

NIOSH CONTROL TECHNOLOGY ASSESSMENT
at
General Tire and Rubber Company
Waco, Texas

Survey Conducted By:
Matthew K. Klein, P. E.
William A. Heitbrink, C. I. H.
Vladimir Hampl, Ph.D.
Perry Lemaster
Ova Johnston

Date of Survey:
February 18-21, 1980

Report Written by:
William A. Heitbrink, C. I. H.
Matthew K. Klein, P. E.
Date of Report: July 20, 1981

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
Cincinnati, Ohio 45226

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

DISCLAIMER

Mention of company name or products does not constitute endorsement by the
National Institute for Occupational Safety and Health.

111

PURPOSE OF STUDY

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

ABSTRACT

This in-depth plant survey report documents air contaminant controls for selected operations at General Tire and Rubber Company's Waco, Texas tire plant. This survey was conducted during the period February, 18-21, 1980. The controls for the following unit operations were evaluated: compounding, mixing, bag disposal, and tire repair.

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

	Page
Purpose.	ii
Abstract.	iii
Introduction.	1
Detailed Evaluations.	5
Hoppers/Bins6
Manual Compounding System.	16
Banbury Mixer44
Pneumatic Disposal System.	55
Tire Repair Table66
Compliance with Existing Standards.74
References.75
Appendices	
I. Description of Occupational Title Groups.76
II. Concentration Data.78
III. Ventilation Measurement Instrumentation.	84
IV. Ventilation Data.85

INTRODUCTION

During February 18-21, 1980, the National Institute for Occupational Safety and Health (NIOSH), conducted an evaluation of selected controls for air contaminants at the General Tire and Rubber Company tire plant in Waco, Texas.

The following controls for particulate air contaminants were evaluated: hood system for hoppers on bins, manual compounding system, mixer ventilation, pneumatic disposal system, and a defect repair table hood.

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

GENERAL DESCRIPTION OF THE FACILITY

During the NIOSH study the plant was operating under normal conditions. Typically this plant operates on all three shifts and can produce approximately 20,000 tires per day. The original structure built in 1945 and with numerous modifications and additions, now occupies approximately 2 million square feet of covered space. The hours of the shifts were 8:00 a.m. to 4:00 p.m. (day), 4:00 p.m. to 12:00 Midnight (evening), and 12:00 p.m. to 8:00 a.m. (night).

OVERVIEW OF THE OCCUPATIONAL EXPOSURES FROM TIRE MANUFACTURING PROCESS

Tire manufacturing involves a series of operations which have the potential for creating worker exposures to a variety of air contaminants. The process is summarized in Figure 1. The occupational title groups developed by Williams¹ provide a standard description of tire manufacturing operations. These are listed in Appendix I. In addition to the classifications listed by Williams, a classification called "precompounding" has been added. Precompounding refers to the emptying of chemicals into bags, bins, or totes. In the mixing areas of the tire plant, rubber, carbon black, process oils, and chemicals are mixed in energy intensive mixers, such as Banbury mixers, and milled to produce rubber stocks. These operations produce air contaminants referred to as "compounding dusts" and "rubber fumes".

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

A cement dissolved in a petroleum distillate is applied to the tread ends and the bottom of the tread. The workers near this operation and the workers in the cement house where the cement is made are exposed to petroleum distillate. This petroleum distillate is essentially naphtha with a trace of benzene contamination.

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

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

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

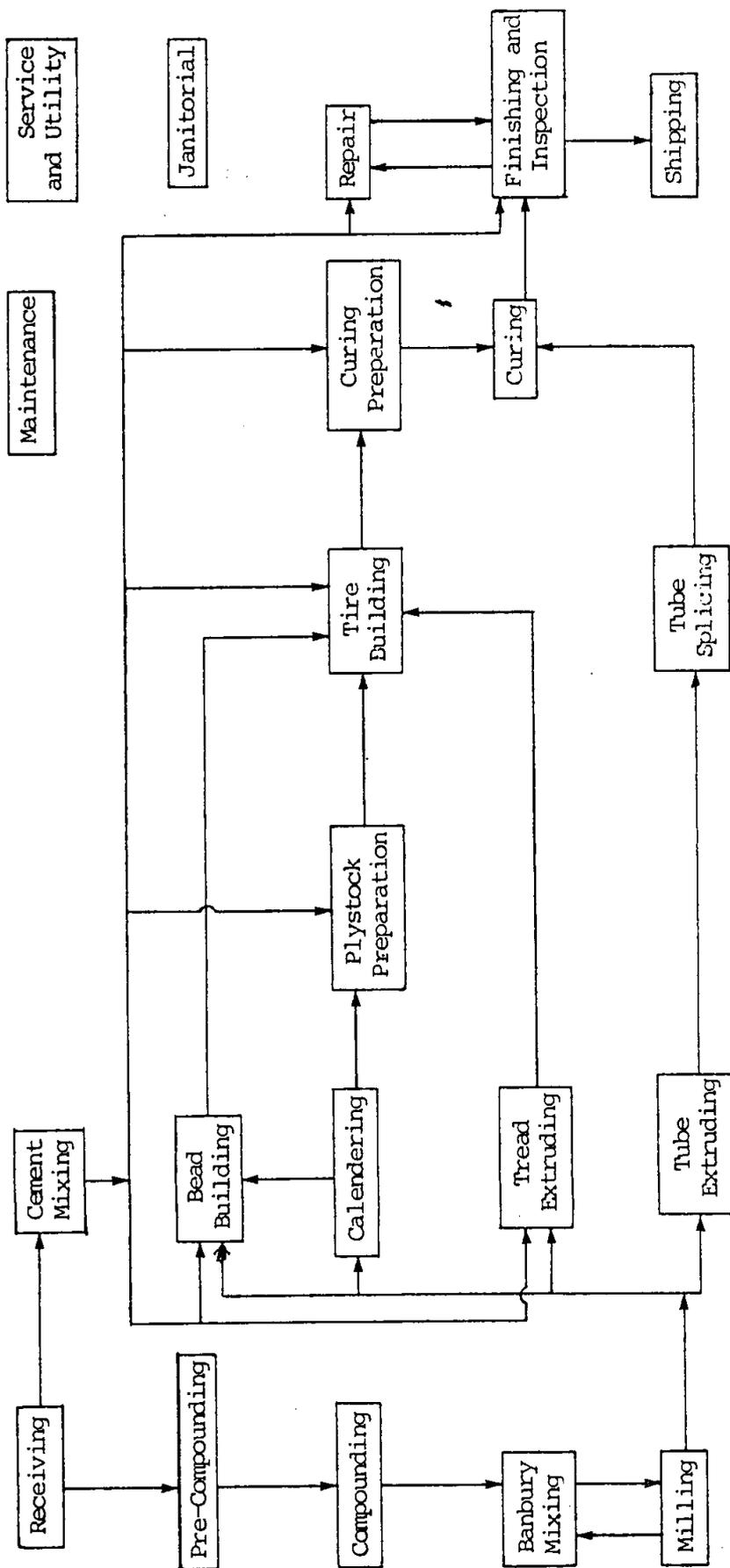


Figure 1. Production Stages in the Manufacture of Tires and Tubes.

DESCRIPTION OF EVALUATION METHODS

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

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. MSA-FWSB filters were also used to collect particulate air samples. These filters were corrected for a mean blank filter loss of 0.06 mg for the FWSB filters. The standard deviation of the mean weight loss was 0.01 mg. Air samples were collected with MSA model G pumps and DuPont P4000 pumps.

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).³ 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 Test⁴ were used to determine whether shift and location affected concentration. The ANOVA is used to compute the mean square error used in Duncan's test. Before proceeding with this analysis, the data was transformed by taking the common logarithm of individual concentrations. Duncan's test was conducted at an overall level of confidence of 95 percent. This type of analysis was used to determine whether samples collected near the worker, the control, the emission sources, and in the general area are different. This analysis is used to judge control effectiveness.

DETAILED EVALUATIONS

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

HOPPER/BINS (1)
AREA: PRECOMPOUNDING

DESCRIPTION

The bins are part of a manual weighing system (for both masterbatch and final batch compounds). Powdered compounds are poured into the bins and weighed out on a lower floor. The loading area has 2 sets of bins containing 7 and 8 bins (total of 15), respectively. There are 10 large bins and 5 smaller bins. A layout of the loading area is shown in Figure 1-1.

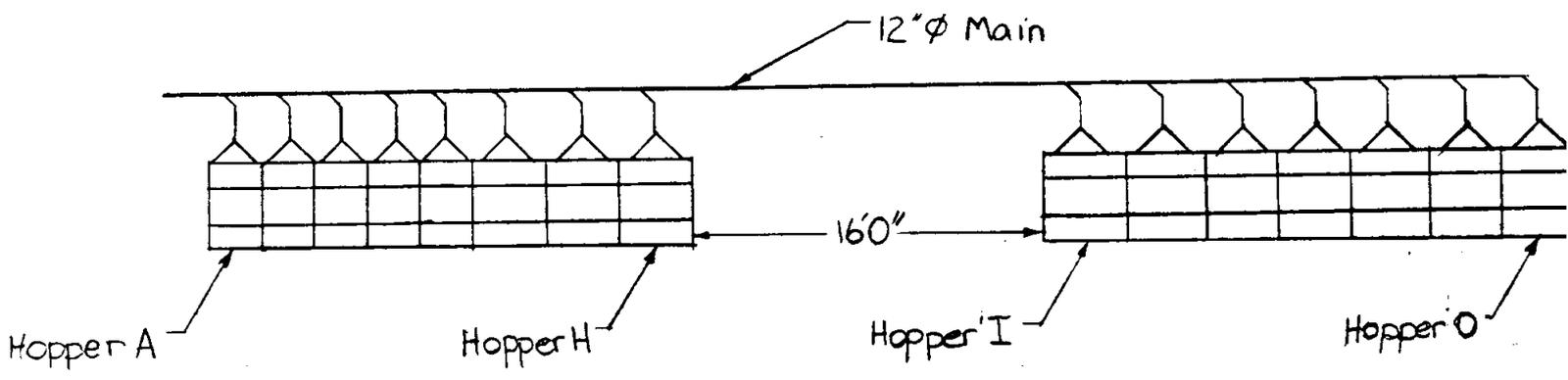
The hoods on the hopper/bins are sized according to the bin. They are shown in Figures 1-2 through 1-5. Each hood is connected to the same main; however, the system is designed so only one hood operates at a time. Consequently, each hood duct is equipped with a shutoff gate and an air-tight door (in case the gate is not shut). The door is made air tight by a molded sponge rubber door gasket.

The bins and their ventilation system were installed in the mid-seventies. No notable changes have been made since its installation.

WORKER'S DUTIES

The primary duty for the worker at the hopper is to pour compounds into the hopper as needed. The method is:

1. A bag of compound is taken from a pallet situated near the hopper/bins.
2. The bag is placed on the ledge in front of the hood door and is slit lengthwise with a knife along the edge facing the back of the hood.
3. The compound is poured from the bag into the hopper/bins.
4. When the bag is empty, it is shaken inside the hood to empty any residues and discarded through a bag disposal system.



Notes: Hoppers A thru E are 2'2" wide while hoppers F thru O are 3'4" wide. All hopper hoods tie into same main. Procedure is to only open slide gate on duct going to hood on hopper being filled at the time.

Figure 1-1. Hopper/bin loading area layout.

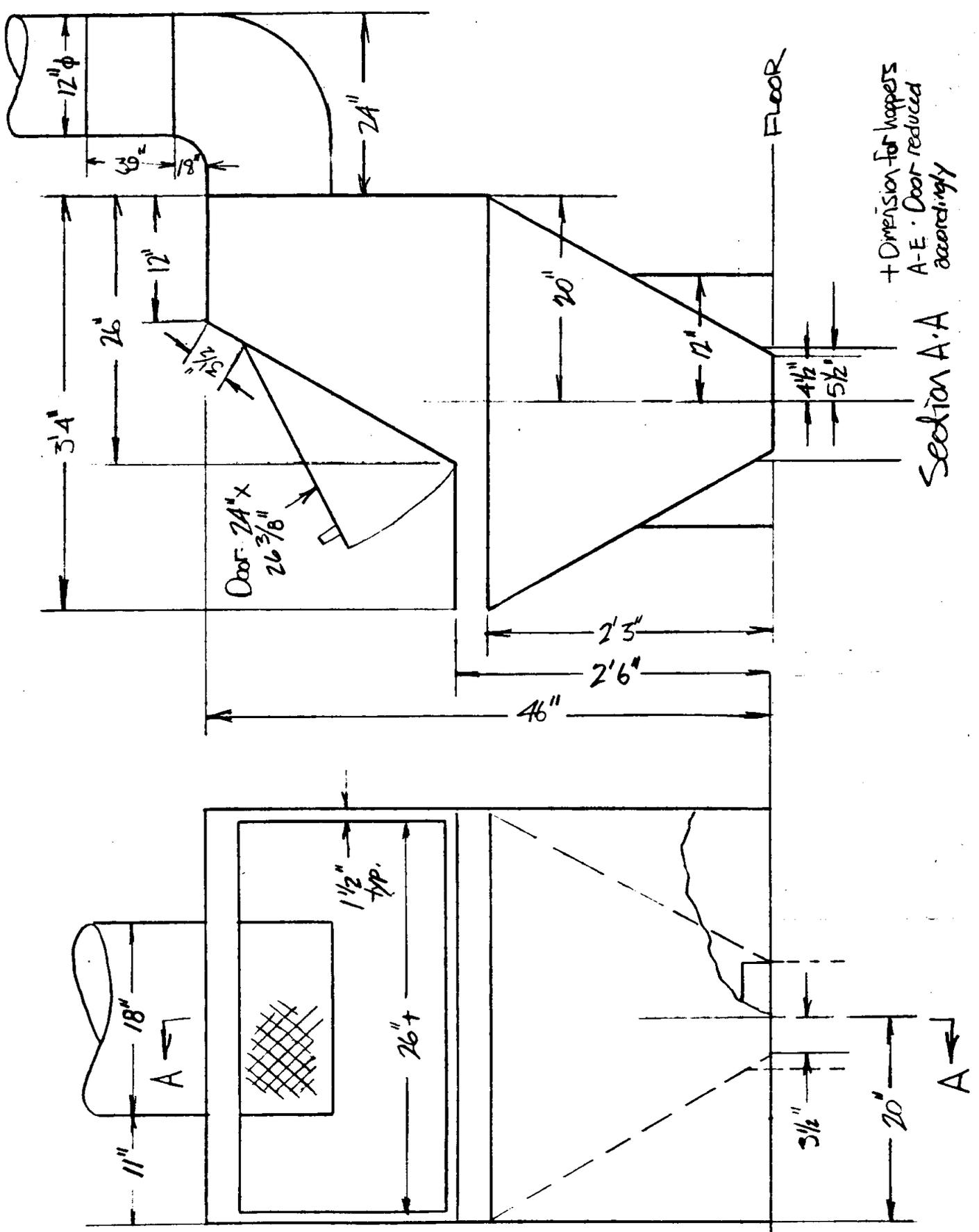
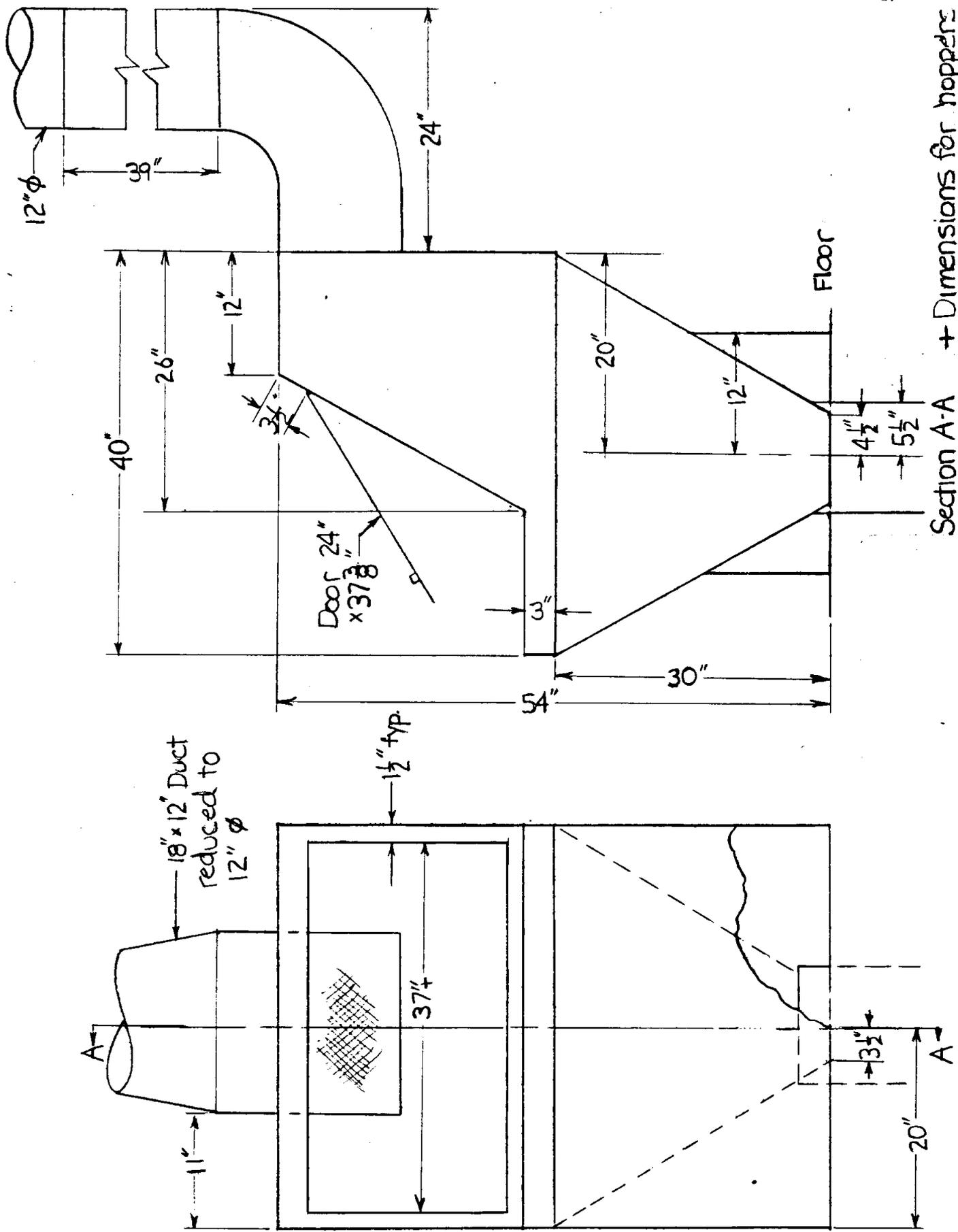


Figure 1-2. Hopper/bin hood detail.



Section A-A + Dimensions for hoppers
F thru O.

Figure 1-3. Hopper/bin hood detail.

Reproduced from
best available copy. 

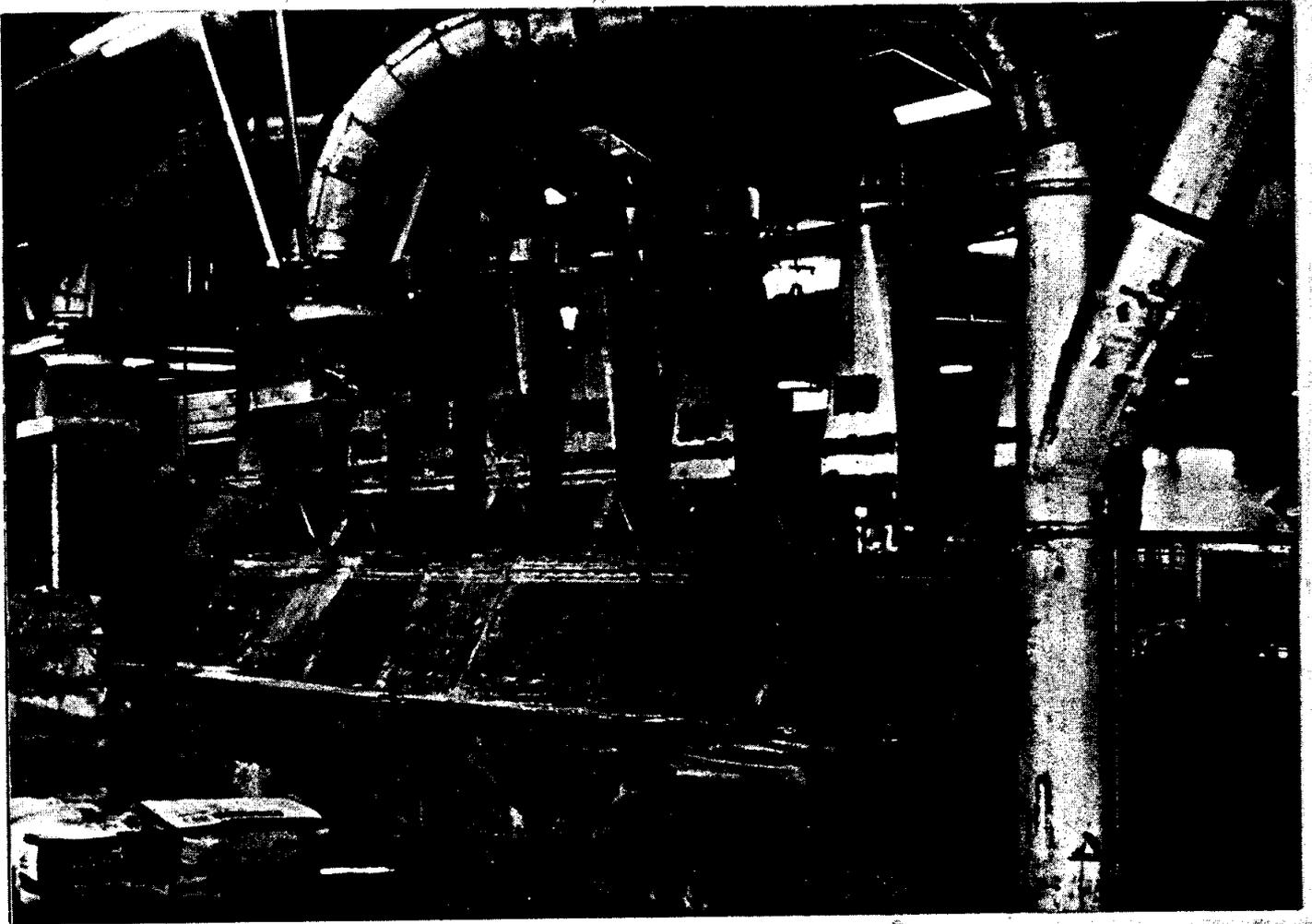


Figure 1-4. Hopper/bin hood detail.
Also shown are inlet hoods for the bag disposal system.

