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NIOSH CONTROL TECHNOLOGY ASSESSMENT
AT
GENERAL TIRE AND RUBBER COMPANY
CHARLOTTE, NORTH CAROLINA

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Date of Survey:
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This in-depth plant survey report documents air contaminant controls for selected operations at the General Tire and Rubber Company tire plant in Charlotte, North Carolina. This survey was conducted during the period November 26-30, 1979. The controls for the following unit operations were evaluated: vacuum cleaning, tilt stand charging, kaolin slurry mixing, drop mill, curing, and cement house.

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 is 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 the General Tire and Rubber Company tire plant in Charlotte, North Carolina. This survey was conducted during the period November 26-30, 1979. The controls for the following unit operations were evaluated: vacuum cleaning, tilt stand charging, kaolin slurry mixing, drop mill, curing, and cement house.

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 November 26-30, 1979, the National Institute for Occupational Safety and Health (NIOSH), conducted an evaluation of air contaminant controls for selected processes at General Tire and Rubber Rubber Company's tire plant in Charlotte, North Carolina. The following process/control systems were evaluated: vacuum cleaning system, a tilt stand charging system, a Banbury mixer, a mill, a kaolin slurry mixing tank, a row of tire curing presses, and a cement house.

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

GENERAL DESCRIPTION OF THE FACILITY

At the start of this study, the plant was operating normally. During the week production was slowed and then stopped to reduce inventory. Typically, this plant operates all three shifts and has the capacity of producing approximately 20,000 tires per day. It was built in 1967 and occupies approximately 1.5 million square feet of covered space. Because of the mild climate, the plant was open to the outside environment. The plant had three shifts, a day shift (8:00 a.m. to 4:00 p.m), evening shift (4:00 p.m. to 12:00 midnight), and a night shift (midnight to 8:00 a.m.).

A joint union-company safety committee.was also operating during the study.

OVERVIEW OF THE TIRE MANUFACTURING PROCESS

The tire manufacturing process involves several operations which are sources of worker exposures to a variety of air contaminants. The process is summarized in Figure 1. The occupational title groups developed by Williams[1] provide a standard description of tire manufacturing operations. These are listed in Appendix I. A classification called "precompounding" has been added to the classifications listed by Williams. 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 the rubber's elasticity by applying a shear-stress to the rubber. This results in friction, heat, and the generation of a fume.

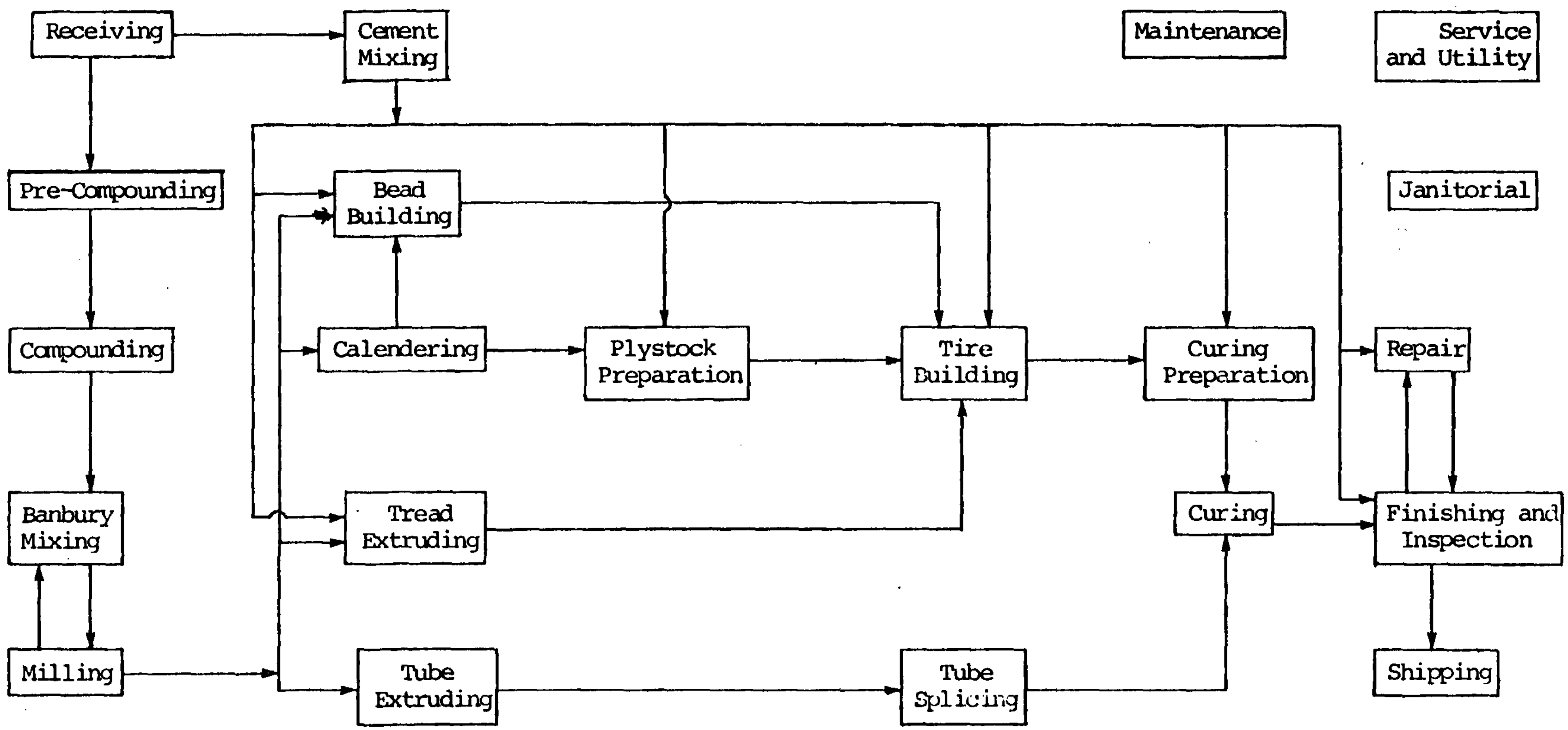


Figure 1. Production Stages in the Manufacture of Tires and Tubes.

A cement dissolved in a petroleum distillate is applied to the tread ends and the bottom. The workers near this operation and the workers in the cement house where the cement is made are exposed to petroleum distillate. This petroleum distillate is essentially a 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 and by making ventilation system measurements and process and work practices observations. Air samples and observations were made on one day and two night shifts. Samples were collected only while equipment was in operation. Sampling periods were frequently less than a full shift.

Air samples for total particulate and respirable particulate were collected in accordance with the NIOSH Sampling Data Sheet 29.02.[2] The sampling rates were 1.5 and 1.7 liters per minute (Lpm) for total and respirable particulate respectively. In the curing room, particulate samples were collected on a Gelman DM 800 filter. Because of a shortage of DM 800 filters, MSA-FWSB filters were also used to collect particulate air samples. These filters were corrected for a mean blank filter loss of 0.06 milligrams (mg) for DM 800 filters and a blank filter loss of 0.02 mg for the FWSB filters. In both cases the standard deviation of the mean weight loss was 0.02 mg. Unfortunately a large number of DM800 filters came from a lot which lost significant weight.

Data from these filters could not be used in the study. Air samples were collected with MSA model G pumps and DuPont P4000 pumps.

Air samples for petroleum distillate were collected on standard charcoal tubes and analyzed according to NIOSH method P&CAM 127.[3] 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 benzene, 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. 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).[4] 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[5] 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 results are presented in the form of case studies. These case studies will be used to prepare a final report.

VACUUM CLEANING SYSTEM (1)

AREA: PRECOMPOUNDING AND COMPOUNDING

(Dust Generation Areas)

DESCRIPTION

The vacuum cleaning system is used to clean up spills of powdered compounds from floors and structures. One or more outlets are located at each dust generation location, such as bag emptying operations. The system, upon which information was gathered, is set up to operate one or two vacuum lines at a time.

The piping of the system consists of 3-inch diameter piping for the main and 2-1/2-inch diameter branches. Cleanouts are spaced at regular convenient intervals along both the main and branches. A schematic of the system's typical outlet arrangement is shown in Figure 1-1.

Specifications for the system taken from company drawings are:

Vacuum Source:	Frame Model Number 4208A multistage centrifugal type fan with a 25 horsepower totally enclosed fan cooled motor; generates 406 standard cubic feet per minute at 11.5 inches Hg
Primary Collector:	Manufacturer: Hoffman Air Systems Type: cyclone Storage capacity: 53 cubic feet (ft^3) Dimensions: 36-inches diameter by 96 inches long Discharge: manual
Secondary Collector:	Manufacturer: Hoffman Air Systems Type: baghouse Dimensions: 36-inches diameter by 96 inches long Filter: bag type - polypropylene material

Discharge: auto shaker

Controls: Vacuum overload sensor and reset

Accessories: 25-foot lengths of 1-1/2-inches diameter Hoffman VF hose; miscellaneous tools recommended by Hoffman

Distributor: Weed Equipment Corporation
Cleveland, OH

WORKER'S DUTIES

The worker uses the hose to clean up compound spills immediately after they occur. The system is also used to clean up accumulated materials from ventilation system openings, and machinery and structural members.

AIR SAMPLING DATA

No measurements made.

VENTILATION DATA

No measurements made.

EMISSION SOURCES OBSERVATIONS

The source of the materials for which this system is used is the powdered compounds needed to make tires. The emission sources are any dust generating processes or operations, or leaks in seals of material handling systems. At this plant the outlets of the vacuum system were located in the carbon black charging and manual compounding areas.

WORK PRACTICES OBSERVATIONS

The hoses and accessories for the system were stored in cabinets on the walls. Consequently, workers had a tendency to use brooms on spills instead of the vacuum system.

ENGINEERING CONTROLS OBSERVATIONS

These are some suggested parameters for the vacuum system:

1. Outlets for the system should be located so hoses do not have to cross aisles. Reportedly, several hoses had been destroyed by forklifts

2. Outlets should be guarded so they are not susceptable to forklift or other inadvertent damage. Overhead piping was at least 10 feet above the floor to provide clearance for the forklifts.

3. The vacuum cleaning system should not be used to clean up wet spills. Moisture causes clogs in the pipes and collectors.

MONITORS OBSERVATIONS

A vacuum overload sensor was used on the system.

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

No personal protective equipment was specified for use with the system.

TILT STAND CHARGING SYSTEM (2)
AREA: PRECOMPOUNDING

DESCRIPTION

In this plant, Tote™ bins are used to handle carbon black. The Tote bins are commercially made, metal containers with approximate dimensions of 3-feet 6-inches wide by 3-feet 10-inches deep by 8-feet tall. Carbon black is placed in the bins through a port in the top and dispensed through a door located on the lower part of one of the 3-feet 6-inches wide faces. Totes are transported from the filling room to the dispensing stations by forklift

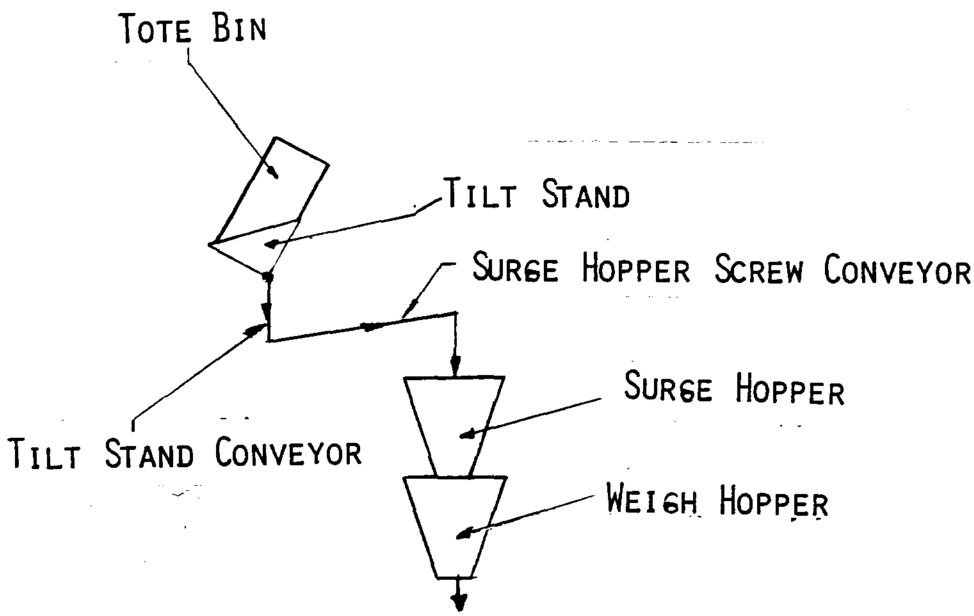
Dispensing of carbon black is facilitated by a tilt stand/conveyor system. The tilt stand angles the tote so that the bin's door opens and permits enclosed dispensing of carbon black into the tilt stand conveyor.

The tilt stand conveyor transports the carbon black to the surge hopper screw conveyor which, in turn, carries it to the surge hopper. The surge hopper dispenses into the weigh hopper. A schematic of the system is shown in Figure 2-1.

There are two tilt stand conveyors for each surge hopper conveyor and three surge hopper conveyors to one surge hopper. This set of systems as a whole comprise one dispensing station. Usually, each of the three surge hopper conveyors is fed one type of carbon black (thus, the two bins dispensing into that conveyor also carry the same type of carbon black).

In essence, the whole bin, tilt stand conveyor, and surge hopper conveyor system is like an ink cartridge pen - the bin is the cartridge, and the tilt stands, their conveyor and the surge hopper conveyor are the pen. Parts of the system are shown in Figures 2-2 and 2-3.

The ventilation on the tilt stand charging system consists of exhaust slots built into the sides of the tilt stands and a tapered canopy hood located over the inlet to the surge hopper. The former is shown in Figures 2-4 and 2-5, and the latter in Figure 2-6.



NOTES: One surge hopper at each station

Three surge hopper screw conveyors for each surge hopper.

Two tilt stands for each surge hopper screw conveyor.

Six Tote bins for each station.

Figure 2-1. Schematic of Tote™ bin carbon black handling system.

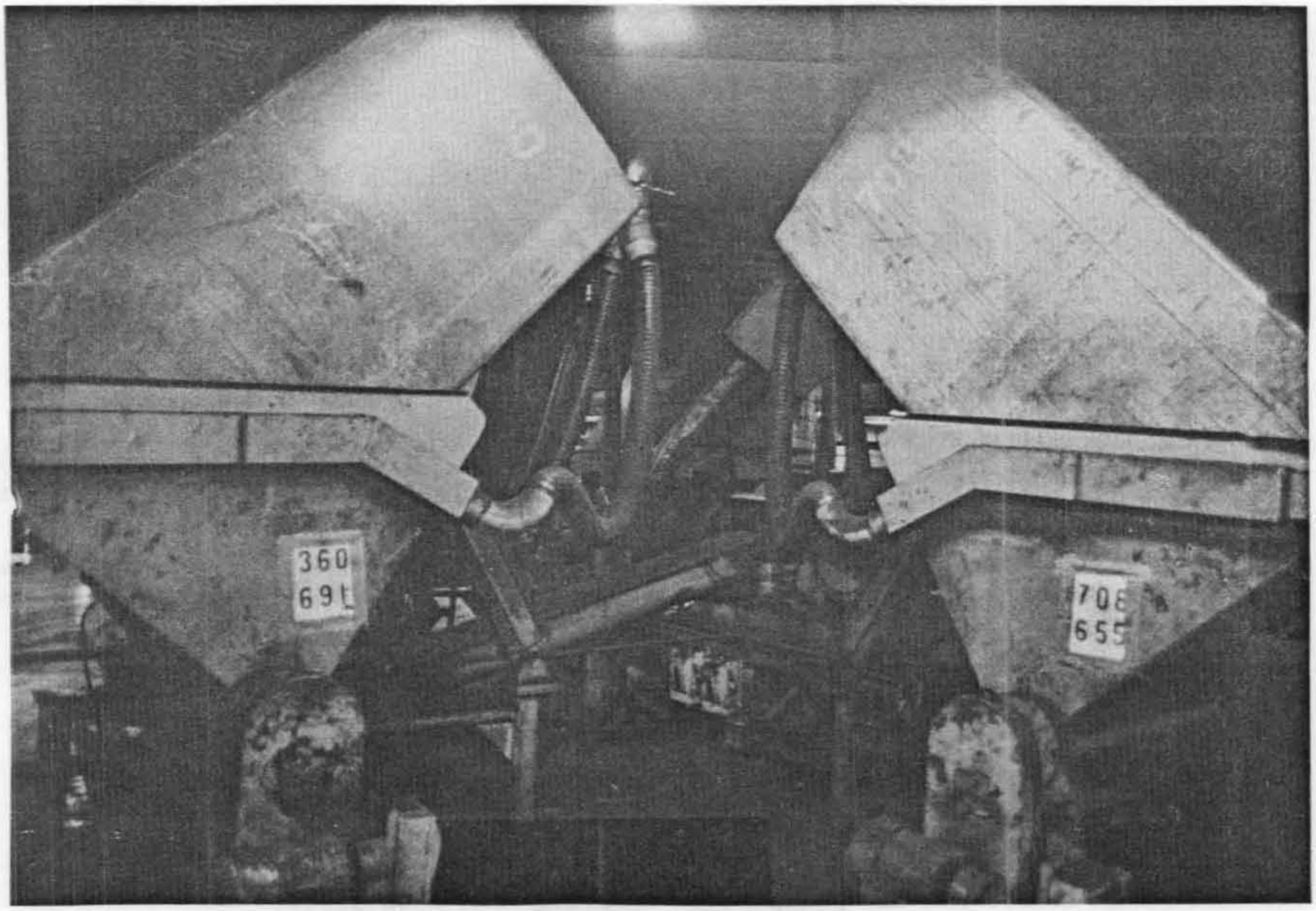


Figure 2-2. Carbon black charging station showing tilt stands, Tote™ bins, and conveying systems.

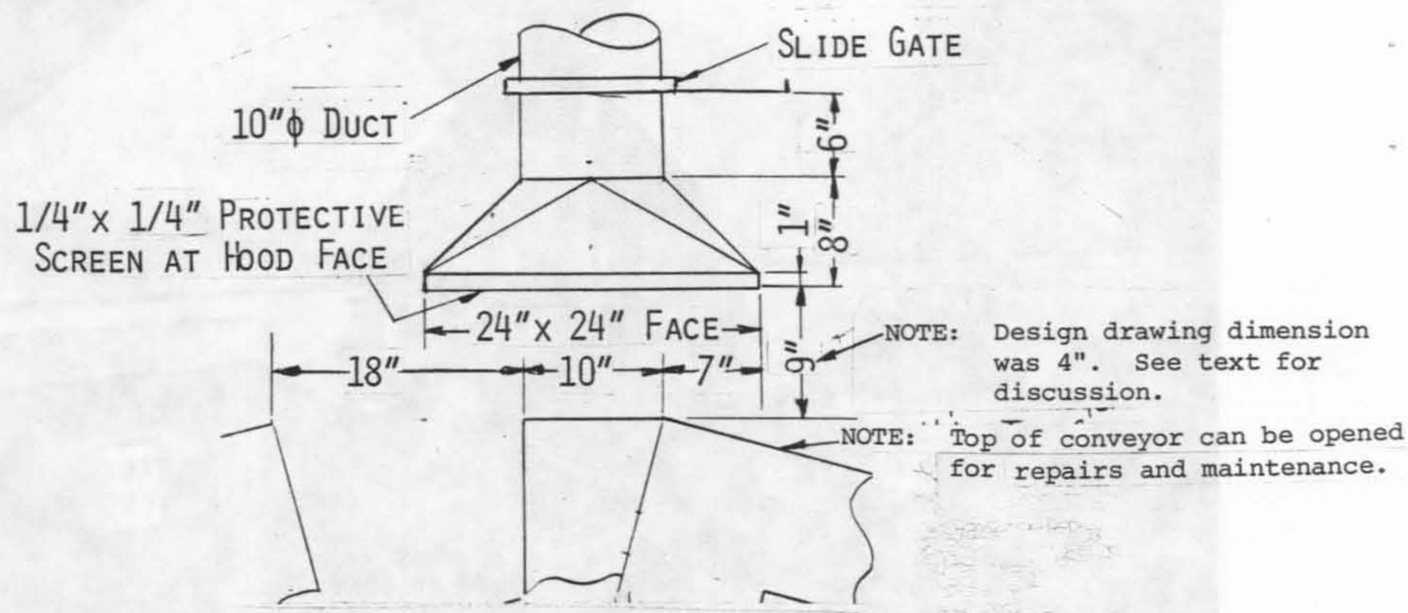


Figure 2-3. Surge hopper hood detail.

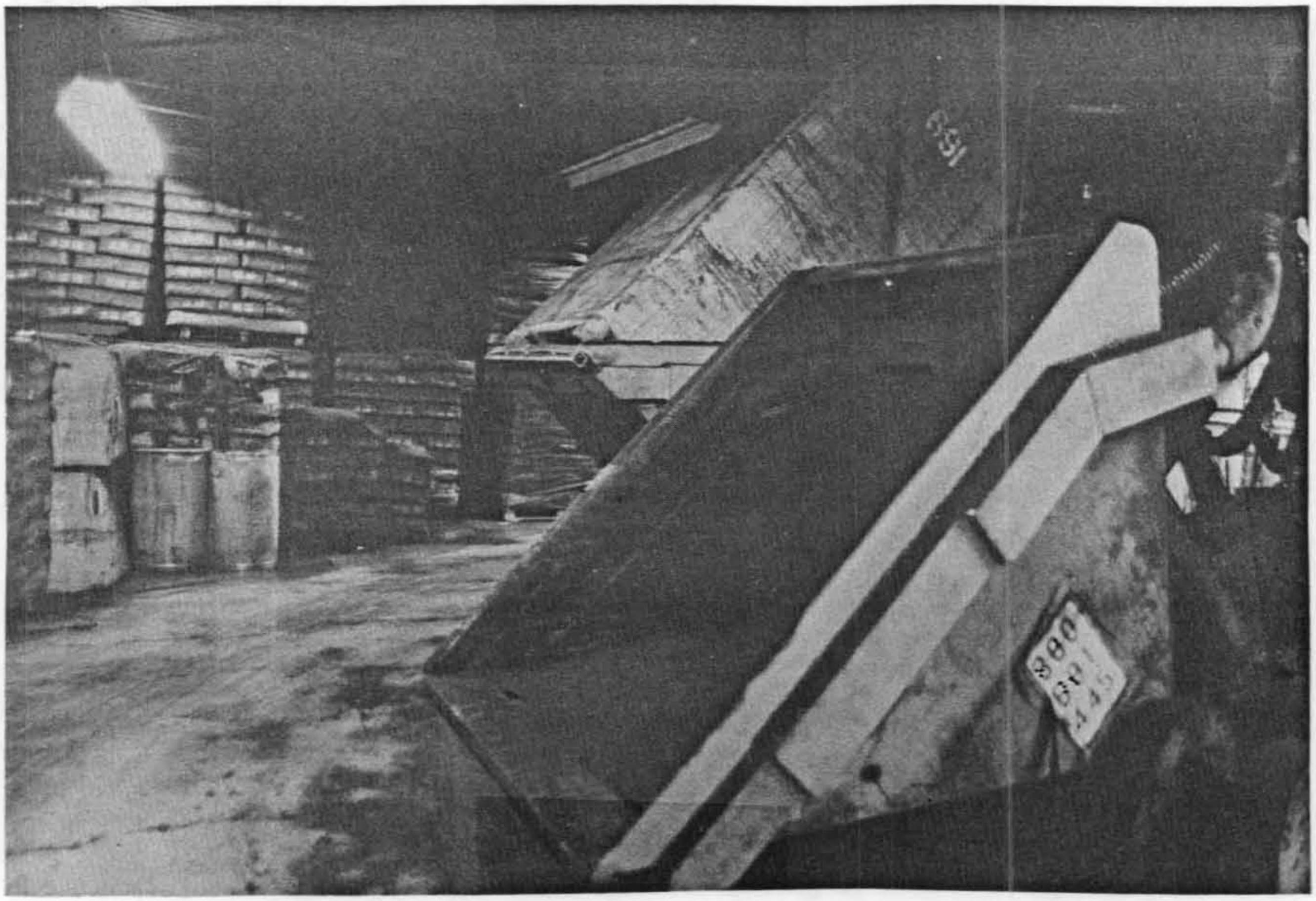


Figure 2-4. Tote^{TM} bin tilt stand and ventilation system.

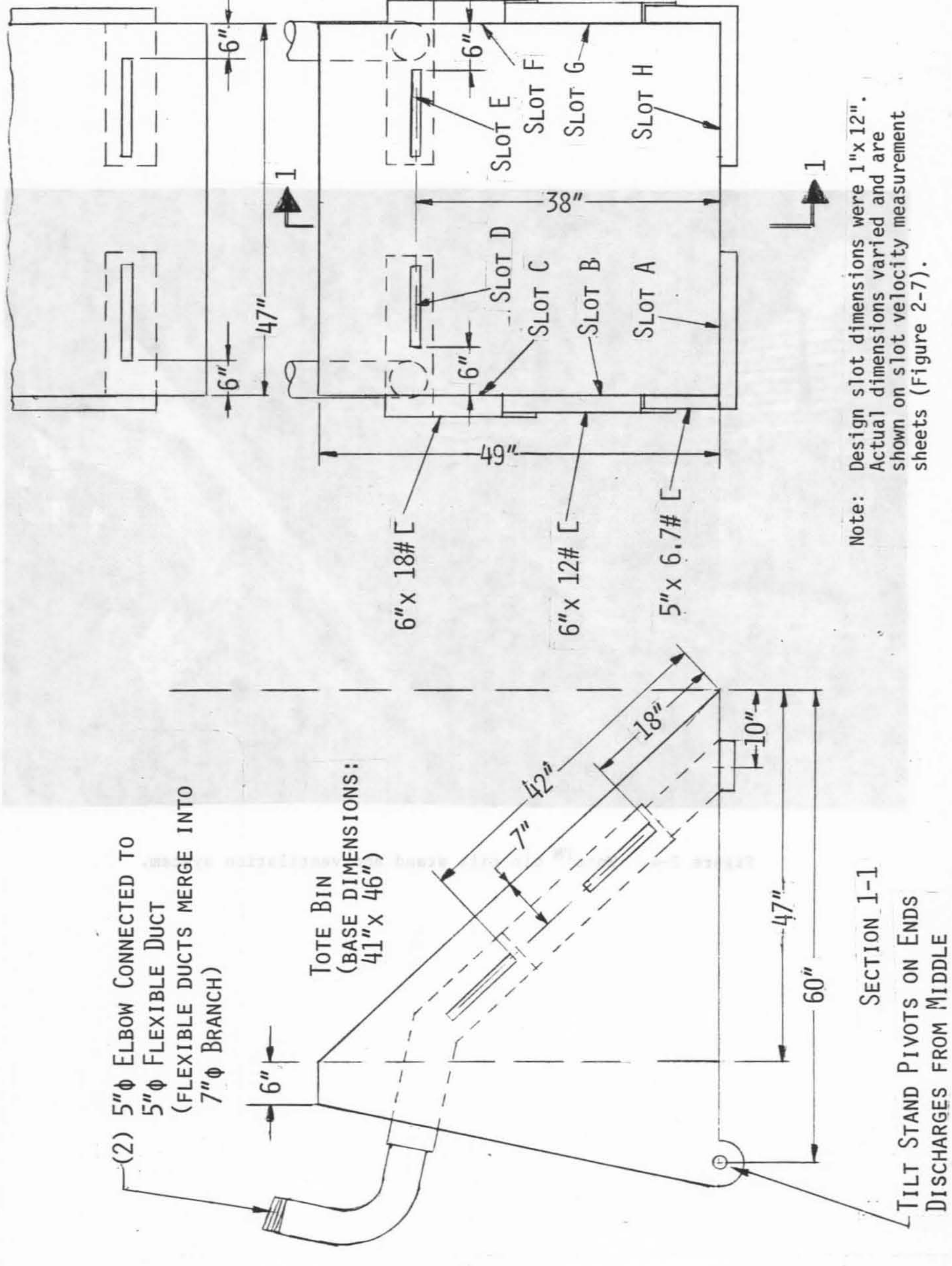


Figure 2-5. Tilt stand ventilation detail.

