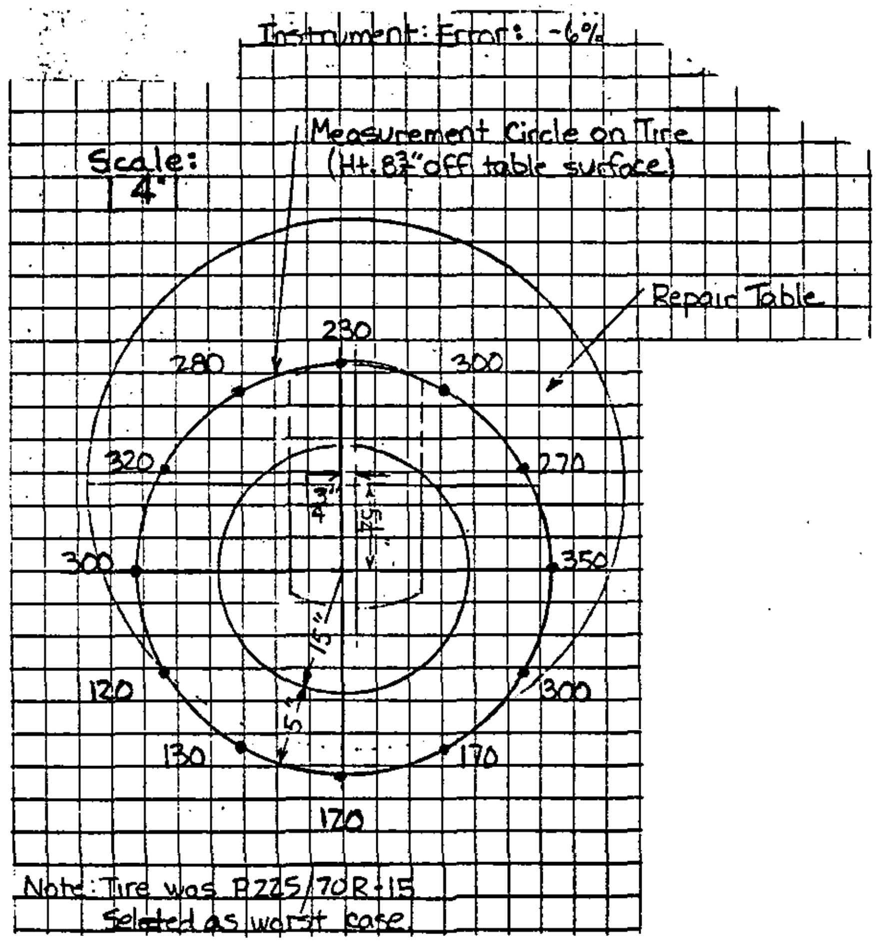

Figure 9-3. Tire repair table hood capture velocities.

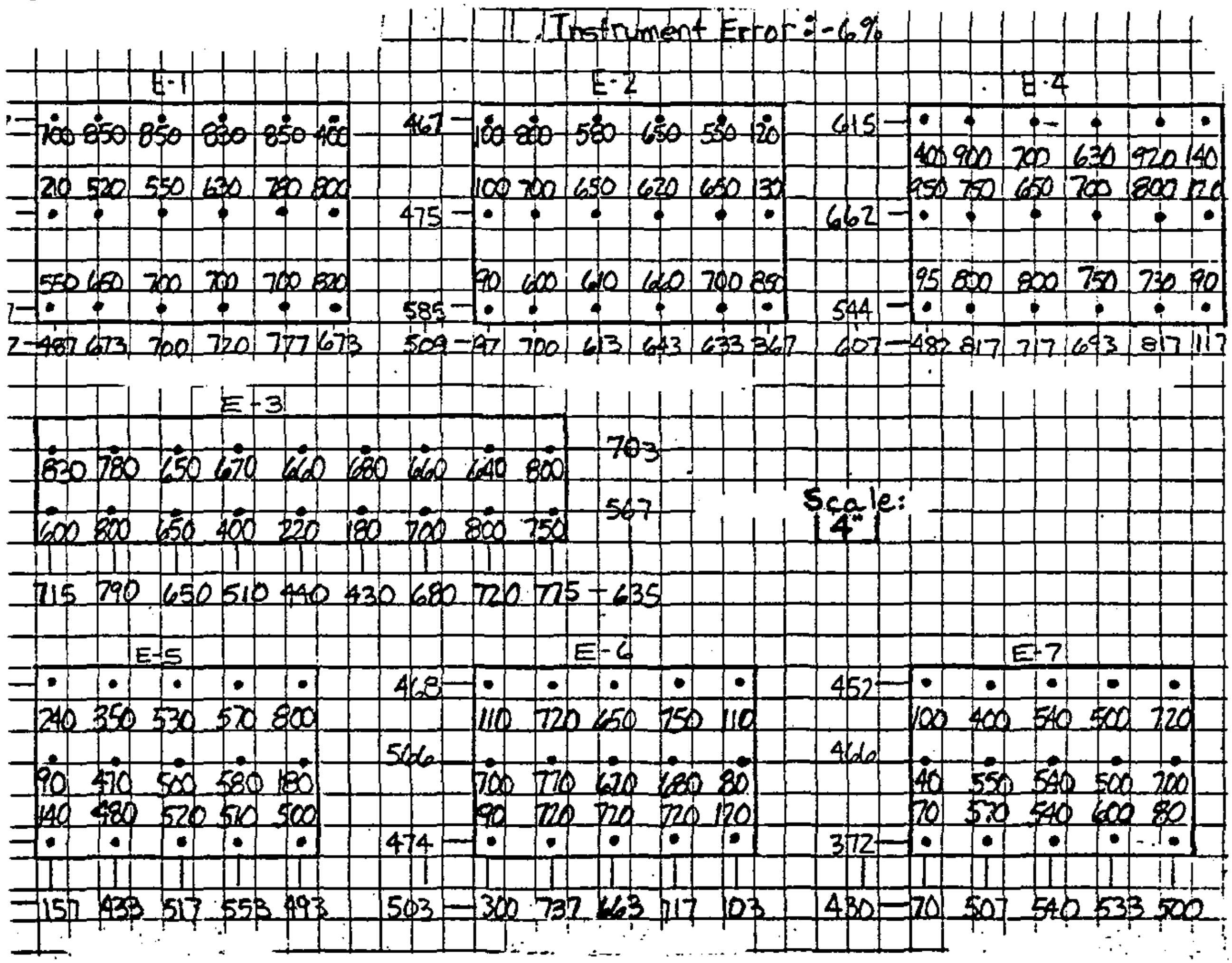

Figure 10-5. Cement house exhaust vent velocities.