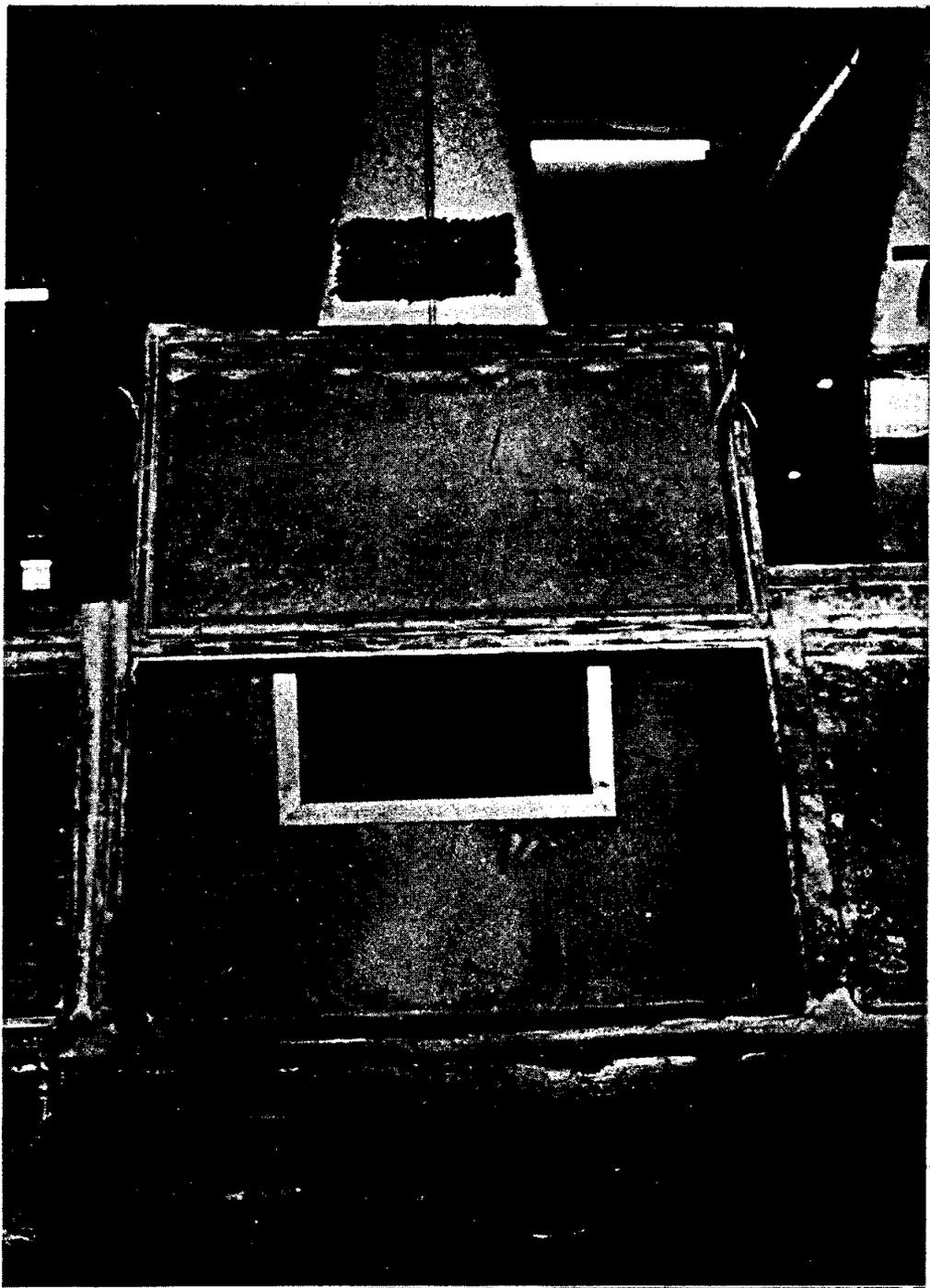


Figure 1-5. Bin loading hopper hood.

The worker's other jobs, relative to the hoppers, are moving pallets of bagged compounds to the hopper/bins opening and closing the appropriate hood duct, and keeping the hood doors closed when not in use. The total time spent performing these and the bin loading jobs is about two hours per shift. The rest of the worker's time is spent performing other jobs in the plant.

AIR SAMPLING

Total and respirable particulate samples were collected on a worker while he was loading chemicals into the bins. Only one set of these samples was collected and the results are shown in Table 1-1.

Table 1-1. Full shift personal particulate concentrations for bin loading.

Sample	Concentration GM (mg/m ³)
Total particulate	.61
Respirable particulate	.09

VENTILATION DATA

Ventilation measurements were made on J bin's hood and were made with the ducts to all other hoods closed. The measurement results and design values are summarized in Table 1-2 and shown in Appendix IV.

Table 1-2. Hopper/bin hood ventilation data.

Measurement	Quantity Measured	Design
Average duct velocity ^a	3650 fpm	3375 fpm
Calculated duct flow	2865 scfm	2650 cfm
Duct static pressure	1.85 in. H ₂ O	Unknown
Average face velocity	215 fpm	Unknown

a. Measurement location in main for hoods on hopper/bins I through O.

EMISSION SOURCES OBSERVATIONS

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

1. Dusts forced into air or entrained in air displaced when bags were emptied into the hopper/bin.
2. Dusts forced into air by slinging empty bags.
3. Dusts entrained in air displaced from collapsing empty bags.
4. Dusts from spilled compounds being forced into air or entrained in air.

In addition, leaks from nearby carbon black systems were observed. This carbon black could drift into the bin loading area and increase background particulate levels.

WORK PRACTICE OBSERVATIONS

The worker generally had close contact with the material being poured into the bins. Dust generation inevitably results from this operation. Therefore, work practices appeared to have an important effect on the worker's exposure. The worker sampled appeared to have exemplary work practices. This worker did not crush or sling empty bags and took care to properly switch the ducts.

Overall, workers were observed to conscientiously operate the ventilation system properly and handle compounds to minimize dust generation. However, some work practices were observed for other workers which could cause a decrement in the ventilation system performance or could increase the worker's exposure:

1. Squashing bags which forced dust-laden air into the room air. Workers were observed to stack several empty bags on the ledge beside the bin they were filling. Just prior to disposing of the bags they would squash the bags so they would fit into the bag disposal opening. The plant management had specified disposing of one bag at a time.

2. Not cleaning up spilled compounds from the floor and hopper structure. Residues from emptied bags appeared to be the primary source of the spilled materials.
3. Dry-sweeping powdered compounds.
4. Not maintaining door seals. This could lead to leaks in the ventilation system.
5. Not repairing bent bin doors. This would cause leaks in the ventilation system because the door could not seat correctly.
6. Shaking bags out too vigorously. Some materials were thrown into the hoods' duct entrances.

ENGINEERING CONTROLS OBSERVATION

No dusts were observed escaping from the hood during the filling operation.

These design features were noted:

1. The duct entrance placement for the hoods is very good. It is located far enough above the bin filling operation that it can pull dusts out of the worker's breathing zone, but not waste a large quantity of material. This location also prevented damage to the duct entrance--the screening over the duct entrance was not damaged.
2. The construction of the hood allowed visibility and sufficient room to perform the operation. The worker only needed to put his arms inside the hood. The ledge built on the hopper allowed a convenient work surface for slitting bags and pouring compounds.
3. A tap for each hood was provided in the duct as shown in Figure 1-4. This tap appeared to be for monitoring the ventilation system

The calculated hood airflow, using the duct entrance velocities, was 2070 cfm, while that calculated from duct velocity measurements was 2865 scfm. The duct velocity measurement location was in the main for the hoods on hopper/bins I through O. This may indicate a loss of air through leaks in the ventilation system.

MONITORS OBSERVATIONS

No monitors for ventilation performance or specific contaminants were noted.

PERSONAL PROTECTIVE EQUIPMENT

Workers were observed wearing coveralls. They were provided two cleaned pairs a week.

DATA INTERPRETATION

Bin filling, dry sweeping, and other housekeeping practices, and bag disposal can generate dust directly into the workers' breathing zone. Dust from spills can be generated into the general room air elevating the background particulate concentrations. Background concentration elevation can also result from contaminants drifting into the area from surrounding areas.

The hoods on the hopper/bins were observed to control dusts generated from bin filling, but could not control dusts generated from the handling of empty bags outside the hood. Proper work practices eliminate this exposure.

Overall, the hood's design was very accommodating to the bin filling operation. It was unobtrusive to worker's movements and duct entrance location did not cause waste of materials during bin filling operations.

MANUAL COMPOUNDING SYSTEM (2)

AREA: COMPOUNDING

DESCRIPTION

This manual compounding system consists of final and master batch compounding stations. A layout of the entire area is shown in Figure 2-1. These areas are described separately below.

Masterbatch Compounding

This station consists of a series of 7 bins containing powdered compounds, 2 bins containing flake waxes, and 2 movable weighing trolleys. Two workers weigh compounds into plastic bags at this station.

The bins containing the powdered compounds are loaded from another floor. These bins are shown in Figures 2-2 and 2-3. The compounding workers fill the wax bins.

The weighing trolleys carry the scales for weighing the compounds and the plastic bags. The trolley rides on overhead rails. Plastic bags are held by a holder mounted on the scale. Several views of the trolley are shown in Figures 2-4 through 2-7. The trolleys' exhaust systems consists of dual side draft hoods oriented near the plastic bag holder, as shown in Figures 2-4 through 2-7. Connection of the hood ducts to the main system is by a zipper duct manufactured by Kirk and Blum. This duct necessitated a motorized drive for the trolleys.

The bins, trolleys, and ventilation system were all retrofitted to the plant around the mid-seventies. The original drawings on the trolley compounding hoods called for the hoods to run parallel along the sides of the bag holder. The change in the installed hoods from the original design appeared to have been initiated at the plant because the design hood may have interfered with the compounding operation.

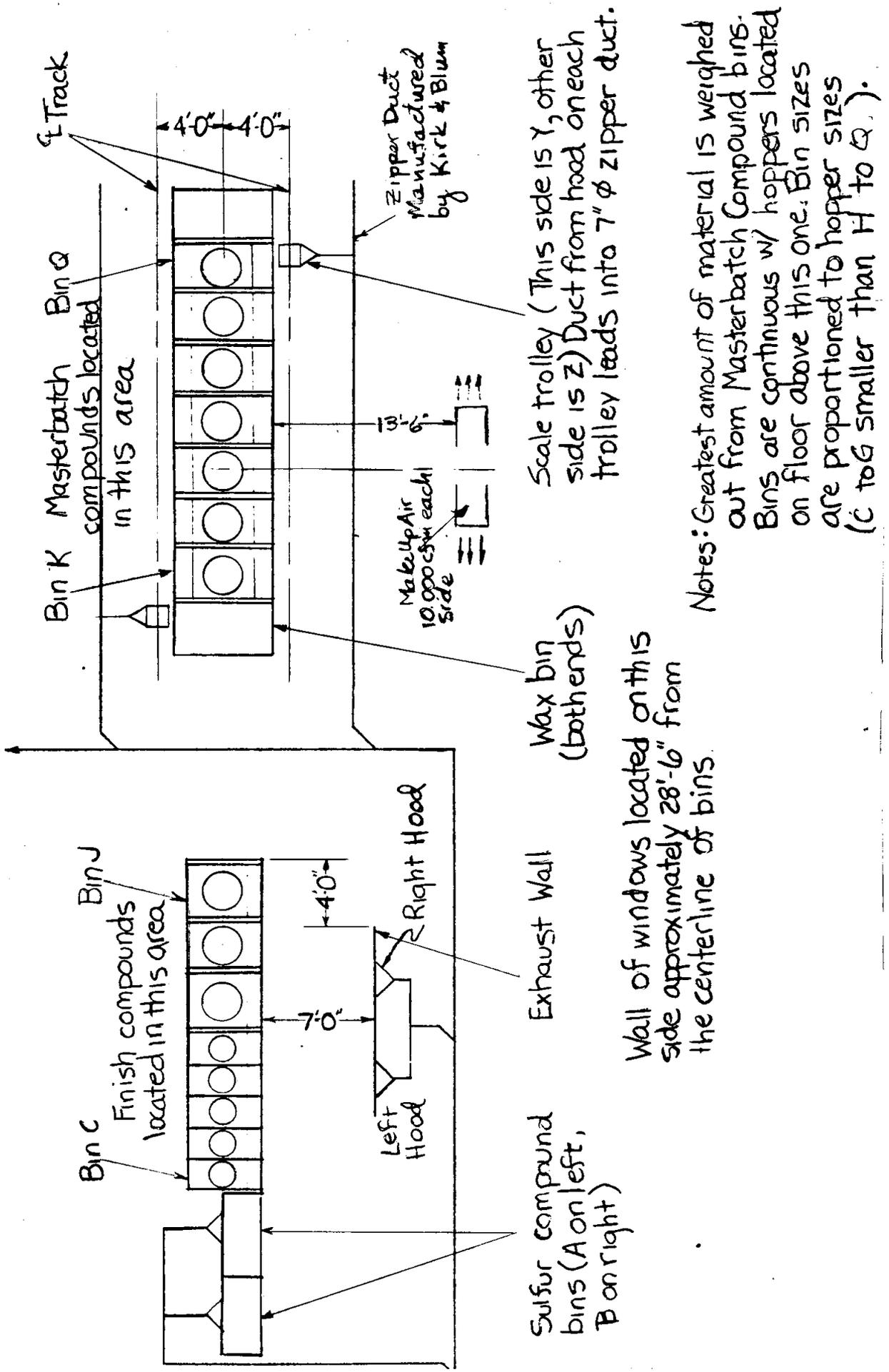


Figure 2-1. Manual compounding system layout.

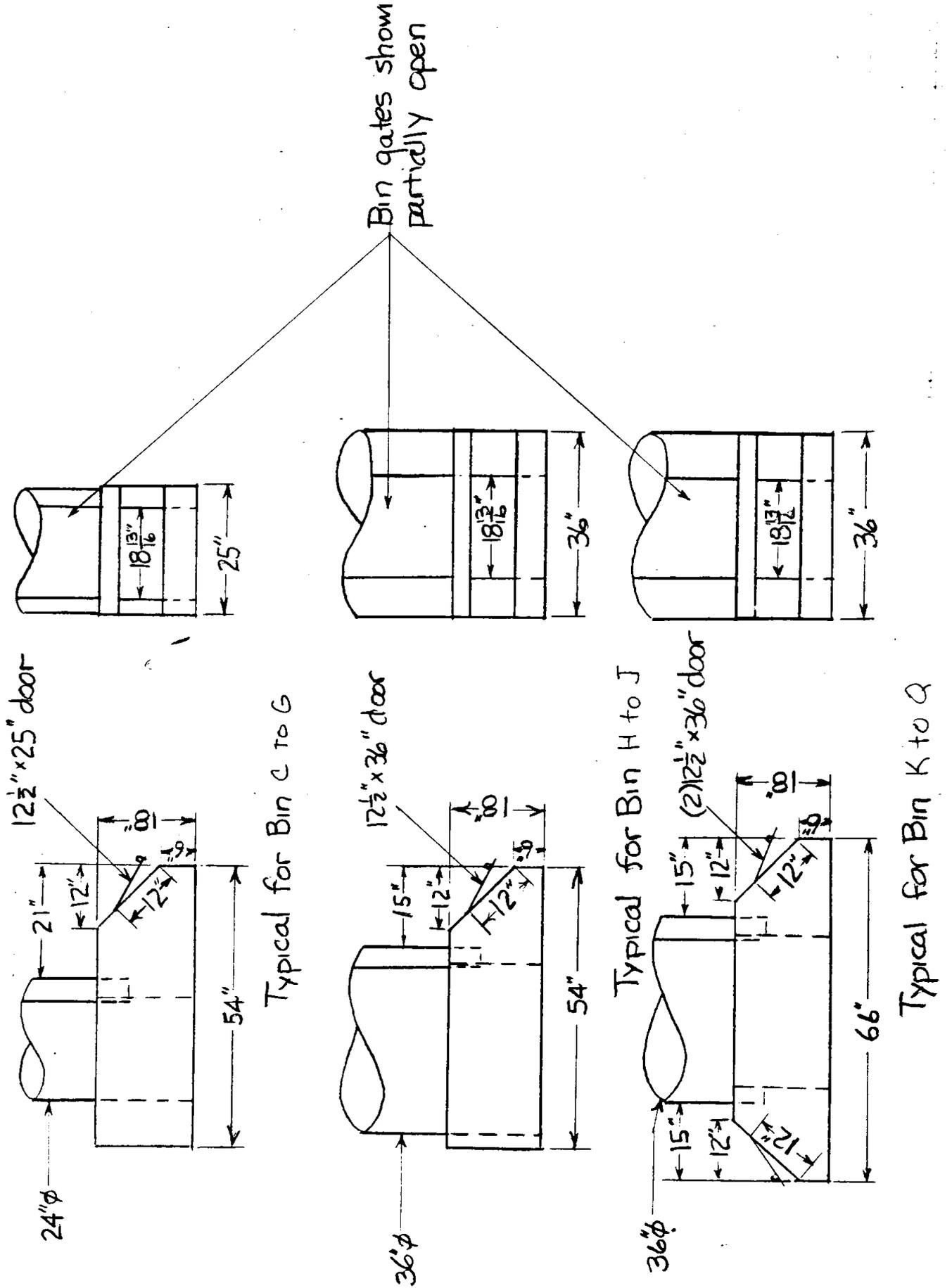


Figure 2-2. Manual compounding system bin details.

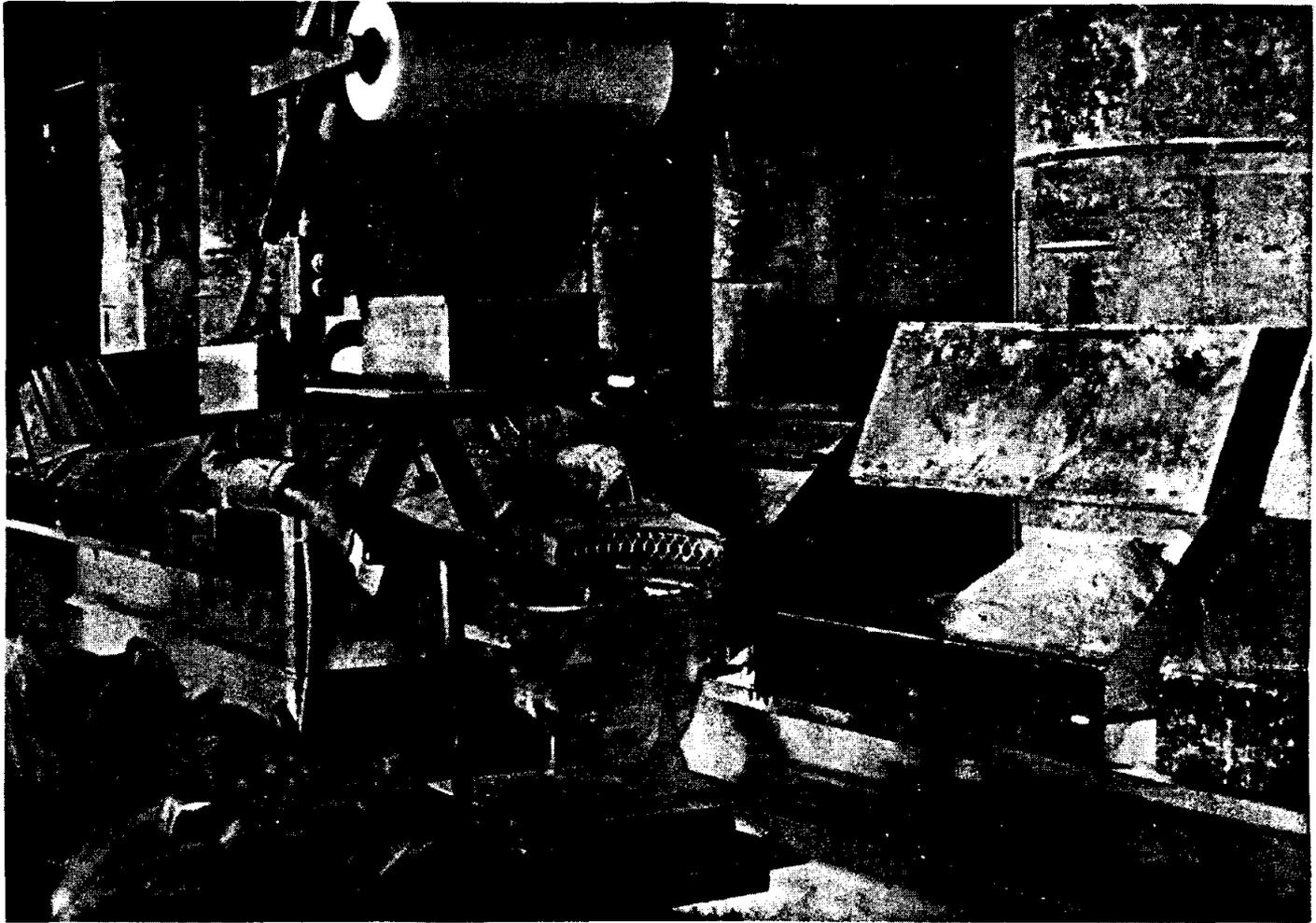


Figure 2-3. Manual compounding system trolley scale hoods.

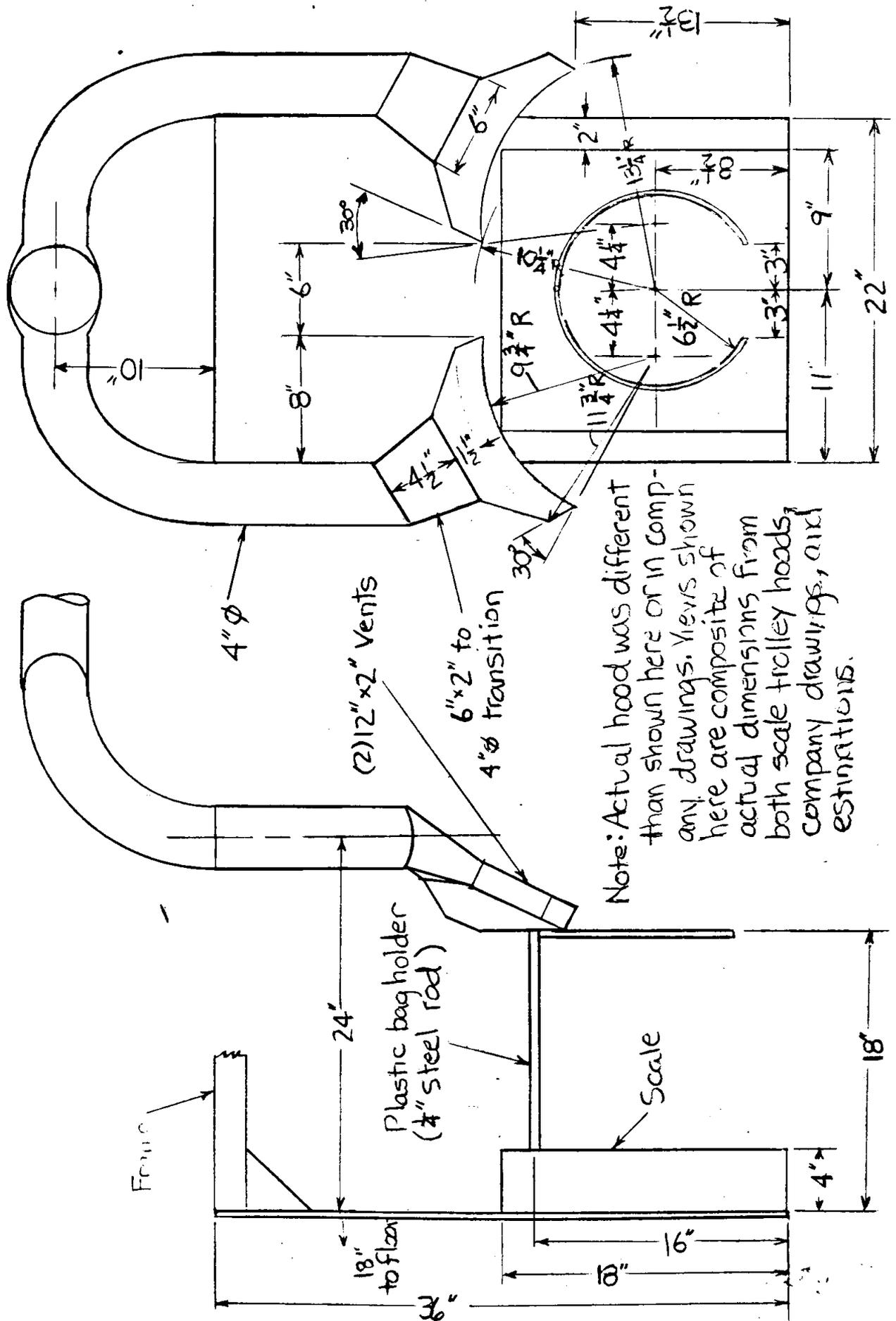


Figure 2-4. Manual compounding system trolley scale hoods detail.