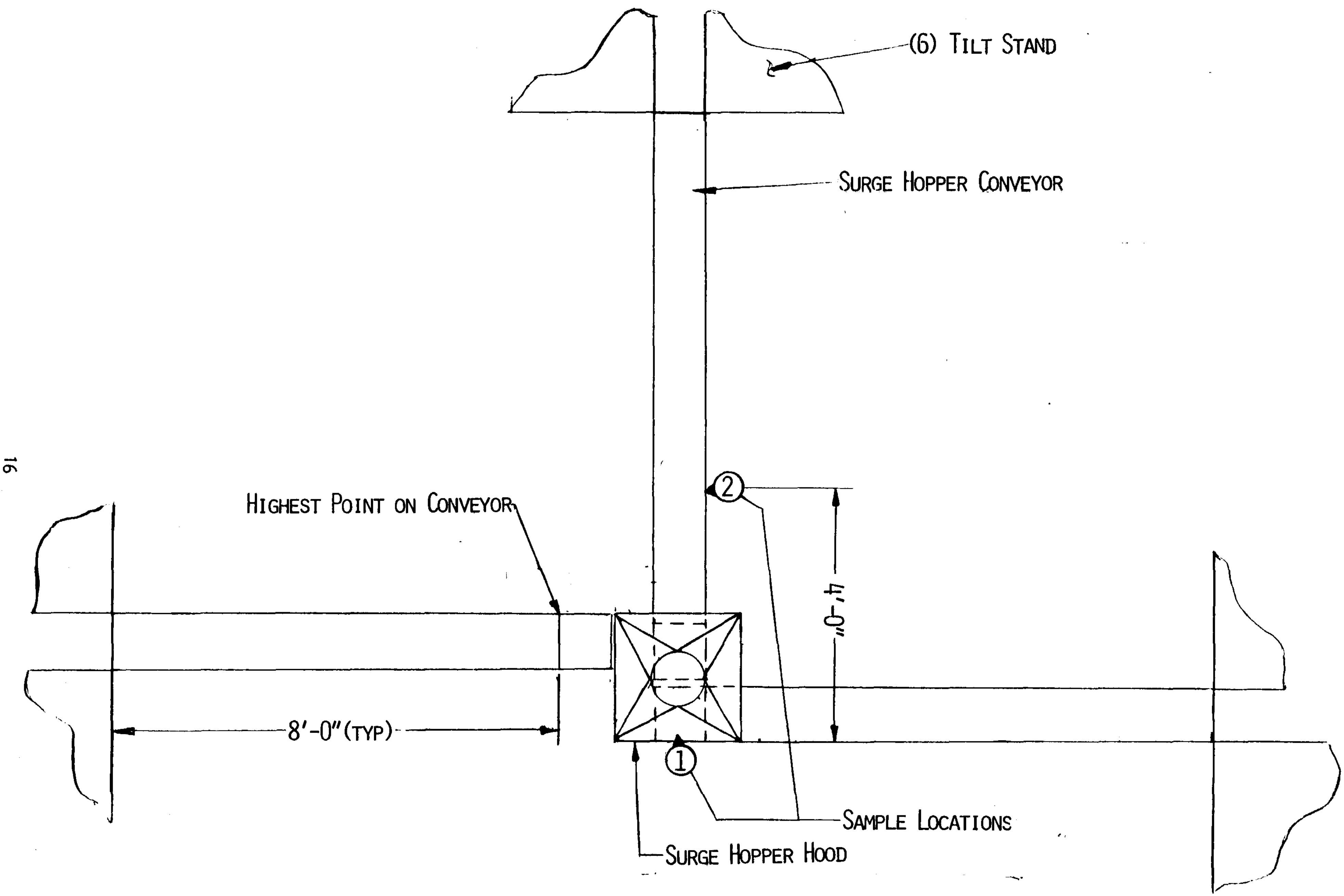


Figure 2-6. Carbon black charging station sample locations.

The ventilation system was retrofitted to the dispensing station in the mid-seventies. For the tilt stands, this was facilitated by welding ducting, made from car channel, to the existing tilt stand walls and torch cutting slots in the tilt stand walls. Also, two exhaust ducts are attached to the tilt stand ducting - one exhaust for all the slots on one side of the tilt stand. The exhaust ducts were both attached to a common branch by flexible ducting.

Since the original design, these change have been made in the ventilation system:

1. The surge hopper hood's designed location was 4 inches above the top of the surge hopper conveyors entering the surge hopper, and was centrally located over the tops of the two parallel surge hopper conveyors. The actual installation dimension for the former was 9 inches instead of 4 inches and 9 inches off-center for the latter. Other stations checked were similar. Apparently, the design location interfered with opening the surge hopper conveyor lids.

2. The slots on the tilt stand studied were specified to be 12 inches long. Instead the measured lengths were from 10 inches to 12 inches (average 11-3/8 inches). This appeared to result from the torch cutting operation.

WORKER'S DUTIES

The worker's duties involving the dispensing station are on an as-needed basis. At the dispensing station the worker's primary jobs are changing bins, "punching" carbon black bridges, and housekeeping. Other duties primarily involve jobs on the same floor and materials handling.

The method for changing bins is:

1. The tilt stand is put into its non-tilt position.

2. Through a hole in the front of the tilt stand, the bin door is closed and latched.

3. The bin is removed from the tilt stand by forklift.

4. Steps 1 to 3 are repeated in reverse order.

Normally, bins are removed only when they are empty. However, they may also be removed while partially full for an ingredients change or mechanical problem.

The "punching" operation is to break carbon black bridges in the surge hopper. This involves opening the lid on a surge hopper conveyor and ramming a pole through the bridged black in the surge hopper. When done, the worker recloses and clamps the conveyor lid.

Housekeeping involves cleaning up spills around the tilt stands and cleaning out the slots in the tilt stand ventilation.

AIR SAMPLING DATA

Limited sampling data were obtained due to an operation shutdown. For the samples collected, total particulate area samples were collected at the locations shown in Figure 2-6. Sampling results are summarized in Table 2-1 and detailed in Appendix II.

Table 2-1. Full shift particulate concentration for carbon black charging system.

Location (Number from Fig. 2-6)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Surge Hopper Hood (1)	3	0.38	2.61	0.49	0.13-0.82
Surge Hopper Conveyor (2)	3	0.37	2.70	0.49	0.13-0.94

VENTILATION DATA

The ventilation measurements are summarized in Table 2-2 and shown in Appendix IV, Figures 2-7, 2-8, and 2-9. Special conditions under which the measurements were made are noted in the table and figures.

Table 2-2. Carbon black charging system ventilation data.

Measurement	Measured	Design
Tilt Stand "A" Ventilation:		
Average duct velocity	2770 fpm[c]	3740 fpm[a]
Calculated duct flow	740 scfm	1000 cfm
Duct static pressure	3.5-in. water	--
Average Face or Slot Velocity	1260 fpm[b,d]	1500 fpm[a]
Tilt Stand "B" Ventilation:		
Average duct velocity	2495 fpm[c]	3740 fpm[a]
Calculated duct flow	670 scfm	1000 cfm
Duct static pressure	3.1-in. water	--
Surge Hopper Hood:		
Average duct velocity	6425 fpm	3665 fpm[a]
Calculated duct flow	3505 scfm	2000 cfm
Duct static pressure	3.2-in. water	--
Average face velocity	540 fpm[c]	500 fpm

a. Based on design flow.
b. Averaged from totally open slots. Also measured with tilt stand in non-tilt position.
c. Measured with corresponding tilt stand in tilt position.
d. Instrument error corrected.

EMISSION SOURCES OBSERVATIONS

The source of the emissions in the charging station area are the carbon black in the bins, the dust collector return system, and material handling systems. Around the study charging station, no specific emission sources were observed;

however, accumulations of carbon black on floors and structures indicated emissions were present or had occurred recently. These possible sources were noted:

1. Leaks in bin door seals or from improperly closed doors.

2. Leaks through open bin filler ports. Shifting of carbon black in the bin as it empties displaces air which entrains the carbon black and floats it out of the ports.

3. Dusts falling from the top of the bin when it is transported or tilted. These dusts evidently come from spills on the tops of the bins during filling.

4. Dusts entrained in air displaced by shifting materials as they exit the bin or are taken up by the tilt stand conveyor system. Reportedly, these emissions are prevalent when the bin is nearly empty and also are reported to stay near the floor of the tilt stand.

5. Leaks in improperly closed surge hopper conveyor lids.

6. Dusts entrained in the air displaced by punching operations and re-emission of dusts adhering to utensils used for punching.

7. Re-emission of dusts adhering to structures and accumulated beneath tilt stands.

8. Dusts entrained in air displaced by material moving through the dust collector return duct and free-falling into an open container placed beneath the return.

WORK PRACTICES OBSERVATIONS

These improper work practices were noted:

1. Not repairing leaks in bin door seals.

2. Not tightly sealing bin doors before transporting bins.

3. Not replacing bin filler port lids after filling.

4. Spilling materials on top of the bins during filling and not cleaning it up prior to transport and installation.

5. Not cleaning up material spilled in the bottom slots of the tilt stand ventilation. This spill is reported to result from the practice listed in Item 2.

6. Not cleaning up material spills around the charging station or sweeping them beneath the tilt stands.

7. Not cleaning up material that had accumulated on structures.

8. Dumping material traveling down the dust collector return into an open container at some locations.

9. Not repairing a tear in one flexible duct.

10. Not cleaning material from the screen at the surge hopper hood faces. This accumulation plugged parts of the hood face.

These proper practices were noted:

1. Specifying method for changing bins which minimize spills from bin doors.

2. Sweeping the charging area with a mechanical sweeper several times a shift. A soap solution was used in the sweeper.

3. Tightly clamping the lids on the surge hopper conveyors to prevent leaks. The clamps used are common "C" clamps. To assure the clamps are not lost, they are fastened to the conveyors with chain.

4. Using plastic bags in combination with fiber drums on the dust collector returns, mentioned in Item 8 above. The plastic bags can be tightly sealed around the returns with tape and the drums prevent inadvertent puncturing of the bags.

ENGINEERING CONTROLS OBSERVATIONS

No emissions were observed escaping from the tilt stand ventilation. Also, the punching operation was not observed and the effectiveness of the surge hopper hood during that operation was not evaluated. However, the plant reports that prior to the installation of the ventilation system, a "fog" of dust could be seen in the air of the entire floor. After the installation, the air was considerably clearer.

Several problems with the charging station ventilation were found:

1. The total tilt stand ventilation and the surge hopper hood are connected to the same main. Based on the measurements, the total tilt stand ventilation was estimated to be 1800 cfm below design, while the surge hopper hood is 1500 cfm above design. Apparently the ventilation system is unbalanced.

2. The tilt stand slot velocities and thus flow rates varied greatly depending on their location relative to the branch exhaust ducts, as shown in Figure 2-7.

3. The use of common materials for ducting and the adaption of them to the existing tilt stands could have increased the static pressure losses of the ventilation system. These losses could occur from items such as right angle elbows, increased wall friction, and right angle entries.

4. The combination of 90^{o} elbows and too long flexible ducting for the tilt stand branch ducts caused kinks in the flexible ducts whenever the tilt stand was in the non-tilt position. A difference of about 160 cfm exists between the flow calculated from the slot velocities and that from the duct velocities. The former was measured with the tilt stand in the non-tilt position and the latter in the tilt position. Additionally, this combination could cause extra losses to the system with the tilt stand tilted by creating "artificial elbows," as shown in Figure 2-2.

5. The small size of the screen on the surge hood face encourages plugging as carbon black impacts and adhers to the screen.

MONITORS OBSERVATIONS

No monitoring equipment ventilation performance or specific contaminants were noted.

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

Workers were issued two sets of coveralls per week and some workers were observed wearing them. Gloves were the only other personal protective quipment noted.

DATA INTERPRETATION

Because of reduced production, the air sampling data may not be representative. Therefore, conclusive statements are based primarily on observations and ventilation data. References to the air sampling data are made with the assumption that it is valid and representative of the norm.

The worker can be directly exposed to dusts at the dispensing station during bin changing and carbon black punching. This exposure is judged to be of the short duration, high concentration type and therefore probably not a major contributor to the worker's overall exposure.

Generated dust appears to remain suspended for significant periods elevating background concentrations in the work area. Carbon blacks used in tire manufacturing have a mean particle diameter of less than 0.5 um[6] and a specific gravity of about 0.1.[7] The settling velocity for a 10 um particle (specific gravity of 2.7) is about 1.5 fpm.[8] In comparison, the settling velocity of a particle with a diameter of 0.5 um and a specific gravity of 0.1 is estimated to be 2×10^{-4} fpm.[9] Therefore, the background concentration may cause a long-term exposure that may be much greater than any direct exposure.

Based on observations, the ventilation system on the tilt stands appears to control the emissions from bin emptying and the basic concept for the control appears to be sound. However, this system has problems which make it operate less efficiently:

1. The slots in the floor of the tilt stand were judged to be very important for control of dust emissions, but they are easily plugged indicating the velocity into the slots and the ducting is not sufficient to clean material out of the slot. Moreover, the velocity for the various slots is not uniform.

2. Misuse of construction materials, as described in "Engineering Controls Observations" above, add needless losses to the system.

Redesign of the tilt stand ventilation to obtain a more uniform airflow among the slots, elimination of the elbows on the branch ducts, and shortening of the flexible ducting would improve the system's already good design.

Without observing the punching operations, no conclusions can be developed about the effectiveness of the surge hopper hood in controlling emissions generated by this operation. However, this hood appears to be only serving as general exhaust ventilation since it is relatively distant from potential dust sources.

The lids on the surge hopper conveyors are clamped shut with C-clamps. These lids were tight because no leakage was observed. To ensure the clamps did not get lost, the clamps were attached to the conveyors by chains.

Improper work practices are felt to be the largest contributor to dust levels in the area. Poor housekeeping and maintenance can cause sources of emissions which are not controllable by a ventilation system Also, as stated above, emissions generated by these sources remain airborne due to their low settling velocity.

KAOLIN SLURRY MIXING TANK (3)
AREA: PRECOMPOUNDING

DESCRIPTION

Rubber is milled after mixing and then dipped in a slurry of kaolin in water to detackify the rubber. The kaolin/water slurry is mixed in a tank and then piped to the dipping tank.

The slurry mixing tank studied has about a 300-gallon capacity and is 48 inches in diameter. Two of these tanks are positioned beside each other at several locations in the plant.

In the mid-sixties, the plant retrofitted hoods on each mixing tank to control dust emissions from the kaolin powder being poured into the solution in the tank. The tank and hood are shown in Figure 3-1. The area not covered by the hood or loading grid is covered by sheet metal. Since two tanks are located side by side, the hoods for both tanks are connected to the same ventilation system. Furthermore, since only one tank is filled at a time and the tank filling operation is an intermittent job, an automatically timed damper system was installed in the ducts. The worker opens the damper before beginning the loading operation and shuts the damper when finished, but, should the worker forget, the timer will activate the damper closing mechanism. The damper system permitted the plant to add the tank hoods onto another ventilation system. This reduced energy requirements and saved money. The damper and its actuation circuit are shown in Figures 3-2 and 3-3, respectively.

The hoods from each pair of tanks are not designed to operate simultaneously; however, the dampers could both be opened at the same time.

WORKER'S DUTIES

The slurry tank is filled on an as-needed basis. The worker performing the job has other duties in the plant. The total time for filling one tank is about 15 to 30 minutes each shift.

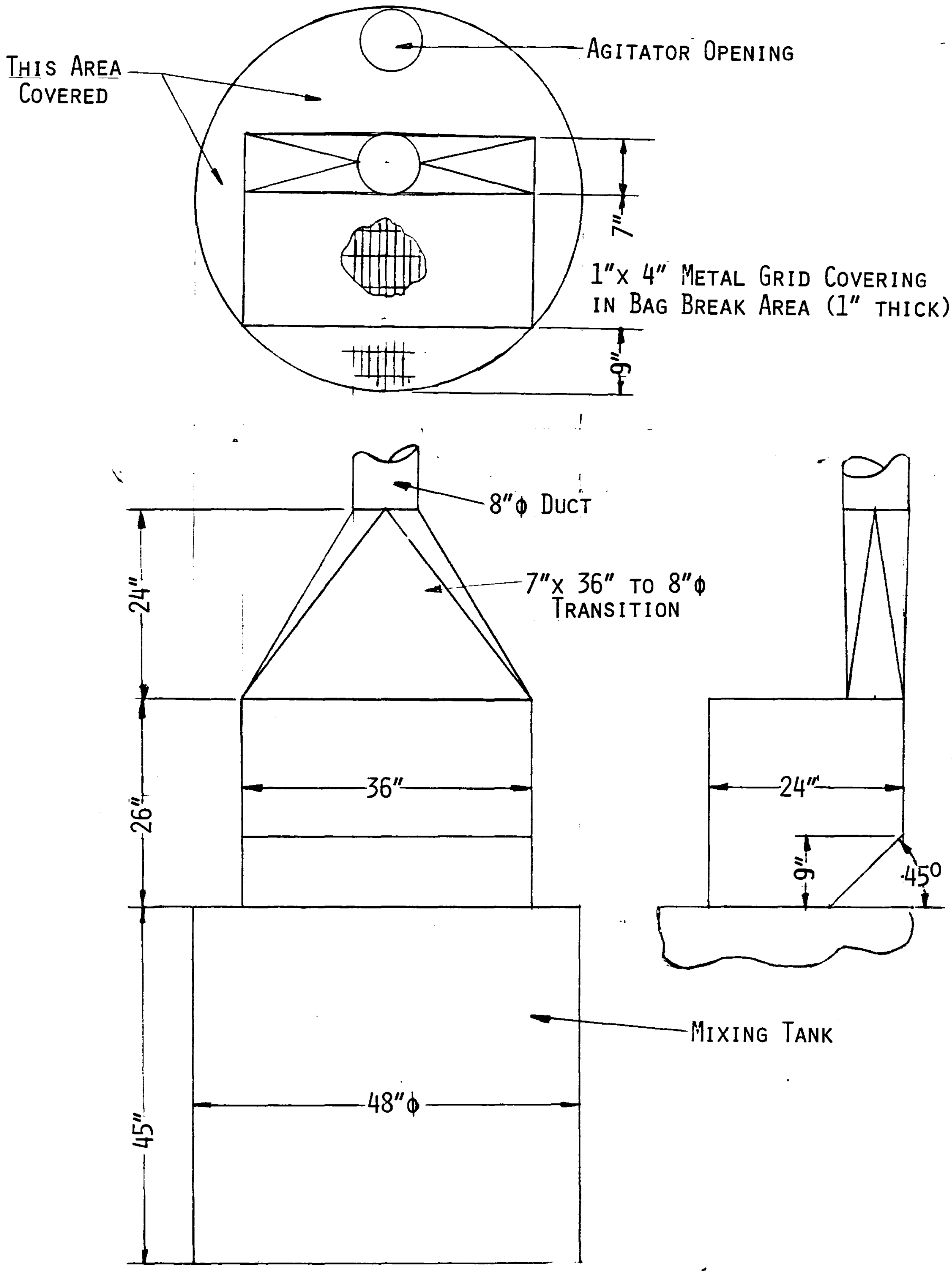


Figure 3-1. Kaolin slurry mixing tank hood detail.

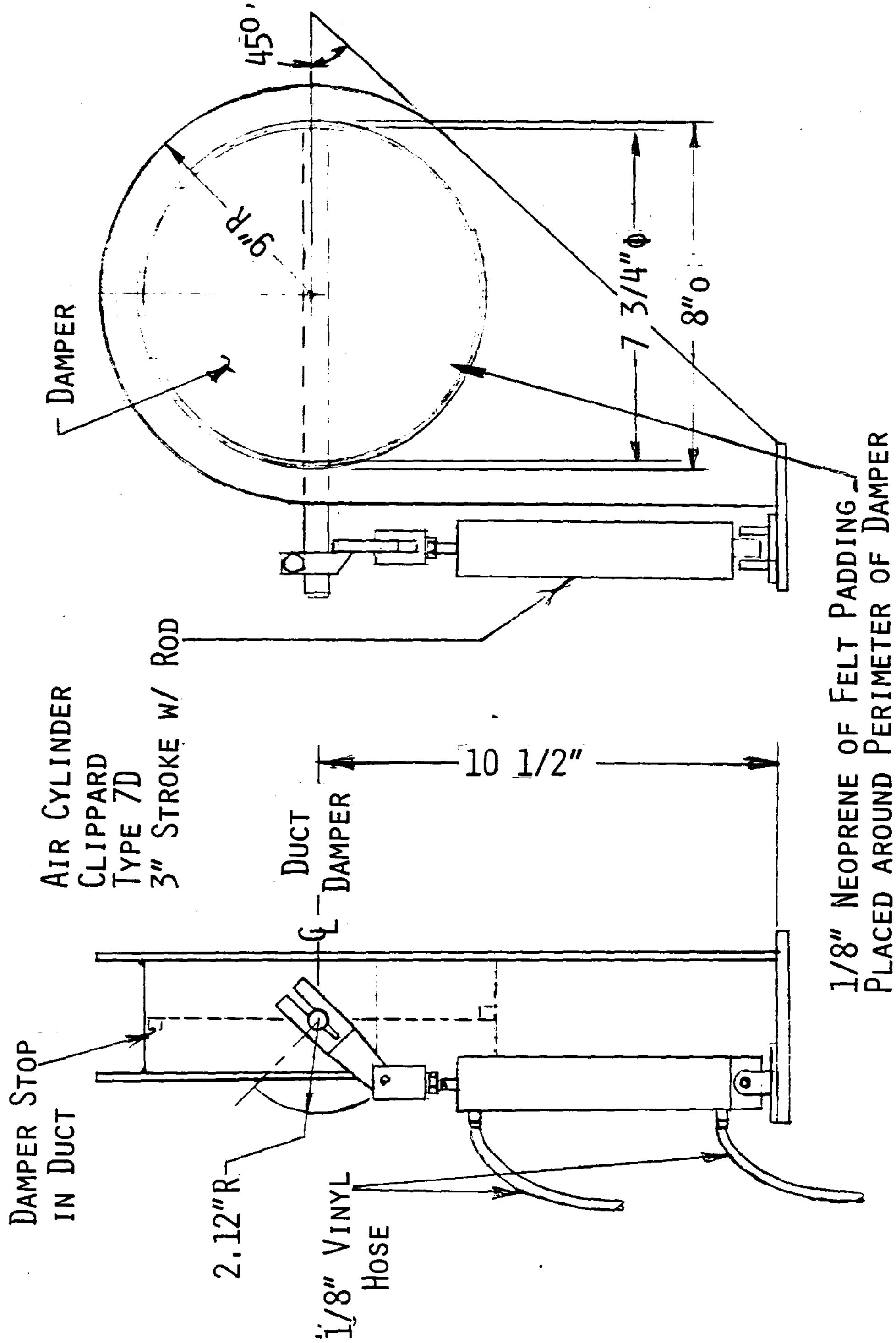


Figure 3-2. Kaolin slurry mixing tank hood duct damper detail.

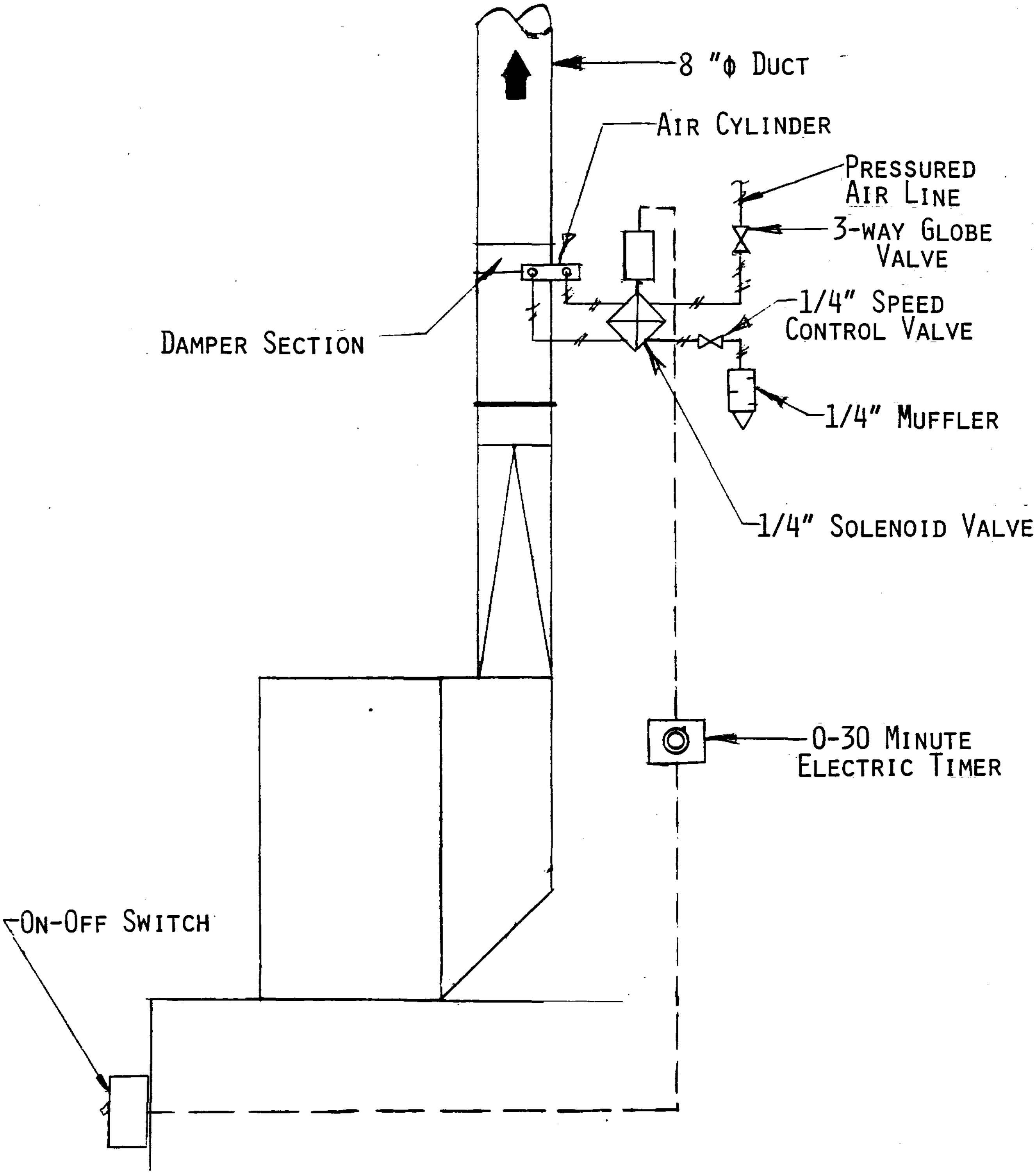


Figure 3-3. Kaolin slurry mixing tank hood duct damper actuator schematic.

The worker performs the tank loading operation this way:

1. The tank is filled with water to the proper level and the mixer started.

2. The damper to the hood on the tank is opened.

3. A bag of kaolin powder is removed from a pallet placed next to the tank platform and placed on the loading grid inside the hood face.

4. The bag is slit with a knife down the side of the bag inside the hood.

5. The bag is emptied into the tank by lifting on its ends.

6. The bag is shaken out over the tank and tossed into a trash container.

AIR SAMPLING DATA

None taken.

VENTILATION DATA

The measurements taken are summarized in Table 3-1 and shown in Appendix IV, Figures 3-4 and 3-5. Special conditions under which the measurements were taken are indicated in the table and figures.

Table 3-1. Kaolin slurry mixing tank hood ventilation data.

Measurement	Measured	Design
Average duct velocity[a]	4,330 fpm	3,400 fpm
Calculated duct flow	1,510 cfm	1,200 cfm
Duct static pressure	2.1 in. H_2O	--
Average face velocity	240 fpm	180 fpm

a. Pitot tube traverse location less than 7.5 duct diameters from disturbance.

EMISSION SOURCES OBSERVATIONS

The source of emissions around the slurry mix tank is the kaolin dust. These specific emission sources were noted:

1. Dusts from torn stacked bags and normal bag emptying operations entrained in air.

2. Residual dusts entrained in air displaced from crushed empty bags.

3. Dusts from previous spills of powdered material, dried splatter from the mixing tanks, or dried spills of slurry solution re-entrained in air.

WORK PRACTICE OBSERVATIONS

These proper work practices were noted:

1. To prevent splatter of slurry from the mixing tank, maintaining at least one foot of freeboard.

2. Keeping the area clean - a mechanical sweeper passed through the area several times per shift.

3. Specifying a method for slitting and emptying bags which did not cause uncontrollable dust generation.

These improper work practices were noted:

1. Not repairing stacked bags of material which had split.

2. Not cleaning up slurry spilled outside the tank.

3. Not cleaning up material spilled on the platform The construction of the platform floor, however, would make this difficult.

4. Dropping empty bags from the worker position on the platform into the trash container on the floor (estimated drop of 6-feet).

ENGINEERING CONTROL OBSERVATIONS

The mix tank hood was measured to be 300 cfm over design. The extra airflow is believed to be drawn from other hoods attached to the ventilation system. This may be the result of an unexpected imbalance in the system.

The area beneath the slurry tanks had a curbing around it to form a catch basin so spills from the tanks were contained.

The plant noted one problem with the damper system. The clamp on the damper axis could come loose through repeated use. This would prevent the damper from opening when the cylinder is actuated.

MONITOR OBSERVATIONS

The timer switch had a small light on it to indicate when the timer was actuated. There was no monitoring equipment for ventilation performance or specific contaminants noted.

DATA INTERPRETATION

The workers can be directly exposed to dusts generated from bag emptying operations. Spilled materials or materials adhering to bags or structures can be generated into the room air elevating background dust levels.

The slurry mix tank hood was observed to control the emissions from the bag emptying and shake-out operations. Emissions resulting from torn bags, spills, or bag disposal are not controlled by the hood. However, these appear controllable through use of proper work practices.

BANBURY MIXER (4)

AREA: MIXING

DESCRIPTION

The ventilation system studied is on a size 11 Banbury mixer with a 450-pound maximum capacity. The mixer is equipped with a drop door discharge and operates on an automatically timed cycle with manual override capability. Normally, this mixer is used for mixing masterbatches or doing remill work.

Three charging methods are used to move the batch ingredients to the mixer: rubber stocks are fed by conveyor into the mixer hopper, carbon black and process oils are automatically charged directly into the mixing chamber, and powdered compounds are manually dumped into the mixer hopper by the worker after the rubber stock is charged. The powdered compounds are weighed in another area of the plant and contained in paper bags, metal garbage cans, or small plastic containers resembling office trash cans.