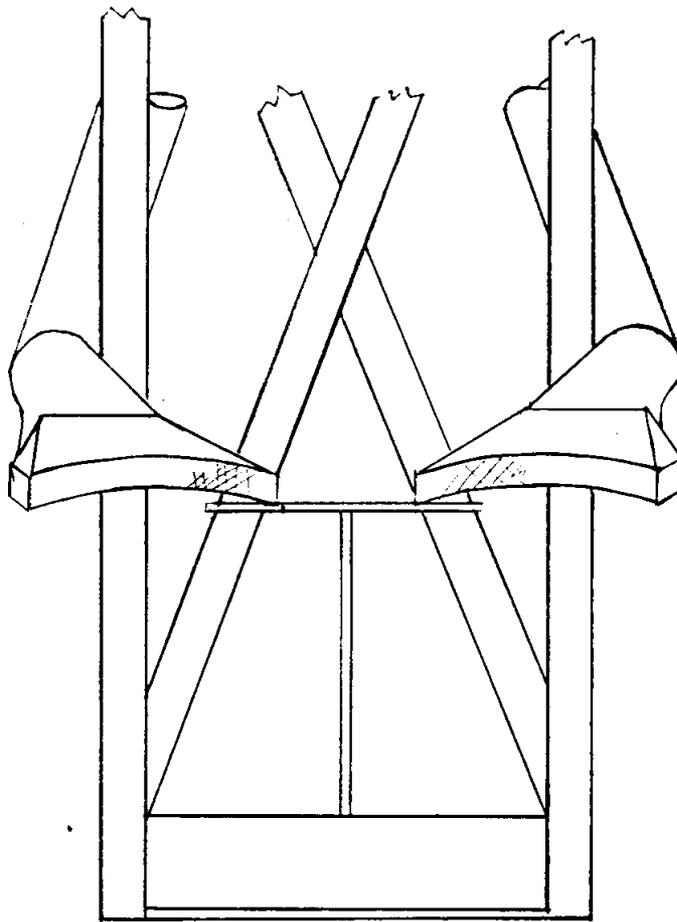


Figure 2-5. Manual compounding system trolley scale hoods - front view.

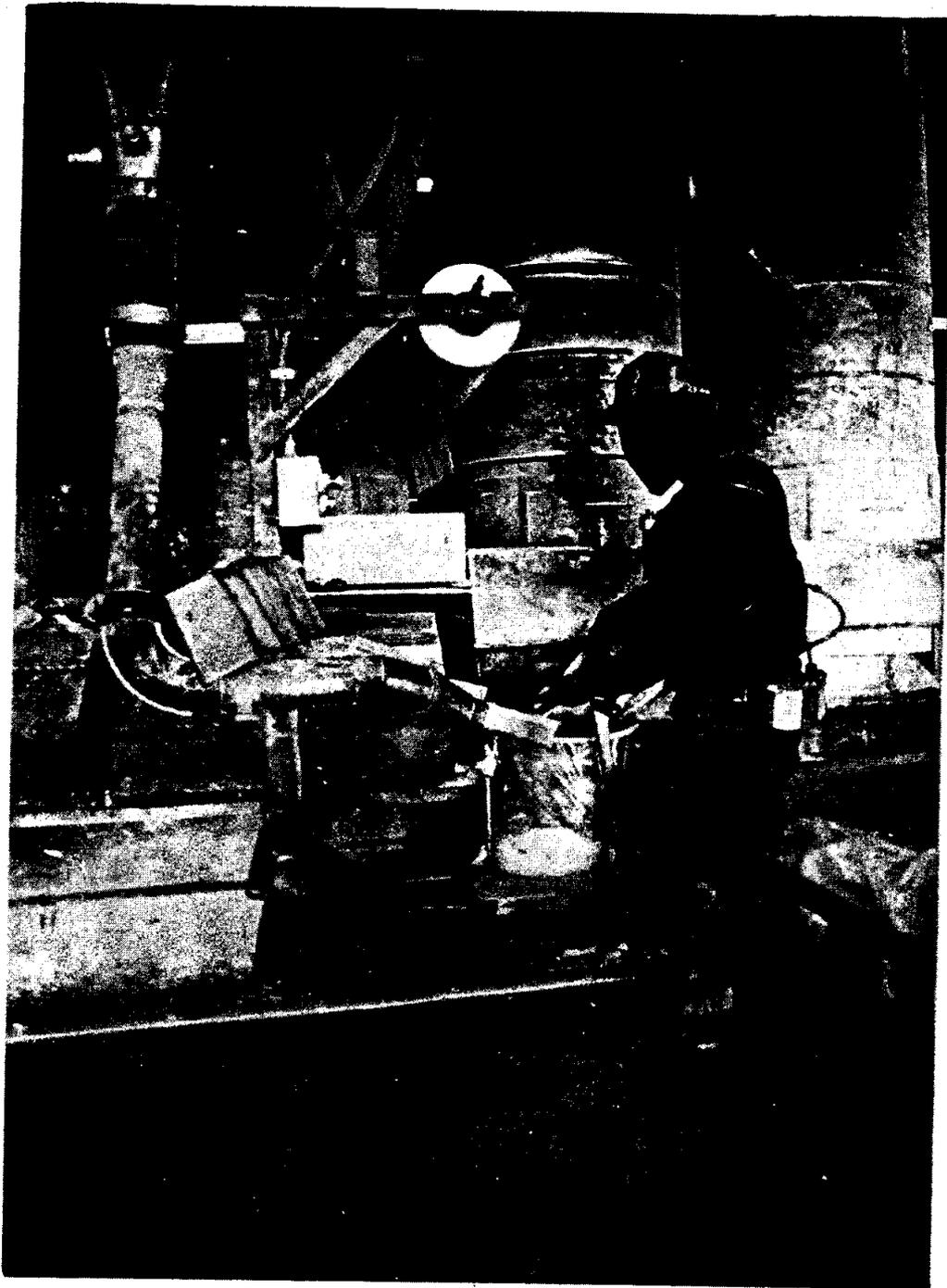


Figure 2-6. Manual compounding system trolley scale hoods.

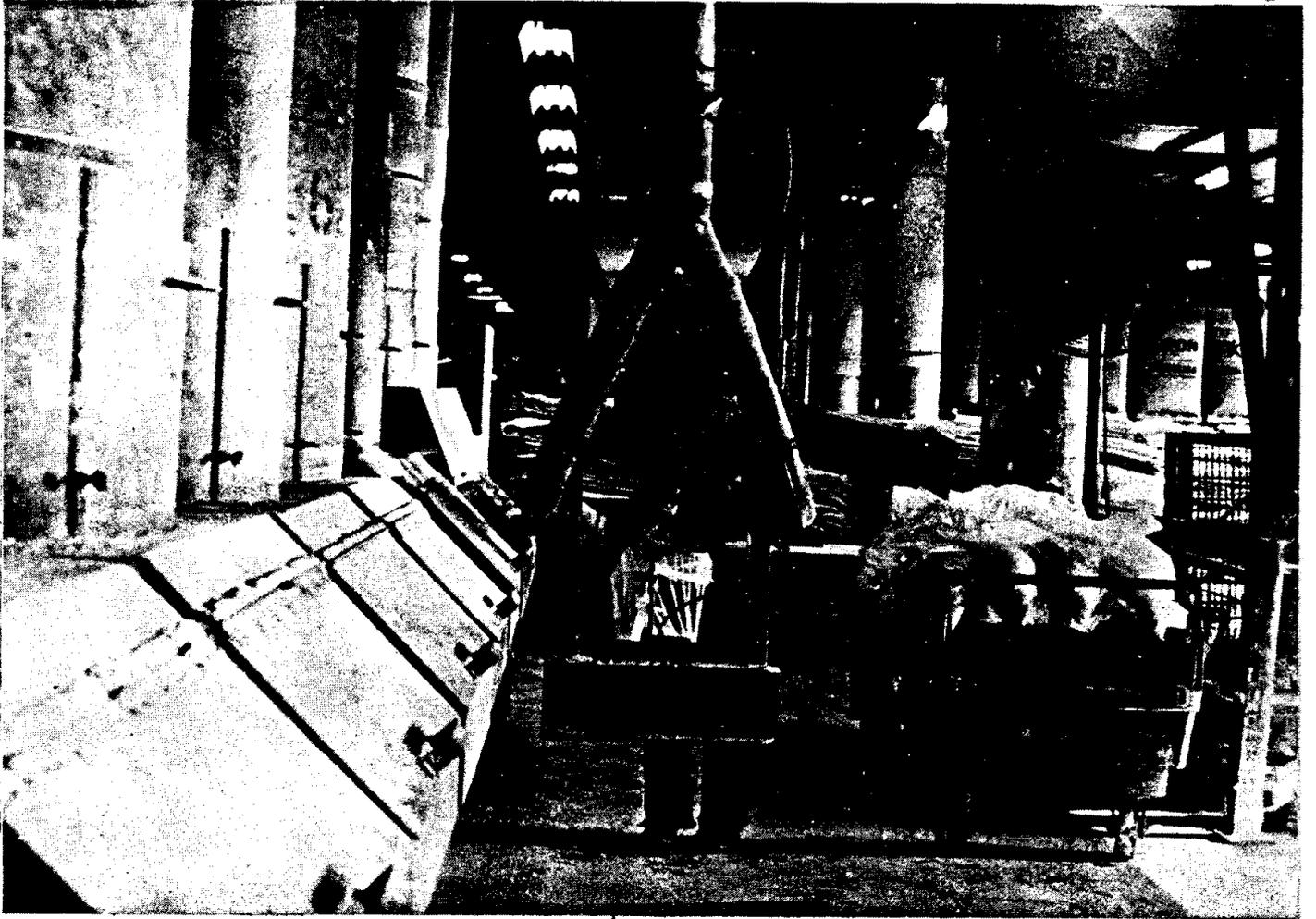


Figure 2-7. Manual compounding system trolley scale hoods.

Final Batch Compounding

This compounding station consists of a sulfur compound weighing area, and an area for weighing out other final batch compounds. The former are held in the bins shown in Figures 2-8 and 2-9, and the latter are held in the bins shown in Figure 2-2.

The sulfur compounds are manually added to the bins by the same worker who weighs them out. The other compounds are added to their bins by a different worker on another floor. Normally, compounds from both sets of bins are weighed into one set of bags, as explained below.

Compounds from both bins are weighed into paper sacks on a cart as shown in Figure 2-10. The scale on which the compounds are weighed is also mounted on a cart. Cart size is an important design parameter for designing parts of the compounding area and system.

The ventilation and bin systems for the final batch compounds were retrofitted to the plants around the mid-seventies. For the sulfur compound bins local exhaust hoods were added, as shown in Figures 2-8 and 2-9. Since the original installation of these hoods, the bottom edge of the hood was relocated from the top of the bins to 8 inches above the bins. Evidently, this was to prevent waste of the compounds by the ventilation system.

The ventilation system for the compounds in the other bins consists of a baffle wall with two side draft hoods located as shown in Figures 2-10 and 2-11. During compounding, the cart holding the bags is adjacent to the baffle so dusts generated from pouring compounds into bags could be pulled into the hoods. No changes were noted in this system from the original design.

WORKER'S DUTIES

For both the masterbatch and final batch compounding operations, the workers' primary duties are weighing out compounds, housekeeping, and some bin filling. Although the duties are similar, there are some procedural differences.

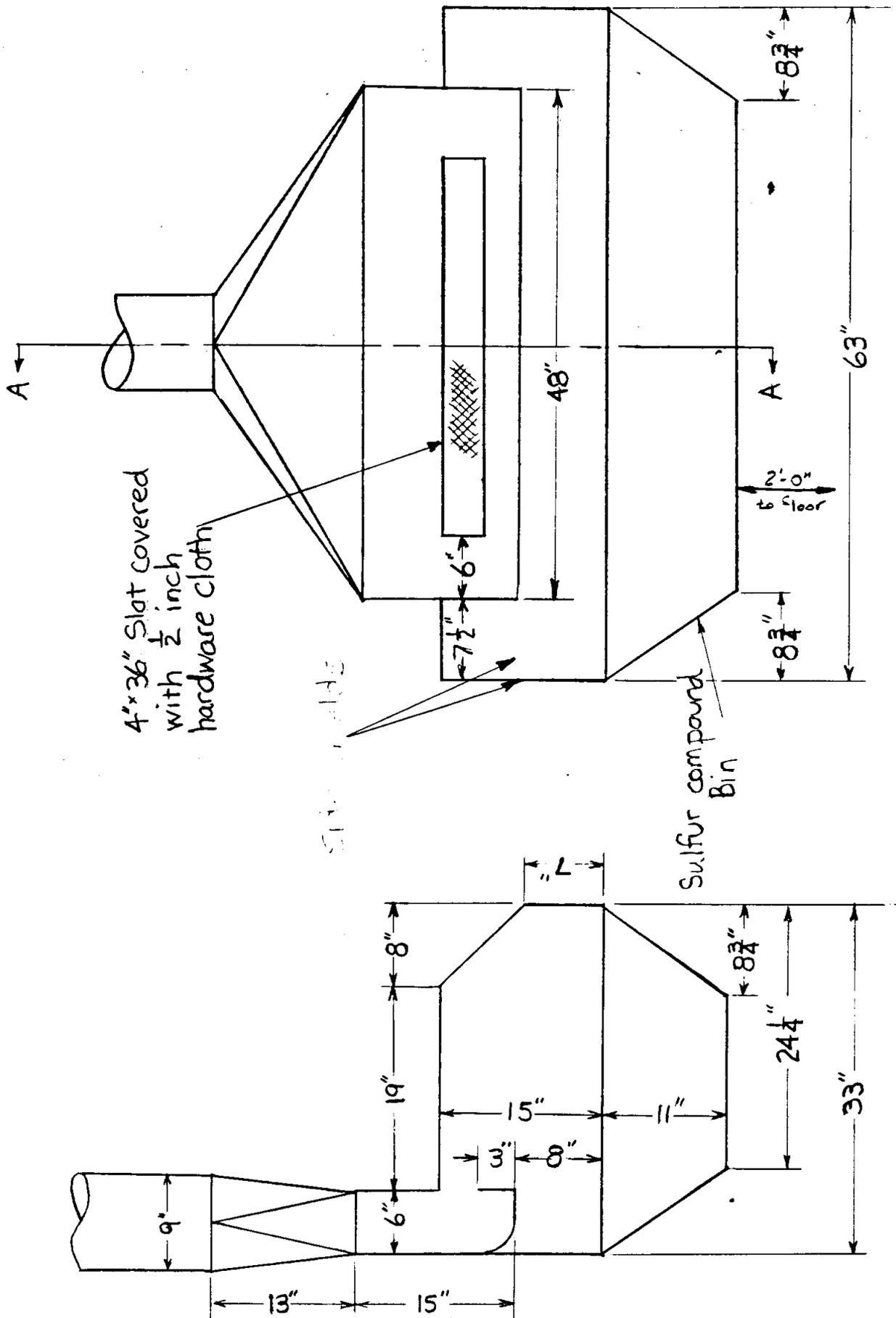


Figure 2-8. Manual compounding system sulfur compound bin hood detail.

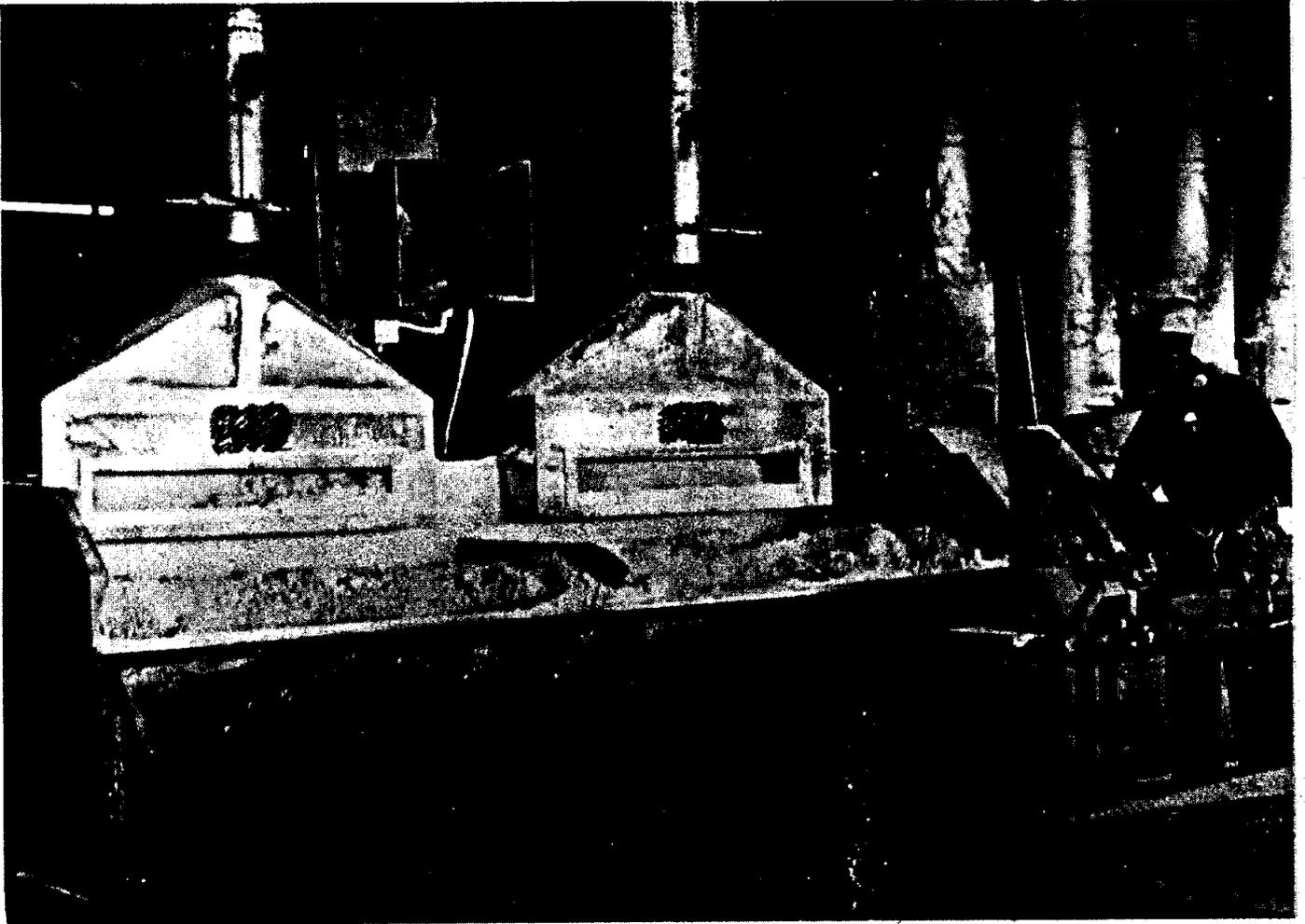


Figure 2-9. Manual compounding system sulfur compound bin hood.
Also shown is an inlet hood for the bag disposal system.



Figure 2-10. Manual compounding system final batch compounding exhaust wall.

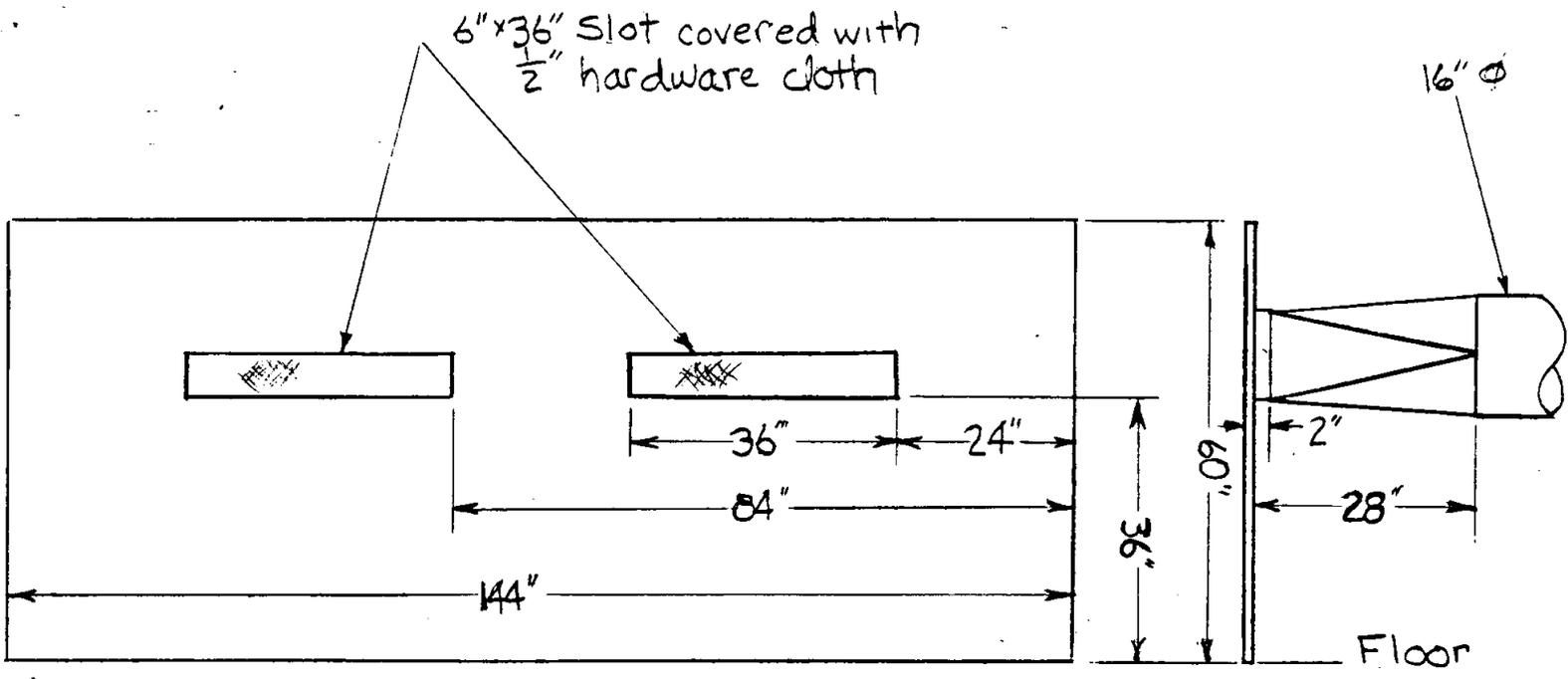


Figure 2-11. Manual compounding system final batch compounding exhaust wall detail.

Masterbatch Compounding

The worker's primary duties at this compounding station are to fill the wax bins and weigh out compounds as specified on recipe cards. To do the former, the worker opens the wax containers (usually plastic lined boxes) and pours the material into the bin. No special procedures are taken with the wax since it does not generate any dust.

To weigh out the powdered compounds, the worker is supposed to follow this procedure:

1. The trolley is placed next to the bin containing the compound needed.
2. A bag is torn from the roll and placed on the bag holder.
3. The compound is removed from the bin by a scoop and poured into the bag until the proper weight is achieved. Adjustments to the weight of material were made by hand.
4. The trolley is then moved to the bin of the next specified compound and weighed as above.
5. The above steps are repeated until all the required compounds have been added to the bag.
6. The bag is finally removed from the trolley and placed on a cart.
7. When fully loaded, the cart is moved to a holding area or to a mixer.

Some workers parked the trolley in one location and transported compounds from the individual bins to the trolley.

In addition to compounding duties, the workers are responsible for keeping bin doors closed when not in use, alerting the bin filler when the material level in the bin gets low, and housekeeping.

Final Batch Compounding

The workers' primary duties at this compounding station are to load the sulfur compound bins and weigh out compounds as specified on recipe cards. To do the former, the worker positions a bag of the oiled sulfur compound on the forward edge of the bin and slits the bag lengthwise along the edge facing the hood. The worker then lifts the bag forward and dumps the compound out. The bag is finally shaken out and discarded in a disposal system.

Compounds from both sets of bins are weighed into paper bags. To weigh out the compounds, the worker follows this procedure:

1. The load and scale carts are positioned in front of the sulfur compound bins.
2. Compound is taken from the bin with a scoop and poured onto the scale pan. The weight of compound was adjusted by hand.
3. When the proper weight of chemical is obtained, the compound is poured from the pan into a paper bag set on the load cart.
4. The sulfur compound is weighed into bags until the load cart is full.
5. The carts are moved in front of the second set of bins.
6. At these bins, the weighing procedure is repeated until all the bags have received the additional specified compounds.
7. The loaded cart is finally transported to a holding area or a mixer.

In addition to the above duties, the worker is responsible for keeping the bin doors closed, alerting the bin filler when the bins get too low, and house-keeping.

AIR SAMPLING DATA

Total particulate area samples were collected at the locations shown in Figure 2-12. Also, total and respirable particulate samples were collected on the compounding workers. The sampling data are summarized in Table 2-1 and detailed in Appendix II. Statistical analysis of the total particulate sampling results using analysis of variance and Duncan's Test is also summarized in Table 2-1. Analysis of variance showed that location significantly affected concentration. The results of the analysis are found in the "Duncan's Test" column and explanations at the bottom of the table.

VENTILATION DATA

The ventilation measurements are summarized in Table 2-2 and shown Appendix IV. Special conditions under which the measurements were taken are indicated in the figures. The gates in the ducts of the baffle wall hoods were found to be partially closed. A comparison of the measurements made with the gates partially closed and fully open, showed that the latter was closer to design. Therefore, it is presented in the table instead of the measurements with the gates partially closed. The measurements presented for the trolley scale hoods are also with the baffle wall hood gates fully open, since all of these hoods are connected to one main.

Table 2-1. Full shift particulate concentrations for a manual compounding system.

Location (No. from Fig. 2-12)	N	GM (mg/m ³)	GSD	AM (mg/m ³)	Range (mg/m ³)	Duncan's Test ^a
Total Particulate:						
Baffle wall, left (1)	5	0.44	1.6	0.48	0.20-0.71	A
Column near masterbatch station (10)	5	0.81	1.5	0.89	0.56-1.50	A,B
Masterbatch scale, Y side (4)	5	0.83	1.3	0.85	0.66-1.34	A,B
Masterbatch scale, Z side (7)	5	1.00	1.3	1.04	0.66-1.33	B,C
Masterbatch worker, Y side (5)	5	1.67	1.3	1.78	0.93-2.50	C,D
Masterbatch worker, Z side (8)	5	2.04	1.9	2.40	0.91-3.60	D
Final batch worker (2)	5	2.13	1.7	2.32	1.05-3.34	D
<hr style="border-top: 1px dashed black;"/>						
Respirable Particulate:						
Final batch worker (3)	5	0.32	1.2	0.32	0.27-3.39	--
Masterbatch worker, Y side (6)	5	0.63	1.5	0.68	0.36-1.00	--
Masterbatch worker, Z side (9)	5	0.65	1.5	0.76	0.55-0.96	--

a. Locations with the same letter are not significantly different. Also locations beneath the dashed line were not included in Duncan's Test.

Table 2-2. Manual compounding system ventilation data.

Measurement	Quantity Measured	Design
Sulfur Compound Bin B Hood^a		
Calculated average duct velocity	3280 fpm	3565 fpm
Calculated duct flow	1450 cfm	1575 cfm
Duct static pressure	5.0 in. H ₂ O	Unknown
Average face velocity	1450 fpm	1575 fpm
Baffle Wall Hoods^b		
Calculated average duct velocity:		
Right hood	4175 fpm	3615 fpm
Left hood	4315 fpm	3615 fpm
Calculated duct flow:		
Right hood	5830 cfm	5050 cfm
Left hood	6025 cfm	5050 cfm
Duct static pressure (branch for both hoods):	2.9 in. H ₂ O	Unknown
Average face velocity:		
Right hood	3885 fpm	3365 fpm
Left hood	4025 fpm	3365 fpm
Trolley Scale Hoods, Y Side		
Calculated average duct velocity:		
Right hood ^c	4790 fpm	4585 fpm
Left hood ^c	5020 fpm	4585 fpm
Calculated duct flow:		
Right hood	420 cfm	400 cfm
Left hood	440 cfm	400 cfm
Duct static pressure (branch for both hoods)	2.1 in. H ₂ O	Unknown
Average face velocity:		
Right hood	2510 fpm	2400 fpm
Left hood	2625 fpm	2400 fpm
Trolley Scale Hoods, Z Side		
Calculated average duct velocity:		
Right hood ^c	4985 fpm	4585 fpm
Left hood ^c	5225 fpm	4585 fpm
Calculated duct flow:		
Right hood	435 cfm	400 cfm
Left hood	455 cfm	400 cfm
Average face velocity:		
Right hood	2610 fpm	2400 fpm
Left hood	2735 fpm	2400 fpm

- a. Sulfur compound bin A hood was about 25 percent blocked by material accumulation. A gate in the hood's duct was partially closed. Measurements were not made on the hood.
- b. Gates in hood ducts adjusted prior to measurement. See the text for an explanation.
- c. Orientation is from worker's perspective at his position in front of the trolley. This is shown schematically in Figure 2-15.

EMISSION SOURCES OBSERVATIONS

The sources of the emissions from the compounding operation appear to be dusts from the powdered compounds.

1. Dusts entrained in air displaced from material being poured or tossed into containers. This occurs when bags and bins were filled and when materials were tossed back into bins.
2. Dusts entrained in air displaced by shifting compounding materials. This occurs from materials shifting as bins empty or are filled from another floor.
3. Dusts entrained in air displaced by collapsing empty bags. This occurs from squashing empty bags or dropping them on the floor.
4. Dusts dispersed directly into the air. This occurs from spilling materials, tossing materials through the air, and materials falling off tools, containers, or structures.
5. Dusts forced directly into air or entrained in air caused by movement of an object through or across dusty materials or surfaces. This occurs from moving a scoop through material, brushing something across a dusty item (for example, sweeping a floor), or air movement over a dusty surface.
6. Dusts forced directly into air by rebounding off other objects. This occurs when materials are tossed into bins and bags.

WORK PRACTICE OBSERVATIONS

Workers at both compounding stations had close contact with the compounds they were weighing. Also, some dust emissions were the direct result of the way they performed their job. Therefore, work practices could have an important effect on their exposures. Work practices could also have an effect on the performance of the ventilation system.

Some of the notable work practices which could reduce worker exposure were:

1. Placing the wax flakes in the bags last. This could help prevent dusts from the compounds beneath the wax from escaping the bags.
2. Placing end of scoop or scale pan into bag when pouring compounds into the bags.
3. Cleaning up material spills from floors.
4. Keeping the bin doors closed when not in use.

Observed work practices which could contribute to the worker's exposure or decreased ventilation system performance were:

1. Handling compounds by hand.
2. Tossing compounds into bags or back into bins.
3. Transporting compounds relatively long distances between bins and bags. This results in dust emissions and spilled materials.
4. Carelessly handling compounds. Some compounds were spilled on floors, structures, and clothes.
5. Brushing spilled compounds off carts and scales onto the floor.
6. Stacking bags too high on carts. This increases the chances for bags falling and breaking open.

7. Not twisting plastic bags closed and transporting compounds in open paper bags. This increases the chances of spills while transporting compounds.
8. Blowing off carts with air hoses.
9. Allowing compound levels in bins to get too low. This permitted compounds to blow out of the bins when they were filled from another floor. But, judging levels in bins was difficult because there were no level indicators.
10. Dry sweeping compounds.
11. Beating on bins to break up bridged material. This caused noticeable denting of the bins and, in some cases, leaks around bin gates.
12. Not maintaining the trolley drives. This could be the reason workers did not move the trolley to each bin to pick up materials - the trolley was reported to be difficult to move manually.
13. Using man-cooling fans around ventilation systems.
14. Not cleaning out material accumulated in hoods.
15. Not cleaning materials off structures and allowing it to accumulate on floors. Workers performed housekeeping as fill-in work.

In addition, gates on ducts to some hoods were adjusted so the hood had insufficient airflow. But, in common practice, the gates used to balance the system airflow are set in position and then welded in place. This helps prevent tampering with the system.

Because of the close adherence of the ventilation system to the design drawings, the parent company's procedure for specifying and contracting ventilation projects was investigated. It is:

1. The parent company's safety division or the Tire Division's safety manager are informed of the need for a control by plant management or union personnel.
2. The problem is investigated by personnel in Item 1. The parent company's engineering department and plant personnel decide which control approach is needed.
3. If a ventilation system is needed, the project can be sent to an outside contractor, or designed by the present company's engineering department or plant personnel. The procedure used depends on the type and size of the job.
4. After the project is designed, it is sent to the parent company for approval by the engineering department personnel and the personnel in Item 1.
5. Upon approval, the project is assigned to someone in the engineering department for contracting and monitoring. Small projects are returned to the plant for completion.
6. The assignee sends the design out for bids.
7. After a contractor is selected, the job begins.
8. Depending on the size and type of the job, the assignee may go into the field during the installation to investigate the job. However, any significant changes in the installation must be approved by the parent company. This approval is necessary to monitor cost and potential effects on the system.
9. After the project is installed and balanced, the assignee goes to the plant to inspect the installation.

Tight control on the project is maintained throughout the project's life. The contract is monitored by a person knowledgeable in ventilation.

Contractors are required to install systems exactly as they are designed - all changes require justification and approval.

ENGINEERING CONTROLS OBSERVATIONS

These observations concern the sulfur compound bin hoods:

1. Dusts were noted to escape the hood when bags of compounds were emptied into the bins. The hood also did not capture dusts generated from pouring the compound into bags, but the hood was apparently not designed to control this source.
2. As noted above, material had accumulated in the hood of bin A. Whether this was caused by inadequate airflow in the hood or the worker pouring compounds into the hood is unknown.
3. A 150 to 170 fpm draft flowing parallel to the hood face was noted while trying to measure capture velocities on bin B. The capture velocity measured perpendicular to the face at several locations was found to be 10 to 50 fpm.
4. The design drawings for the hood showed a calculated centerline capture velocity of 83 fpm for this hood. Using the ACGIH Ventilation Manual equation for a flanged slot hood, this capture velocity was reproduced. Although the hood was operating within 10 percent of its design specifications, the capture velocity was significantly less than that predicted.

These observations concern the baffle wall hoods:

1. Dusts generated by pouring compounds into bags were captured by the hoods. However, this ability to capture the dust diminished as the distance from the hood face increased. The hoods did not capture dusts generated from handling materials at the bins, but the hood was apparently not designed to control this source.

2. The design drawings show a centerline capture velocity of 172 fpm at a distance of 42 inches from the hood face and with a flow rate of 5050 cfm. Using the ACGIH Ventilation Manual's equation for a flanged slot hood, this capture velocity was reproduced. The average velocity measured in a plane 42 inches from the face was about 25 fpm at a flow rate of about 6000 cfm. The actual capture velocity was significantly less than that predicted.

These observations concern the trolley scale hoods:

1. Dusts from bag filling were observed to be captured by the Y side trolley hoods. Some of the dusts were captured by the Z side trolley hoods but a thin layer of fine dust was noted on top of the hoods indicating some by-pass of the hood. Also, the plume of dust generated from bag filling was generated in the direction of the hood.
2. Dusts generated from materials handling in the bins, and between the bins and the bags, were not captured by the ventilation system, but the hood was apparently not designed to control these sources.
3. The overall design of the trolley benefited the compounding job. All parts needed for the job were conveniently located. The placement of the bag holder appeared to be at an easy work height, and the top of the holder was slightly lower than the bin edge. Unfortunately, the use of a zipper duct necessitated a drive for the trolley.
4. The construction of the actual trolley hoods, shown in Figures 2-4 and 2-5, is a derivation of the actual hood installation and the original design drawings. The actual construction was rough - the hoods were not dimensionally equal, the hood tilt was not the same between hoods, and the distance from the bag holder to the hood face varied between hoods. On all hoods the face dimensions were about the same.
5. The orientation of the hood may critically affect the hood performance. For the Y side trolley hoods, the average capture velocity, hood flow rate, and radial distance from the centerpoint of the bag holder to the hood's face were 155 fpm, 430 cfm, and 12.25

inches, respectively. For the Z side hoods, they were 70 fpm, 445 cfm, and 11.75 inches, respectively. The differences in the flow rates and distances between the two sets of hoods do not correlate to the average capture velocities. The Y side hoods have a lower flow rate and greater centerpoint distance than the Z side hoods, but the Y side hoods have over twice the capture velocity of the Z side hoods. Possibly, the more parallel the hood face is to the top of the bag holder, the better the capture velocity produced by the airflow.

These observations concern the ventilation system in general:

1. Monitoring tap holes were placed in all hood ducts. In some cases, the hood (duct) static pressure was measured through these holes. For hoods, where the tap was placed in or near as duct expansion or contraction, turbulence was encountered. The turbulence resulted in static pressure fluctuations of 0.5 inches.
2. Bin doors did not latch - they stayed closed by gravity. When bins with low material levels were filled, the material squirted out of the bins. This occurred even when the bin doors were closed. The bin gates were not closed during bin filling. The function of the gates appeared to be for adjusting material levels in scooping area of the bin - not prevention of the above problem.
3. A general make-up air system which included the compounding ventilation system was installed as part of the dust abatement program. It was designed to provide 12 percent more make-up air than the exhaust ventilation would remove. Its outlet, relative to the compounding stations, is shown in Figure 2-1. Workers still used man-cooling fans and open windows to keep cool.
4. A 2-inch accumulation of a sulfur-like compound was noted in the bottom of the main duct of the compounding ventilation system. The average velocity in the duct was measured to be 3420 fpm.

5. The ducting for the ventilation system was well-designed according to convention. Among other proper design practices, there were large radius elbows, correctly placed entrances, and correctly angled transitions
6. As mentioned above, compounds tended to bridge in bins. The only way to break the bridge appeared to be punching the bridge with a pole from the top. However, workers beat on the sides of the bin to work the bridge loose. The bins were not supplied with vibrators or bridge breakers.

The use of plastic bags with necks long enough to be twisted closed helped reduce dust emissions as did the use of oiled and pelletized compounds.

MONITORS OBSERVATIONS

No monitors for specific contaminants or ventilation performance were noted.

PERSONAL PROTECTIVE EQUIPMENT

Workers were supplied two pairs of coveralls with cleaning service each week by the plant. Some workers, primarily in final batch compounding, were observed wearing them. Most of the workers were observed wearing a head cover. These covers were baseball caps, bandanas, and hats fashioned from cutoff paper bags. Reportedly, these covers were to keep dusts out of the workers' hair.

DATA INTERPRETATION

Dust generated by compounding operations can directly enter the worker's breathing zone. Dusts generated from bin filling from another floor, spills, and some housekeeping practices (for example, dry sweeping) can be generated into the general room air and can elevate background concentrations.

Overall, the air sampling data show that the compounding workers' exposure levels were significantly different than all of the area samples except the samples collected on the Z side trolley scale. This indicates that the

ventilation system as a whole may not have been capturing all of the dust generated by compounding, the work practices significantly affected the workers exposure.

The sulfur bin compounding hoods did not capture all of the dust generated from emptying bags into the bins or pouring compounds into paper bags. Not much dust was generated from scooping material out of the bins so this dust appeared to be easily controlled by the hoods. These hoods were designed to capture dust from the bin filling and scooping operations, but apparently not bag filling.

Based on the ventilation measurements and the design criteria on bin B, the design equations for centerline capture velocities in the ACGIH Ventilation Manual appear inadequate. The hood was operating within 10 percent of its design airflow and the design capture velocity (calculated using the equation for flanged slot hood in the ACGIH Ventilation Manual) was over 80 fpm at the front of the bin. The measurements, however, showed that the capture velocity was about 10 fpm. Therefore, the equations are either inaccurate or do not account for additional parameters which occur in this plant.

The baffle wall hoods only captured dusts generated by bag filling. They were apparently not designed for capturing and did not capture dusts generated from materials handling at the bins.

As with sulfur compound bin B, the design capture velocity calculated from the ACGIH Ventilation Manual for a flanged slot hood was inaccurate. The hoods were operating at greater than design, but the measured capture velocity was 25 fpm while the design velocity was 170 fpm.

A great difference in the average capture velocities was measured between the Z side trolley scale hoods (70 fpm) and the Y side trolley hoods (150 fpm). Statistical analysis of the particulate concentration data showed difference between the Z side worker and the Y side worker. Furthermore, observations showed the Y side hoods to capture dust emissions better than the Z side hoods. Therefore, the Y side hoods appear to capture dust emissions from bag filling, while the Z side hoods are only partially effective. Based on

statements above, this suggests that the hoods are capturing most dusts during bag filling and that work practices may be elevating the workers' exposures.

Even though most of the hoods appear to be ineffective or only partially effective, observations showed that the dusts were primarily generated by the manual compounding operations. Therefore, work practices can have a drastic effect on the worker's exposure.

BANBURY MIXER (3)

AREA: MIXING

DESCRIPTION

The mixer studied is a size 11D 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. A layout of the charging area is shown in Figure 3-1.

Two methods are used to charge the batch ingredients to the mixer: (1) rubber stocks and powdered compounds are fed by conveyor into the mixer hopper; and (2) carbon black and process oils are automatically charged directly into the mixing chamber. The powdered compounds are weighed into plastic bags in another area of the plant.

The mixer ventilation system, which is shown in Figures 3-2, 3-3, 3-4 and 3-5, consists of a charge door hood, carbon black charge chute vent exhaust, and four dust ring hoods. The discharge door area is totally enclosed.

The mixer ventilation system was installed in the late seventies. The only noted change in the installed system from the design drawings was in the placement of the duct entrance on the charge door hood. The drawings showed a horizontal duct entrance at the top of the hood while the actual installation had a vertical duct entrance. The reason for the change was not obtained.

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 weigh conveyor and, after weighing, is advanced to the charging conveyor by the worker.

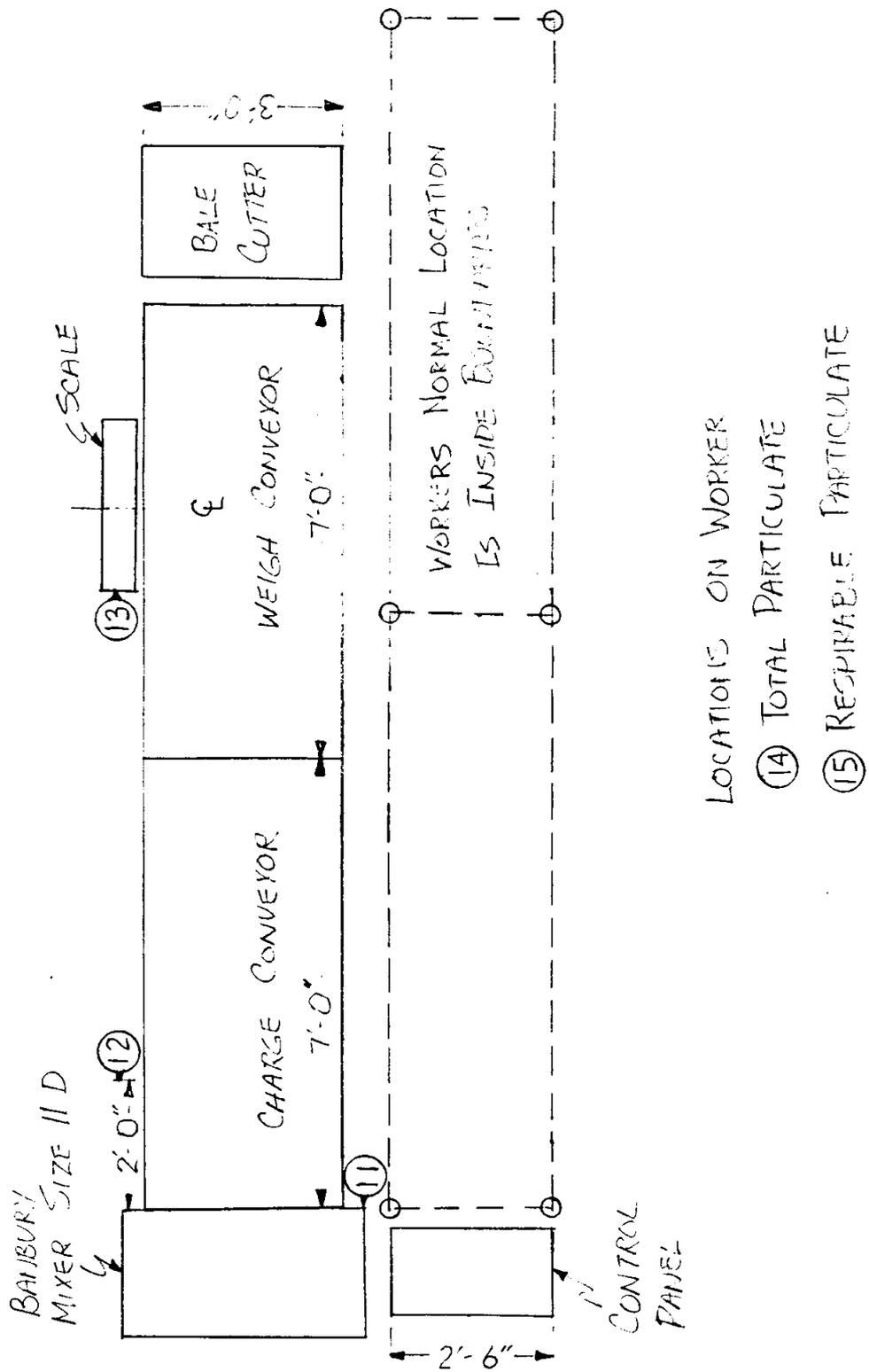


Figure 3-1. Mixer charging area layout and sample locations.

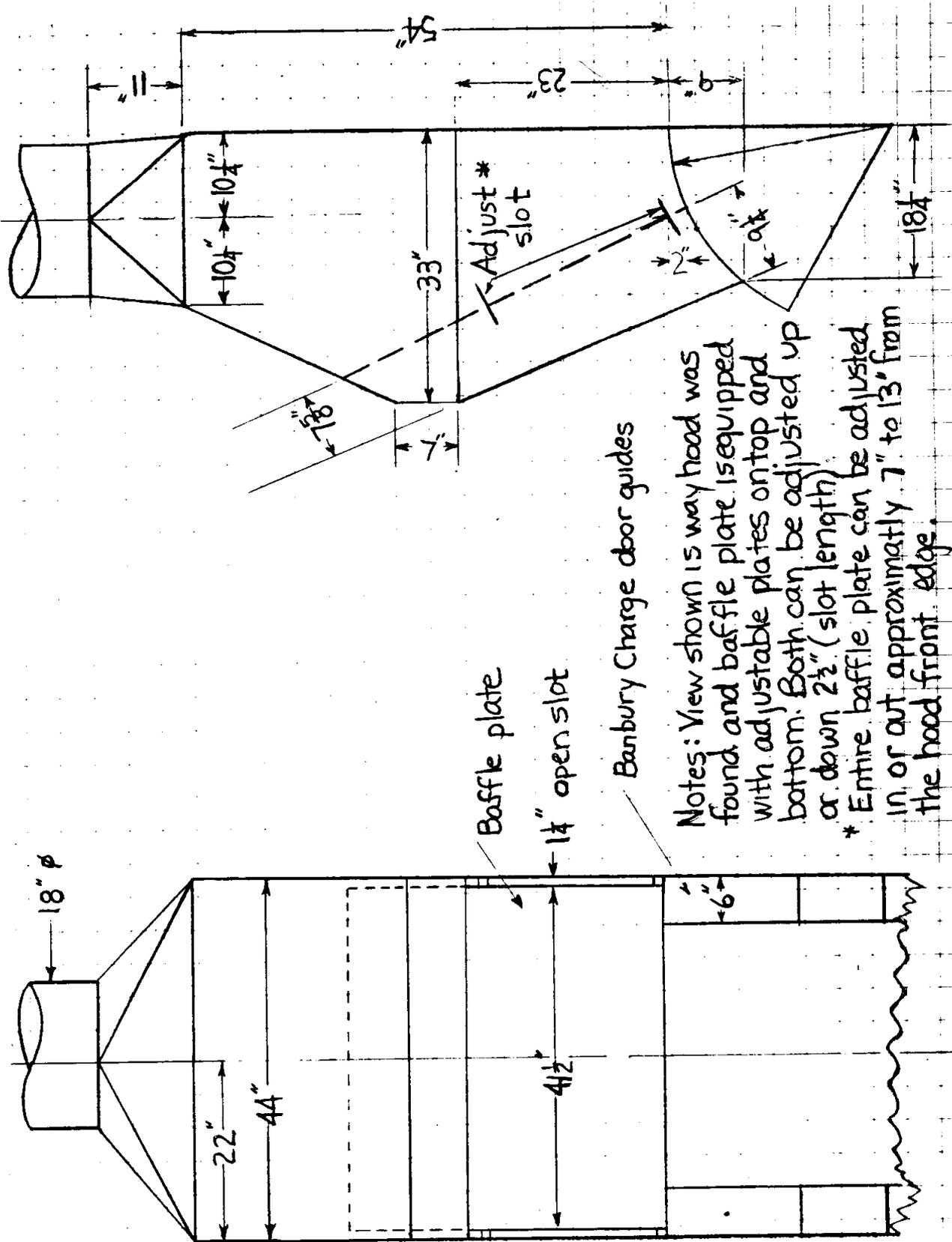


Figure 3-2. Mixer charge door hood detail.