The mixer ventilation system consists of a charge door hood, carbon black charge chute vent exhaust, four dust ring hoods, and a discharge door hood. The first three hoods are shown in Figures 4-1, 4-2, and 4-3, respectively. The discharge door hood was created by covering the open area between the legs of the mixer on one side and pulling air through the other side by the mill hood ventilation on the floor below. The mill hood was not connected to the mixer ventilation system.

Company drawings for the ventilation system were not available, therefore, the age, design parameters, changes since installation, and whether it is retrofit are unknown. The carbon black charging chute vent exhaust, however, did appear to be an adaption as noted in the "Engineering Controls" section.

WORKER'S DUTIES

The worker's primary duties are to weigh and charge rubber, charge powdered compounds, and operate the mixer. The rubber stock is weighed on the conveyor.

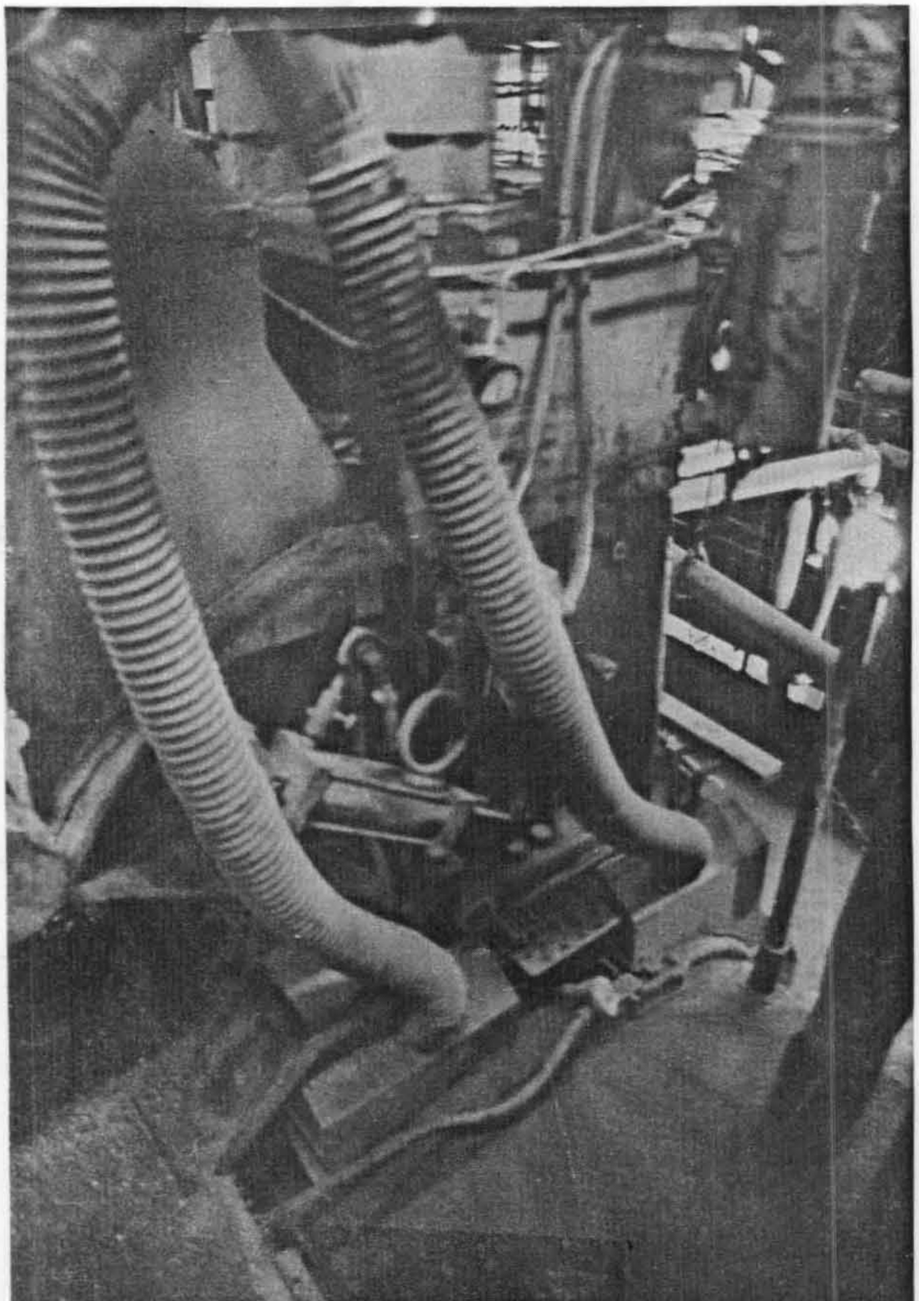


Figure 4-1. Banbury mixer dust ring ventilation system.

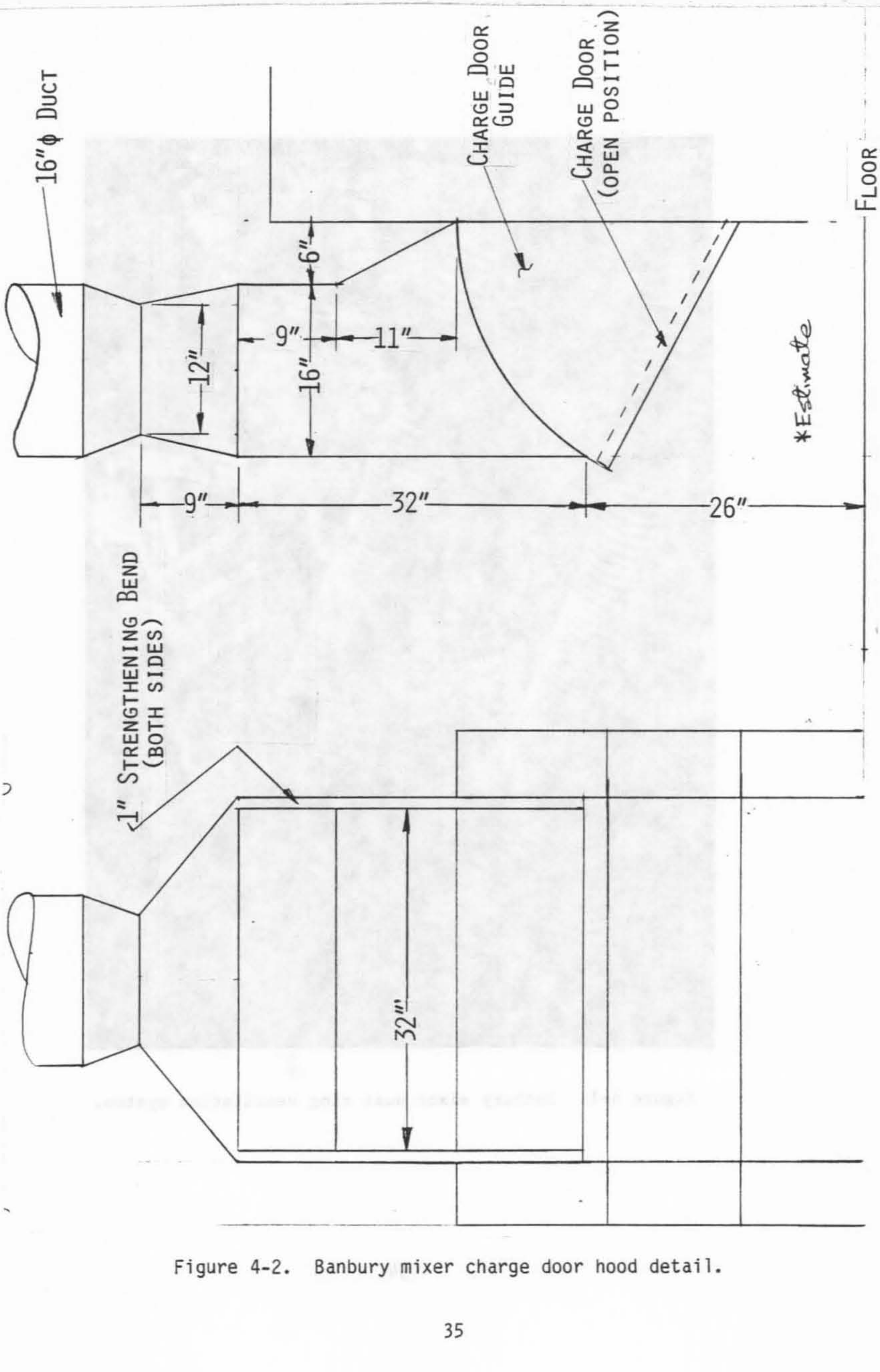


Figure 4-2. Banbury mixer charge door hood detail.

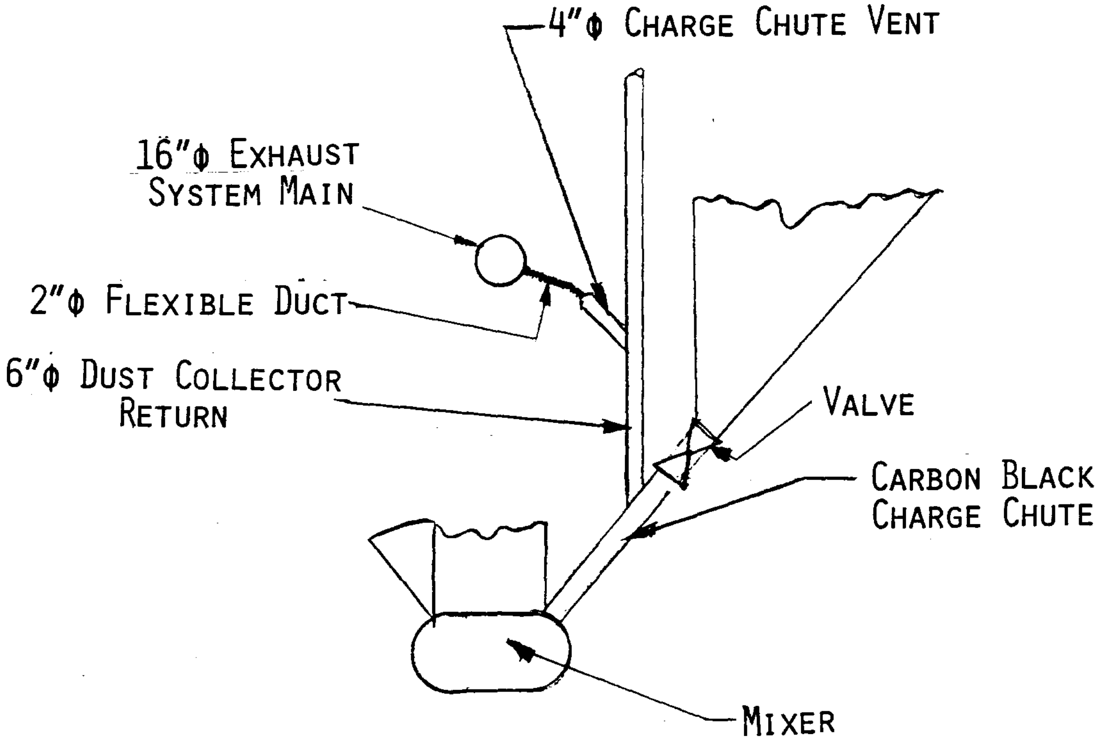


Figure 4-3. Banbury mixer carbon black charge chute vent exhaust.

Unprocessed rubber is placed in chunks on the conveyor, while previously processed slab rubber is pulled onto the conveyor by a loader and cut off at the desired weight by the worker.

When the charge door opens after a previous mixing cycle, the worker charges the rubber and then manually pours the preweighed compounds into the mixer through the charge door. Charging of the compounds is usually from the left side of the charge door. The mixer door is closed by the worker to start the mixing cycle which proceeds automatically.

The containers holding the powder compounds, as mentioned, are either paper bags, metal cans, or plastic containers. The paper bags after emptying are thrown into open garbage receptacles. The other containers are placed on carts for return to the compounding area.

The worker's normal location at the mixer is shown in Figure 4-4.

AIR SAMPLING DATA

Limited sampling was accomplished due to an operation shutdown. Total particulate area samples were collected at the positions shown in Figure 4-4. In addition, total and respirable particulate samples were collected on the workers. Samples were only collected while equipment was operating. Sample results are summarized in Table 4-1 and detailed in Appendix II.

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.

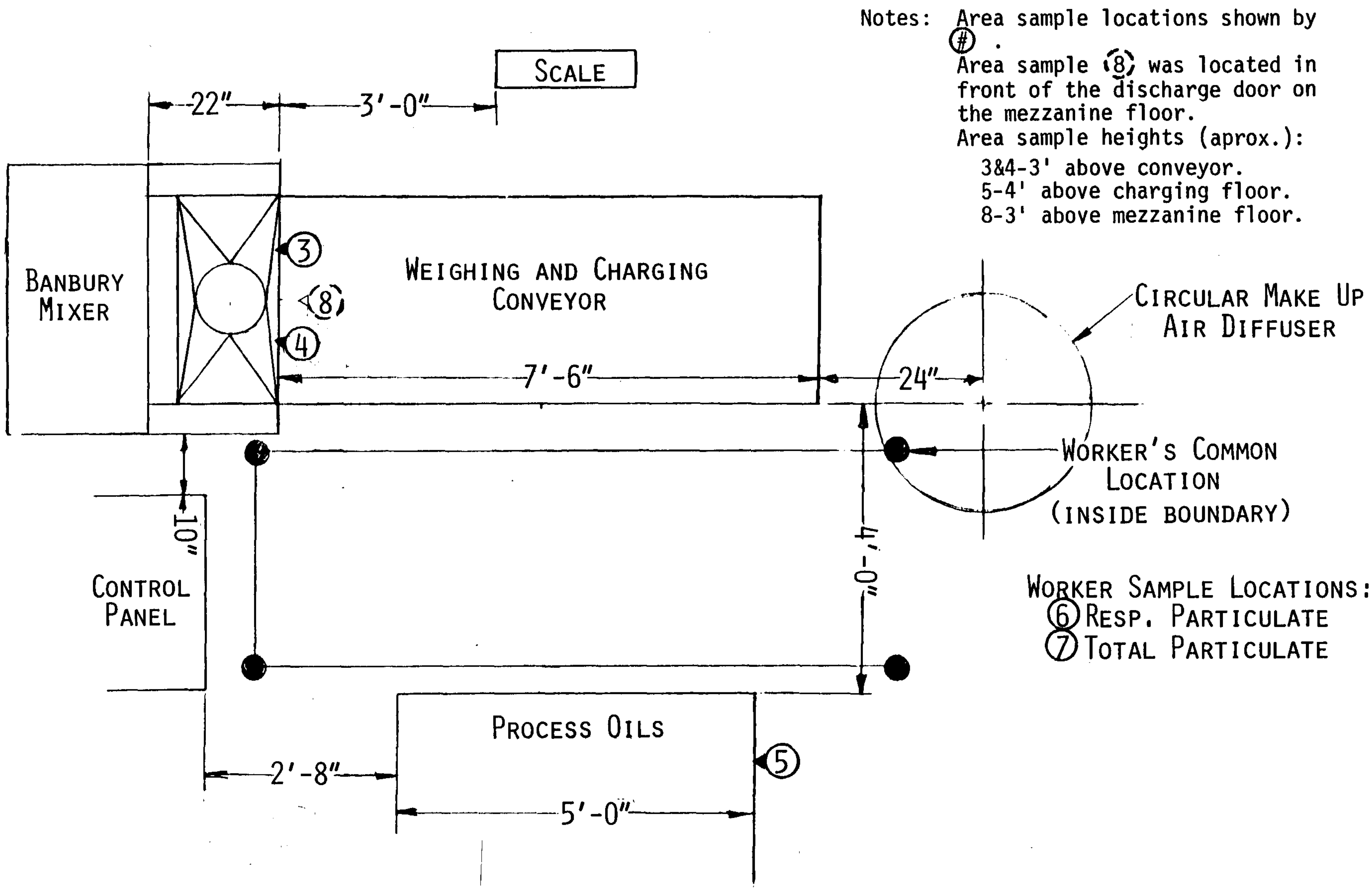


Figure 4-4. Banbury mixer charging area layout and sample location.

Table 4-1. Partial shift particulate concentrations for a mixer.

Location (Number from Fig. 4-4)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)	Duncan's Test[a]
Charge door hood, right (3)	3	0.25	1.8	0.27	0.13-0.43	A
Column next to oil heater (5)	3	0.25	1.2	0.25	0.21-0.28	A
Charge door hood, left (4)	3	0.86	1.6	0.92	0.49-1.24	B
Worker, total part., overall(7)	3	1.54	2.3	1.90	0.68-3.50	B
- - - - - - - - - -	- - -	- - -	- - -	- - -	- - -	-[b]
Worker, total particulate						
Worker 1	1	3.50	--	--	--	--
Worker 2	1	1.50	--	--	--	--
Worker 3	1	0.68	--		--	--
Worker, resp. part. overall(6)	3	0.34	1.7	0.37	0.25-0.64	--
Discharge hood, front (8)	2[c]	1.09	--	0.27	0.13-0.43	--

Notes:

a. Locations with the same letter are not significantly different.
b. Locations beneath dashed-line were not included in Duncan's Test.
c. One sample was 161 mg/m^3 and was not included in table. Also, spilled compounds were observed falling on the samples, so they were excluded from the statistical analysis.

VENTILATION DATA

The ventilation measurements are summarized in Table 4-2 and shown in Appendix IV, Figures 4-5 and 4-6. All the measurements were made without the mixer operating, the charge door open, and the make-up air unit near the mixer operating.

Turbulent air was encountered for the lower vertical foot of the charge door hood. Air velocity measurements and smoke tube tracers in the proximity of the hood showed that the effect was caused by the make-up airflow. Therefore, to get an accurate indication of the line average velocities in the area, the upper four line averages and the correspnding distance from the top of the hood face were used to derive the last three line averages by an exponential curve fit. The values and calculations based on them are shown in parenthesis in Figure 4-5 and Table 4-2. The coefficient of determination for the generated curve was 0.99.

Table 4-2. Mixer ventilation data.

Measurement	Measured
Charge Door Hood:[a,b]	
Calculated duct velocity	2580 fpm
Calculated duct flow	3600 scfm
Duct static pressure	0.75 in. of water
Face velocity:	580 (540)[d] fpm[c]
Left Dust Ring Hoods:[a]	
Average duct velocity	1120 fpm
Calculated duct flow	220 scfm
Duct static pressure	0.34 in. of water
Face velocity:	not measured
Right Dust Ring Hoods:[a]	
Average duct velocity	1060 fpm
Calculated duct flow	210 scfm
Duct static pressure	0.68 in. of water
Face velocity	not measured
C.B. Charge Chute Vent Exhaust:[a]	
Average duct velocity	970 fpm
Calculated duct flow	85 scfm
Duct static pressure	0.73 in. of water
Discharge Door Hood:[a]	
Face velocity:	90 fpm

a. No design airflow data available.
b. Measured with charge door open.
c. Adjusted for instrument error.
d. See Text for explanation.

EMISSION SOURCES OBSERVATIONS

The observed emissions appeared to be dusts clinging to building structure and machine parts, process materials, and by-products of processed materials. These specific emission sources were observed:

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

2. Rubber fume from processed rubber being discharged from the mixer.

3. Dusts entrained in air displaced by movement of powdered compound containers. This occurred after the compounds in the containers had been dumped in the mixer and the containers were being returned to the cart.

4. Dusts entrained in air displaced by crushing empty bags.

5. Dusts forced into the air by careless handling of process materials.

6. Dusts dispersed into air from processed rubber. This occurred during remill operations when the processed rubber was being pulled onto the conveyor. The dust was observed to be from the clay type, anti-tack coating on the rubber.

7. The dusts mentioned in item 6 adhering to the conveyor. This dust is entrained in air displaced by materials being dropped on the conveyor belt and is expected to be shaken into the air by movement of the belt.

8. Dusts entrained in air displaced by process material movement, such as air displaced by carbon black flowing down the charge chute.

9. Dusts entrained by air moving across compounds in open containers.

WORK PRACTICES

In some cases, work practices could affect dust generation because workers handled dusty materials. These proper work practices were observed:

1. Regular wet sweeping of mixer charging areas.

2. Using rigid containers to transport powdered compounds.

These improper work practices were observed:

1. Carlessly handling powdered compounds causing spills. Workers were also observed to throw materials from containers into the mixer similar to dousing a fire with a bucket of water. This could generate more dust than if the compounds were poured gently.

2. Passing the open end of just-emptied rigid containers through the worker's breathing zone. Contaminated air from the container is introduced directly into the worker's breathing zone.

3. Wadding empty paper bags. Contaminated air displaced from the bags is introduced directly into the worker's breathing zone.

4. Tossing bags basketball-style into trash containers.

5. Compressing trash in open trash containers. One worker was observed getting into the trash container and using his feet to stomp down the trash.

6. Transporting compounds in open containers. This creates two problems - air movement across the container can entrain compounds and material is easily spilled from the open containers.

ENGINEERING CONTROLS

No visible emissions were observed escaping from the charge door hood when the door opened or from the discharge door hood when it discharged mixed rubber. Also, no emissions were observed escaping from the dust ring hoods. There were, however, several items noted about the mixer ventilation system's design:

1. The positioning of the make-up air diffuser was close enough to the charge door hood so that make-up air caused turbulence at the lower portion of the hood face.

2. The charge door hood face area appeared larger than needed. It did not appear that access to machine parts or structures in the area below the charge belt was necessary, so enclosure of this area may be possible.

3. The duct entrance from the charge door hood was not constructed according to conventional design. An unnecessary static pressure loss may result from the converging-diverging construction of the duct entrance.

4. The duct entrance from the dust ring hood was not tapered (Figure 4-3); this would result in a static pressure loss.

5. The combination of the flexible ducting and poorly designed branch entries for the dust ring hoods results in an unnecessary static pressure losses. The flexible ducting connected to one dust ring hood was noted to be almost kinked, as shown in Figure 4-3.

6. The use of flexible ducting on the dust ring hoods appeared unnecessary. Flexible ducting causes undesirable loss of static pressure. Use of metal ducting with quick-disconnect collars may be better.

7. The design of the carbon black charge chute vent exhaust appeared to be an adaptation. Normally, on Banbury mixers, a hole is provided in the mixer hopper cover to vent the interior of the mixer. From observations at other plants, a duct from the ventilation system is usually connected to the vent. This vent was not provided on this mixer. However, the 2-inch duct normally connected to that vent was connected by flexible ducting to the charge chute vent instead. Unfortunately, this resulted in a poor design and results in an unnecessary static pressure loss from the converging-diverging ducting and poor entrances.

8. No expansion of the main duct was provided at branch entries to this main. Branches entering into nontapered mains result in an additional static pressure loss.

MONITORS OBSERVATIONS

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

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

Workers are provided two sets of work clothes per week. Some workers were observed wearing them.

DATA INTERPRETATION

The workers can be directly exposed to dusts generated from manual compounding and materials handling. Emissions from process machinery and products and from improper housekeeping can enter the general air elevating background dust levels.

The data in Table 4-1 suggests that the background total particulate concentration for the mixer charging area is approximately 0.25 mg/m^3 since it is the lowest level of the area samples. This is further supported by the fact that these samples were collected at a location away from the process - the column next to the process oil heater.

Samples collected on the right side of the charge door hood reflect the background level, since they are not significantly different than background (the process oil heater samples). The left side samples, however, are significantly different than background. But, the worker adds powdered compounds to the mixer from the left side, and personal sampling showed that the worker's exposure levels are also significantly different than background. Furthermore, no emissions were observed to escape the hood when the charge door opened. Therefore, the conclusion is that the charge door hood does control emissions from the charge door area, but that the worker is still exposed to emissions generated from manual compound charging and handling of containers. The emissions from sources outside the hood are only partially controlled by the hood; it appears that work practices may be needed to control exposures.

Samples collected in front of the discharge door hood are higher than background, but no emissions were observed leaking from the hood. However, material spilled by the worker during charging operations was observed to fall through a hole in the mixer charging floor and onto the sampling cassette in front of the discharge door hood. Therefore, the discharge door hood appears to contain emissions from material being discharged from the mixers, but other emissions are generated in the area because of improper work practices.

Based on judgement, the dust ring hoods and carbon black charge chute vent exhaust may contain emissions from these sources. However, this cannot be stated conclusively because emissions were not observed being generated from the sources these systems were intended to control.

The design problems concerning the ventilation system and discussed in the "Engineering Controls Observations" section, do not appear to affect the performance of the hoods. Therefore, the problems appear to cause only a loss of efficiency for which the system has the capacity to compensate. Since design information for the system was unavailable, the decrement in performance between design and actual caused by the construction deficiencies could not be ascertained.

The following sources of emissions in the charging area were uncontrolled: dust emitted by the rubber stock coating, dust emitted from the conveyor belt when it moved or had items dropped on it, and dusts emitted because of spills of compounds. The use of ventilation to control these sources does not seem practical because of the large area involved and the random occurrence of spills.

MILL (5)

AREA: MIXING

DESCRIPTION

The hood studied is on a mill with 2-feet 2-inch diameter rollers that are 7-feet-long. The distance between the roller centerline and floor is about 3 feet.

Rubber from the mixer is dropped directly on the mill through a chute. The chute outlet is positioned high enough above the rollers so the entire batch of rubber is visible when dropped .

The mill hood is a side draft canopy hood and is fashioned primarily from metal curtains hung from the floor above the mill. The mill hood is shown in Figures 5-1 through 5-6. The hood has these design features:

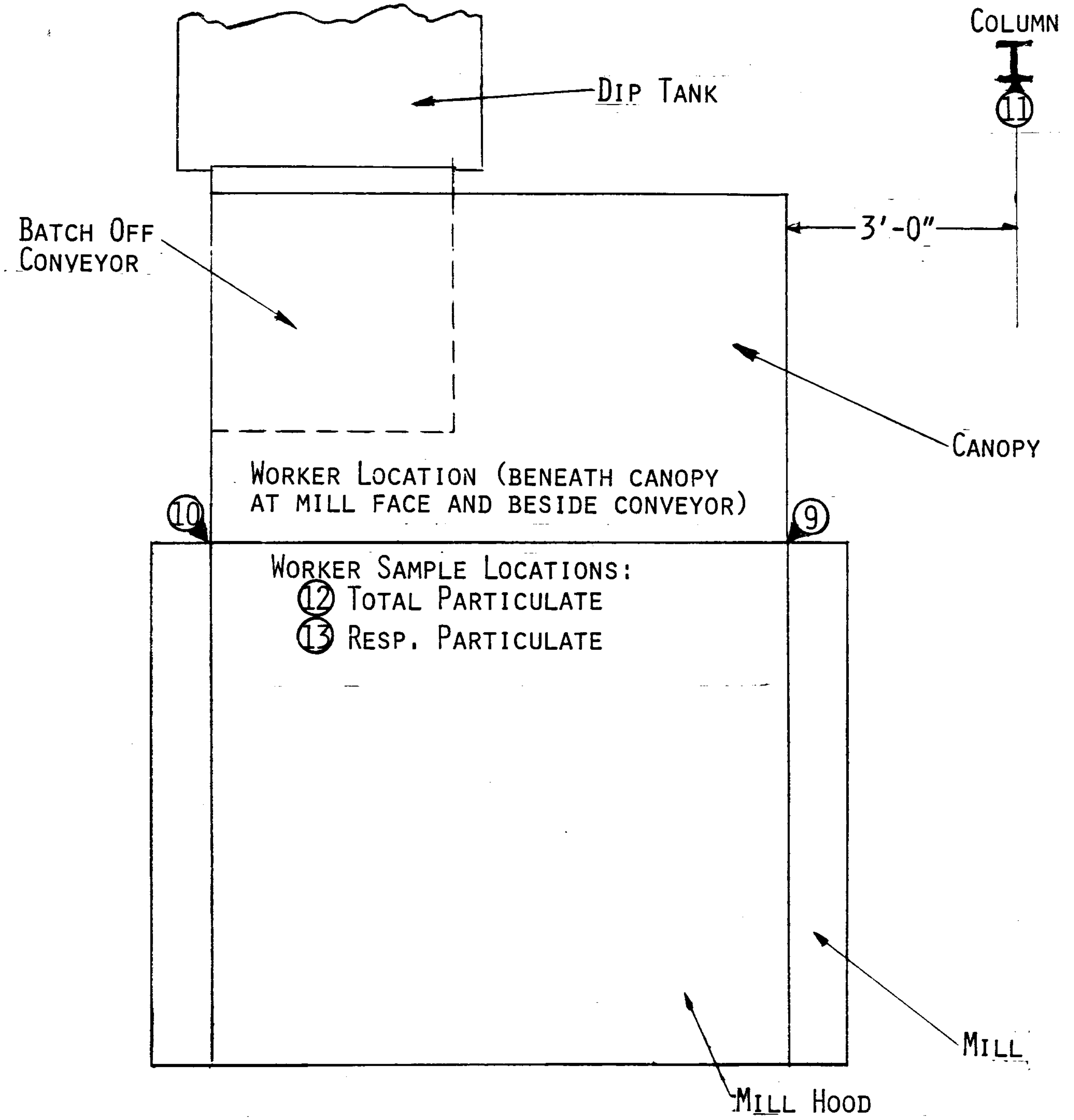
1. The two exhaust vents on the back of the hood are positioned to draw exhaust air from around the sides of the drop chute.

2. Directly beneath the metal curtain on the back is a curtain made from used conveyor belt. It is as wide as the hood, so it could not be sucked into the hood by the exhaust. Hooks are provided at the top of the curtain so it can be hung out of the way when necessary.

3. Also, on the back of the hood there are two metal doors to provide easy access to the area below the mill rollers. Between the doors and the floor there is a strip of sheet metal to support the doors and provide a catch-tray beneath the rollers.

4. The metal canopy, on the front of the hood is evidently intended to catch emissions from the rubber sheet running from the mill to the dip tank.

5. The hood was designed specifically to allow a fan to blow into the hood face without blowing the emissions out of the back. The fan for

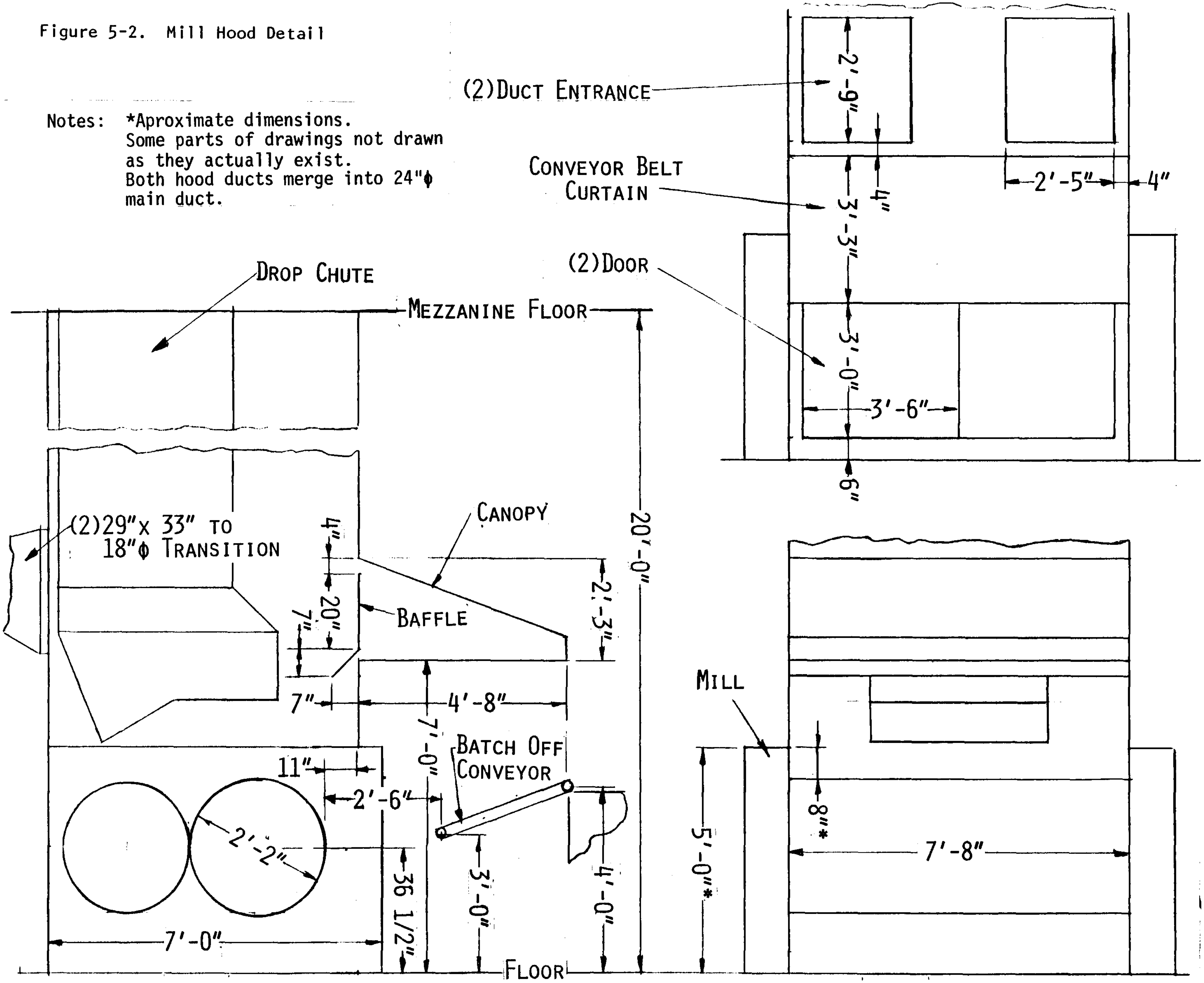


Notes: Area sample locations shown by (#).
All area samples about 5 to 6' above floor.

Figure 5-1. Mill layout and sample locations.

Figure 5-2. Mill Hood Detail

Notes: *Aproximate dimensions.
Some parts of drawings not drawn as they actually exist.
Both hood ducts merge into 24"ϕ main duct.



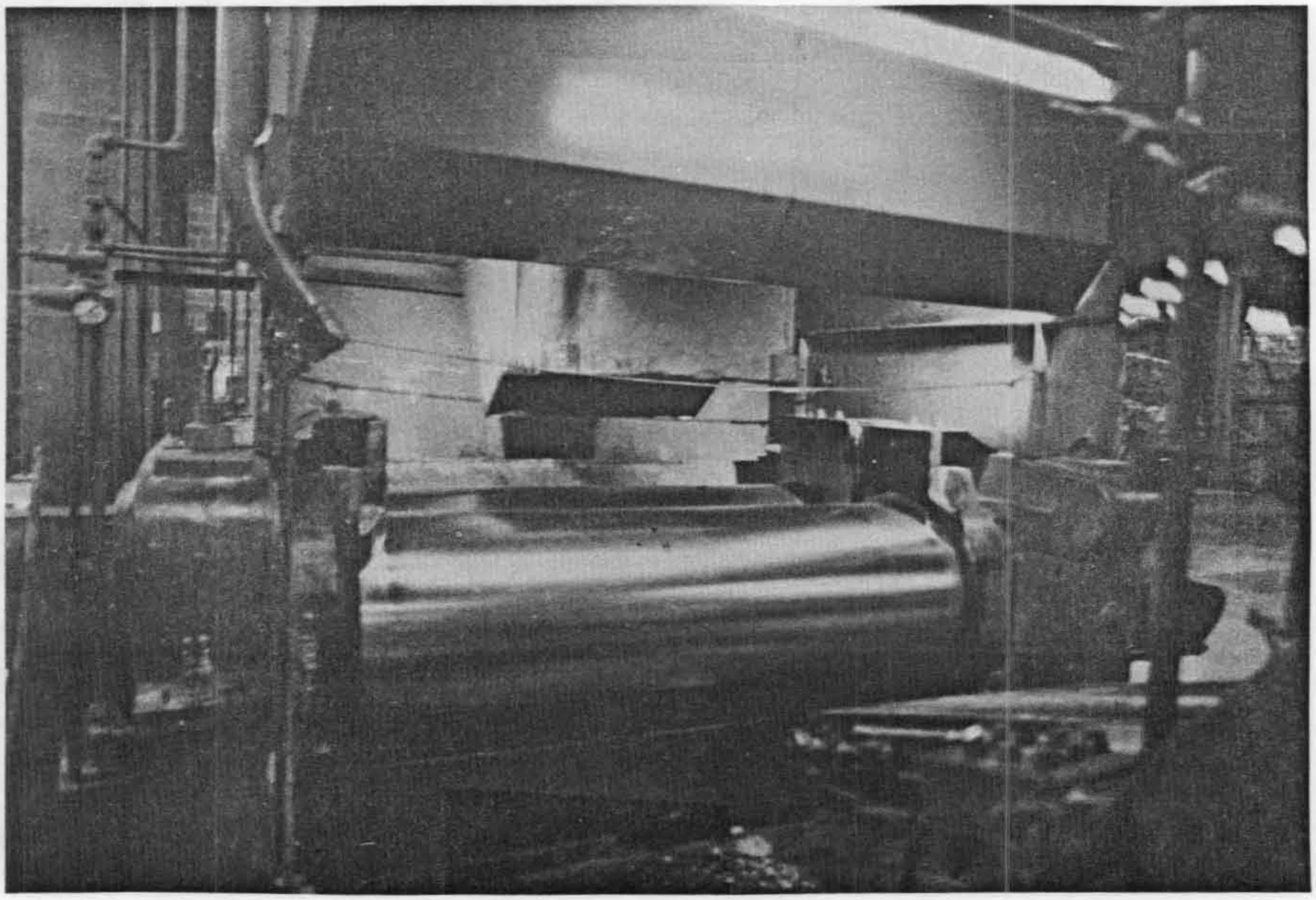


Figure 5-3. Mill showing drop chute and canopy hood baffle plate.

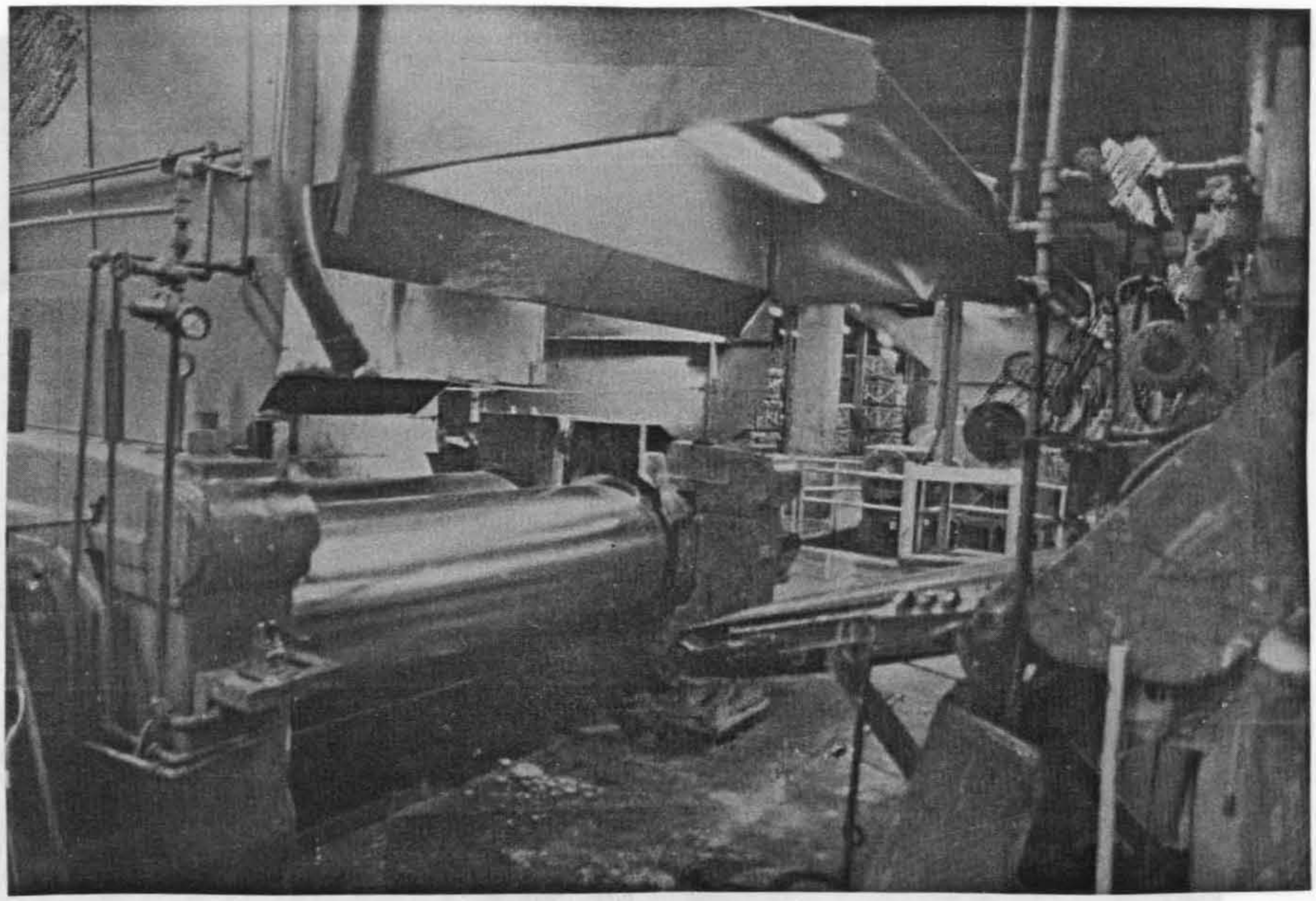


Figure 5-4. Mill hood showing canopy and baffle plate.
Also shown is batch-off conveyor and portion of dip tank.

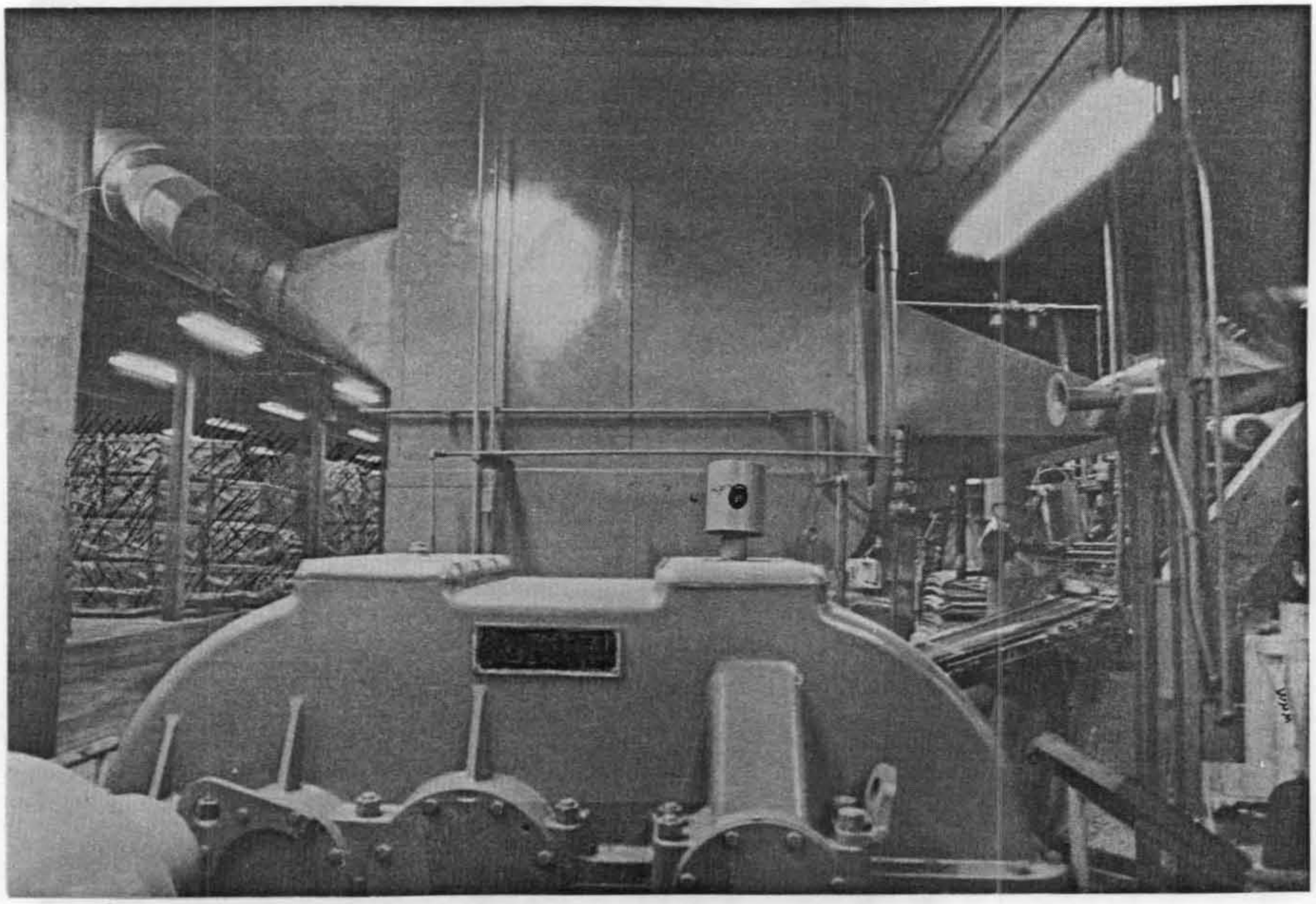


Figure 5-5. Mill hood showing canopy and duct entrances.

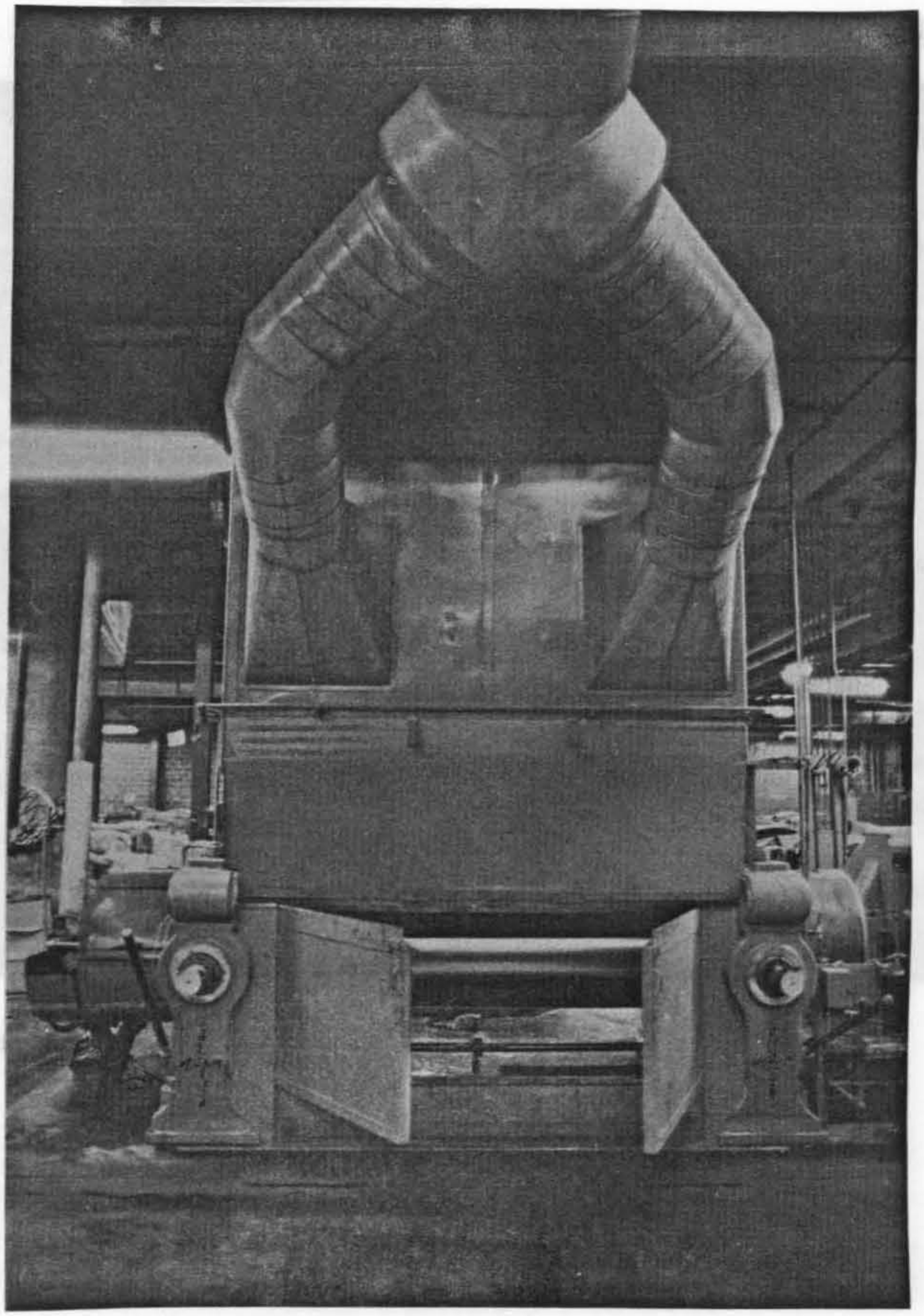


Figure 5-6. Mill hood showing back of hood, duct entrances conveyor belt curtain, and doors.

this hood is mounted on a column next to the left side of the dip tank. Reportedly, the fan is needed to cool the worker because of the heat radiated from the mill rollers and the rubber.

The hood is a retrofit, but its installation date is unknown. During the time of this study, the baffle plate shown in Figure 5-2 was added to reduce the hood face area.

WORKER'S DUTIES

The worker's primary duties are milling rubber and overseeing the festoon and wigwag operations. The procedure for the milling operation is:

1. The rubber batch is dropped on the mill from the mixer.

2. When a good coating of rubber is on the rollers, a sheet of rubber is cut onto the floor on the left side of the mill.

3. When the rubber is pulled completely into the rollers, the cutting of the sheet onto the floor is stopped and the mill is allowed to recover the rubber from the floor.

4. A sheet of rubber is then cut on the right side of the mill; this cutting is done by the mill cutters. The rubber sheeted off during this part of the operation is manually started on the take-off conveyor to the dip tank. From the dip tank, it proceeds to the festoon for drying and the wigwag for stacking on a pallet.

A piece of the rubber sheet on the take off conveyor is normally cut off and an identification number written on it. This piece of rubber is set aside on the bench for quality control. Additional responsibilities of the worker include housekeeping around the mill and keeping the hood doors closed.

The worker's primary location is shown in Figure 5-1. To oversee the festoon and wigwag operations, however, the worker must frequently walk around the machinery.

AIR SAMPLING DATA

Limited sampling data were obtained because the operation shut down and because several area samples lost weight. Total particulate area samples were collected at the locations shown in Figure 5-1. In addition, total and respirable particulate samples were collected on the mill worker. Sample results, excluding those which lost weight, are summarized in Table 5-1 and detailed in Appendix II. During the sampling periods the cooling fan mentioned above was not operating.

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

Location (Number from Fig. 5-1)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Total Particulate:					
Mill hood, left side (9)	1	0.19	--	--	--
Mill hood, right side (10)	1	0.22	--	--	--
Column next to dip tank (11)	1	0.25	--	--	--
Worker (12)	3	0.73	--	--	--
Respirable Particulate:					
Worker (13)	3	0.37	--	0.39	0.26-0.61

Even though the samples which lost weight were not used in the table above, they indicate that the concentrations obtained for the area samples are the norm. These samples showed a weight loss of 0.1 mg while the average weight loss for four blanks from the same sample lot was 0.2 $\pm$ 0.01 mg. The concentration which would result if the area samples lost the same weight as the blanks is 0.2 mg/m^3.

VENTILATION DATA

The ventilation measurements are summarized in Table 5-2 and shown in Appendix IV, Figures 5-7 and 5-8. Special conditions under which the measurements were made are noted in the table and figures.

Table 5-2. Mill hood ventilation data.[a]

Measurement	Measured
Average main duct velocity[b]	3,675 fpm
Calculated main duct flow	11,545 scfm
Main duct static pressure	greater than 5 inches water[c]
Average hood face velocity[d]	
Overall	280 fpm
Above baffle plate	410 fpm
Below baffle plate	270 fpm

a. Design data were not available.
b. Measured while mill was operating.
c. Measuring instruments full scale reading was 5-inches.
d. Measured while mill and cooling fan were not operating. Also, air turbulence was encountered in front of mill roller. See Figure 5-8 for explanation of data treatment.

EMISSION SOURCES OBSERVATIONS

The sources of the emissions are the mixed rubber stock, the anti-tack dip solution, and unmixed batch compounds. The specific emission sources are:

1. Rubber fume given off by the mixed rubber. These emissions are carried into the air by convective forces and were observed to occur from the time the rubber batch is dropped on the mill rolls until it enters the dip solution.

2. Dusts from unmixed compounds entrained in the air. Entrainment may be caused by natural air currents, ventilation or convective forces, or air displaced by process materials or machinery.

3. The dusts in Item 2 forced into the air by housekeeping practices or entrained in air displaced by such practices.

4. Contaminants generated by the dipping process. These emissions appear to be in a mist generated by the vibration, heating or boiling of the dip solution.

WORK PRACTICES OBSERVATIONS

These improper work practices were noted:

1. Getting too close to the hot rubber or placing head in air currents carrying rubber fume.

2. Sheeting rubber onto the floor outside of the hood.

3. Leaving the doors on the back of the hood open (occasionally).

4. Cutting pieces of rubber for analysis and placing them in an uncontrolled area (worker's bench). However, this is considered to be a relatively minor source of exposure to the worker.

The area around the mill was very clean indicating good housekeeping practices. In addition, a mechanical sweeper was observed to pass through the area several times a shift.

ENGINEERING CONTROLS OBSERVATIONS

No visible emissions were observed escaping the hood over the top of the mill. Along the face of the hood turbulence was encountered around the area of the mill roller. This seems to be due to air "rolling" on the roller as it enters the hood face.

As stated, the hood was specifically designed to permit a cooling fan to blow directly into the hood face. Where this was observed on another mill hood, no emissions were blown out of the back or front of the hood.

Smoke tube traces at the batch-off conveyor indicated that the overhead canopy was ineffective. Instead of being drawn toward the canopy, the smoke was drawn toward the large open area of the mill hood face.

MONITORS OBSERVATIONS

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

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

Workers were observed to wear gloves.

DATA INTERPRETATION

The worker can be directly exposed to rubber fume when their head intrudes into a contaminated air stream. Fume generated outside the hood passes through their breathing zone as it moves to the hood.

Although the air sampling data collected is too limited to make conclusive statements, it does suggest that the workers' exposure levels are greater than any of the area levels. The data also suggests that the particulate concentrations for samples collected on the hood are about the same as the sample collected on the column and therefore reflect the background. Based on this, the hood appears to contain the emissions from the rubber stock, while the worker is still being exposed to rubber fume.

The hood was observed to contain emissions from rubber inside the hood; however, the rapid decrease of the hood face velocities near the mill roller suggests that little or no capture velocity would exist between the floor and bottom of the roller. Therefore, emissions from the rubber being sheeted onto the floor may not be captured.

Furthermore, based on smoke tube traces and observations, emissions from rubber stock running between the mill and the dip tank are not expected to be captured by the canopy hood. Instead these emissions and those from rubber stock sheeted on the floor would be blown away from the hood across the floor of the area with the cooling fan on. With the cooling fan off, the emissions would be drawn toward the mill hood face, because the hood generates a local draft in the area (determined by smoke tube traces). In the latter case, these emissions were drawn directly through the workers' breathing zone. This would explain why personal exposure levels were greater than background.

CURING PRESS ROW (6)

AREA: CURING

DESCRIPTION

One press row was selected from several for this study. The press rows do not all cure the same size tire, but all of them have canopy hoods. Makeup air is distributed throughout the curing room.

A layout of the press row is shown in Figure 6-1. The press row contains approximately 20 curing presses (unknown size).

The canopy hood over the press row studied is fabricated from metal "curtains" hung from the curing room ceiling. The curtains extend down to a level 9 feet 4 inches above the curing room floor. A projection of the hood perimeter is shown in Figure 6-1. Exhaust air is pulled from the hood by five roof ventilatiors located in the positions shown in Figure 6-1.

Makeup air is supplied around the hood in the locations shown in Figure 6-1. A volume control and circular diffuser are used at the outlet of each make up air duct. The diffuser's measured louvre angles are shown in Figure 6-2. The diffuser outlet is 13 feet 8 inches above the curing room floor. An air curtain, also shown in Figure 6-1, separates the curing room from the tire building room.

The hood was installed as a retrofit in the late seventies. No noteable changes have been made since its installation. Several views of the curtain are shown in Figures 6-3, 6-4, and 6-5.