Reproduced from
best available copy.

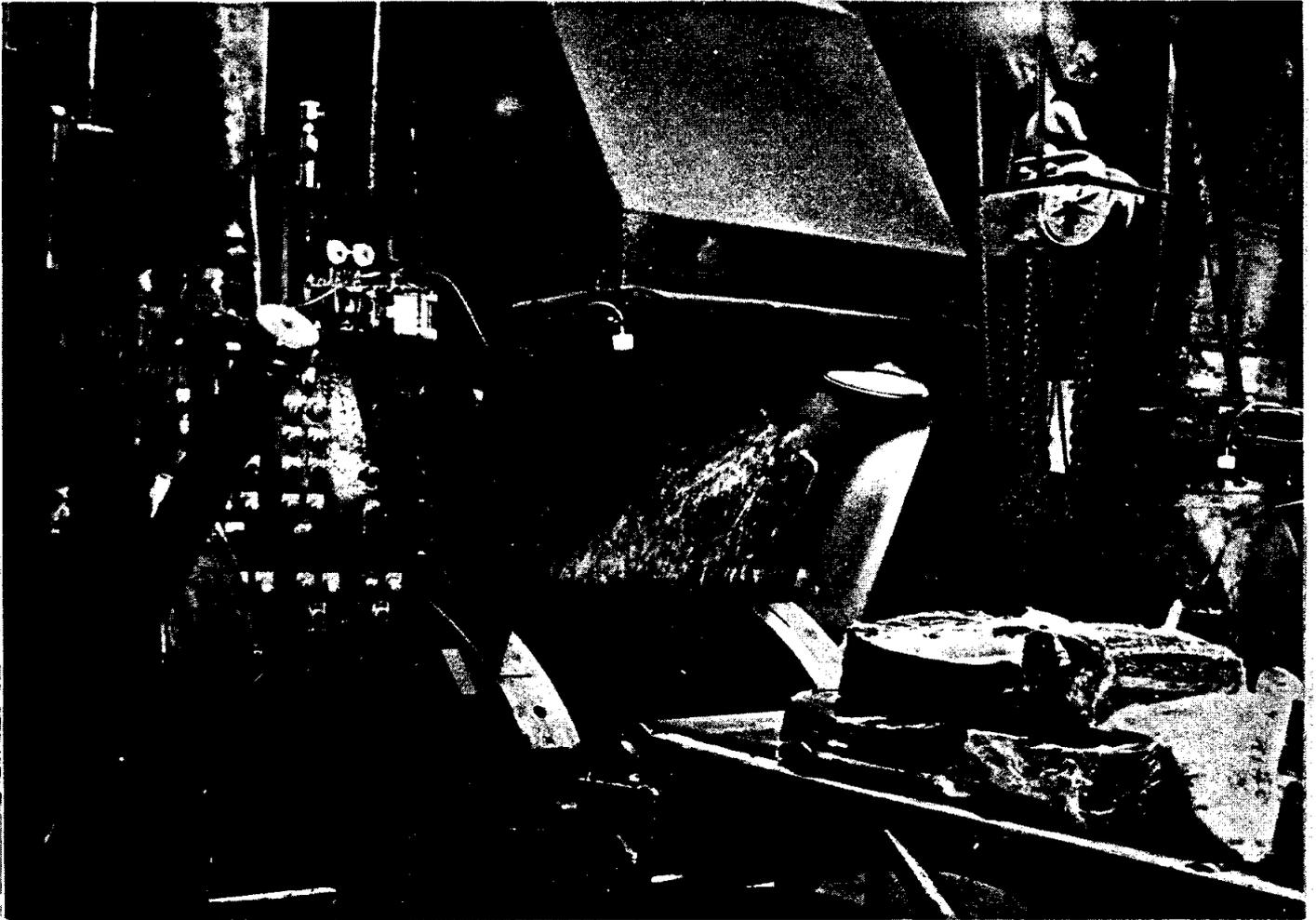


Figure 3-3. Mixer charge door hood.

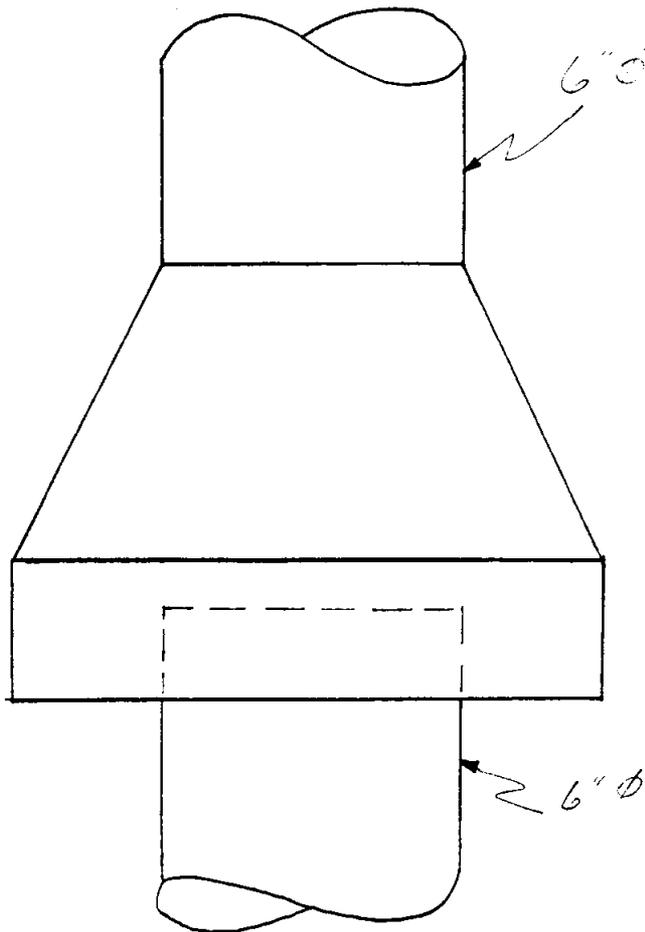


Figure 3-4. Mixer carbon black chute vent hood detail.

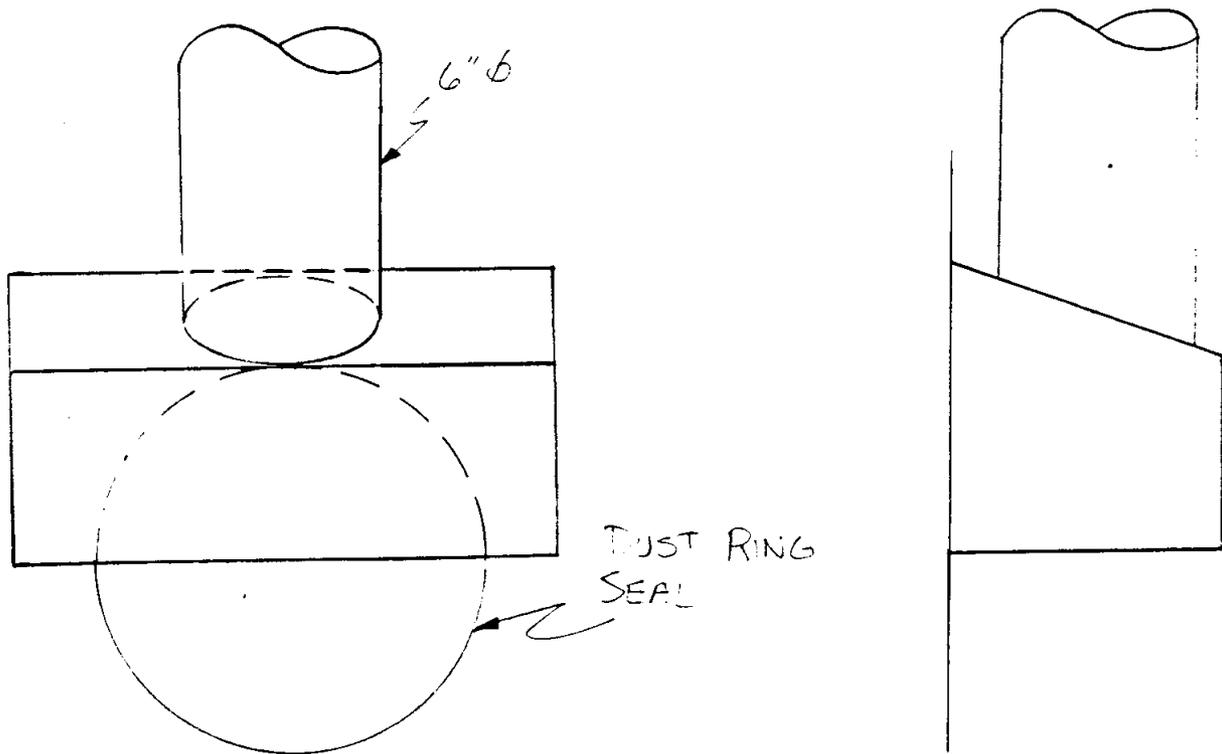


Figure 3-5. Mixer dust ring hood typical detail.

VENTILATION DATA

The ventilation measurements are summarized in Table 3-2 and shown in Appendix IV. Special conditions under which the measurements were made are shown in the figure. Design airflow parameters for the ventilation system were unavailable.

Table 3-2. Mixer ventilation data.

Measurement	Quantity Measured	
Charge Door Hood		
Calculated duct velocity	2715 fpm	
Calculated duct flow	4795 scfm	
Duct static pressure	Not measured	
Average face velocity-overall	1000 fpm	
Area above charge door (lines A to G in Fig. 3-6)	855 fpm	
Dust Ring Hoods	<u>Left</u>	<u>Right</u>
Average duct velocity ^a	1990 fpm	2750 fpm
Calculated duct flow	390 scfm	540 scfm
Duct static pressure	1.23 in. H ₂ O	1.93" H ₂ O
Carbon Black Charge Chute Vent Hood		
Average duct velocity ^a	3490 fpm	
Calculated duct flow	685 scfm	
Duct static pressure	1.82 in. H ₂ O	

a. Measured less than 7.5 duct diameters from a disturbance.

EMISSION SOURCES OBSERVATIONS

The sources of the emissions around the mixer appeared to be the dusts from powdered compounds used in the rubber and unknown emissions from process oils. These specific sources were noted:

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. Dusts entrained in air displaced by process material movement, such as air displaced by carbon black flowing down the charge chute.
3. Emissions from process oils. These emissions were coming through the open lid of a process oil heater tank.

WORK PRACTICE OBSERVATIONS

The worker at this mixer normally had little contact with the powdered compounds. Powdered compounds arrived at the mixer preweighed in plastic bags. The powdered compounds were charged, bag and all, into the mixer with the rubber. Aside from carelessly handling bagged compounds, work practices appeared to have little potential effect on the dust generation. Compared to workers at other mixers who manually handled compounds, workers at the study mixer remained relatively clean while the other workers collected dust on their clothes. The greatest difference between the operations at the mixers was that the workers at other mixers emptied compounds from bags into the mixer and then disposed of the bags.

Some of the work practices which could elevate the worker's exposure are:

1. Keeping the area around the mixer cluttered. Pallets of rubber bales were placed non-uniformly around the mixer. This could prevent proper housekeeping of the area.
2. Leaving the lid on the process oil heater tank open.

ENGINEERING CONTROLS OBSERVATIONS

Visible emissions were not observed escaping the mixer hoods or the discharge door enclosure. Also, emissions were not observed coming from the dust ring seals.

The ventilation system had some improper design practices which could increase the static pressure losses of the system. They were use of flexible ducting

where solid wall ducting could be used, not expanding mains at each duct entrance and not using large radius elbows. Attempts were made to provide angled entrances of branches into the main.

MONITORS OBSERVATIONS

A current indicator light was provided to indicate fan motor operation. Prior to making the ventilation measurements, the fan on the ventilation system was found to be cycling on and off. When notified, the plant promptly found and repaired the problem (a faulty relay on the fan motor). Even though the fan was not operating correctly, the indicator light was illuminated, and therefore did not really indicate that there was a ventilation system malfunction.

PERSONAL PROTECTIVE EQUIPMENT

The plant provides the workers with two pairs of clean coveralls a week. The workers on the mixer studied were not observed wearing the coveralls. Workers at other mixers where compounds were manually poured from bags into the mixer were observed to wear them. These workers, contrary to the workers on the mixer studied, were covered with dust by shift's end. No other personal protective equipment was noted.

DATA INTERPRETATION

At the mixer, no contaminant was generated directly into the worker's breathing zone. Instead, the worker's exposure appeared to come from particulates in the general room air. The air sampling results support this because the homogeneity of the particulate concentrations. Based on observations and the air sampling results, contaminants generated at the mixer appeared to be controlled by the mixer ventilation. This is supported by the homogeneity of the particulate concentrations.

Work practices appeared to have little effect on particulates generation and thus the workers' exposure because the worker had little direct contact with

dusty process materials. This is supported by the air sampling results because there is no significant difference between the workers at the mixer or significant interaction between the worker's location and surrounding sample locations. However, work practices, such as leaving the lid on the process oil heater tank open, can result in contaminant emissions into the general room air. This causes an elevation of the background concentrations and possibly the worker's exposure.

At the mixer studied, the worker's job did not appear to significantly contribute to his particulate exposure. Instead this exposure may have been the result of dust generated by other operations. The fact that the particulate concentrations are homogeneous suggests that particulate permeates the entire area. Particulate from sources at the mixer are felt to be a minor contributor to the background particulate concentrations.

PNEUMATIC DISPOSAL SYSTEM (4)

AREA: PRECOMPOUNDING, COMPOUNDING, AND MIXING (REFUSE GENERATION AREAS)

DESCRIPTION

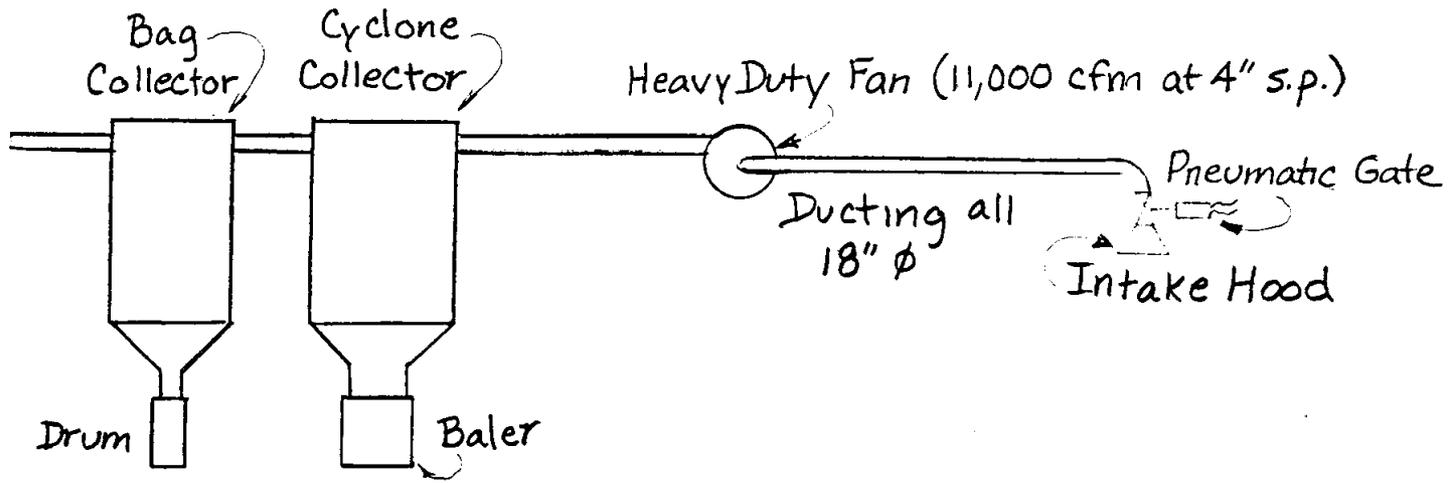
The purpose of the pneumatic disposal system is primarily to collect and transport refuse to a collector and baler. The refuse for which the system was designed is the empty shipping bags which contained the powdered compounds, and the empty bags used to transport compounds from the compounding area to the mixer charging area. The shipping bags usually come from the compounding and precompounding areas, while the other bags come from the mixer charging area.

The original disposal system was designed and installed by Ohio Blowpipe, Cleveland, Ohio. It consists of intake hoods and their pneumatically operated gates, ducting, a heavy duty fan, cyclone and bag collectors, and refuse baler. This system is shown schematically in Figure 4-1a.

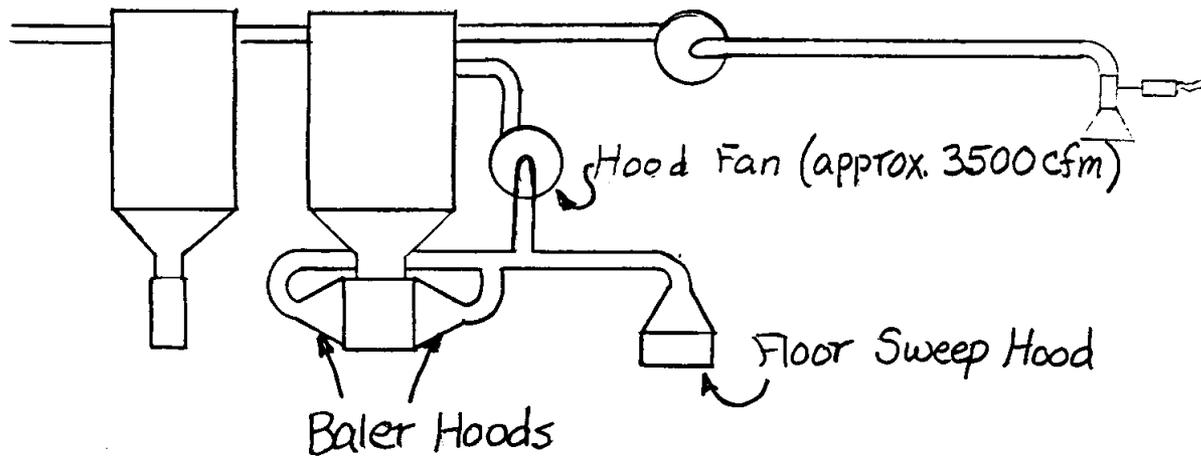
The intake hoods for the system are located in the precompounding and final batch compounding areas and at each mixer. There are two types of hoods, shown in Figure 4-2, depending on the location and application. The overhead hood is located in the precompounding area, while the other type of hood is located in the final batch compounding area and at each mixer. Several views of the hoods are shown in Figures 1-4, 2-9, and 4-3.

Since the disposal system was designed to handle only one intake hood at a time, a pneumatically controlled gate was installed at each hood. The valve and cylinder on the gate are actuated by the worker stepping on a footswitch when he wishes to dispose of a bag. Indicator lights at each hood location go out each time a hood is opened indicating the system is in use. Workers have been trained not to use the system when the light is out.

Original System



First Change



Present System

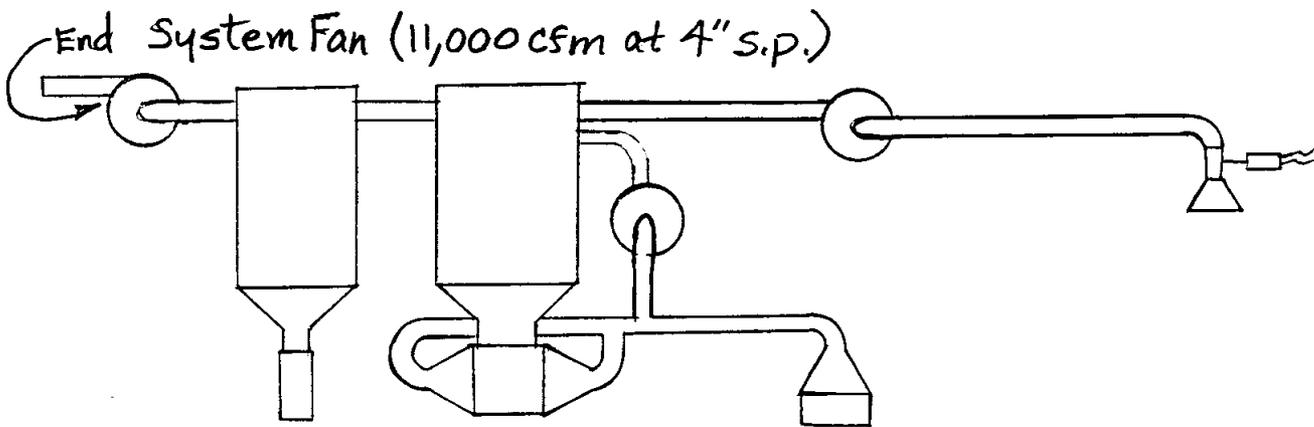


Figure 4-1. Schematic of original disposal system with subsequent alterations.