WORKER'S DUTIES

Two workers operate the process in the press row studied. One 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. The other worker vacuumed rubber out of the vent holes in the molds prior to a green tire being

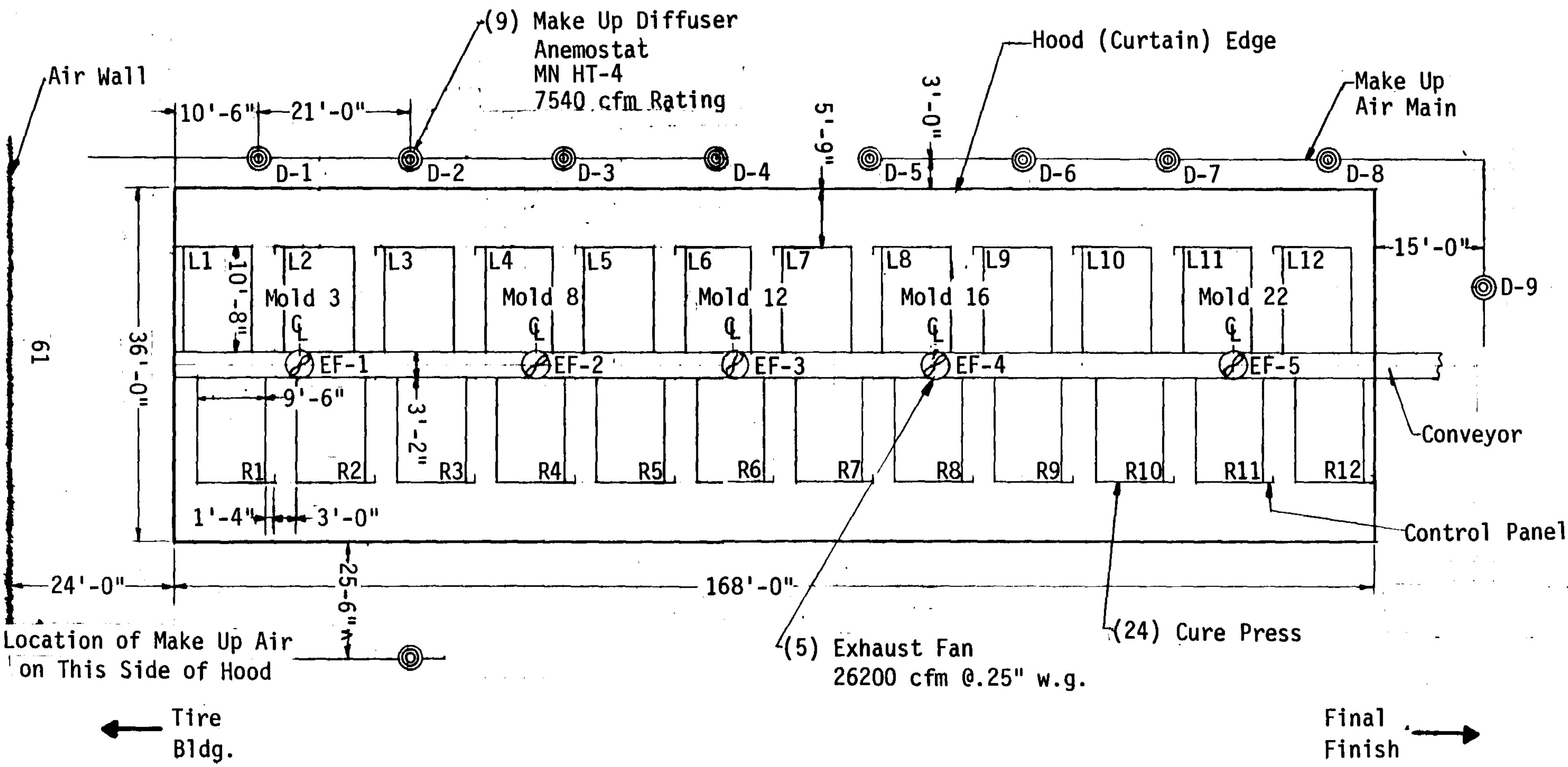


Figure 6-1. Curing press row layout and ventilation system specification.

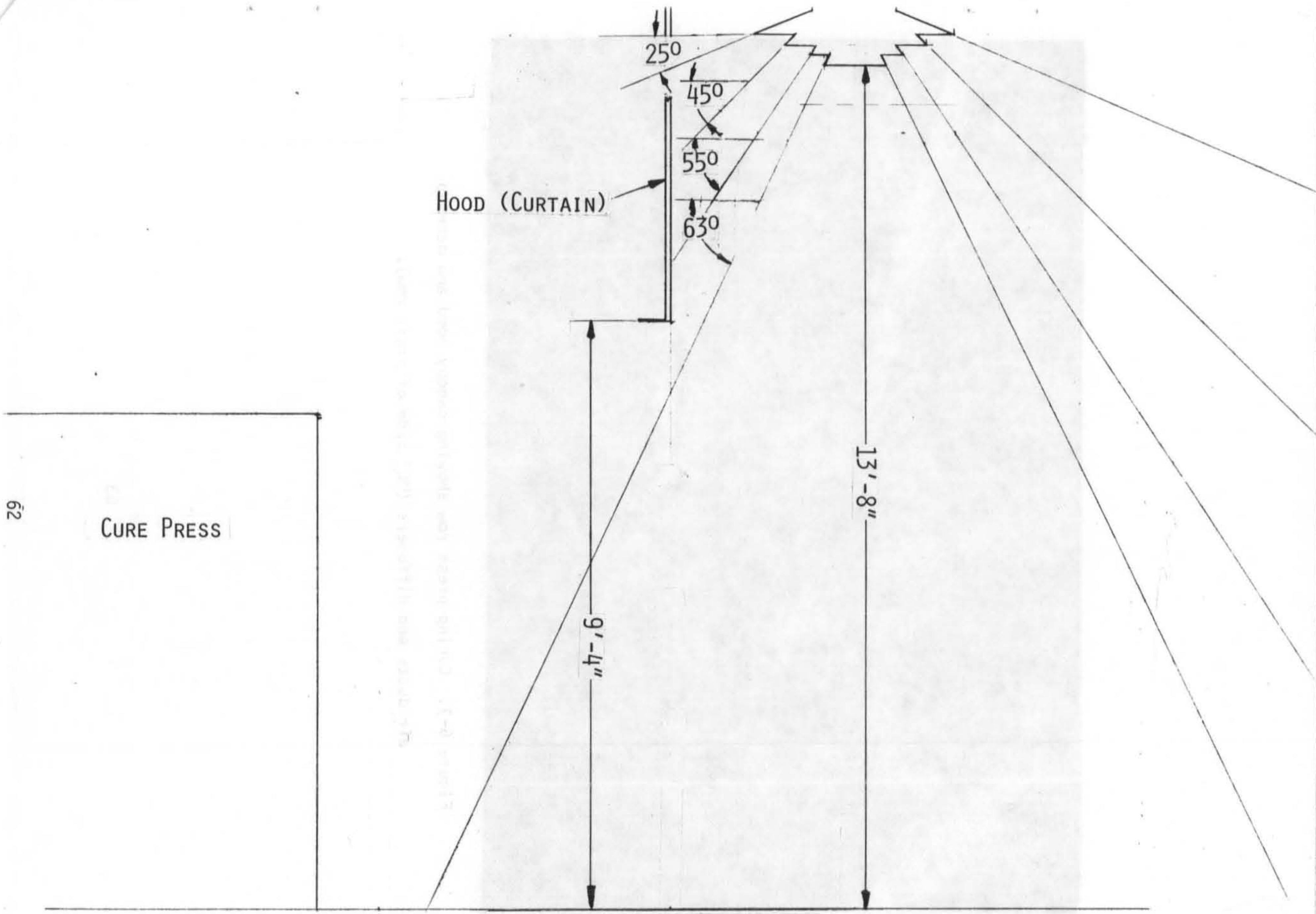


Figure 6-2. Curing Press Row Elevation Showing Make Up Air Diffuser Angles and Location Relative to Hood.

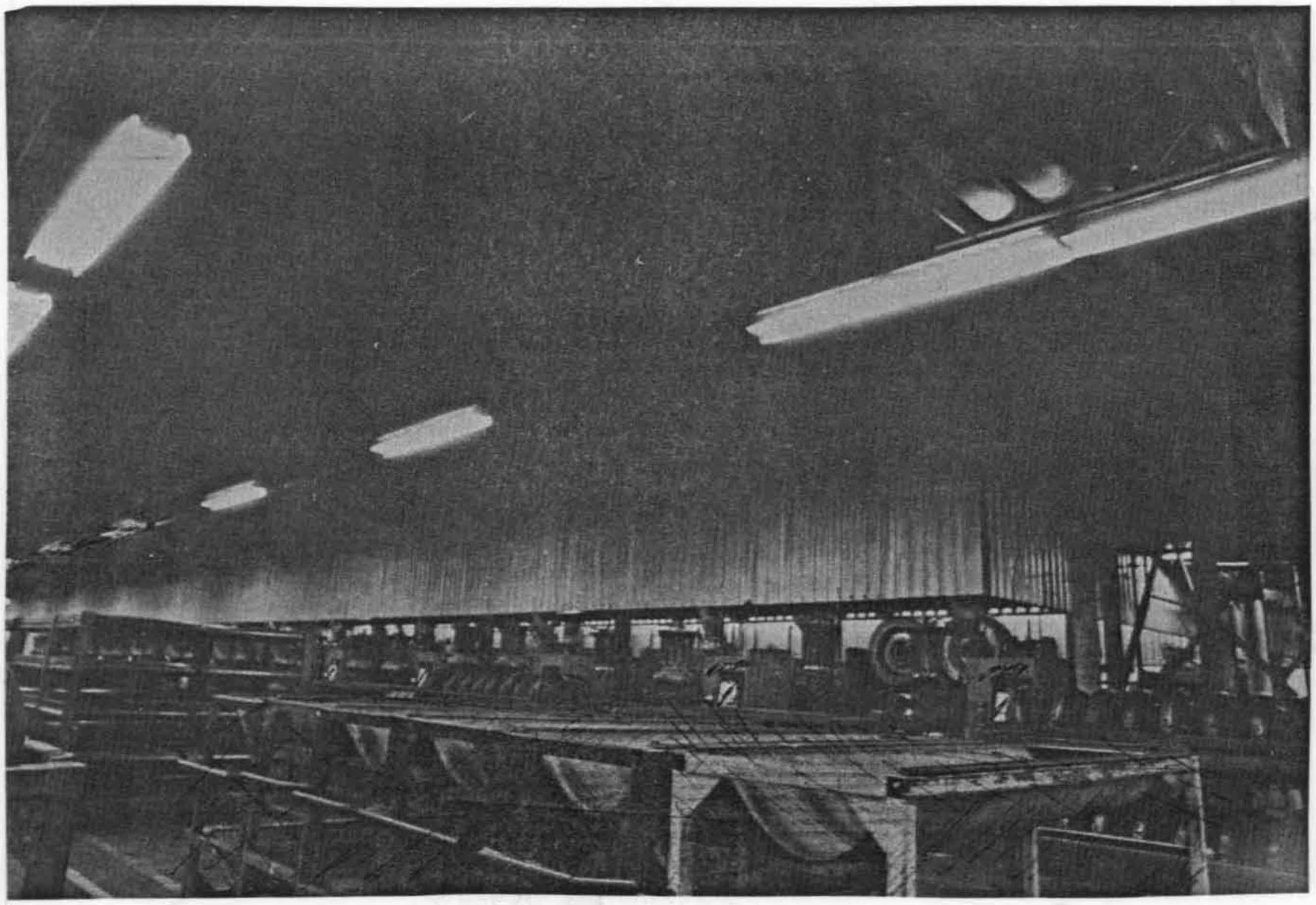


Figure 6-3. Curing press row showing canopy hood and make-up air ducts and diffusers ("L" side of press row).

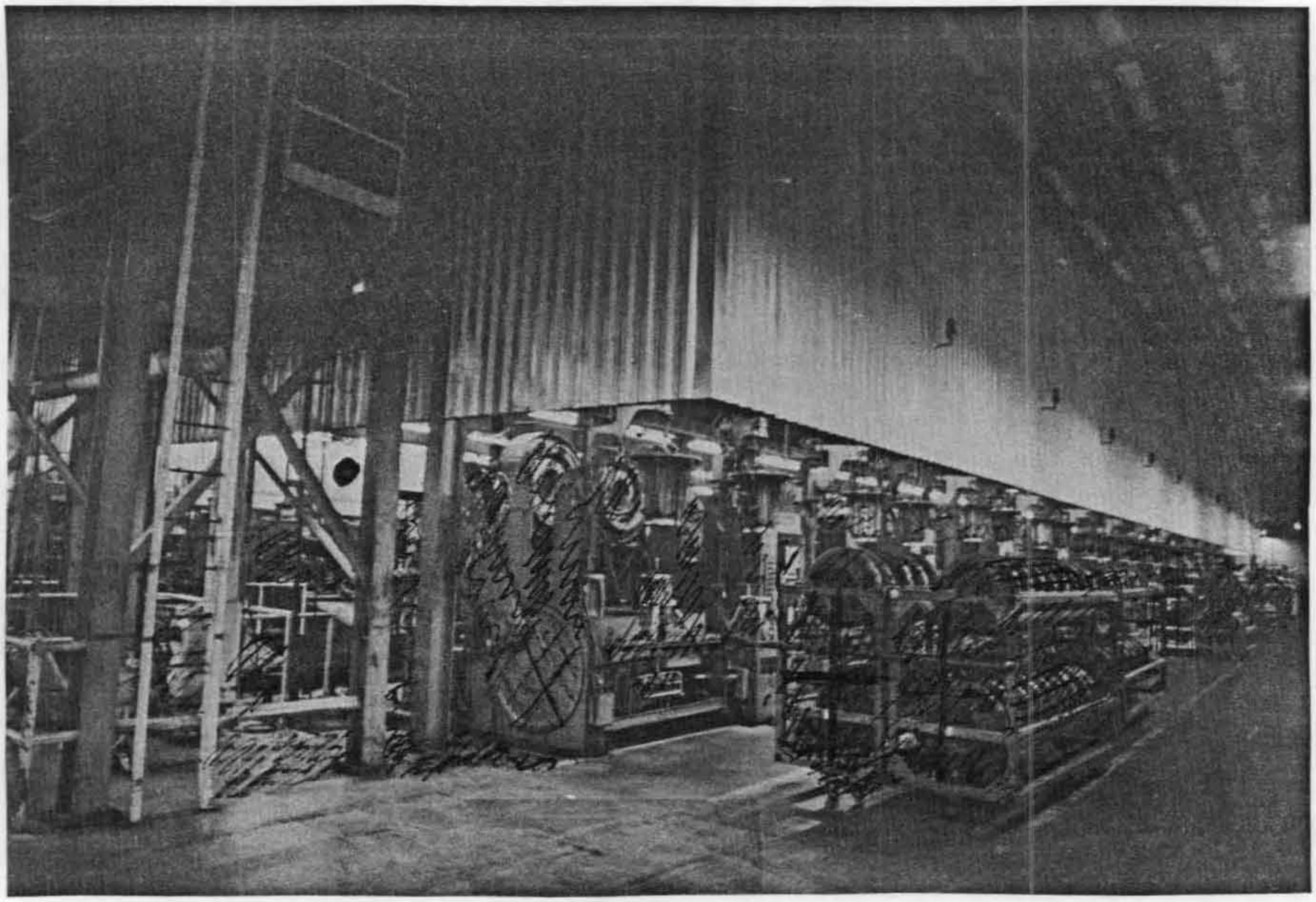


Figure 6-4. Curing press row showing canopy hood and press trouble lights ("R" side of press row).

Figure 6-5. Curing press row showing inside of canopy hood.

placed in the mold. The latter worker also cycled new bladders prior to their being placed in operation.

The normal location for both workers is between the front of the curing presses and the hood's face. Correcting tire jams requires the worker to go to the conveyor at the back of the presses.

AIR SAMPLING DATA

Limited samples were available for analysis because of a shutdown in curing operations and because several samples lost weight which made them unusable. Total particulate area samples were collected at the positions shown in Figure 6-6. Also, total and respirable particulate samples were collected on the worker vacuuming the molds. The results of these samples are summarized in Table 6-1 and detailed in Appendix II. Because of the limited sampling data, a meaningful statistical analysis of the data could not be performed.

Table 6-1. Full shift particulate concentrations for curing press row.

Location (Number from Fig. 6-6)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Total Particulate:					
Press L4, front (18)	3	0.09	1.3	0.09	0.07-0.12
Press L3, back (19)	1	0.09	--	--	--
Press R4, front (20)	1	0.09	--	--	--
Press L9, front (22)	1	0.12	--	--	--
Press L8, back (23)	2	0.11	1.4	0.12	0.09-0.14
Press R9, front (24)	1	0.12	--	--	--
Worker	1	0.12	--	--	--
Respirable Particulate:					
Worker	1	0.05	--	--	--

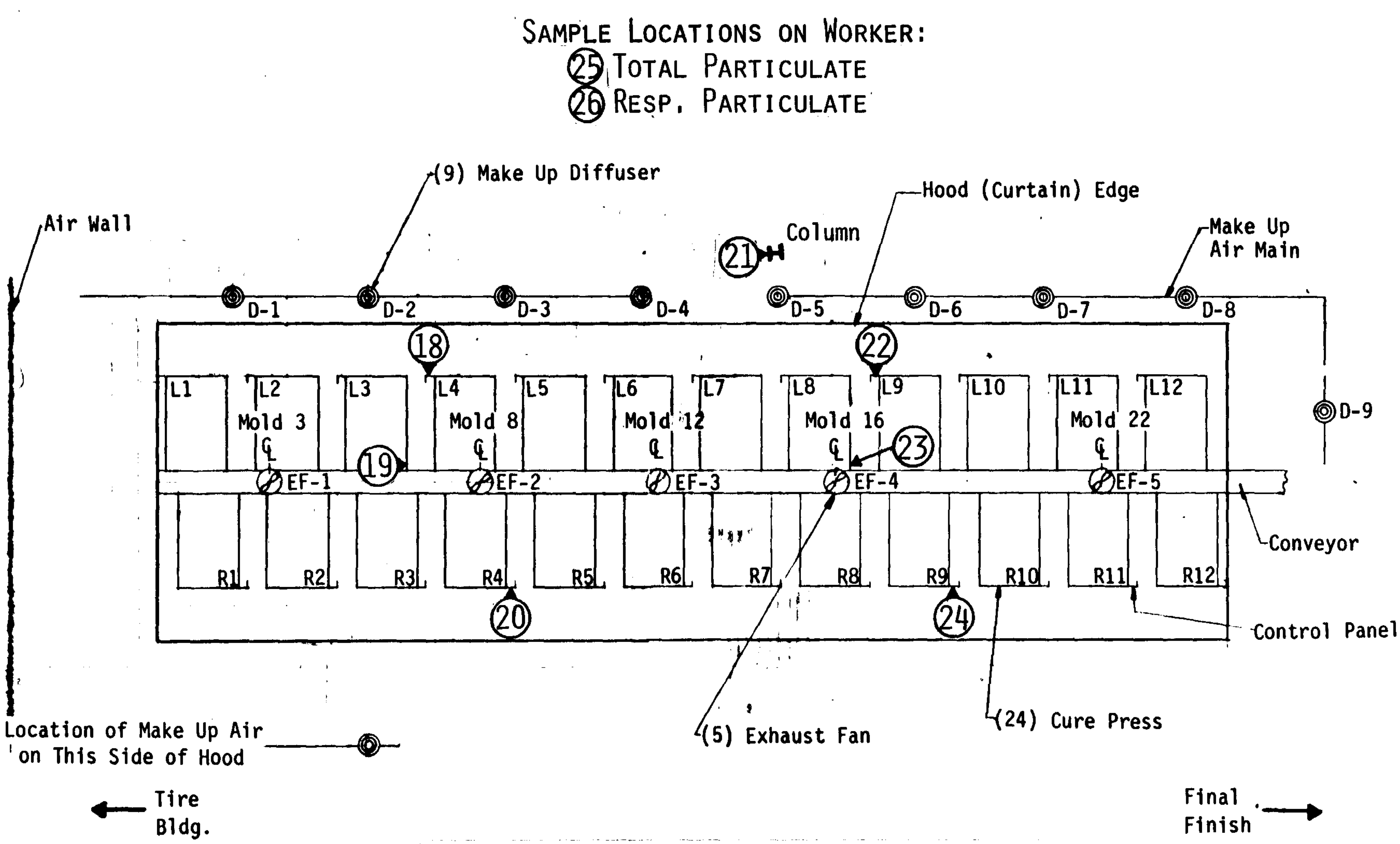


Figure 6-6. Sample locations for curing press row.

VENTILATION DATA

The ventilation measurements are summarized in Table 6-2 and shown in Appendix IV, Figure 6-7, 6-8, and 6-9. Special conditions under which measurements were made are indicated in Figure 6-7.

Table 6-2. Curing room ventilation data.

Measurement	Measured	Design
Calculated exhaust fan flow:		
EF-1	26,950 cfm	26,200 cfm
EF-3	28,595 cfm	26,200 cfm
Total calculated hood flow:	138,875 cfm	131,000 cfm
Avg. outlet velocity of make-up air:		
D-1	855 fpm	unknown
D-4	2,410 fpm	unknown
Makeup airflow:		
Each diffuser	a	7,540 cfm
Total flow for D-1 to D-8	a	60,320 cfm
Hood average face velocity:[b]		
"L" side (next to make-up air)	50 fpm	not available
"R" side (opposite make-up air)	30 fpm	not available
End sides	40 fpm	not available
Dimensions:		
Distance from control panel face to hood face:		5 ft.-9 in
Height of hood edge from floor:		9 ft.-4 in
Calculated hood volume:		94,752 ft^3

a. Insufficient data taken to calculate flow.
b. See noted conditions in Figure 6-7.

EMISSIONS 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.

WORK PRACTICES OBSERVATIONS

The worker vacuuming the molds had to position his face over the mold to perform his duties. However, sufficient time was allowed between discharge of the tire and the cleaning operation so that visible emissions were not observed at the mold.

ENGINEERING CONTROLS OBSERVATIONS

These observations were made:

1. No visible emissions were observed leaking from the hood.

2. Because of the low curtain height, press trouble indicator lights were diffcult to see. The plant resolved this problem by placing the lights outside of the hood as shown in Figure 6-4.

3. Make-up air that is provided for the left press row appears to increase the face velocity of the hood, as shown in Table 6-2 under "Hood average face velocity."

MONITORS OBSERVATIONS

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

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

No personal protective equipment was noted.

DATA INTERPRETATION

Because of limited air sampling, definite statements about the hood's ability to control curing fumes are impossible. But, no visible emissions were observed escaping the hood indicating that the hood may effectively control the emissions.

CEMENT HOUSE (7)

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 in the middle of the room.

3. Solid materials are either stored in bags or boxes on pallets or in upright 55-gallon drums along the walls of the cement house. Processed rubber is also stored on pallets along the walls.

4. Heavily used mixtures, such as cements and mold lubricants, are blended in mixing tanks and then piped into holding tanks. From the holding tanks, these mixtures are poured into plummer tanks (a small capacity, enclosed transport tank) which are used to transport them into the plant. Plummer tanks which are 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 7-1. A general view of part of the cement house is shown in Figure 7-2.

Cements and other high volume materials are blended either in large (about 250 gallon) enclosed mixing tanks. Stationary cowl mixers (motor, mixing blade, and tank lid) are used to mix materials in 55-gallon drums as shown in Figures 7-3 and 7-4.

Specifications:

EF-1 (exhaust fan):
Aerovent VW 384B
15HP TEFC Motor
27000 cfm @.5" w.g.

E-1 to E-6 (general exhaust vents):
Titus 30GLS-5 OBD
30"w x 24"h
14" above floor.
Rated 2250 cfm.

E-7 to E-8:
Same as E-1 to E-6 except 16'-0" above floor.

E-8 to E-12:
Same as E-1 to E-6 except 14'-0" above floor.

H-1 to H-10 (local exhaust hoods):
Details shown in Figures 7-5 and 7-6.

MU-1 (make up air unit):
Rated 12850 cfm-no other specs. known.
Also supplies tire bldg. area.

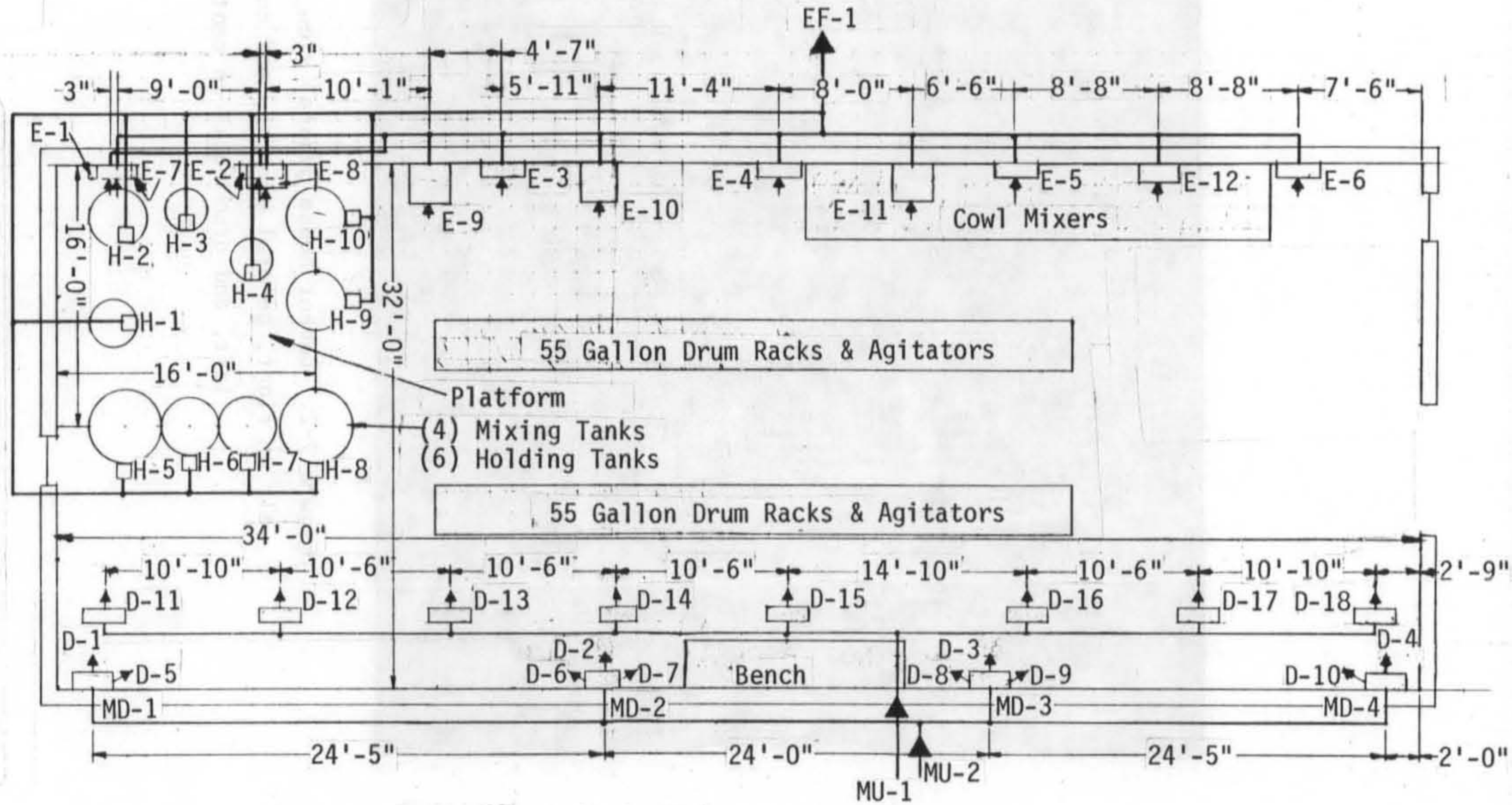
MU-2:
Aerovent VW 333B
7.5HP TEFC Motor
12850 cfm @ 1.25" w.g.

D-1 and D-4 (make up air diffuser):
Titus 272FS 45° deflection damper
30"w x24"h
14" above floor .
Rated 2880 cfm.

D-2 and D-3:
Same as D-1 and D-4 except 18"h and rated 2215 cfm.

D-5 to D-10:
Same as D-1 and D-4 except 12"w x 12"h, 17" above floor,and rated 443 cfm.

D-11 to D-18:
Specs. unknown except 30"w x 18"h
14'-0" above floor.



Notes: Dimensions on exhaust and make up air diffusers are ℄ to ℄.
All motors are located out of duct air streams and are spark proof.

Figure 7-1. Cement house layout and ventilation system specifications.

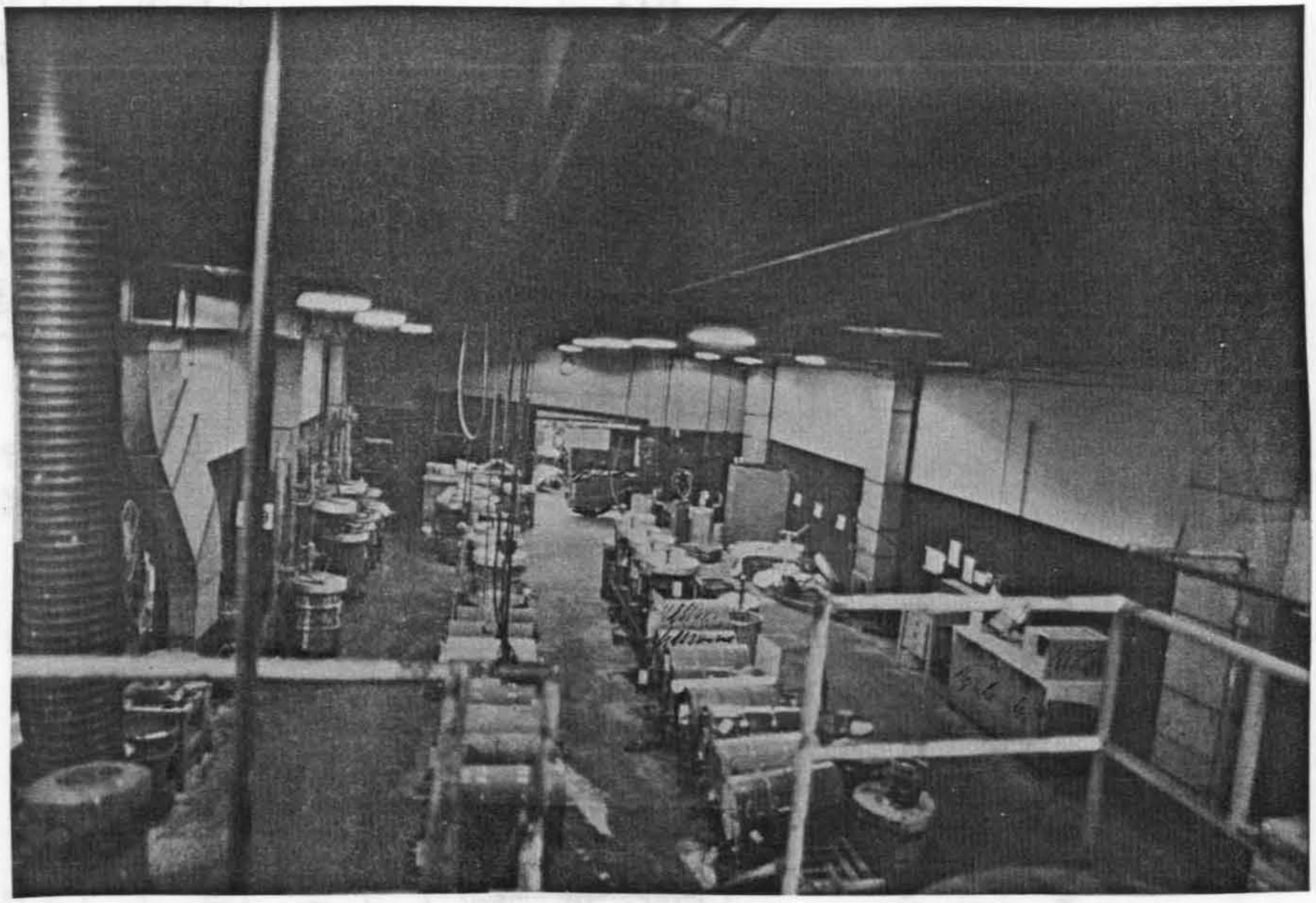


Figure 7-2. Cement house general view showing makeup air on right, general exhaust, and cowl mixers on left, and drum racks in center.