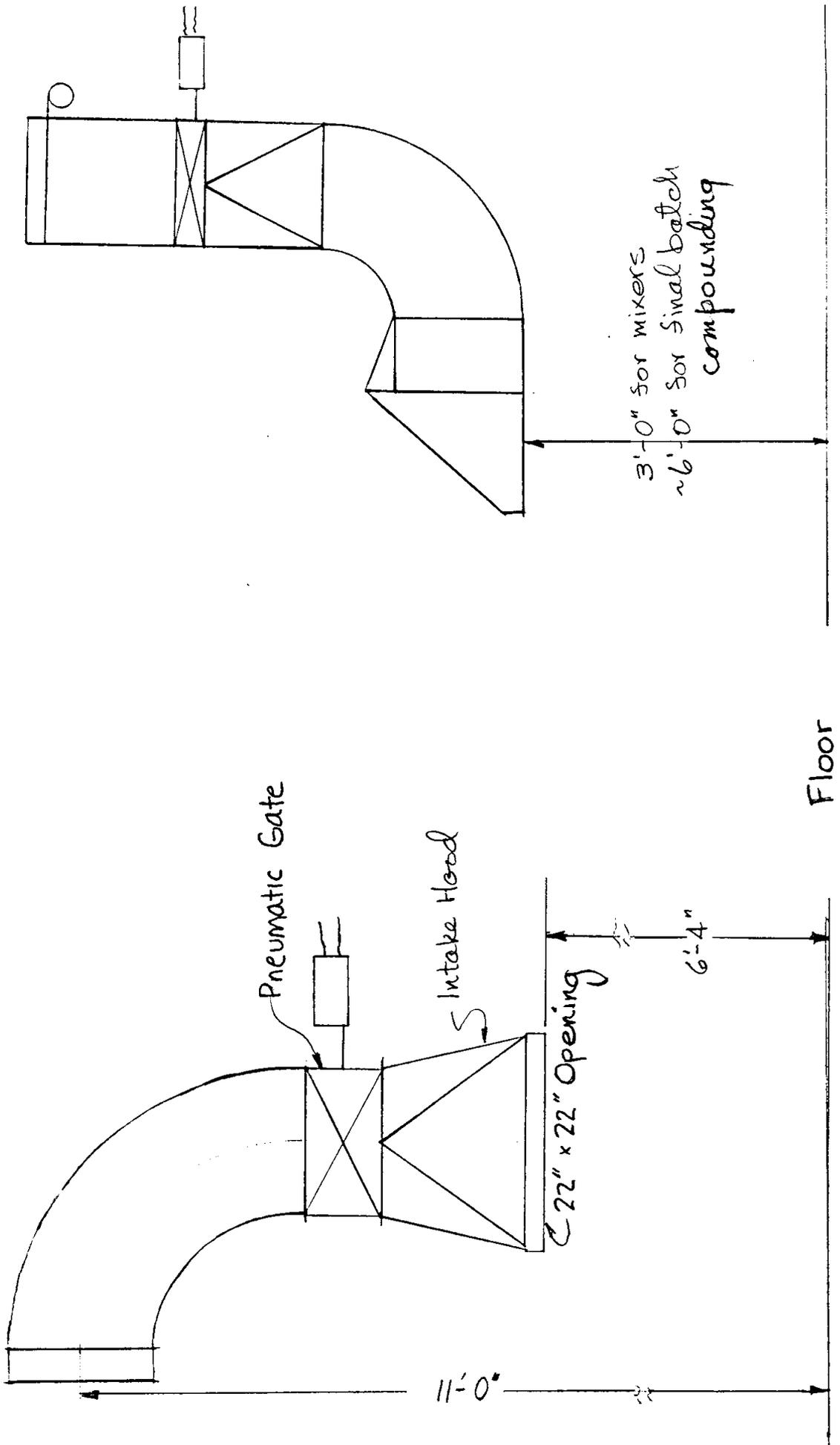


Figure 4-2. Disposal system inlet hood details.

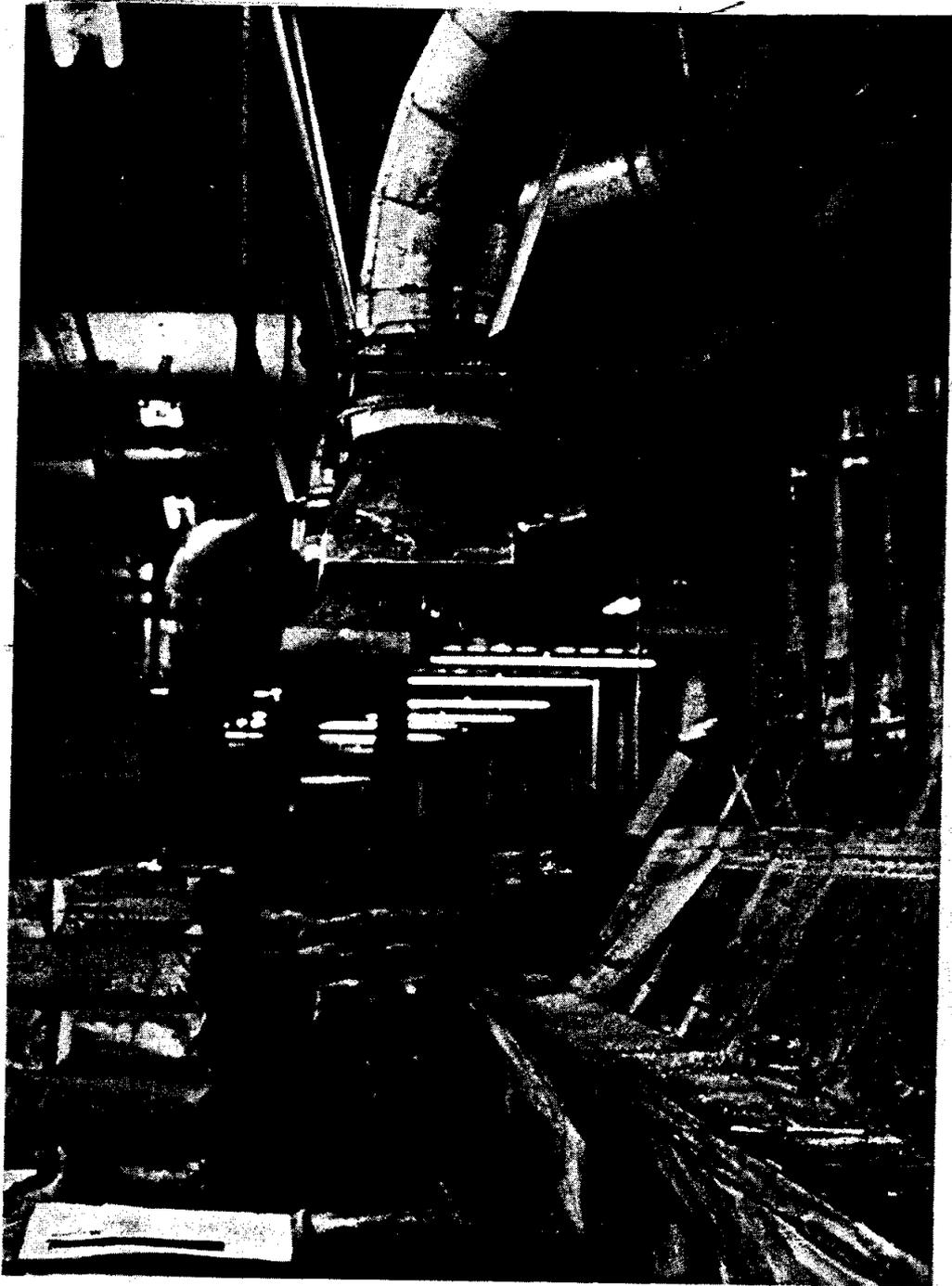


Figure 4-3. Disposal system inlet hood details.

It takes approximately one second for a bag to travel from an intake hood to the baler. The duct branch entries are all less than 45° and the elbows have a two-diameter centerline radius.

The heavy duty fan for the system reportedly has 3-inch thick blades so bags can be pulled through the fan. The fan shreds the bags enroute to the collector, maintains adequate suction for the system, and releases dust from the bag for possible recycling of the compounds and the paper.

The paper is separated from the air stream by a cyclone collector and sent to a baler. Reportedly, the cyclone was placed on the positive pressure side of the fan to help force the paper into the baler.

Dusts separated from the bags during transit normally by-pass the cyclone and are collected by a fabric bag collector. These dusts fall through a flexible return duct on the collector and empty into a drum. The flexible duct is attached to a lid which fits over the drum.

Since the original installation, these changes have been made to the disposal system:

1. Originally, dust squirted out of openings in the baler. When the collected paper was being compressed into a bale. To solve this, Ohio Blowpipe installed a ventilation system on the baler and in the baler room consisting of a series of hoods on the baler, a floor sweep hood, and a blower, as shown in Figure 4-1b. The baler hoods collected dusts from the baler during bale compression while the floor sweep hood was used to collect dusts and trash that escaped baling. This system is connected to the disposal system's cyclone collector.
2. When the dust control system on the baler failed to contain the dusts, another fan was installed on the exit duct of the fabric collector, as shown in Figure 4-1c. Apparently, the intent was to pull the dust

emissions from within the baler and balance the disposal system's airflow into the cyclone. The addition reportedly complicated matters because the new fan pulls paper out of baler hopper and causes it to float in the cyclone return. Eventually, this paper clogs the return, forcing a shutdown.

The concern over the baler's dust stems from the baler's location in a room connected to the plant. Whenever dust escapes the baler, it migrates into the plant. Cleaning up the dust is also a housekeeping problem.

WORKER'S DUTIES

To use the disposal system the worker is supposed to follow these steps:

1. When the worker has a bag to dispose of, he checks the disposal system indicator light for clearance.
2. When the system is clear, the worker steps on the foot switch and actuates the gate.
3. The worker holds the bag to the face of the intake hood and releases it. The gate then shuts automatically after a few seconds.

The worker's duties at the baler were not determined.

AIR SAMPLING DATA

None taken.

VENTILATION DATA

No ventilation measurements were made, but the airflow specifications are shown in Figure 4-1.

EMISSION SOURCES OBSERVATIONS

The purpose of the disposal system is to transport refuse from the area where it is generated to a collector. This helps to eliminate dust generated from empty bags and other problems. The source of the dust in the empty bags are the compound dusts adhering to the walls of the empty bags and residual compounds emptied from the bag. The disposal system generates dust when bags are pulled into the intake hood, dropped into the baler hopper, and compressed into bales.

WORK PRACTICE OBSERVATIONS

The disposal system was observed to be diligently used by workers. The company's specified method for using the system were partially effective for reducing dust generation. However, observations revealed that the work practices were inadequately specified. This was particularly true for handling of bags before they were put in the system. The work practices associated with the bag handling were observed to generate a visible amount of dust. Therefore, work practices could effect the workers exposure.

Some of the work practices which could increase dust generation were:

1. In precompounding, accumulating a pile of empty bags prior to disposal. Just before disposing of the bags, some workers would manually compress the bags to a size that would fit into the disposal system.
2. In precompounding, transporting bags to the disposal system in ways which caused dust emissions, such as handling bags so materials sprayed from the slit side and carelessly handling empty bags in ways which forced dusts from them.

3. In mixing, wadding up the brown paper bags in which the final batch compounds were transported to the mixer. Workers then tossed the bags like balls into the intake hood of the disposal system. Wadding of the bags could generate dust emissions directly in the workers breathing zone. Tossing the empty bags around could generate dust into the general room air. Workers also accumulated a number of the "bag balls" before disposing of them.

No observations were made of operations involving the handling of the trash bales, unplugging the cyclone, or disposing of the fabric collector residue.

ENGINEERING CONTROLS OBSERVATIONS

The disposal system easily collected bags placed near the intake hood face. Reportedly, the suction of the system was so powerful that caps from workers standing beneath overhead intake hoods could be sucked into the system. Bags introduced to the hood did not hang up on the hood, but were compressed by the hood as they were pulled in.

The compression of large bags as they entered the hood generated dust outside the intake hoods. The smaller dust particles were drawn back into the hood before the gate closed. However, large particles of dust, or possibly compounds not emptied from the bags, fell to the floor beneath the hood.

The placement of the intake hoods at the mixers was across the charging conveyor from the worker (see Figure 3-3). This location appeared hard for the workers to reach and may be the reason for them wadding the bags and tossing them into the hood.

The ventilation system on the baler was reported to be ineffective. Moreover, the addition of the fan at the system outlet did not solve the problem, but generated a new one - clogging of the collector. No recommended methods for ventilating the baler are available in the ACGIH Ventilation Manual.

The ducting for the system requires that it be located or guarded to prevent damage caused by forklifts. One branch duct had been damaged because it had been placed too close to the floor. The placement of the intake hoods and ducting specified for this plant are shown in Figure 4-2.

MONITORS OBSERVATIONS

Outside of the indicator lights for the gates, there were no monitors for system performance.

PERSONAL PROTECTIVE EQUIPMENT

No personal protective equipment was noted.

DATA INTERPRETATION

For the production workers, this system appears to alleviate many of the health hazard and nuisance problems associated with conventional disposal. Based on observations of the latter at other plants, much less dust appeared to be generated with the use of the disposal system. The dust from empty bags can affect the worker's exposure either by direct emission of dust into the worker's breathing zone or by elevating the background particulate concentrations. The disposal system removes bags from the area so they are not a continuing source of dust generation.

At the compressing and baling end of the system, problems still exist. The first is the clogging of the cyclone with pieces of refuse. This appears to be solvable. Since it occurred after the installation of the exit duct fan, this fan may be the source of the problem. Proof of this is:

1. The baler has many holes, such as those through which baling wire is pressed, through which air can enter the baler hopper.
2. When the disposal system intake hoods are all closed, virtually no air enters the cyclone from the disposal system.

3. With all the disposal system intake hoods closed and the exit duct fan operating, less air is being supplied to the cyclone via the baler ventilation and disposal systems than is being exhausted by the end system fan. Thus, an imbalance exists and air would be drawn through any openings in the disposal system, particularly those in the baler since it is directly connected to the cyclone.
4. Air drawn through the baler into the cyclone could re-entrain pieces of refuse and carry them into the cyclone return.

Overall, the benefits of having the exit duct fan appear questionable. While dusts generated during bag disposal may be captured, the capture of dusts generated during bag compression is suspect since the baler ram would block the cyclone return during compression. Thus, the exit duct fan could not draw air through the baler during the period of heaviest dust generation. Therefore, the greatest amount of dust from the baler is not captured by this addition to the disposal system.

The second problem is dust generated during bale compression. The plant reported that the ventilation system installed by the manufacturer on the baler did not work properly, while the manufacturer reported that the ventilation system is adequate. But, the manufacturer suggested a possible source of the problem. As part of the baler ventilation system, a floor sweep hood is provided so refuse can be swept into it. This hood was supposed to work only when the baler was not compressing a load. The hoods were supposed to be manually switched, using slide gates in the ducts, whenever the floor sweep hood was to be used. Possibly, the floor sweep hood was used continuously. This could reduce baler hoods airflow rendering them almost useless.

The final problems are dust generation from bags landing in the baler hopper and the positive pressure on the hopper by the disposal system (before the addition of the exit duct fan). Dust from the baler hopper might be captured by the baler ventilation if it were working properly. Normally the ACGIH Ventilation Manual specifies a gate on the return for cyclone collectors. The

manufacturer explained that while this is possible, it adds cost to the system. Instead, the baler controls can be reset so the ram is left in an extended position. This would block the cyclone return and serve as a valve so that air is pushed into the baler hopper intermittently instead of continuously.

In summary, the disposal system appears effective in reducing worker exposure to dusts generated from empty bag handling. Problems identified with the baler portion of the system may be solvable. But, investigation of the problem is needed to see if it can be solved or if further research is needed.

TIRE REPAIR TABLE (5)

AREA: FINAL FINISH

DESCRIPTION

The repair table studied is used to repair minor defects on the tire sidewall and bead, and was selected from several tables. The repair table and hood are shown in Figure 5-1 and 5-2. The hand tools used at the station are primarily electric grinders, as shown in Figure 5-3. A solvent-paint mixture was also used at the station.

The actual repair table consists of a rotatable, circular, horizontal table upon which the tire is laid for repair. The hoods for the tables were similar except that the duct entrances for the other repair table hoods were different than the one studied. One of these tables can be seen in Figure 5-3. Each table has a make-up air supply. The diffuser for the make-up air is aimed at the hood face. A deflector was supplied at the diffuser so the airflow can be directed away from the worker.

WORKER'S DUTIES

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

1. Grind the defect on the tire.
2. Blow off the spot with an air hose and paint the blackwall with the solvent-rubber mixture.
3. Spray a protective coating on the whitewall.
4. Place the tire on a return conveyor.

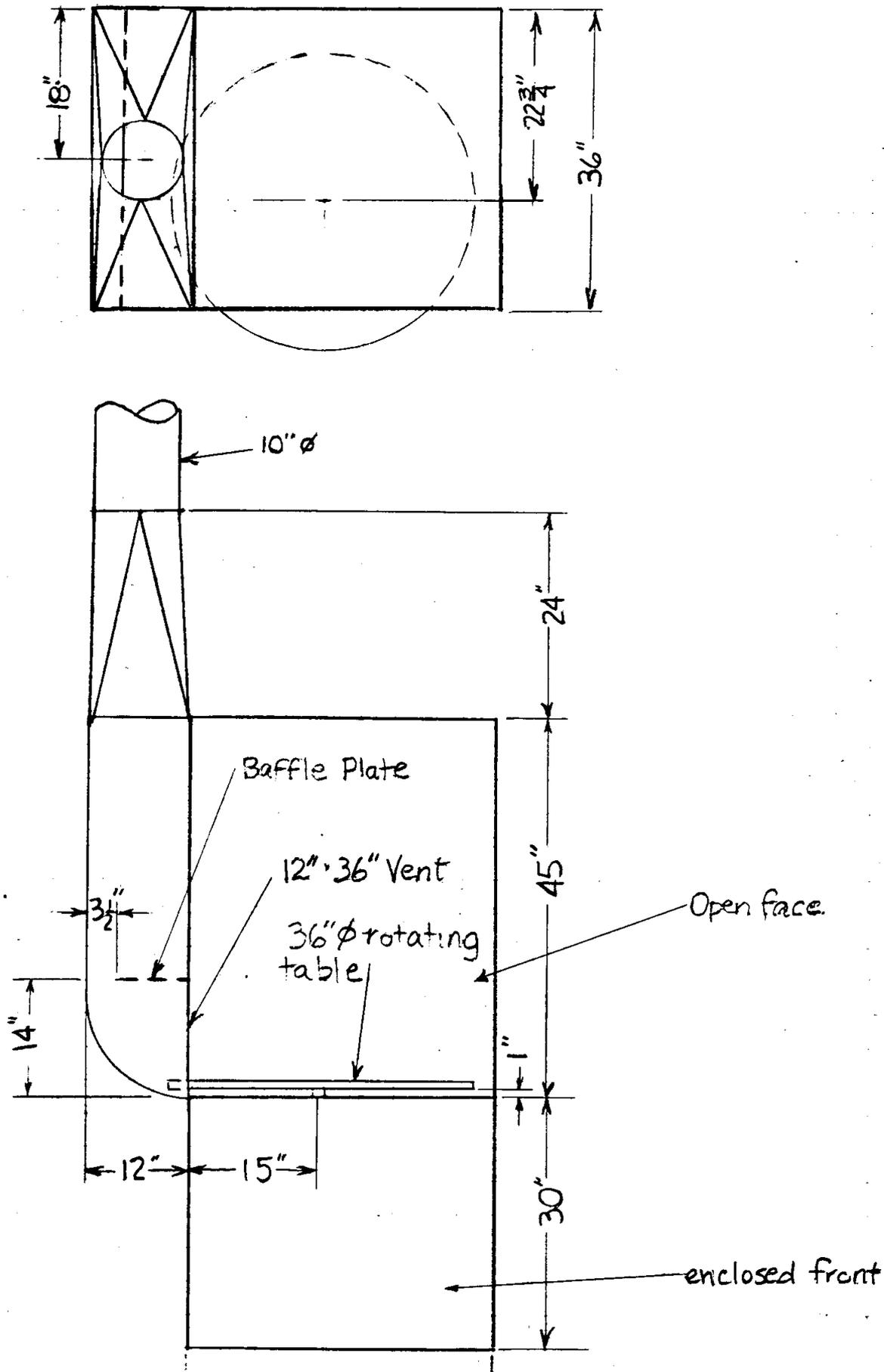


Figure 5-1. Defect repair table hood detail.

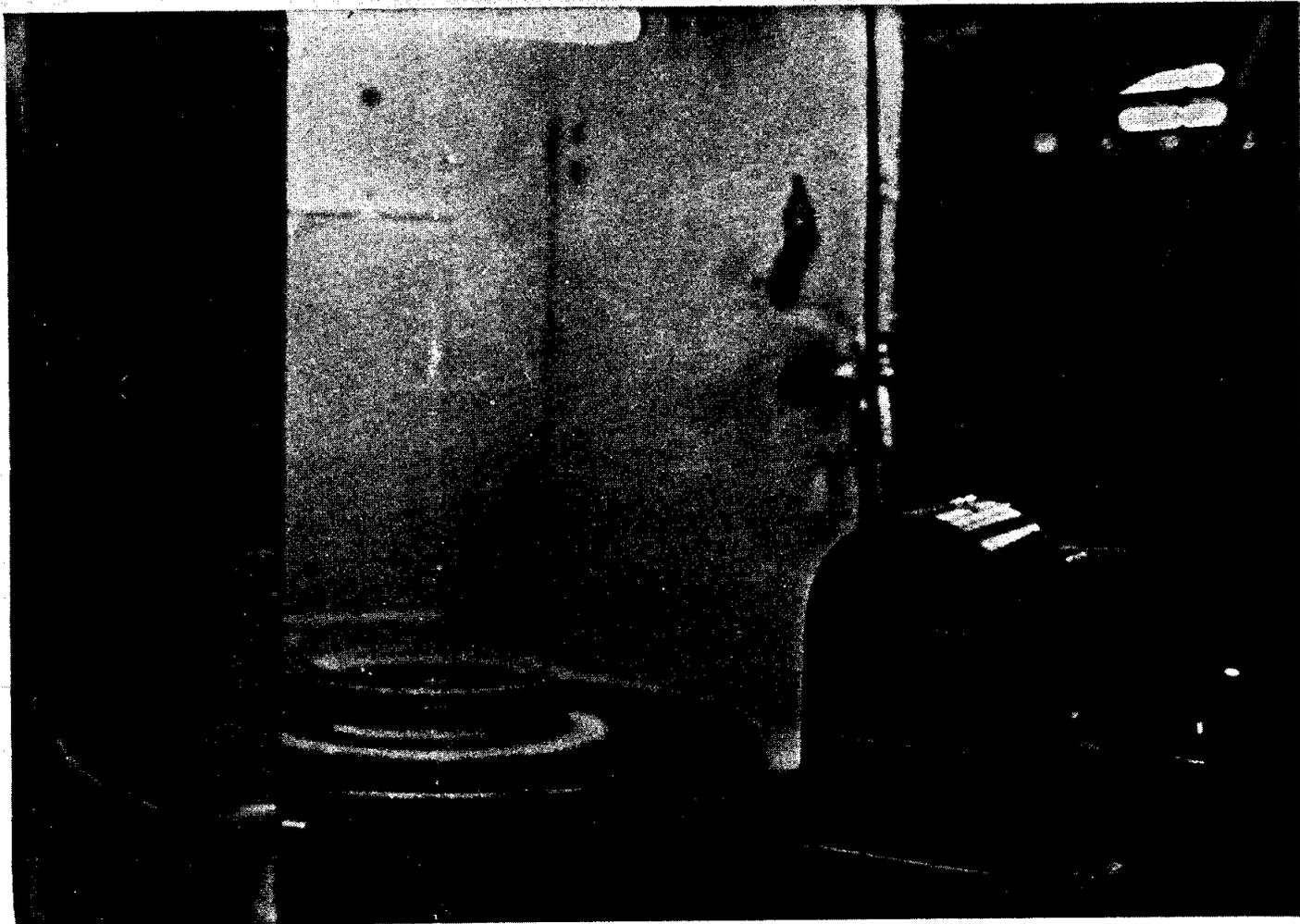


Figure 5-2. Defect repair table hood.

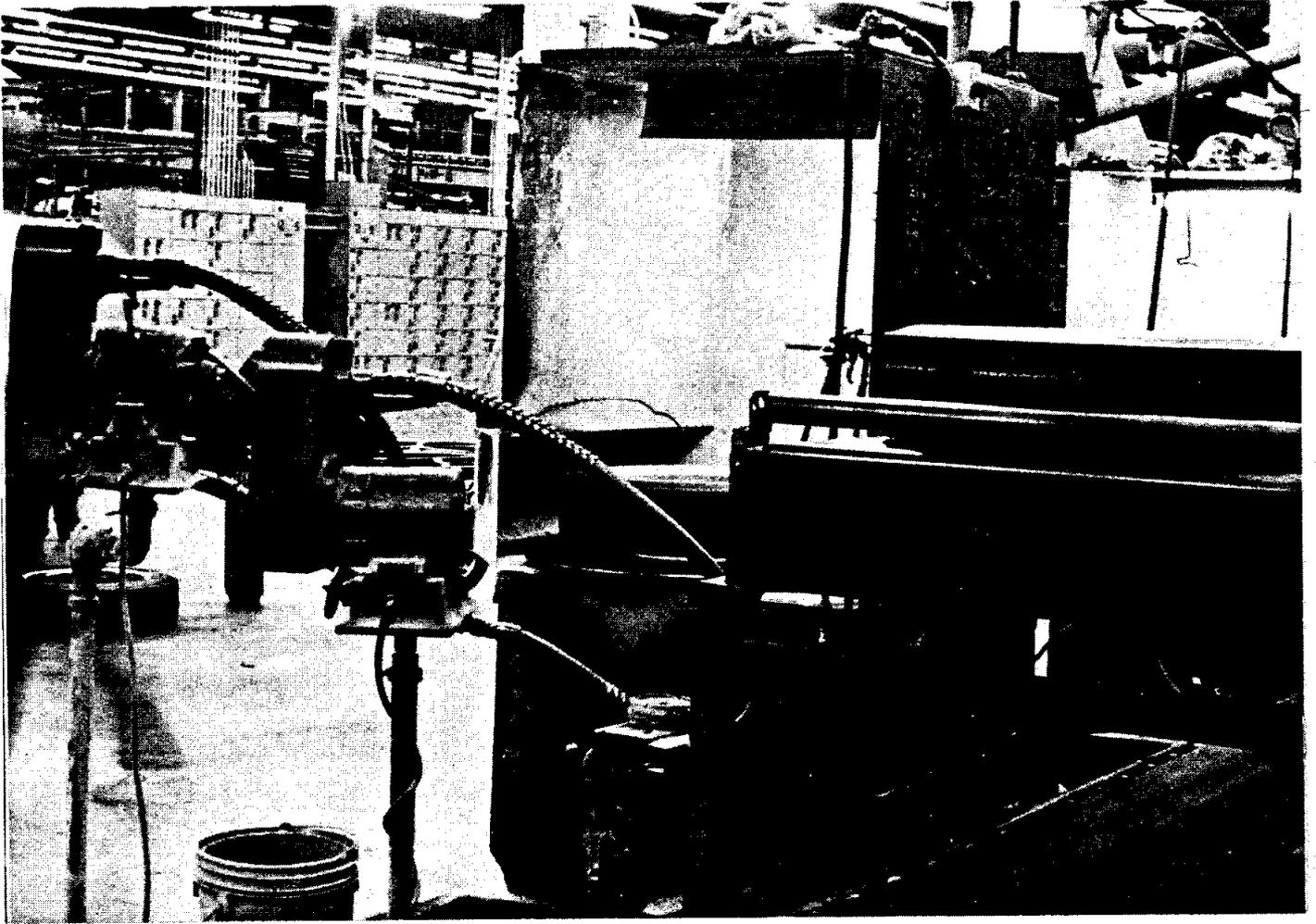


Figure 5-3. Defect repair table hood showing hand tools.

AIR SAMPLING DATA

Total particulate area and personal samples were collected. The area sample was located at the left side of the hood about 5 to 6 feet from the floor. Sample results are summarized in Table 5-1 and detailed in Appendix II.

Table 5-1. Full shift particulate concentrations for a tire repair table.

Location	N	GM (mg/m ³)	GSD	AM (mg/m ³)	Range (mg/m ³)
Worker	5	0.18	1.6	0.19	0.14-0.40
Table hood, left	5	0.22	1.2	0.23	0.16-0.25

VENTILATION DATA

The ventilation measurements are summarized in Table 5-2 and shown in Figures 5-4 and 5-5 in Appendix IV. Design airflow parameters were not available.

Table 5-2. Defect repair table hood ventilation data.

Measurement	Quantity Measured
Table A:	
Average duct velocity	5375 fpm
Calculated duct flow	2930 scfm
Duct static pressure	4.7 in. H ₂ O
Average face velocity	220 fpm
Average duct entrance velocity	1020 fpm
Table B:	
Average face velocity	230 fpm
Average duct entrance velocity	900 fpm

EMISSION SOURCES OBSERVATIONS

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

1. Evaporation from open containers of the solvent.
2. Evaporation from the surfaces where they are applied.
3. Evaporation from utensils used with the paint.
4. Evaporation from spills of the paint or cleaner.

The sources of the particulate emissions are:

1. Spray from the grinding and buffing operations.
2. Particulates blown off tires by compressed air.
3. Grindings on the floor and structures.

WORK PRACTICE OBSERVATIONS

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

1. Aiming the grinder so particulate shot out of the hood instead of toward the duct entrance.
2. Blowing off tires with air hoses. This causes dust which the hood cannot capture.

ENGINEERING CONTROLS OBSERVATIONS

Smoke tube traces at the face of the hood and at heights from the table top to the workers breathing zone showed an airflow pattern into the hood duct entrance. Turbulence was noted inside the hood at the back, right corner. However, little grinding particulate is thrown into the area.

Workers sometimes aimed their grinder so grindings shot out of the hood instead of into the duct entrance. The side of the hood could interfere with the operation if the worker was positioned to aim the grindings into the duct entrance. The duct entrance appeared large enough to capture grinding particulate.

MONITORS OBSERVATIONS

No monitors for ventilation performance or specific contaminants were noted.

PERSONAL PROTECTIVE EQUIPMENT

Workers were observed wearing gloves and aprons.

DATA INTERPRETATION

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

Worker exposures to solvent vapors is possible because of the evaporation from open paint cans, painting accessories, and spills. But, the surface area and quantities of these are small so little contribution from these to the worker exposure is expected.

Based on observations and smoke tube traces, the hood is expected to capture the solvent vapors emitted inside it. Control of these emissions outside the hood may be marginal depending on the source location relative to the hood face.

The particulate generated from the grinding operations was not always captured by the hood. Normally, the worker's positioning of the grinder caused the grinding particulate to be sprayed outside of the hood. With correct positioning, the grindings should be thrown into the duct entrance, but in this position, the hood could interfere with the performance of the grinding operation. Although the grinding particulate may be too large to be of hygienic significance, it is a maintenance, housekeeping, and possible safety problem when it is uncontrolled.

COMPLIANCE WITH 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 classified as nuisance dusts or respirable nuisance dusts - dust which passes through the 10 mm nylon cyclone².

The Occupational Safety and Health Administration (OSHA) has established Standards and the National Institute for Occupational Safety and Health (NIOSH) and ACGIH have recommended limits for occupational exposure to the particulate air contaminants found in plants: the following table notes the Standards and the recommended standards:

8-Hour TWA concentrations (mg/m³).

Air Contaminant	OSHA PEL ⁵	NIOSH Recommended Standard ⁶	ACGIH TLV ⁷
Nuisance dust	15	--	10
Respirable nuisance dust	5	--	5

*60 minute ceiling

All particulate concentrations obtained in this study were below those specified in the above table.

According to Fine and Peters⁸, 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/m³ as an 8-hour TWA.

REFERENCES

1. Williams, Harris, Arp, Symons and Ert. 1980. Worker Exposure to Chemical Agents in the Manufacture of Rubber Tires and Tubes: Particulates. *AIHAJ* 41:204-2111.
2. NIOSH. 1977. Manual of Sampling Data Sheets. Cincinnati, Ohio. DHEW (NIOSH) Publication 77-159.
3. American Conference of Governmental Industrial Hygienists. 1979. Industrial Ventilation. 15th Edition. Committee on Industrial Ventilation. Lansing, MI. pp 9-63.
4. SAS Institute. 1979. SAS User's Guide. Raleigh, North Carolina, pp. 237-264.
5. 29 CFR 1910.1000.
6. NIOSH. 1980. Summary of NIOSH Recommendations for Occupational Health Standards. Cincinnati, Ohio.
7. American Conference of Governmental Industrial Hygienists. 1980. Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1980. Cincinnati, Ohio.
8. Fine, L. and J. Peters. 1976. Respiratory Morbidity in Rubber Workers - III Respiratory Morbidity in Processing Workers. *Archives of Environmental Health*. 31:195-200.

APPENDIX I

DESCRIPTION OF OCCUPATIONAL TITLE GROUPS IN TIRE AND TUBE MANUFACTURING¹

Occupational Title Group	Description of Process
Compounding	Batch lots of rubber stock ingredients are weighed and prepared for subsequent mixing in Banburys; solvents and cements are prepared for process use.
Banbury Mixing	Raw ingredients (rubber, filler, extender oils, accelerators, antioxidants) are mixed together in a Banbury mixer. This internal mixer breaks down rubber for thorough and uniform dispersion of the other ingredients.
Milling	The batches from the Banbury are further mixed on a mill, cooled, and the sheets or slabs coated with talc so they are not tacky. The stock may return to the Banbury for additional ingredients, or go on to breakdown or feed mills prior to extrusion or calendering.
Extrusion	The softened rubber is forced through a die forming a long, continuous strip in the shape of tread or tube stock. This strip is cut in appropriate lengths, and the cut ends are cemented so as to be tacky.
Calendering	The softened rubber from the feed mill is applied to fabric forming continuous sheets of plystock by the calender (a mill with three or more vertical rolls and much greater accuracy and control of thickness).

Appendix I (cont'd)

Occupational Title Group	Description of Process
Plystock Preparation	The plystock from the calender is cut and spliced to the correct size for tire building, and so the strands in the fabric have the proper orientation.
Bead Building	Parallel steel wire is insulated with rubber vulcanizable into a semi-hard condition and covered with a special rubberized fabric. The beads maintain the shape of the tire and hold it on the wheel rim in use.
Tire Building	The tire is built from several sheets of calendered plystock, treads and beads.
Curing Preparation	The assembled green or uncured tire is inspected, repaired, and coated with agents to keep it from sticking to the mold in vulcanization.
Tube Splicing	Assembly of tube stock; i.e., tube building
Curing	The green tire or tube is placed in a mold and vulcanized under heat and pressure.
Final Inspection and Repair	The cured tire is trimmed, inspected, and labeled; repairable tires or tubes which do not pass initial inspection are repaired.

APPENDIX II

AIR SAMPLE
CONCENTRATION DATA

Table 1. Full shift particulate.
Manual compounding system.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m ³)
Total Particulate				
<u>Location: Baffle wall, left (Figure 2-12, location 1)</u>				
2-18-80	2	339	507	0.53
2-19-80	1	437	656	0.62
2-19-80	2	356	534	0.71
2-20-80	1	430	645	0.36
2-20-80	2	330	495	0.20
<u>Location: Final Batch Worker (Figure 2-12, location 2)</u>				
2-18-80	2	337	506	3.34
2-19-80	1	405	608	2.53
2-19-80	2	352	528	3.10
2-20-80	1	382	573	1.60
2-20-80	2	330	495	1.05

Respirable Particulate				
<u>Location: Final Worker Batch (Figure 2-12, location 3)</u>				
2-18-80	2	337	573	0.35
2-19-80	1	405	689	0.32
2-19-80	2	352	598	0.39
2-20-80	1	382	649	0.29
2-20-80	2	331	563	0.27

Table 2. Full shift particulate.
Manual Compounding System.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m ³)
Total Particulate				
<u>Location: Master batch scale, Y side (Figure 2-12, location 4)</u>				
2-18-80	2	340	510	0.82
2-19-80	1	440	660	1.07
2-19-80	2	345	518	1.04
2-20-80	1	407	611	0.75
2-20-80	2	271	407	0.59
<u>Location: Master batch scale, Z side (Figure 2-12, location 7)</u>				
2-18-80	2	176	264	1.30
2-19-80	1	422	633	1.34
2-19-80	2	180	270	1.07
2-20-80	1	419	629	0.85
2-20-80	2	320	480	0.66
<u>Location: Masterbatch worker, Y side (Figure 2-12, location 5)</u>				
2-18-80	2	334	501	2.17
2-19-80	1	427	641	2.50
2-19-80	2	340	510	1.40
2-20-80	1	400	600	1.88
2-20-80	2	388	582	0.93

Respirable Particulate				
<u>Location: Master batch worker, Y side (Figure 2-12, location 6)</u>				
2-18-80	2	334	501	0.44
2-19-80	1	430	645	1.00
2-19-80	2	340	510	.76
2-20-80	1	400	600	.86
2-20-80	2	328	492	.36

Table 3. Full shift particulate.
Manual compounding system .

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m ³)
Total Particulate				
<u>Location: Column near master batch station</u>				
2-18-80	2	170	255	1.50
2-19-80	1	438	657	1.14
2-19-80	2	358	537	0.59
2-20-80	1	427	641	0.65
2-20-80	2	333	500	0.56
----- Respirable Particulate -----				
<u>Location: Master batch worker, Z side (Figure 2-12, location 9)</u>				
2-18-80	2	155	233	0.91
2-19-80	1	422	633	0.96
2-19-80	2	160	240	0.94
2-20-80	1	420	630	0.55
2-20-80	2	310	465	0.55
<u>Location: Master batch worker, Z side (Figure 2-12, location 8)</u>				
2-18-80	2	155	233	3.60
2-19-80	1	422	633	3.14
2-19-80	2	160	240	3.25
2-20-80	1	398	597	1.07
2-20-80	2	312	468	2.07

Table 4. Full shift particulate.
Banbury Mixer.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m ³)
Total Particulate				
<u>Location: Charge door hood, left side (Figure 3-1, location 11)</u>				
2-18-80	2	405	608	1.14
2-19-80	1	423	635	0.72
2-19-80	2	448	672	0.58
2-20-80	1	437	656	0.61
2-20-80	2	425	638	0.42
<u>Location: Charge conveyor, right side (Figure 3-1, location 12)</u>				
2-18-80	2	403	605	0.79
2-19-80	1	421	633	1.45
2-19-80	2	447	671	0.58
2-20-80	1	437	656	0.94
2-20-80	2	415	623	0.43
<u>Location: Weigh conveyor scale (Figure 3-1, location 13)</u>				
2-18-80	2	464	696	0.59
2-19-80	1	421	632	0.63
2-19-80	2	444	666	0.69
2-20-80	1	437	656	1.12
2-20-80	2	417	626	0.33
<u>Location: Worker (Figure 3-1, location 14)</u>				
2-18-80	2	459	689	0.85
2-19-80	1	306	459	0.84
2-19-80	2	437	656	0.97
2-20-80	1	434	651	0.44
2-20-80	2	411	617	0.82

Respirable Particulate				
<u>Location: Worker (Figure 3-1, location 15)</u>				
2-18-80	2	459	780	0.24
2-19-80	1	363	617	0.60
2-19-80	2	437	742	0.28
2-20-80	1	434	737	0.23
2-20-80	2	411	698	0.24

Table 5. Full shift particulate.
Hopper/bins.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m ³)
<u>Total Particulate</u>				
<u>Location: Worker filling bin</u>				
2-18-80	2	193	290	0.61
2-19-80	1	280	420	7.60*
2-19-80	2	493	740	0.45*
<u>Respirable Particulate</u>				
2-18-80	2	193	328	0.45

Worker exposed to dust from sources other than bin filling.

Table 6. Full shift total particulate.
Tire repair table.

Date	Shift	Sample Duration (min)	Sample Volume (L)	Concentration (mg/m ³)
<u>Location: Worker</u>				
2-18-80	2	366	549	0.16
2-19-80	1	420	630	0.24
2-19-80	2	427	641	0.25
2-20-80	1	450	675	0.25
2-20-80	2	370	555	0.25
<u>Location: Table hood, left</u>				
2-18-80	2	366	549	0.14
2-19-80	1	450	675	0.17
2-19-80	2	490	735	0.19
2-20-80	1	420	630	0.11
2-20-80	2	376	564	0.40

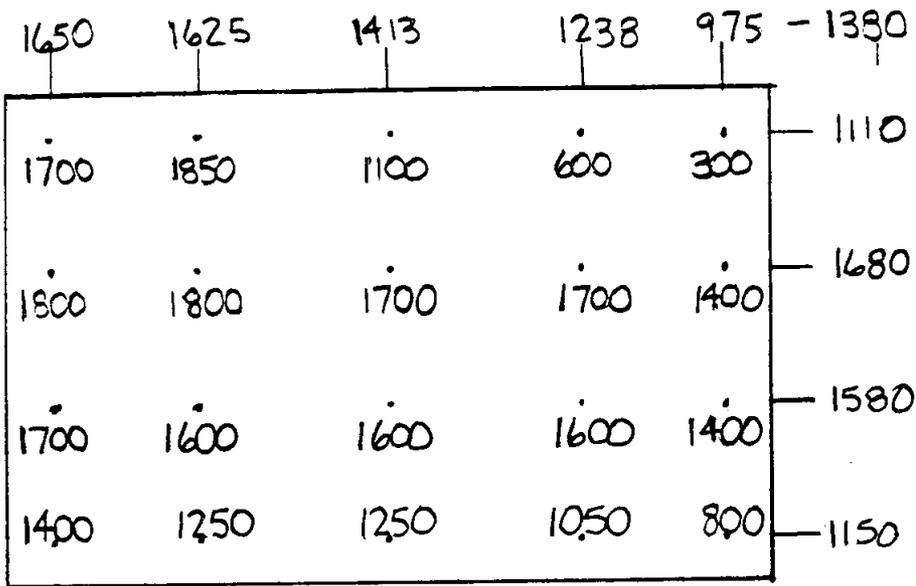
APPENDIX III

VENTILATION MEASUREMENT INSTRUMENTATION

Instrument	Controls
Dwyer inclined manometer w/pitot tube MN 400, Error \pm 5% (Used for duct velocity traverses)	All controls
TSI anemometer MN 1650 SN 2144 Error: \pm 2% fpm (Used for duct entrance, face, and capture velocities)	Hopper/bin Scale trolley hood Charge door hood Repair table hood
Kurz anemometer MN 441 SN 1396 Error: - 6% (all scales) (Used for capture velocity)	Exhaust wall
Gastec (Bendix) smoke tester kit w/TiCl ₄ tubes (Used for smoke tube traces)	All controls

APPENDIX IV
VENTILATION DATA

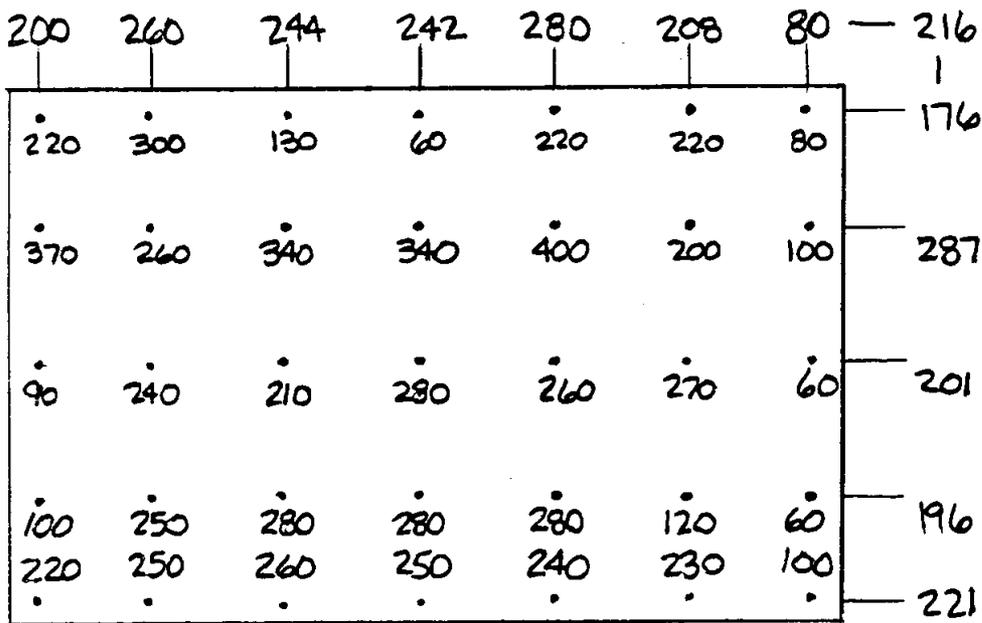
Scale:
2"



Note: All other hood ducts closed during measurement per normal operating procedure

Figure 1-6. Hopper/bin hood duct entrance velocities.

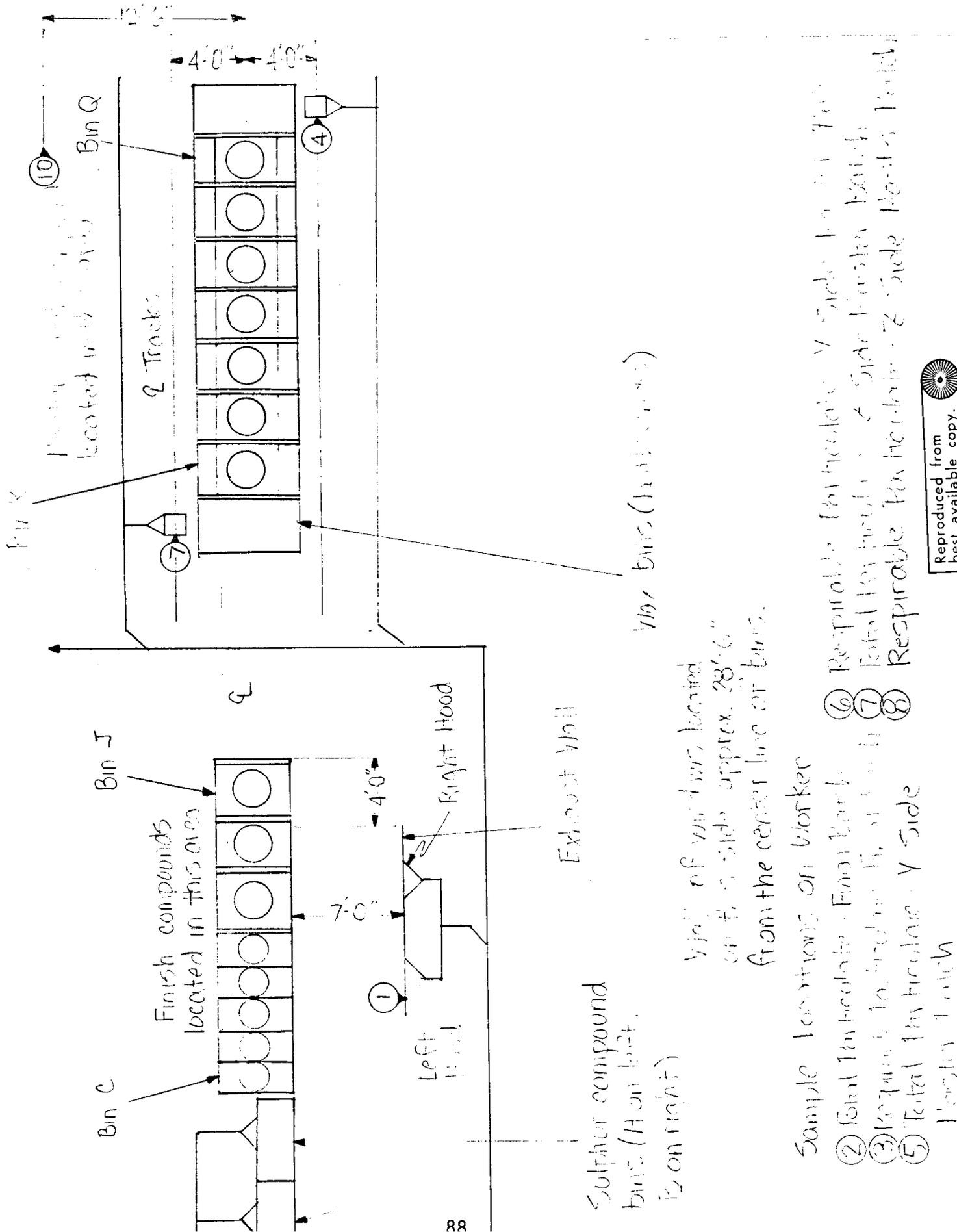
Scale:
4"



Note: All other hood ducts closed during measurements per normal operating procedure.