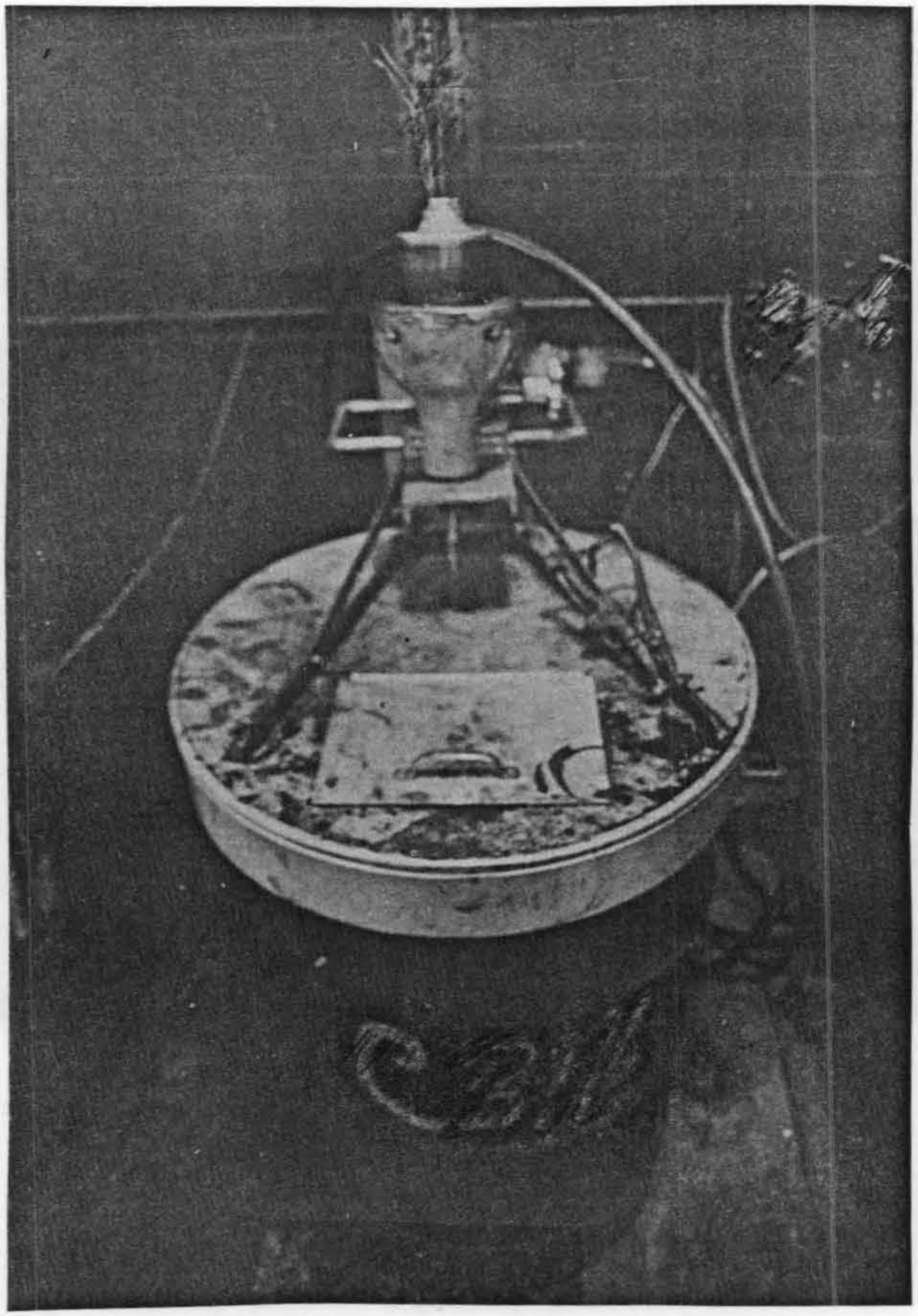


Figure 7-3. Cement house cowl mixer showing motor, blade shaft, and lid. Note door in lid.

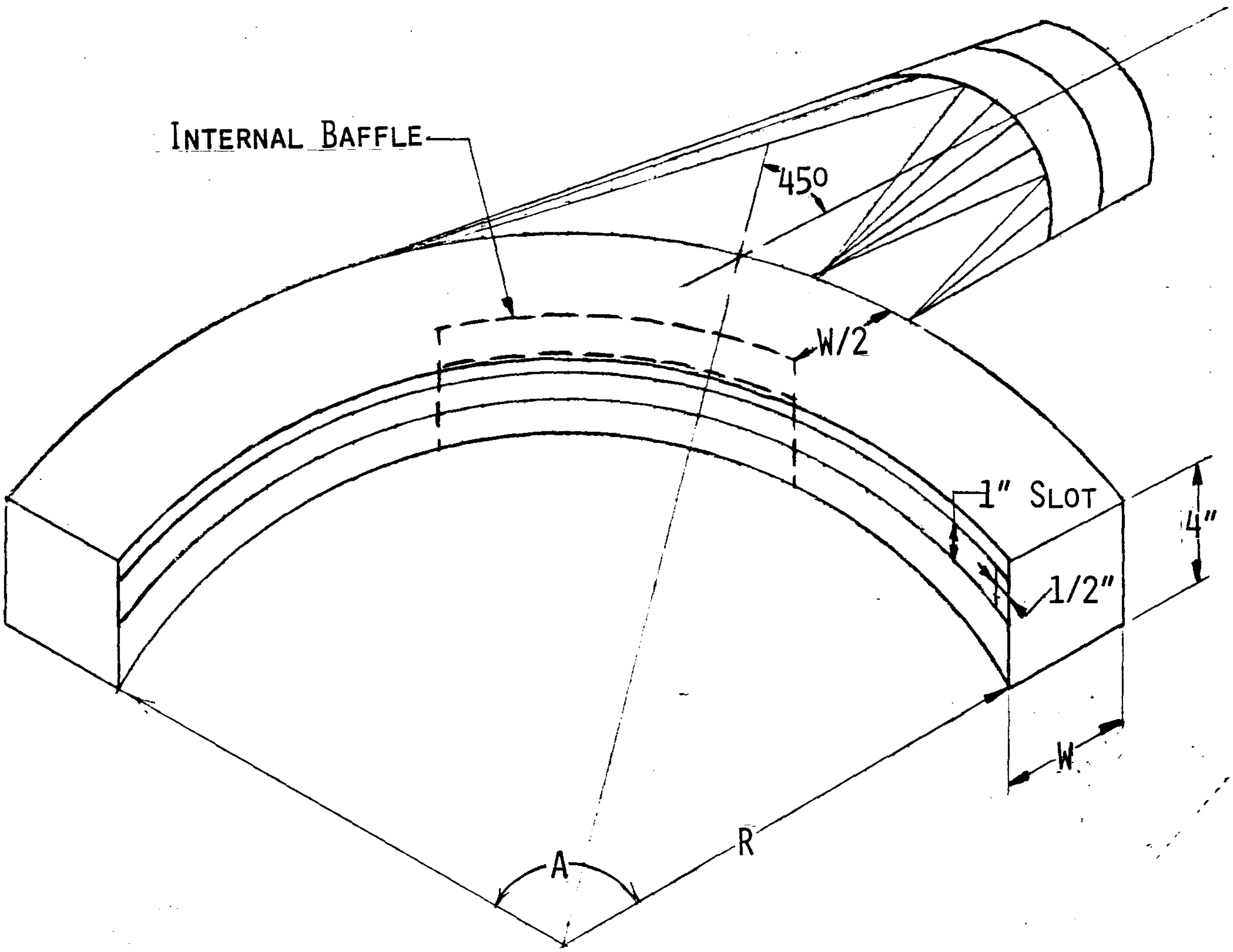
Figure 7-4. Cement house showing cowl mixers to right, and agitators and drum racks in center. Also, note palletted materials.

Distribution of the materials from the cement house to the plant is accomplished via several modes depending on the material. Two of these were observed to be the plummer tanks and plunger pots. The plunger pots usually contain naphtha for use in tire building. They are placed on a cart and filled directly from a supply line. After filling they are transported to the plant for use.

The ventilation system in the cement house is a combination of local and general exhaust with makeup air as shown in Figure 7-1. The system was installed in the mid-seventies. The local exhaust is provided by hoods located at the large mixing tanks openings and at the holding tanks outlets as shown in Figures 7-5, 7-6, and 7-7, respectively.

The general exhaust/makeup air system was designed to provide a sweeping motion across the cement house. To do this, the plant located exhaust inlets and make up air outlets on opposite walls in the cement house. The locations of the outlets and inlets are shown in Figures 7-1 and 7-2. The exhaust inlets are perpendicular to the cement house wall as shown in Figure 7-8. The floor level makeup air outlets (D-1 to D-10 in Figure 7-1) are located on all of the open faces of the makeup air duct as shown in Figure 7-9. Adjustable diffusers on the makeup air outlets allow the makeup airflow pattern to be altered. The upper level makeup air outlets (D-11 to D-18 in Figure 7-1) are perpendicular to their adjacent wall. They also have adjustable louvres.

Originally, the only part of the exhaust/makeup air system that existed was the upper makeup air outlets. The lower makeup air outlets, general exhaust system, and local exhaust hoods were installed in the mid-seventies. The upper makeup air is supplied by a system that also supplies other areas of the plant. Since the installation of these new parts of the system, no notable changes have occurred.



HOOD	A	R	W
H-1	85°	11"	4"
H-2	120°	12"	4"
H-3	24"L	--	4"
H-4	90°	16"	3"

Figure 7-5. Cement house large mixing tank opening hood detail.

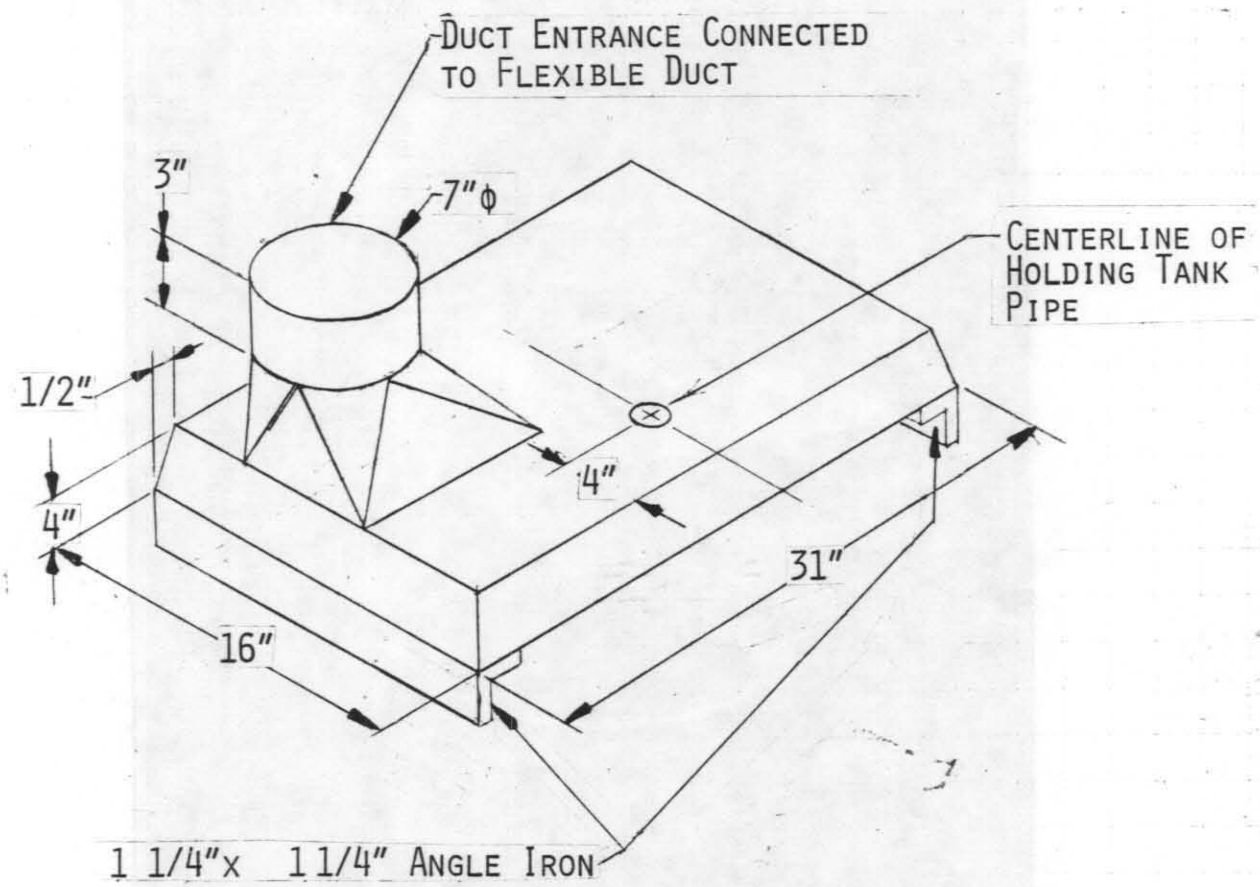


Figure 7-6. Cement house holding tank outlet hood (H-5 through H-10) detail.

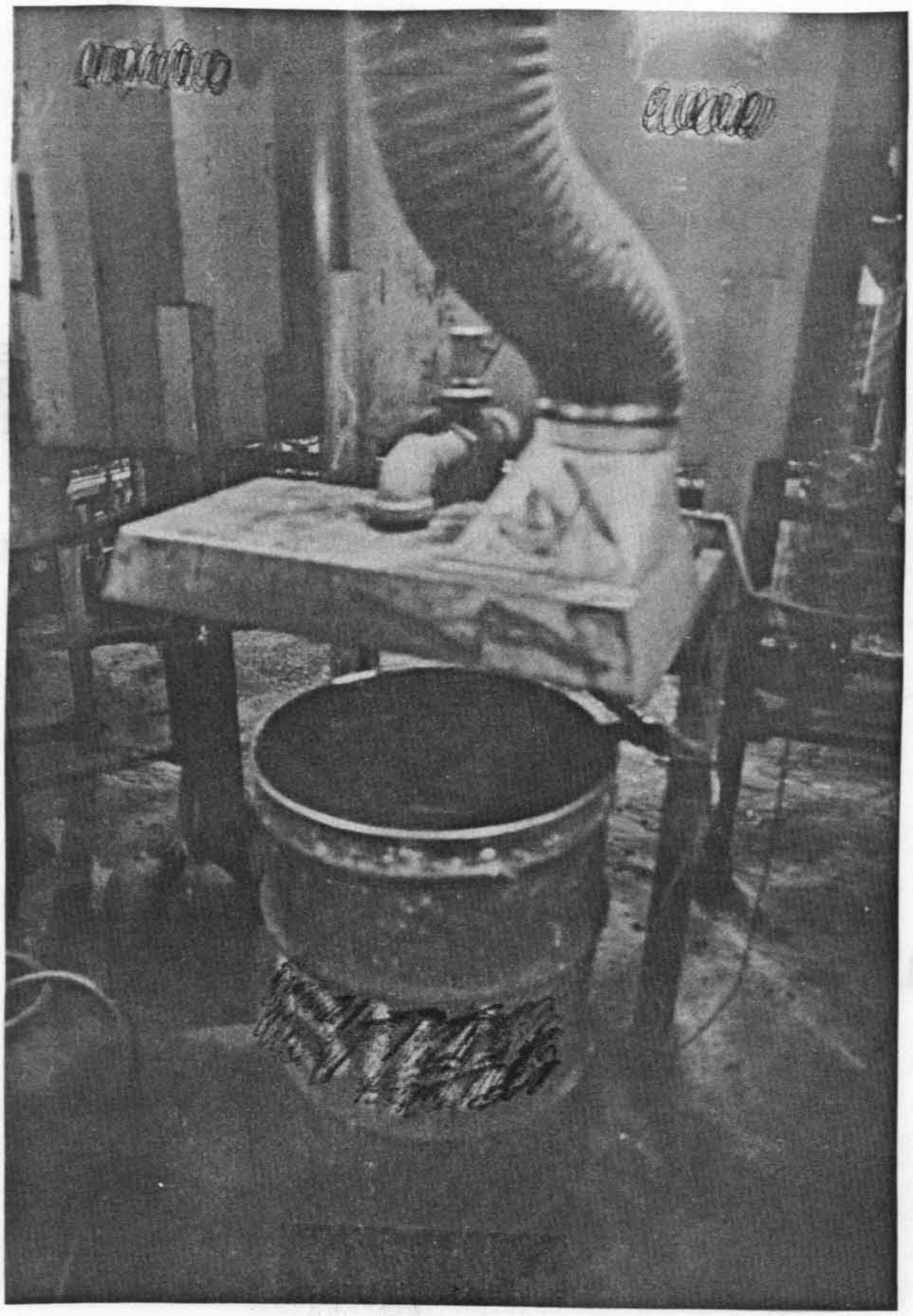


Figure 7-7. Cement house holding tank outlet
hood and plummer tank.

Figure 7-8. Cement house general exhaust inlets and powered compound storage and weighing area.

Figure 7-9. Cement house makeup air outlets. Note grills on front and sides. Also shown are palletted rubber and agitators.

WORKERS DUTIES

Only one worker per shift is allowed into the cement house - all other workers are forbidden access to the area. During the study, the cement house worker spent four hours performing the duties associated with the cement house. Of these four hours, about one hour was spent outside the cement house delivering materials to other areas.

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 or with the cowl mixers.

The mixing in the large, enclosed tank is done by:

1. The tank is half-filled with solvent.

2. The mixing blade is started.

3. Solid ingredients are added through the door on top of the mixer. Typical ingredients include uncured rubber, carbon black, or mold release agent, depending on the recipe.

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

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

Mixing with the cowl mixers is done by:

1. The appropriate 55-gallon drum is placed into positon under the cowl mixer.

2. The cowl mixer is lowered into position. A lid fixed to the cowl mixer covers the 55-gallon drum as shown in Figure 7-3.

3. The mixer is started. Additional ingredients can be added to the material in the drum through a door in the cowl mixer lid.

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

5. The drum is removed and covered.

Safety containers are filled by opening valves on 55 gallon drums and allowing the liquid to flow into them. However, filling the plummer tanks is slightly different. These tanks are normally filled with material stored in the holding tanks unless a special recipe requires mixing on the cowl mixers. To fill the plummer tanks, the worker positions the tank beneath the holding tank outlet and opens the outlet valve. When the tank is filled the valve is shut. A lid is then placed on the tank and it is moved to the appropriate area of the plant or placed on an agitator line in the cement house.

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

AIR SAMPLING DATA

Area charcoal tube samples were collected at the location shown in Figure 7-10. Also, charcoal tube samples were collected on the cement house worker. The samples were collected only during the time the worker was on duty (4 hours per shift) and 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, and total petroleum distillate. The results of the analysis are summarized in Table 7-1 and detailed in Appendix II. Based upon analysis of variance, sampling location did not affect petroleum distillate concentration.

Table 7-1. Partial shift sample results for the cement house.

Location (No. from Figure 7-10)	N	GM (mg/m^3)	GSD	AM (mg/m^3)	Range (mg/m^3)
Petroleum Distillate:					
Holding tank outlet (14)	3	150	1.2	132	72-172
Drum rack (15)	3	93	2.0	110	48-192
Next to cowl mixers (16)	3	164	1.8	183	110-309
Worker	3	157	1.4	163	106-215
Toluene:					
Holding tank outlet (14)	3	2.7	1.7	3.0	1.5-4.2
Drum rack (15)	3	1.4	1.4	4.2	2.9-5.3
Next to cowl mixers (16)	3	1.5	1.4	4.6	3.1-6.0
Worker	3	4.1	1.4	5.0	3.5-6.0
Benzene:					
Not detected at a detection limit of 0.3 mg/m^3.					

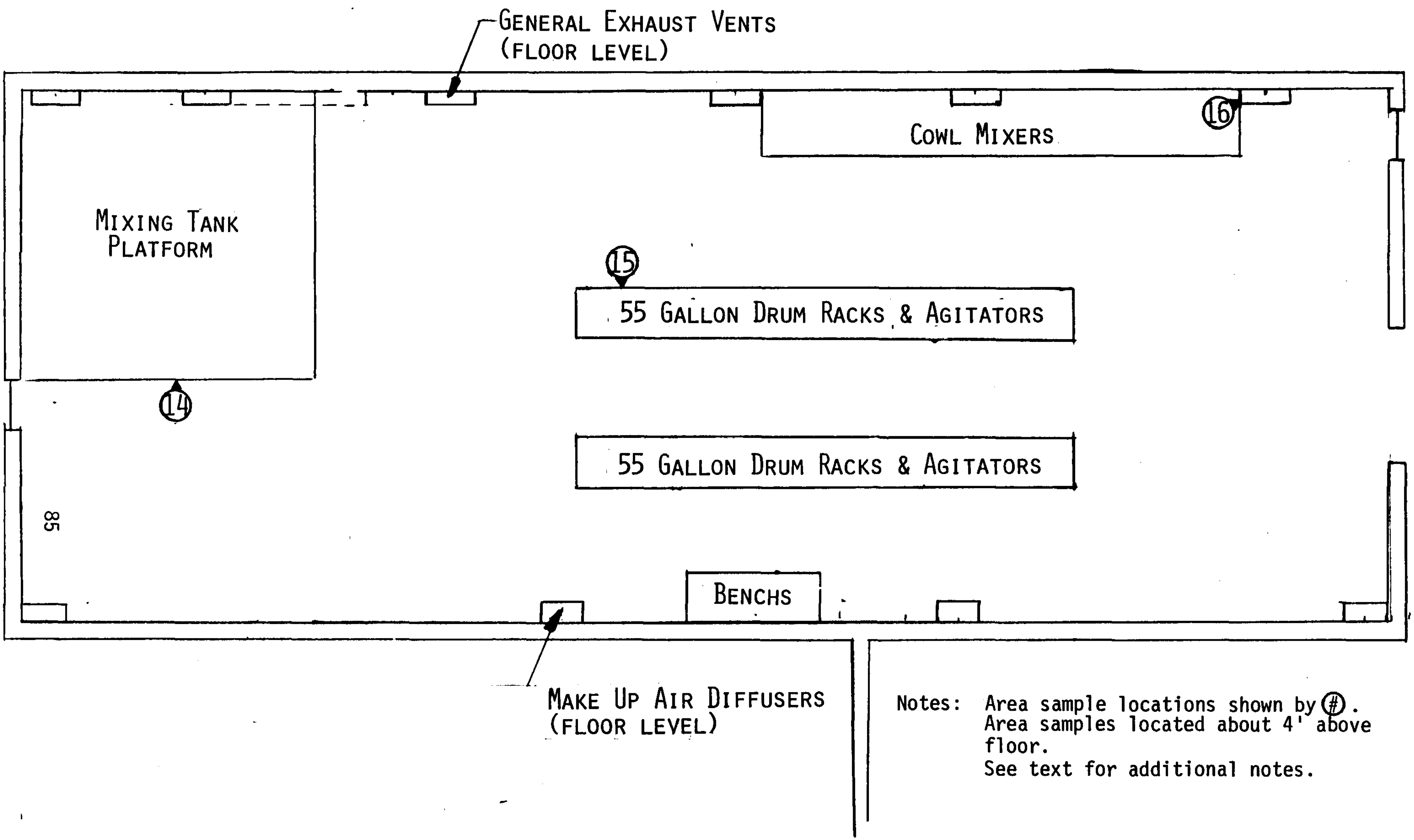


Figure 7-10. Cement house sample locations.

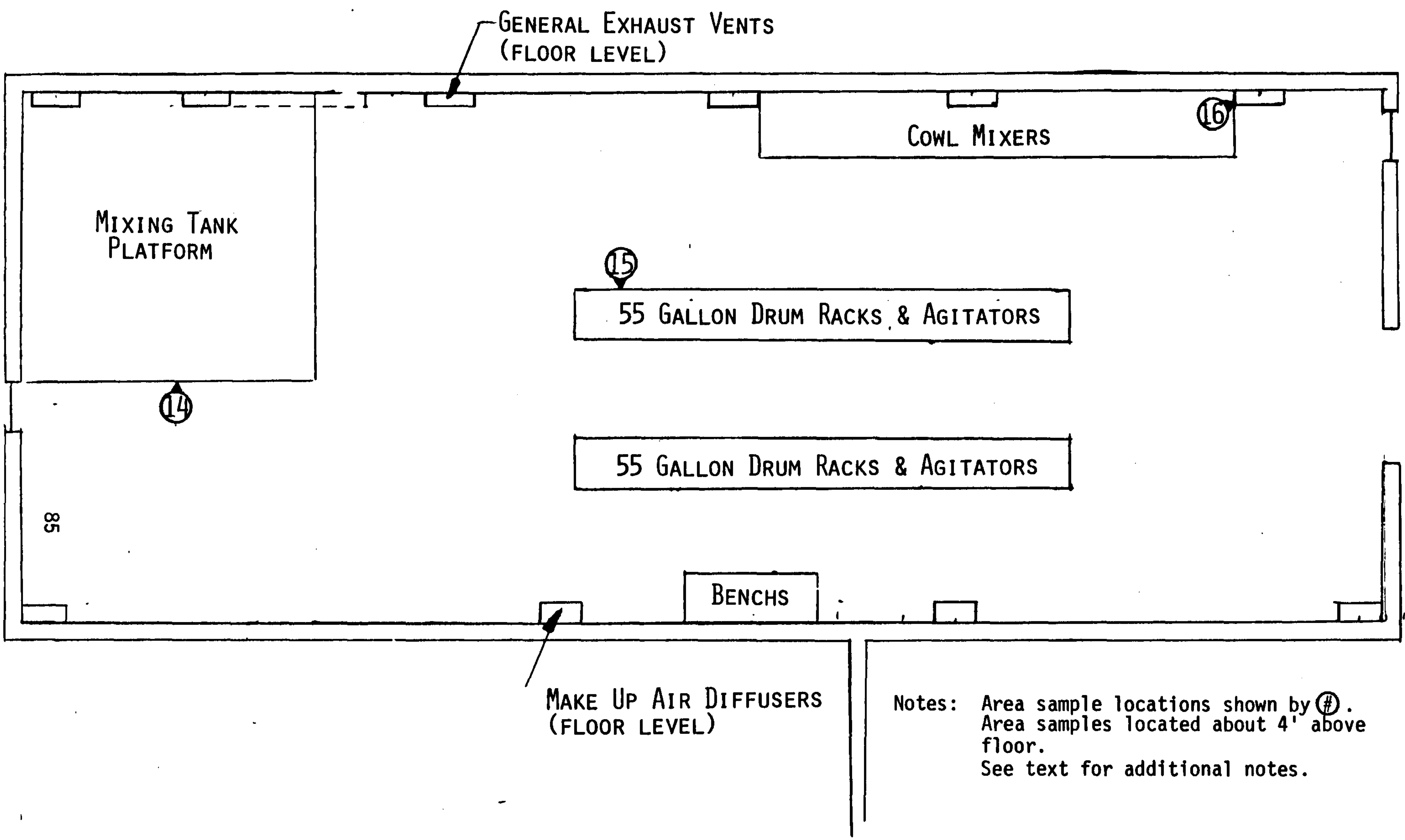


Figure 7-10. Cement house sample locations.

VENTILATION DATA

Ventilation measurements were made on two make-up air ducts, two exhaust inlets, and two holding tank outlet hoods. Also, cursory checks with an anemometer and smoke tubes were made at the opening of the large mixing tank hood; the airflow into the hood was judged inadequate, so detailed measurements on the hood were not performed.

The ventilation measurements are summarized in Table 7-2 and presented in Appendix IV, Figures 7-11 and 7-12. Measurements from the exhaust inlet are not presented because they were judged to be inaccurate. Special conditions under which the measurements were taken are indicated in the figures.

Table 7-2. Cement room ventilation data.

General Ventilation	Measured	Design
Make-up Air:		
Average duct velocity:		
MD-3	1,225 fpm	1,070 fpm
MD-4	805 fpm	1,145 fpm
Calculated duct flow:		
MD-3	3,575 scfm	3,100 cfm
MD-4	2,345 scfm	3,325 cfm
Average	2,960 scfm	3,215 cfm
Duct static pressure:		
MD-3	0.18 in H_2O	Not available
MD-4	0.04 in H_2O	Not available
Exhaust Air		
Duct static pressure:		
Duct to vent E-3	0.51 in H_2O	Not available
Holding Tank Outlet Hoods		
Hood H-8 average face velocity	70 fpm	Not available
Hood H-6 average face velocity	235 fpm	Not available

EMISSION SOURCES OBSERVATIONS

The emissions in the cement house are vapors from the solvents used in the materials and other volatile materials, and dusts from solid materials. Specific sources noted were:

1. Evaporation of materials in open containers such as empty plummer tanks or buckets used to catch leaking material.

2. Evaporation of materials leaking from valves.

3. Evaporation of material through open doors on mixing or holding tanks.

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

5. Evaporation of spilled materials.

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

7. Dust entrained in air from spills or resulting from spilled material.

8. Evaporation from material adhering to machine parts such as the cowl mixer blades.

WORK PRACTICE OBSERVATIONS

These good work practices were noted:

1. Covering table tops upon which mixing or pouring of material were performed with plastic-backed paper.

2. Covering tanks filled with materials.

3. Spacing pallets of materials and cement house furniture a sufficient distance away from makeup air outlets so the airflow pattern was not disturbed or blocked. Moreover, this distance was marked by a line on the wall. During a prior visit to the plant furniture had been found blocking these outlets in the cement house - the plant had corrected the situation at the time of this visit.

4. Placing catch buckets under leaky valves on 55-gallon storage drums.

5. Limiting access to the cement house. Only one worker is allowed in the cement house each shift. This worker was under the observation of his supervisor. This worker's sole job was performing operations in the cement house. He was well trained in handling the cement house materials. A chain across the door and a sign serve as reminders to other workers that admittance is restricted.

These improper work practices were noted:

1. Not cleaning up numerous liquid and dust spills. These primarily were under the large mixing tank platform, under the valves on three 55-gallon storage drums, and around solid compound storage containers (55-gallon drums and palleted bags).

2. Not repairing leaky valves on 55-gallon storage drums.

3. Not emptying catch buckets under 55-gallon storage drums. They were sometimes allowed to overfill and spill on the floor. The catch buckets also did not have lids.

4. Damaging the grill on one makeup air outlet apparently from hitting it with something.

5. Not covering trash containers which contained solvent-soaked garbage.

6. Not covering empty plummer tanks.

7. Not repairing split bags on pallets. This allowed their contents to spill on the floor or other bags.

ENGINEERING CONTROL OBSERVATIONS

These observations were made about the ventilation system:

1. The outlets for the make up air and the inlets for the exhaust air were located over one foot above the floor. This would prevent material from getting stuck to the grilles and reduce the chance for damage to them.

2. Most of the potential solvent spill areas in the cement house are located near the exhaust side of the cement house.

3. Most of the exhaust system was designed like a make up air system. This could increase the static pressure in the system due to the many right angle entrances and large angle expansions. The fan is designed to operate at 1/2-inch water pressure.

4. The hoods on the mixing tank openings, although judged to be well constructed, did not provide significant exhaust.

5. The hoods on the holding tank outlets were designed such that the air distribution was not uniform across the hood face - possibly a result of the location of the duct entrance on the hood.

6. Air streams in the cement house, caused by the make-up air system and drafts into the cement house through openings in the walls resulted in turbulence beneath the holding tank outlet hoods. This was noted during measurements of the capture velocity for the hood.

7. Plastic streamers on the grilles of the upper make up air system outlets showed little airflow from the outlets.

8. Flexible ducting was used to connect the holding tank outlet hood to the main. Flexible ducts inherently increase static pressure. In addition, some of these ducts were too long which created artificial elbows in the system and thus another pressure increase. Use of permanent metal ducting for this application may be a feasible alternative.

These observations were made about other engineering controls in the cement house:

1. Lids to fit 55-gallon drums were fixed to the cowl mixers so the worker would not forget to cover the drum.

2. The plummer tank lids did not clamp down tight on the tank. This could be a source for leaks.

3. The distance from the end of the holding tank outlet pipe to the top of the plummer tank was about 8-inches. It appeared this distance could be reduced.

MONITORS OBSERVATIONS

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

PERSONAL PROTECTIVE EQUIPMENT OBSERVATIONS

Workers wore gloves.

DATA INTERPRETATION

Workers can be directly exposed to solvent vapors generated from filling and mixing operations. Spills and leaks from the various tanks can generate solvent vapors into the general room air elevating background concentration levels. The worker's time near sources of direct exposure is minimal, since he only needs to be near these sources while he is starting the mixer operation, adding materials to the mixers, or filling containers. The majority of his time is spent delivering materials or checking the machinery. Therefore, the worker's exposure should reflect the background levels in the cement house - the air sampling data agrees with this observation.

The local exhaust hoods on the mixing and holding tanks do not provide adequate capture velocities. Furthermore, the air velocity distribution across the latter's face is not uniform. Also, the distance from the end of the holding tank discharge pipe to the top of the plummer tank appeared to be more than necessary to reduce the emission area for the discharge stream and thus permit down-sizing of its hood.

The general exhaust and makeup air systems appear to be well designed and placed. However, the general exhaust system could be redesigned to decrease losses in the system and increase the airflow to the local exhaust hoods. The cross flow of air is believed to be the major factor in keeping low solvent concentrations in the cement house. Good work practices is another major factor.

COMPARISON TO EXISTING STANDARDS

In the portions of the tire plant studied, workers are normally 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 - dust which passes through the 10 mm nylon cyclone[2].

The Occupational Safety and Health Administration (OSHA) has established Standards and the the National Institute for Occupational Safety and Health (NIOSH) and ACGIH have recommended limits for some of the air contaminants found in tire plants. The following table lists the Standard, recommended standard, or TLV for the air contaminants that were studied in this plant:

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

Air Contaminant	OSHA PEL[10]	NIOSH Recommended Standard[11]	ACGIH TLV[12]
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

*60 minute ceiling

All particulate and vapor concentrations obtained in this study were below those specified in the above Table.

According to Fine and Peters[13], workers exposed to processing dust in tire plants have reduced lung function and increased respiratory morbidity. To prevent these problems from occurring, they recommended that worker exposure to respirable processing dusts be kept below 0.5 mg/m^3 as an 8-hour TWA.

Because mixer charging can be a dusty operation which did involve respirable dust concentrations in excess of 0.5 mg/m^3, steps should be taken to prevent such exposures.

The practice of emptying powdered materials from rigid containers into the mixer should be stopped. The use of plastic bags, which were observed at another General Tire plant in Waco, Texas should be investigated.

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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, anti-oxidants) 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 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 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 vulcanized 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

CONCENTRATION DATA

Table 1. Partial shift total particulate concentrations.
Tilt stand charging system.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Location: Surge Hopper Hood (Figure 2-3, location 1)				
11-26-79	2	332	498	0.52
11-27-79	1	409	613	0.13
11-27-79	2	178	267	0.82
Location: Surge Hopper Conveyor (Figure 2-1, location 2)				
11-26-79	2	333	500	0.40
11-27-79	1	406	609	0.13
11-27-79	2	178	267	0.94

Table 2. Partial shift particulate concentrations.
Banbury Mixer.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Charge door hood, right (Figure 4-4, location 3)				
11-26-79	2	405	608	0.43
11-27-79	1	424	636	0.13
11-27-79	2	197	296	0.27
Location: Charge door hood, left (Figure 4-4, location 4)				
11-26-79	2	342	513	0.49
11-27-79	1	424	636	0.49
11-27-79	2	194	291	1.24
Location: Column next to oil heater (Figure 4-4, location 5)				
11-26-79	2	340	510	0.27
11-27-79	1	424	636	0.28
11-27-79	2	191	287	0.21
Location: Mixer worker (Figure 4-4, Location 7)				
11-26-79	2	348	522	3.5*
11-27-79	1	426	639	1.53
11-27-79	2	198	297	0.68
Location: Discharge hood, front (Figure 4-4, location 8)				
11-26-79	2	348	522	161.**
11-27-79	1	426	639	0.61
11-27-79	2	196	294	1.93
Respirable Particulate				
Location: Mixer worker (Figure 4-4, Location 6)				
11-26-79	2	349	593	0.64*
11-27-79	1	414	704	0.25
11-27-79	2	198	337	0.24

* Worker observed jumping up and down in trash recepticle.
**Worker spilled amorphous silica on sampler.

Table 3. Partial shift particulate concentrations.
Mill

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Mill hood, left side (Figure 5-1, location 9)				
11-27-79	1	420	630	0.19
Location: Mill hood, right side (Figure 5-1, location 10)				
11-27-79	1	420	630	0.22
Location: Column next to dip tank (Figure 5-1, location 11)				
11-27-79	1	420	630	0.25
Location: Mill worker (Figure 5-1, location 12)				
11-26-79	2	341	512	0.72
11-27-79	1	420	630	0.57
11-27-79	2	163	245	0.86
Respirable Particulate				
Location: Worker Figure 5-1, location 13)				
11-26-79	2	231	393	0.32
11-27-79	1	421	716	0.26
11-27-79	2	163	277	0.61

Table 4. Partial shift particulate concentrations.
Curing press row.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m^3)
Total Particulate				
Location: Press L4, front (Figure 6-6, location 18)				
11-26-79	2	371	557	0.07
11-27-79	1	412	618	0.09
11-27-79	2	437	656	0.12
Location: Press L3, back (Figure 6-1, location 19)				
11-27-79	1	410	615	0.09
Location: Press R4, rear (Figure 6-6, location 20)				
11-27-79	1	414	621	0.09
Location: Press L9, front (Figure 6-6, location 22)				
11-27-79	1	413	620	0.12
Location: Press L8, back (Figure 6-6, location 23)				
11-26-79	2	384	576	0.09
11-27-79	1	413	620	0.14
Location: Press R9, front (Figure 6-6, location 24)				
11-27-79	1	416	624	0.12
Location: Worker cleaning mold (Figure 6-6, Location 25)				
11-27-79	1	416	624	0.12
Respirable Particulate				
Location: Worker cleaning mold (Figure 6-6, location 26)				
11-27-79	1	417	709	0.05

Table 5. Partial shift total particulate concentrations.
Cement house.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Petroleum Distillate Concentration (mg/m³)	Toluene Concentration (mg/m³)
Location: Holding tank outlet (Figure 7-10, location 14):					
11-26-79	2	147	14.26	154	4.2
11-27-79	1	201	21.51	172	1.5
11-27-79	2	210	20.27	72	3.4
Location: Drum rack (Figure 7-10, location 15):					
11-26-79	2	155	16.74	48	2.9
11-27-79	1	206	21.84	90	4.5
11-27-79	2	209	22.57	192	5.3
Location: Next to cowl mixers (Figure 7-10, location 16):					
11-26-79	2	147	16.02	131	3.1
11-27-79	1	206	21.01	309	6.1
11-27-79	2	208	22.67	114	4.8
Location: Worker					
11-26-79	2	153	14.08	106	3.5
11-27-79	1	211	22.16	170	5.5
11-27-79	2	212	19.50	215	6.0

NOTE: Benzene was not detected at a detection limit of 0.002 mg/sample. The xylene and total solvent detection limits were 0.01 and 0.03 mg/sample, respectively. Based upon 20L nominal sample size, the benzene detection limit was 0.1 mg/m^3, the toluene detection limit was 0.5 mg/m^3, and the total solvent detection limit was 1.5 mg/m^3.

APPENDIX III

VENTILATION MEASUREMENT INSTRUMENTATION

Instrument	Controls Measured
Dwyer inclined manometer w/pitot tube MN 400, Error ± 5% (Used for duct velocity traverses)	Tilt stand ventilation Kaolin slurry Mixing tank hood Mixer hoods Mill hood Cement house ventilation
Kurz hot wire anemometer MN 441 SN 474-1 Error: + 4% (0-300 fpm) + 12% (0-1250 fpm) + 14% (0-6000 fpm) (Used for slot, face and capture velocities)	All controls
Gastec (Bendix) smoke tester kit w/$TiCl_4$ tubes (Used for smoke tube traces)	All controls

APPENDIX IV

VENTILATION MEASUREMENT DATA

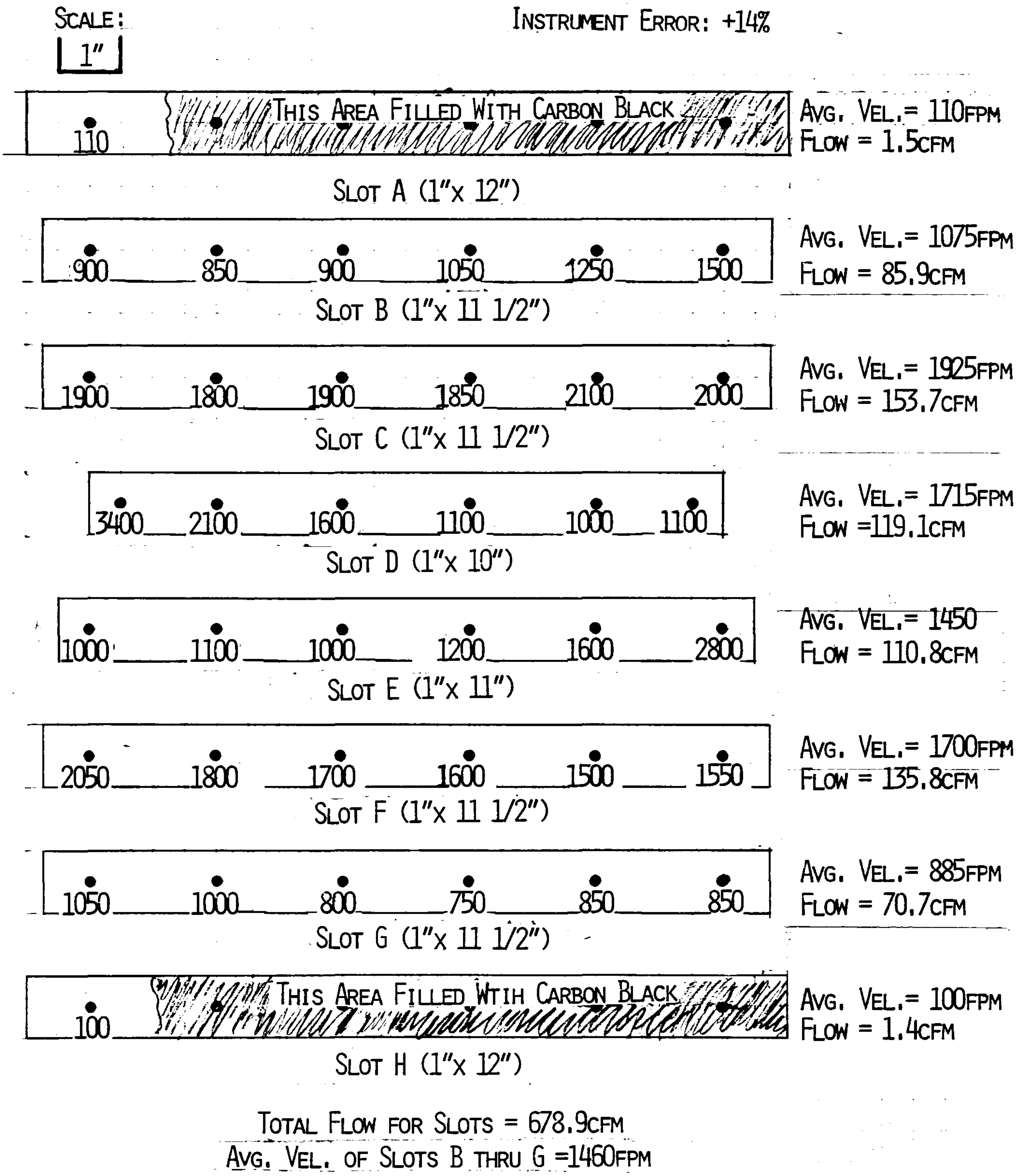


Figure 2-7. Tilt stand ventilation slot velocities.

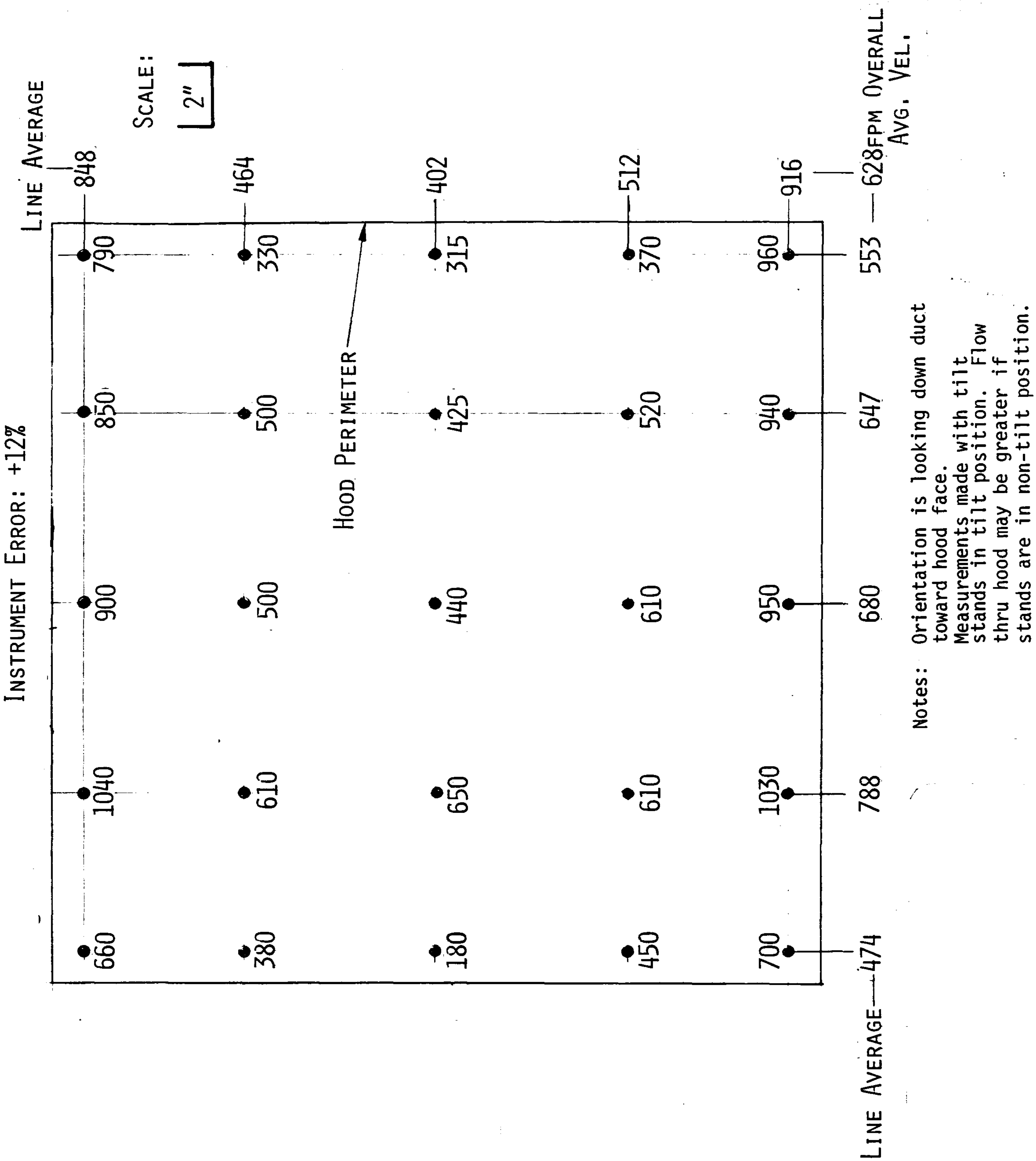


Figure 2-8. Surge hopper hood face velocities.

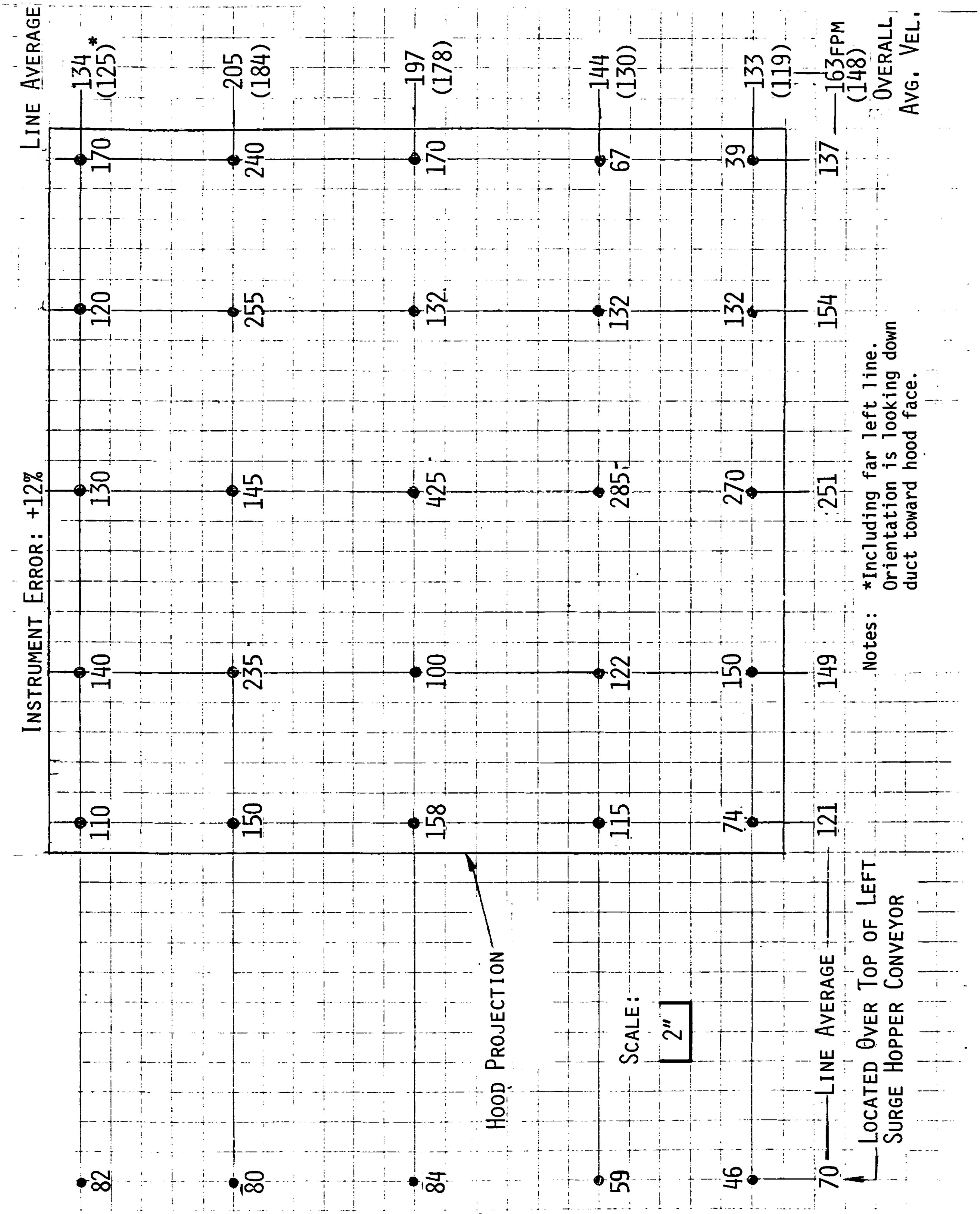


Figure 2-9. Surge hopper hood capture velocities.
(8 inches below hood face)

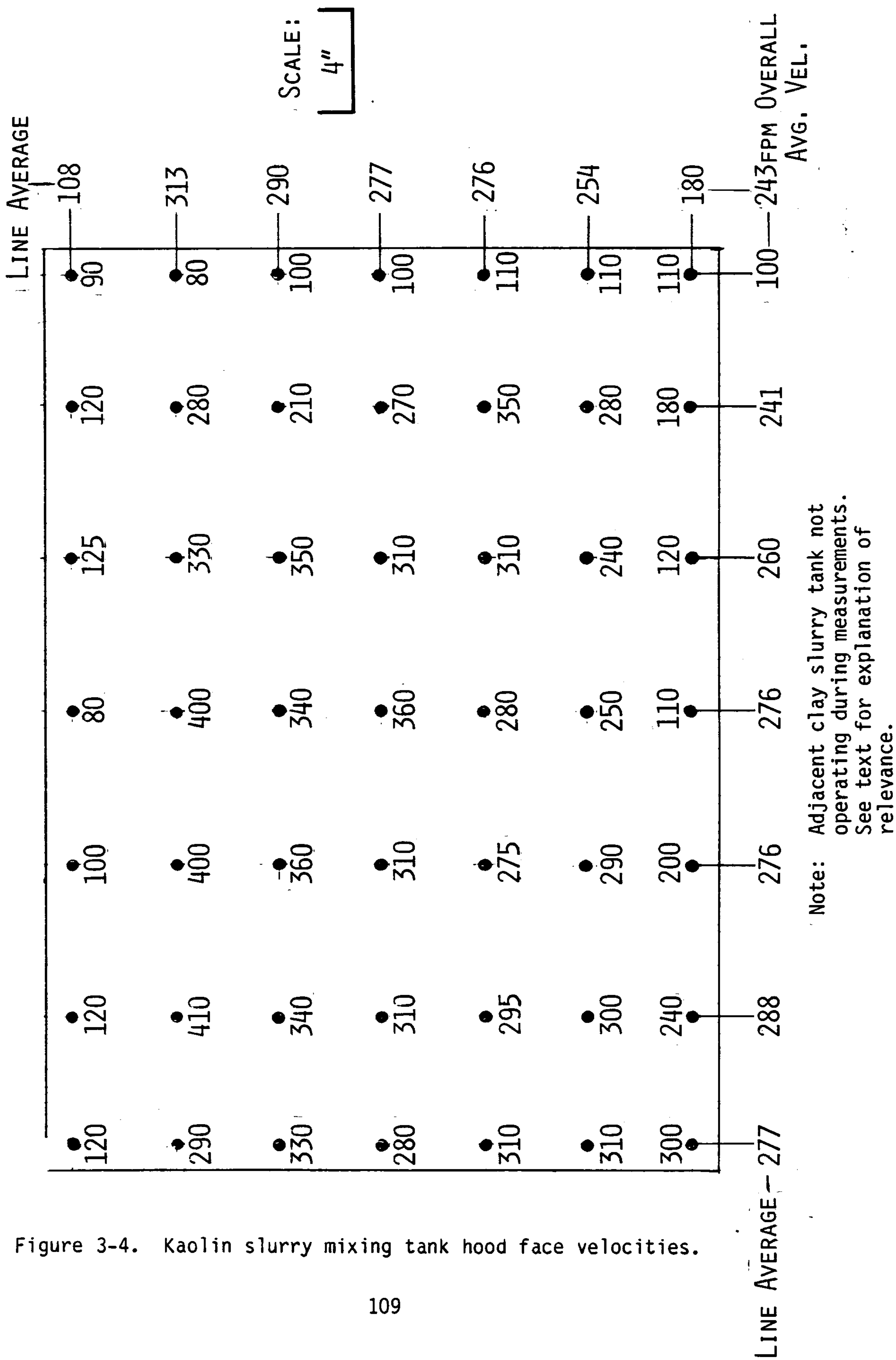
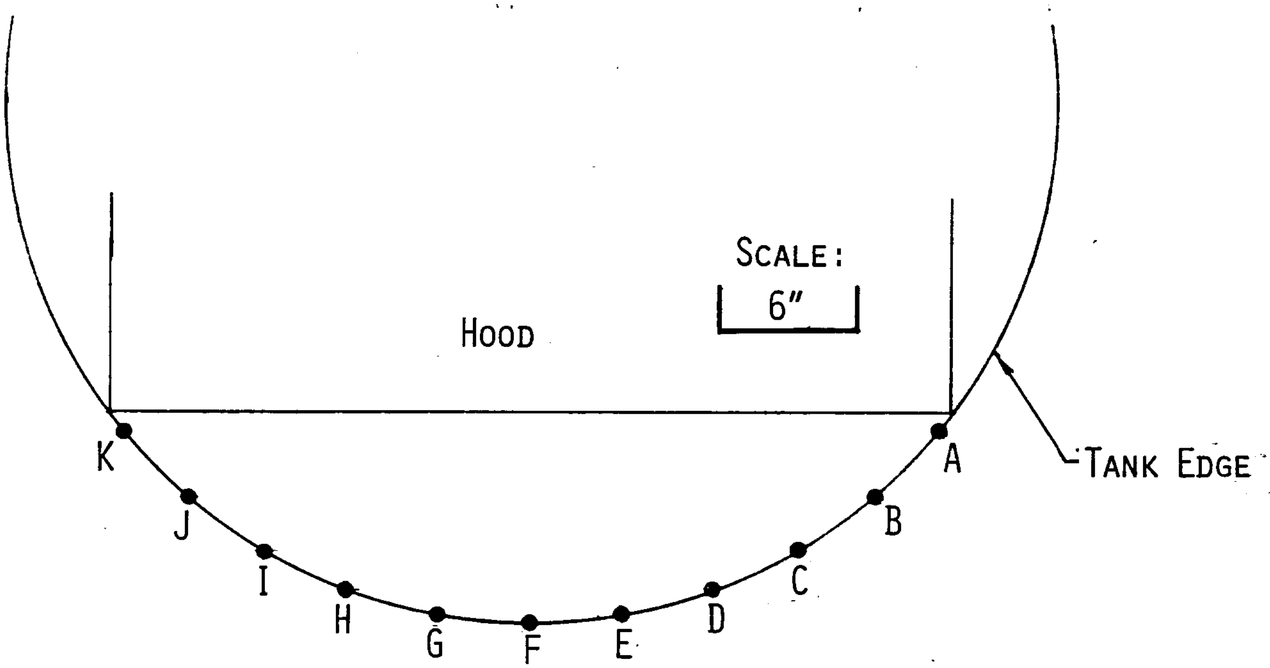


Figure 3-4. Kaolin slurry mixing tank hood face velocities.