Figure 1-7. Hopper/bin hood face velocities.

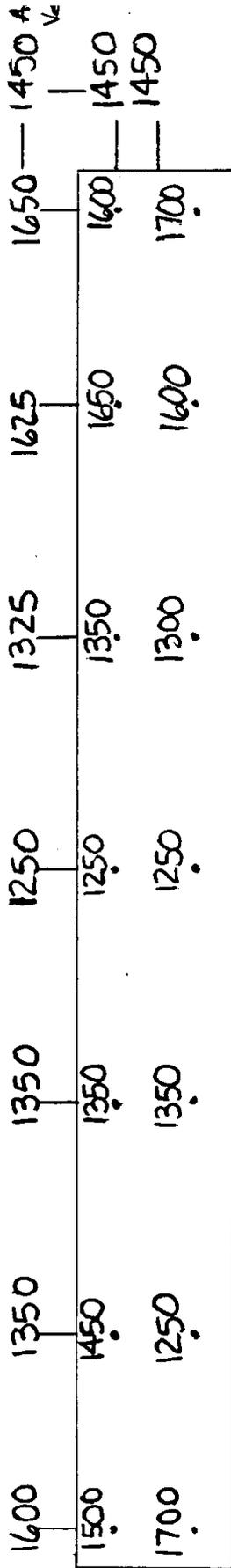
Figure 2-12. Manual compounding system sample locations.



Sample Locations on Worker

- ② Total Inhalable - Final Batch
- ③ Respirable Inhalable - Final Batch
- ⑤ Total Inhalable - Y Side
- ⑥ Respirable Inhalable - Y Side Final Batch
- ⑦ Total Inhalable - Z Side Final Batch
- ⑧ Respirable Inhalable - Z Side Final Batch

Scale:

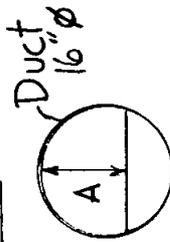
Duct S.P. - 5.0" H₂O

Notes: A 150-170 fpm was blowing tangentially across front of bins during measurement. Other sulfur compound bin had a buildup of material in slot (~25% blockage). This hood's duct was partially closed. During this measurement windows closed and make up air and personnel fans turned off in area.

Figure 2-13. Manual compounding system sulfur compound bin hood face velocities.

Blast gates partially closed

Left slot (A = 10 3/8")



2107	2000	2400	2300	2150	2200	1300
2178	2300	2200	2200	2150	2200	1900

2143	2150	2350	2300	2250	2150	1600
Avg. Vel.						2200

Right slot (A = 10 3/8")

2064	1900	2100	2050	2100	2300	1900
2064	2100	2300	2050	2150	2200	1600

2064	2000	2200	2050	2075	2125	1750
Avg. Vel.						2250

Note: Blast gate was found set at above dimensions.

Scale: 4"

Blast gates open all the way.

Left slot

4050	4300	4000	4100	4000	4200	3400	4007
4500	4300	4300	4100	4200	3700	3100	4028

4275	4300	4150	4100	4100	3950	3250	4018
							Avg. Vel.

Right slot

3200	3400	4200	4000	3800	3100	3600	3729
4100	3900	3900	4100	41500	4200	3600	4042

3650	3650	4050	4050	4150	4050	3600	3886
							Avg. Vel.

Duct SP = 2.9"

DESIGN FLOW = 5050 cfm/side

Figure 2-14. Manual compounding system final batch compounding exhaust wall face velocities.

Scale: 2"

"Z" Side
Blast gates on Exhaust Wall partially closed

Left
4200 4500 4500 4300 3200

Avg. Vel. = 4200 fpm

Right
3300 3950 3700 4200 4400 3700

Avg. Vel. = 3875 fpm

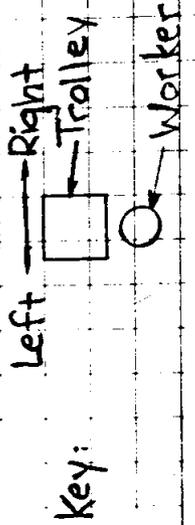
Blast gates on Exhaust Wall open

Left
2400 2800 3000 2800 2950 2950

Avg. Vel. = 2733 fpm

Right
2200 2600 2400 2850 3100 2500

Avg. Vel. = 2608 fpm



"Y" Side
Blast gates on Exhaust Wall partially closed

Left
3500 4600 4700 5200 5100 3700

Avg. Vel. = 4467 fpm

Right
3400 3900 4400 4800 4700 3700

Avg. Vel. = 4150 fpm

Blast gates on Exhaust Wall open

Left
2250 2800 2950 2900 2700 2950

Avg. Vel. = 2625 fpm

Right
2200 2400 2700 3000 3100 1650

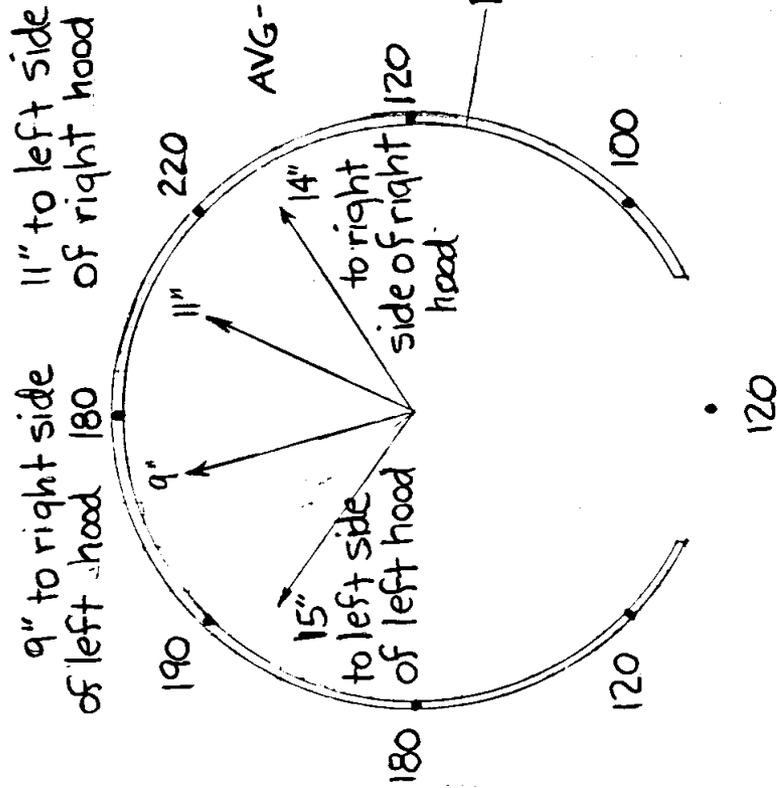
Avg. Vel. = 2508 fpm

Duct S.P. = 2.1"

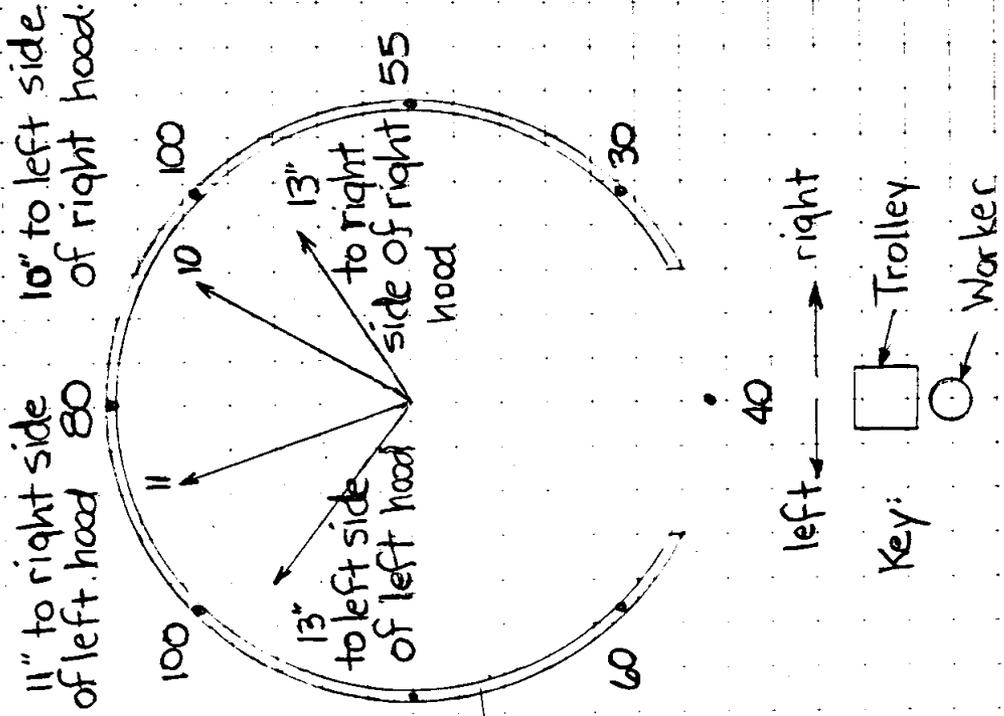
Figure 2-15. Manual compounding system trolley scale hoods face velocities.

Scale: $\frac{1}{2}$ "

Y Side



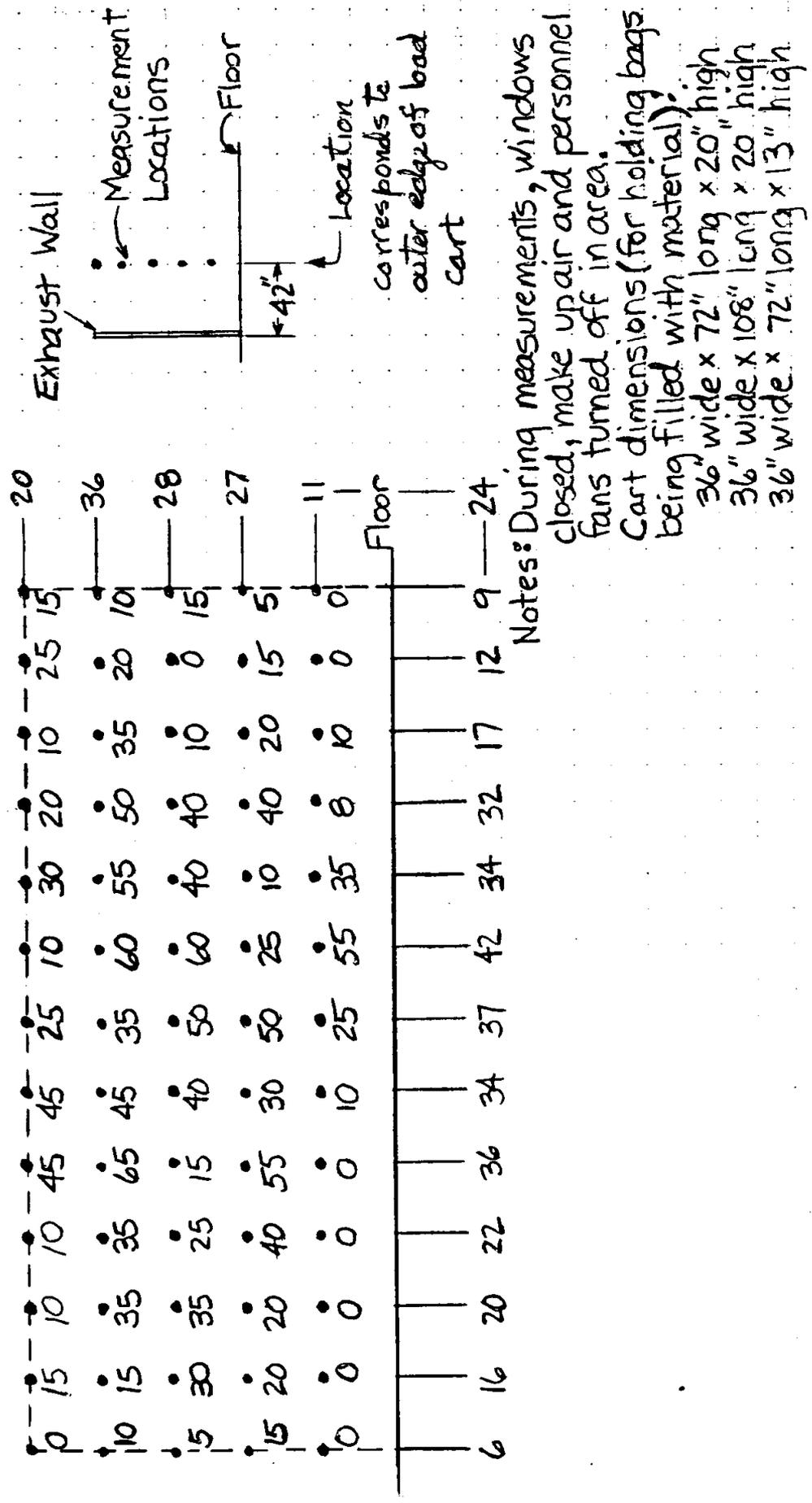
Z side



Notes: Blast gates on exhaust wall were full open
 Measurements made 1" above Bag Holder
 During measurements, windows were closed, make up air and personnel fans were turned off in area.

Scale: 6"

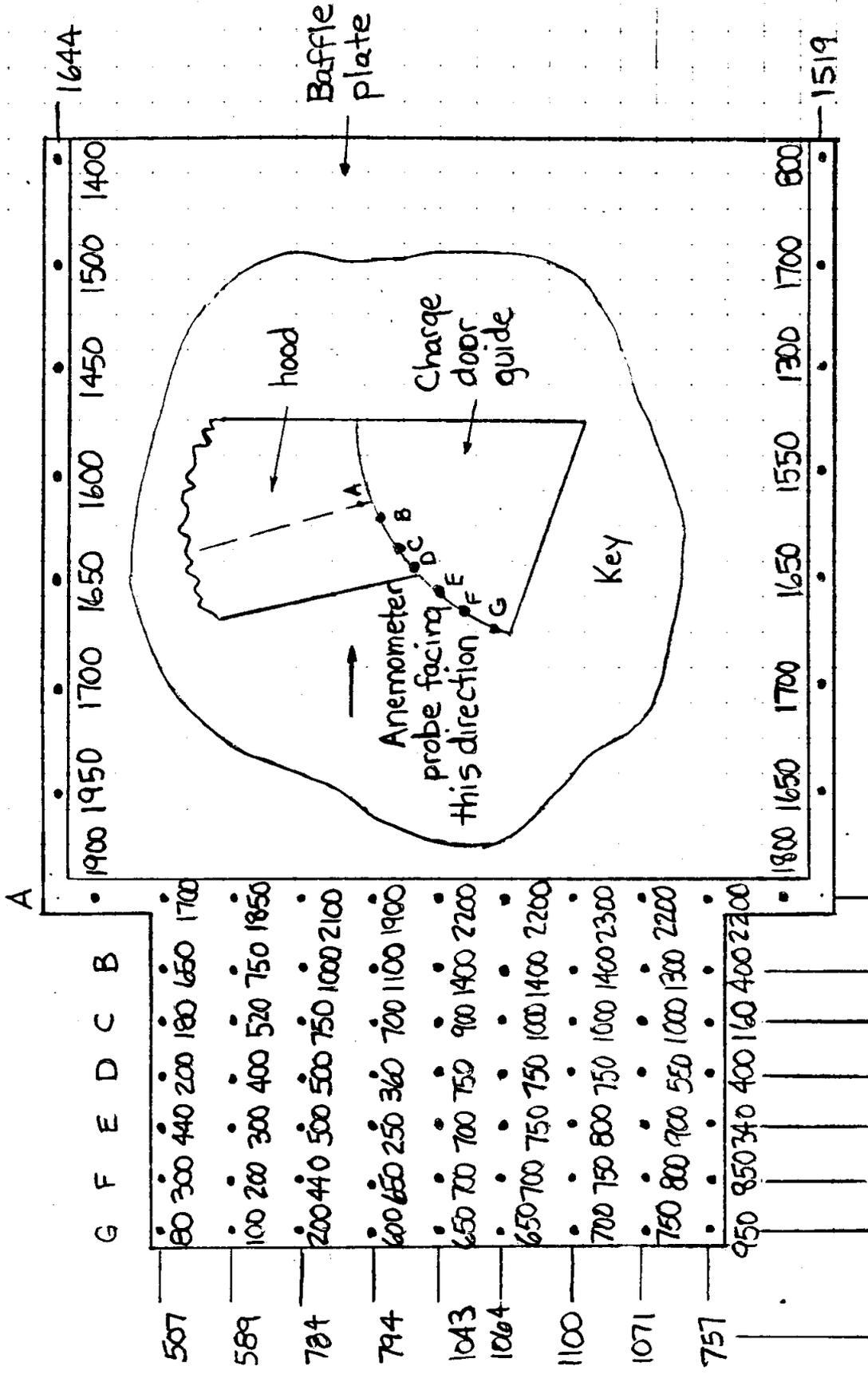
Instrument Error: -6%



Notes: During measurements, windows closed, make up air and personnel fans turned off in area.
 Cart dimensions (for holding bags being filled with material):
 36" wide x 72" long x 20" high
 36" wide x 108" long x 20" high
 36" wide x 72" long x 13" high

Figure 2-17. Manual compounding system final batch compounding exhaust wall capture velocities.

Scale: 4"

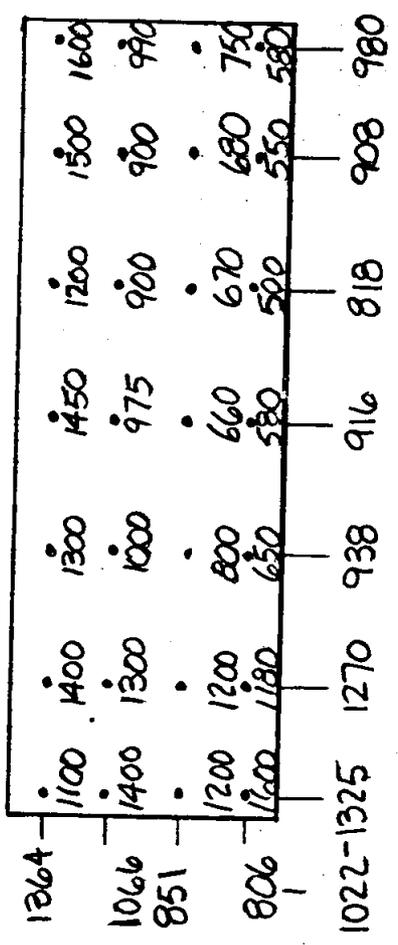


Notes: Banbury was not operating during measurement - charge door closed.

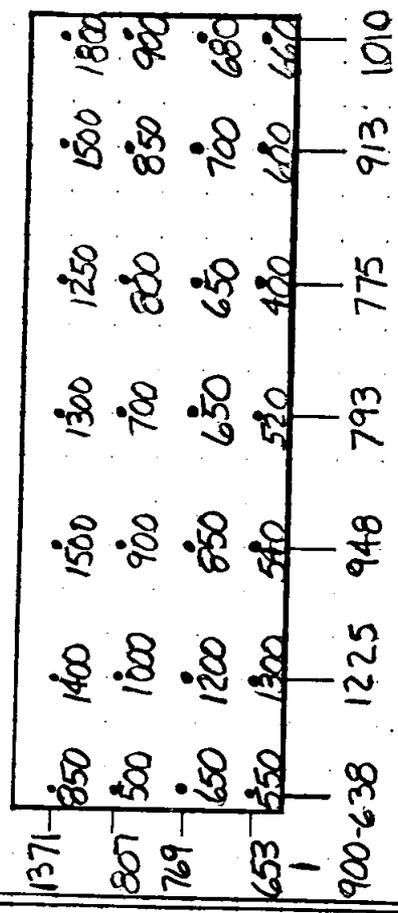
Figure 3-6. Mixer charge door hood face velocities.

Scale: $\frac{1}{4}$ " = 8"

Booth #2



Booth #3

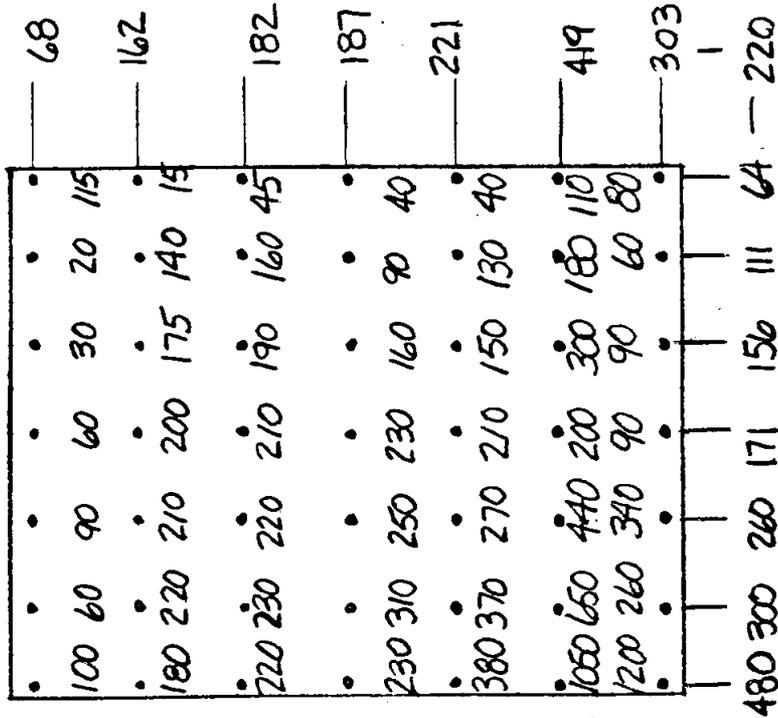


Note: Measurements taken on both booths for comparison.

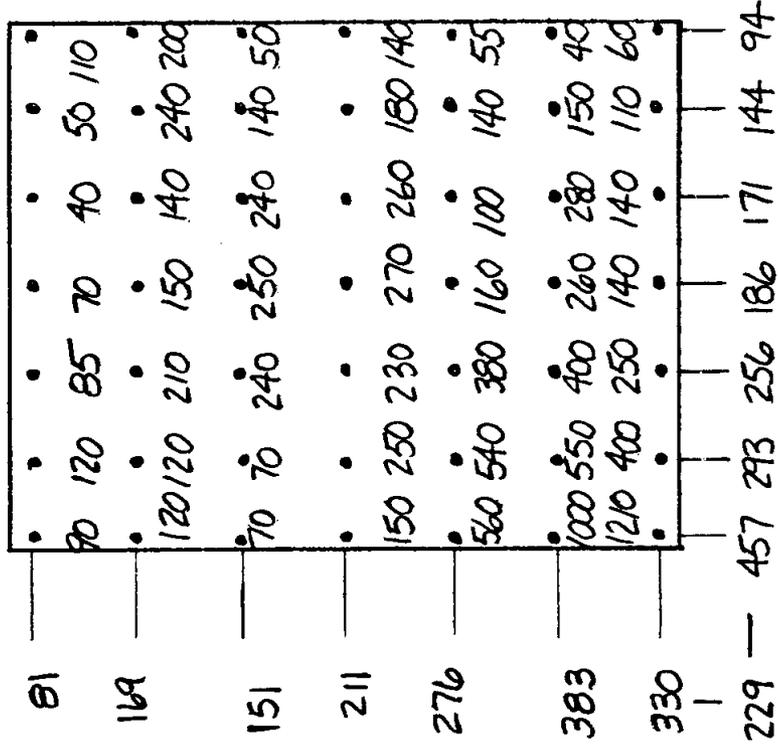
Figure 5-4. Defect repair table hood duct entrance velocities.

Scale:
6"

Booth #2



Booth #3



Notes: Measurements made on both booths for comparison. No tires were on the table and the make up air was directed away from the booth.

Figure 5-5. Defect repair table hood face velocities.