Pt.	Height 1"	6"	12"	18"	Line Avg.
A	160	300	100	210	193
B	110	175	330	260	219
C	210	275	340	330	289
D	240	290	275	295	275
E	200	210	250	210	218
F	210	215	200	210	209
G	200	260	240	110	203
H	190	240	210	240	220
I	200	250	215	205	218
J	200	210	260	215	221
K	190	205	240	300	234
Line Avg.	192	239	242	235	227 fpm Overall Avg. Vel.

Figure 3-5. Kaolin slurry mixing tank hood capture velocities.

Instrument Error: +12%

Scale: 6″

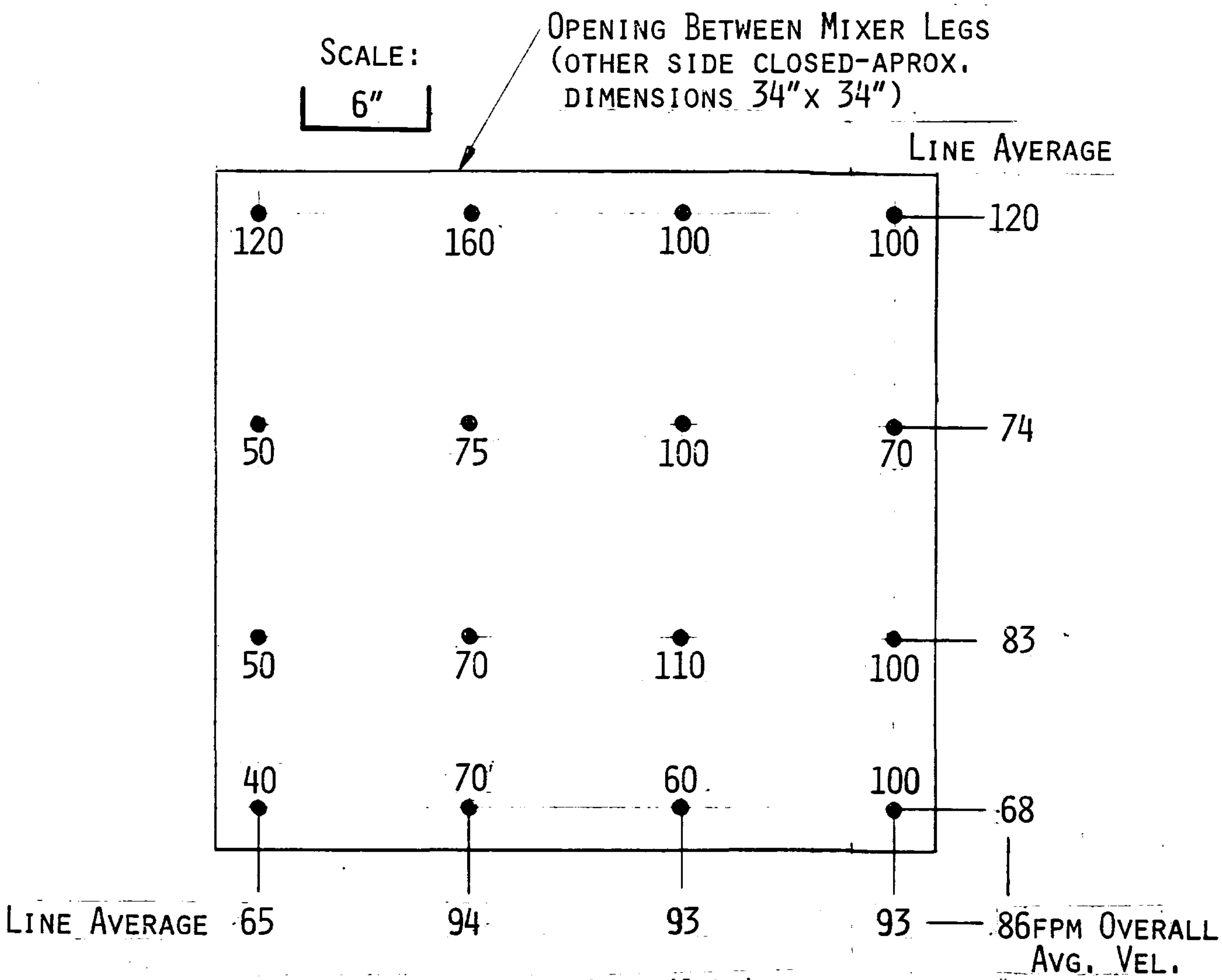
							Line Avg.
850	1100	1510	1400	1580	1480	950	1267
800	1050	1000	1100	1050	990	950	991
600	500	600	750	750	750	750	671
300	250	525	550	600	675	700	514
350	315	490	525	565	625	600	496(374)*
305	220	490	550	475	600	550	456(275)*
85	120	100	475	135	150	290	194(201)*
Line Avg. 470	508	674	764	736	753	684	656(613) FPM Overall Average Velocity

Notes: *Turbulent zone. Values shown are average of range. Numbers in () obtained from exponential curve fit $V=1373.25e^{-0.06d}$ (coef. of det.=0.99). Fit derived from (d,V) values (1,1267), (6,991), (11,671), (16,514).

Make up air outlet may have caused turbulence and increased face velocities of hood face. See text for discussion.

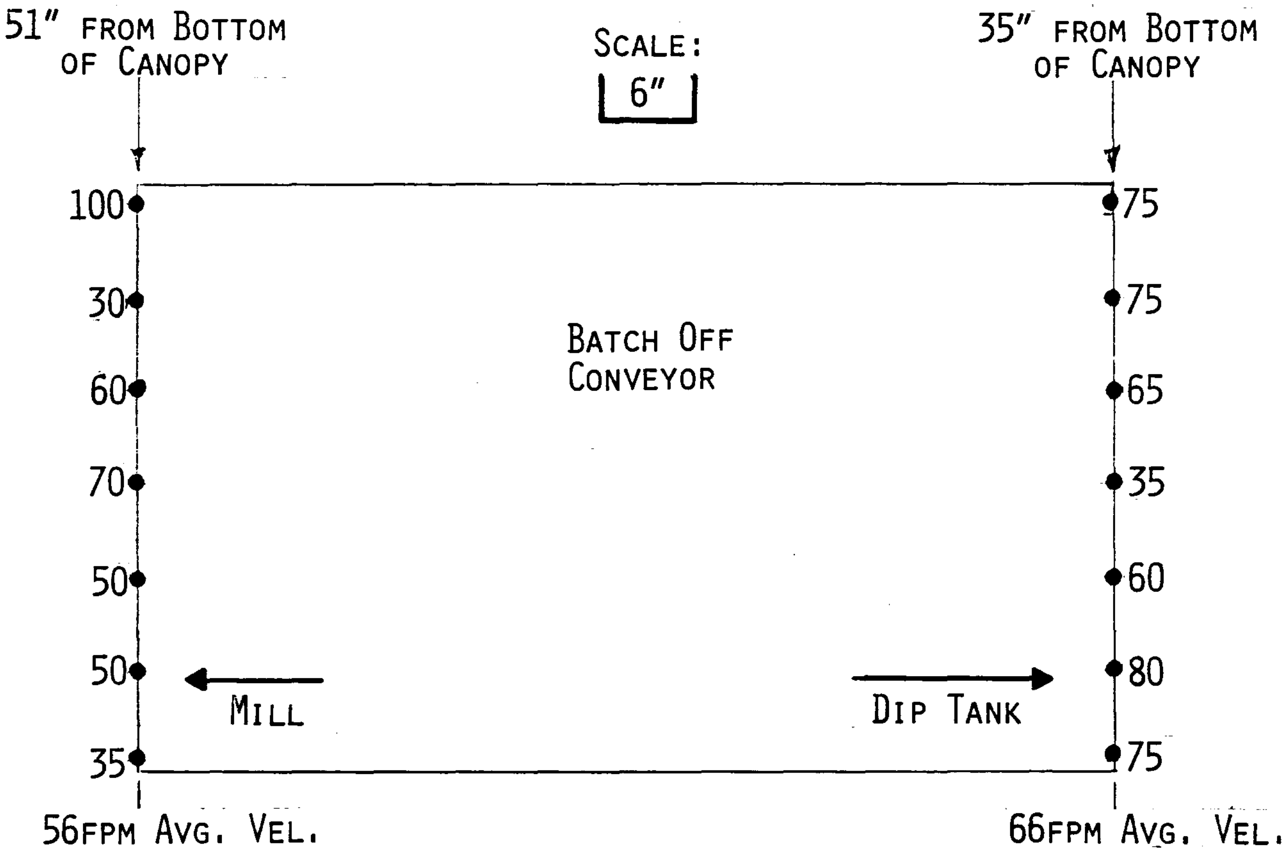
Measurements performed when mixer not operating. Charge door and discharge door both open.

Figure 4-5. Banbury mixer charge door hood face velocities.



Note: Discharge door hood ventilated thru mill hood-it did not have its own exhaust ducting.
Mixer discharge door in open position during measurements.

Figure 4-6. Banbury mixer discharge door hood face velocities.



Notes: Mill not operating during test.
Velocities shown are average of range.
Anemometer probe pointed at a right angle to canopy during measurements.
Measurements made 1-2" above conveyor.
View is looking down from canopy.

Figure 5-7 Mill hood capture velocities at batch-off conveyor.

Figure 5-8. Mill Hood Face Velocities

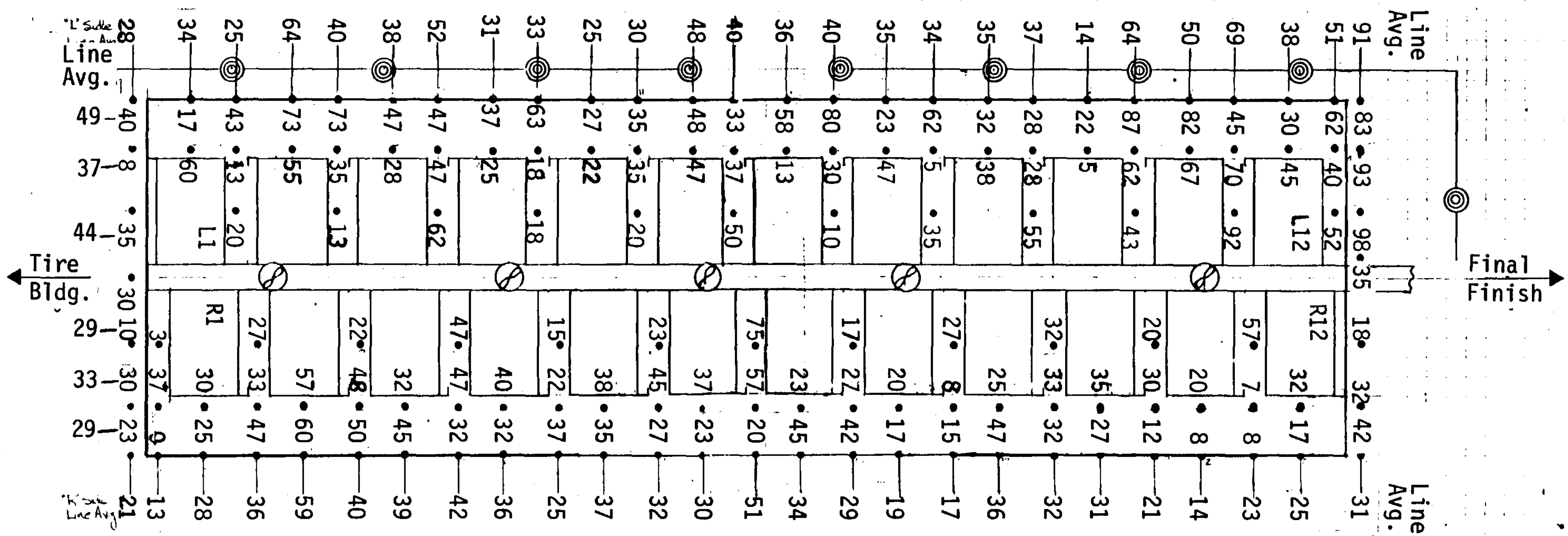
SCALE: 12"

															LINE AVG.
425	420	420	410	410	400	400	395	390	395	395	400	420	420	450	410
BAFFLE															
240	510	510	510	460	480	420	420	460	440	480	495	510	550	510	466(460)
300	480	460	420	420	400	400	325	375	375	400	420	480	510	480	416(425)
400	480	460	420	420	375	375	355	375	375	400	355	480	300	190	384(394)
355	400	420	420	400	375	300	300	300	300	325	420	460	440	300	368(365)
325	375	400	300	400	300	355	375	355	375	375	375	375	375	300	357(338)
220	300	375	375	375	355	220	250	250	280	280	280	300	300	365	302(313)
205	250	235	190	190	130	100	100	115	70	130	130	160	160	100	151(290)*
20	155	85	85	85	65	45	45	85	85	85	115	160	305	10	95(269)*
10	100	160	60	115	60	50	45	35	35	70	70	100	75	45	69(249)*
180	100	130	70	85	115	100	50	50	60	100	50	50	10	20	78(231)* — APROX. ℄ OF FRONT ROLLER
LINE AVG. (EXCLUDING SLOT): 226	315	324	285	295	266	237	227	240	240	265	271	308	303	232	269 FPM OVERALL AVG. VEL.

HOOD FACE OUTLINE

FLOOR

Notes: *Turbulent area. Values shown are average of range.
Numbers in () obtained from exponential curve fit $V=464.2e^{-0.01d}$ (coef. of det.=0.95). Fit derived from (d,V) values (1,466), (7,416), (13,384), (19,368), (25,357), (31,302).
Mill and cooling fan not operating during measurements.



Notes: Only presses L6 to L11 operating during measurements. Other L row presses were warm. R row presses were cold.
Green tire racks moved from in front of anemometer probe during measurements.

Figure 6-7. Curing press row canopy hood average velocities from 3, 5, and 7 feet heights.

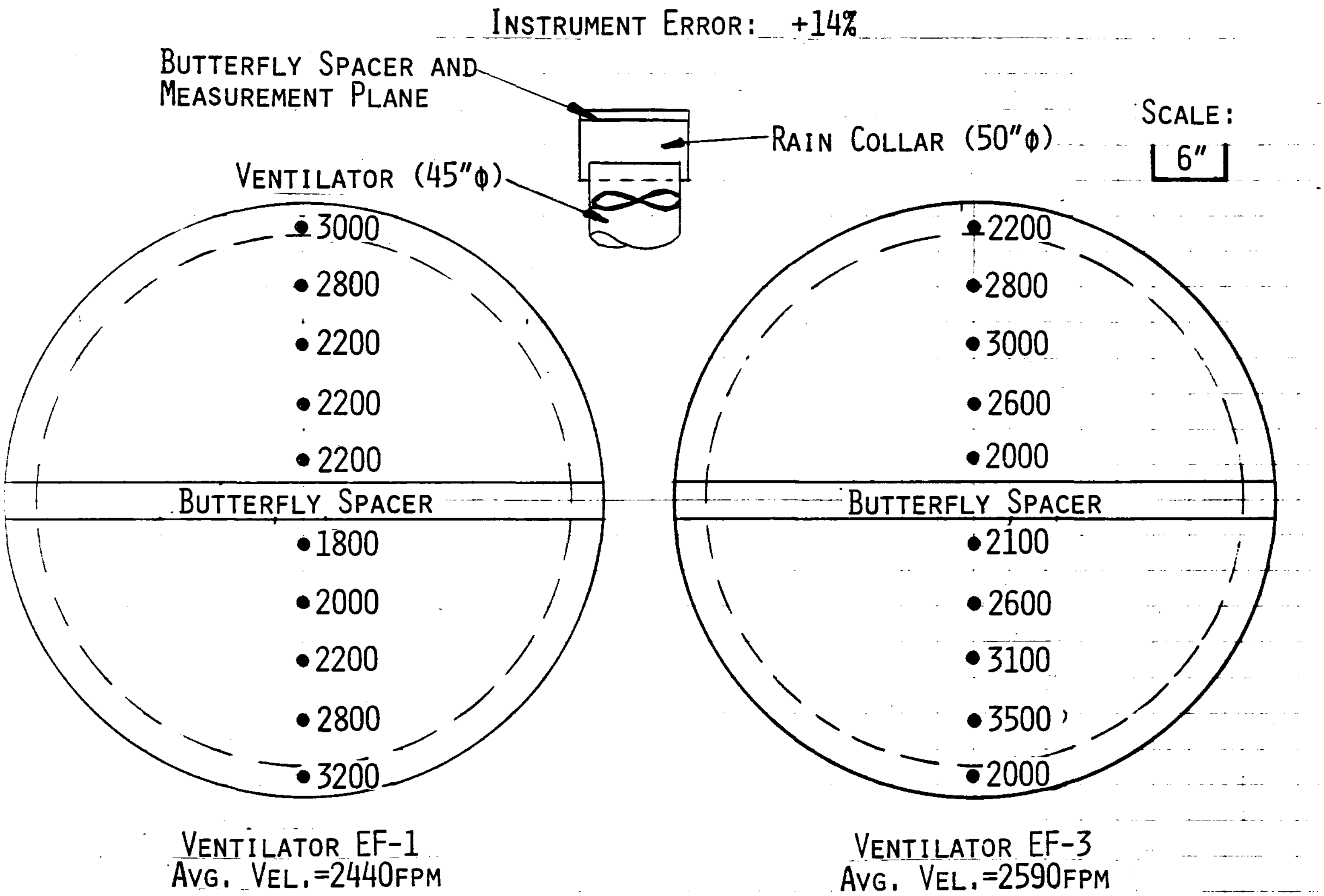
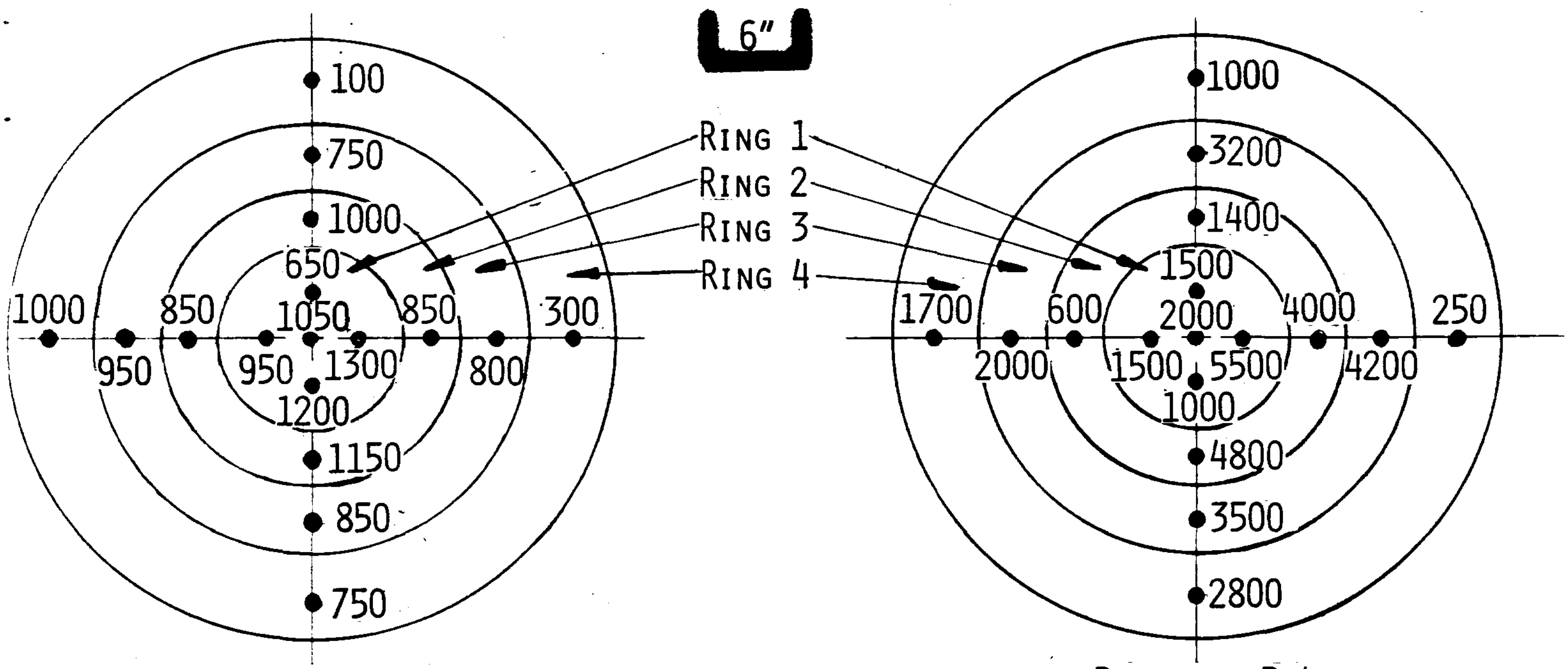


Figure 6-8. Curing press row canopy hood exhaust fan velocities.

INSTRUMENT ERROR: +12%

SCALE:



DIFFUSER D-1

DIFFUSER D-4

AVERAGE VELOCITY OF RINGS:

Diffuser D-1	
RING 1	1030FPM
RING 2	963FPM
RING 3	838FPM
RING 4	538FPM
OVERALL	853FPM

Diffuser D-4	
RING 1	2300FPM
RING 2	3225FPM
RING 3	2700FPM
RING 4	1438FPM
OVERALL	2409FPM

Figure 6-9. Curing press row ventilation system makeup air diffuser velocities.

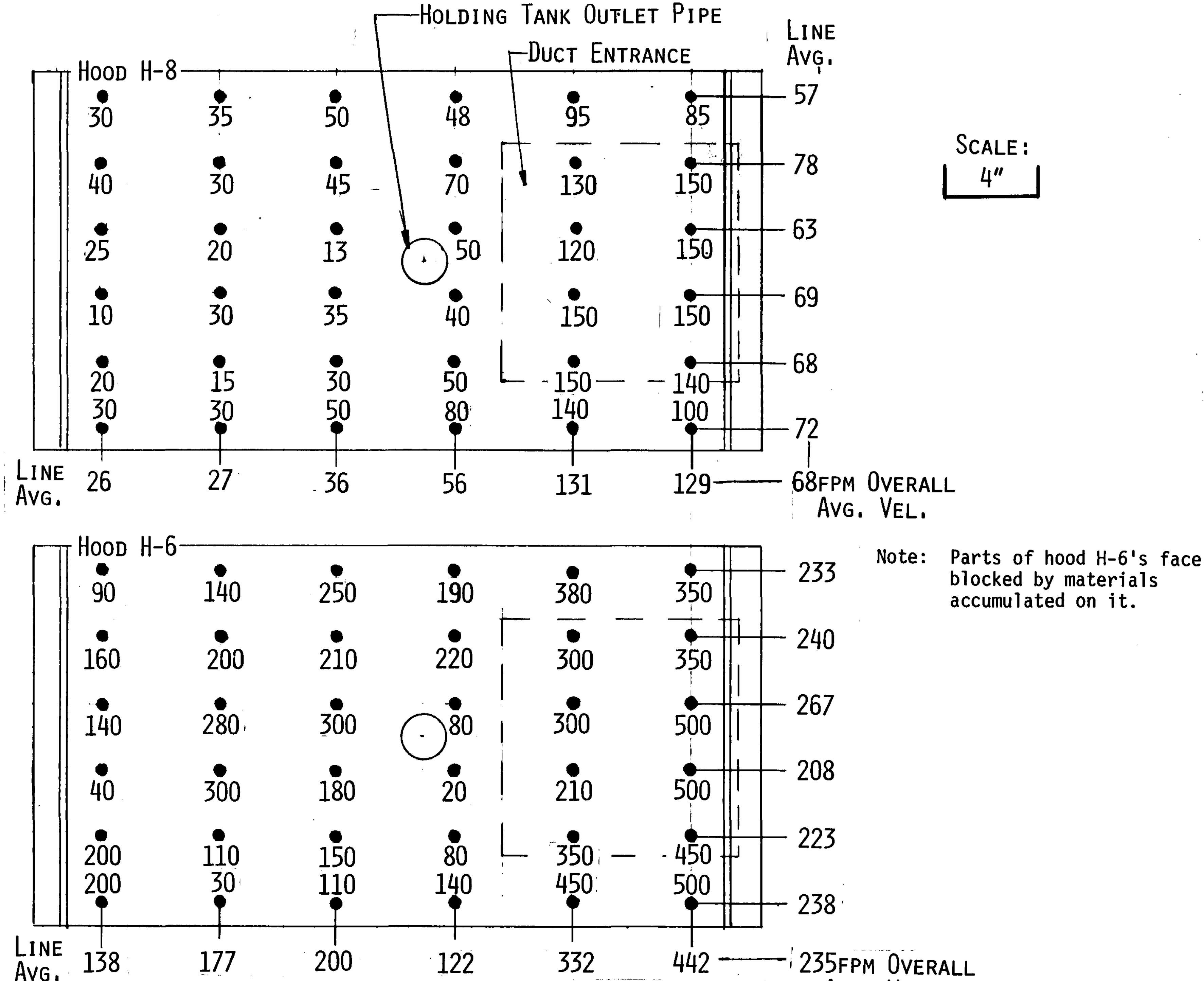
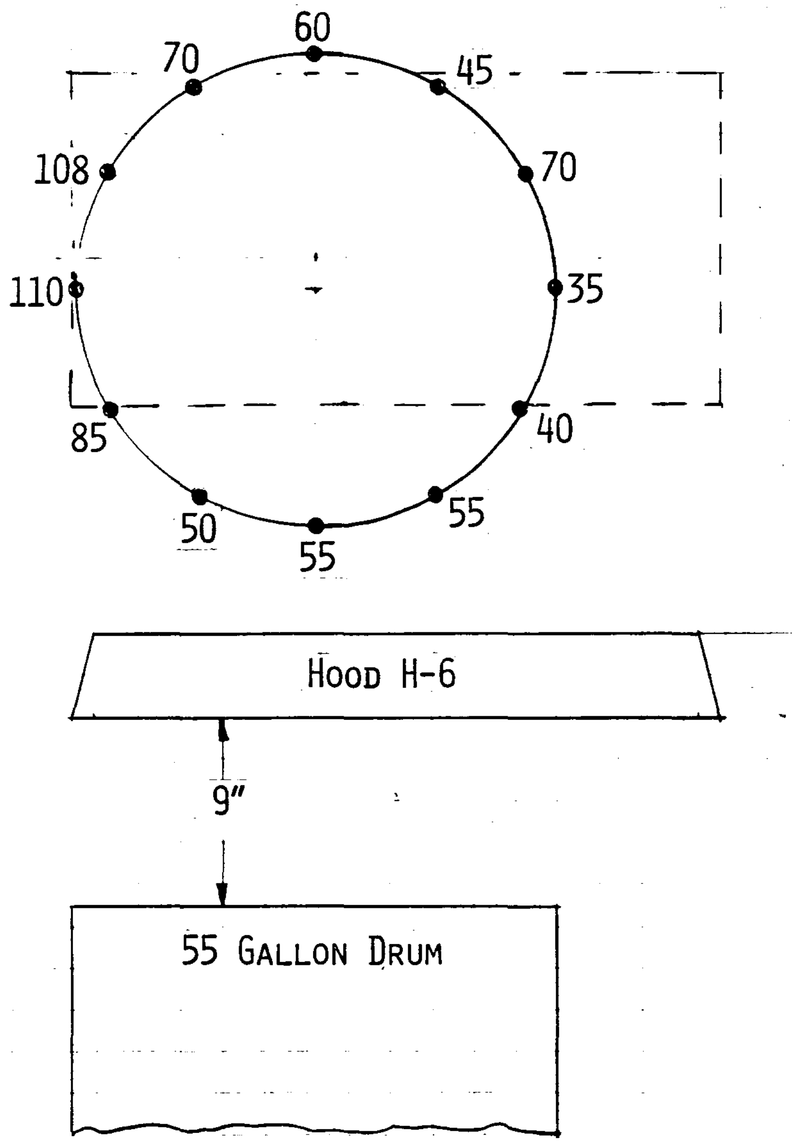


Figure 7-1 . Cement house holding tank outlet hood capture velocities.



Scale:

4"

Notes: Worker positioned drum beneath hood.
Draft from MD-1 disturbed air flow into hood. Vents D-1 and D-5 on MD-1 blocked during measurements.
Air drawn into cement house thru opening in wall near hood caused turbulence at some points at top of drum.

Figure 7-12. Cement house holding tank outlet hood capture velocities.