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# POTENTIAL DUST EMISSIONS FROM A GRAIN ELEVATOR IN KANSAS CITY, MISSOURI

FINAL REPORT

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ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

May 1974

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MRI WASHINGTON, D.C. 20006 • 1522 K STREET, N.W. • 202 293-3800
MRI 6 Skyline Place, Suite 414, 5109 Leesburg Pike, Falls Church, Virginia 22041 • (703) 671-0400

# POTENTIAL DUST EMISSIONS FROM A GRAIN ELEVATOR IN KANSAS CITY, MISSOURI

by

Paul G. Gorman
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Contract No. 68-02-0228, Task No. 24

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EPA Project Officer

Kenneth R. Woodard
Emission Standards and Engineering Division
Office of Air Quality Planning and Standards

Prepared for

Environmental Protection Agency
Office of Air and Water Programs
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

ABSTRACT

A program was conducted at a terminal elevator in Kansas City to obtain information on the quantity of dust collected by each of seven filter systems associated with specific operations in the elevator, identified below:

Truck unloading;
Car unloading;
Car loading;
Corn cleaner;
Gallery belt;
Tunnel belt; and
Headhouse.

Determination of the amount of dust collected by each system was made by mechanical weighers installed on the dust chutes from each filter to continuously monitor the amount of dust being discharged, which was equivalent to the amount of dust being collected by the filters. Readings were taken on the mechanical weighers once each week, and the amount of each type of grain processed by the seven grain-handling operations was obtained from the elevator operating records for the corresponding weekly period. Long-term (weekly) composite emission factors were calculated for each operation, and the results are reported herein. Also, short-term emission data were obtained so that emission factors could be calculated according to grain type and grain quality (i.e., moisture and FM).

Data collected in the study were also used to characterize the total potential dust emissions from the elevator on a weekly, daily, and hourly basis. Average emission factors, obtained from the study for each of the grain-handling operations, were analyzed and used to compute cumulative emission factors that can be used to project potential dust emissions from a terminal elevator on the basis of the amount of grain handled.

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ACKNOWLEDGEMENTS

This report was prepared for EPA/OAP under Contract No. 68-02-0228 and the EPA Project Officer was Mr. Ken Woodard. The work was performed in the Physical Sciences Division of Midwest Research Institute and directed by Dr. Larry Shannon, Head, Environmental Systems Section. This report was written by Mr. Paul Gorman, Project Leader. Data collection and analysis was performed by Mr. Gorman with the assistance of Mr. Mike Hammons, Mr. Doug Weatherman, Mr. Jim Edwards, Mr. Kevin Kline and Ms. Christine Guenther.

Appreciation is extended to Mr. Carlos Bradley, Manager, Kansas City Terminal Elevator No. 1, for his help and permission to conduct the project at the elevator. Special thanks are given to Mr. Newell Ross, Elevator Superintendent, for the time and help he gave and the assistance given by Mr. Danny Watkins and Mr. Tom Cisco. Many others at the elevator also aided in the work, including Mr. Marvin Reed, Mr. Marvin Willenberg, Mr. Phil Swearngin, Mr. Carl Engelbrecht, Mr. Eli Emery, and Mr. Lee Kennedy.

We also want to thank Mr. Ken Cox of the Natkin Company who fabricated the housings for the weighers and installed them in the filter systems at the elevator. His help and advice were of great value to the project, and are sincerely appreciated.

Approved for:

MIDWEST RESEARCH INSTITUTE

H. M. Hubbard, Director
Physical Sciences Division

8 March 1974

# SUMMARY

Potential dust emissions from a terminal elevator were determined by the use of mechanical weighers that continuously monitored the quantity of dust being collected by seven individual filter systems within the elevator. The grain-handling operations served by these filters were:

Truck unloading;

Car unloading;

Car loading;

Corn cleaning;

Gallery belt;

Tunnel belt; and

Headhouse.

Weekly visits were made to the elevator to obtain the readings from the dust weighers, and to extract information from the elevator-operating records for determination of the quantity of each grain processed by each of the seven grain-handling operations. The information then permitted calculation of long-term (weekly) composite emission factors for each operation. Besides obtaining long-term emission factor data, the weigher systems were also used to obtain information on total dust emissions and short-term emission factors during the 6-month study. Pertinent facts about the conduct of the program and the results are discussed below.

During the study, some problems were experienced with the filter systems themselves: primarily intermittent plugging of the filters and malfunction of the cleaning air-pulse valves. These probelms were troublesome, but did not seriously affect the results.

The most important result of the study was determination of the long-term (weekly) composite emission factors for each of the seven grain-handling operations. The range of the emission factors determined each week for the seven operations was wider than expected, often varying by a factor of 5-10 or more. We believe that for the most part this was due to natural variability in grain-dust emissions. The average composite emission factors, based on analysis of the weekly quantities of dust collected and amount of grain handled are:

| | (lb/ton) |
|---|---|
| Truck unloading | 0.64 |
| Car unloading | 1.30 |
| Car loading | 0.27 |
| Corn cleaning | 5.78 |
| Gallery belt | 0.11 |
| Tunnel belt | 1.40 |
| Headhouse | 1.49 |

Comparison of the emission factors obtained in this study with other published data indicates that they agree fairly well although some are higher for some operations and lower for others. However, overall, ours are believed to be more accurate because of the more rigorous experimental methods employed.

Regression analyses of the weekly emission factor data obtained in this study did not indicate any definite relationship between the quantity of dust collected and the amount of each type of grain processed. It was concluded that long-term potential dust emissions can be predicted on the basis of the total amount of all grain handled about as accurately as could be done using "best-fit" individual emission factors for each type of grain.

Therefore, analyses of the average composite emission factors for each operation were used to calculate the cumulative emission factors shown below:

| Elevator Function | Cumulative Emission Factor (lb/ton) |
|---|---|
| Unloading (from trucks) | 2.24 |
| Unloading (from cars) | 2.90 |
| Loading (to cars) | 3.16 |
| Cleaning (of corn) | 10.43 |
| Turning | 3.00 |

These cumulative factors represent the dust emission potential of several individual grain-handling operations that must be carried out for each specific elevator function. For example, the function of truck unloading includes potential dust emission from the following operations: (1) dumping grain from the truck into the receiving pit, (2) elevation of the grain by the leg in the headhouse, and (3) transfer of grain from the leg onto the gallery belt. Therefore, cumulative emission factors can be utilized to predict total potential dust emissions on the basis of the amount of grain processed by certain basic elevator functions.

Short-term emission factors (i.e., for individual cars or trucks) were also obtained during this study, and these verified the wide range in emission factors for each type of grain. On the average they did show a dependency on grain type, as shown below:

| | Truck Unloading (lb/ton) | Car Unloading (lb/ton) | Car Loading (lb/ton) |
|---|---|---|---|
| Soybeans | 1.63 | 1.51 | 0.44 |
| Milo | 0.95 | 1.08 | 0.29 |
| Corn | 0.47 | 0.62 | 0.28 |
| Wheat | 0.52 | 0.50 | 0.17 |

Analysis of the short-term emission factor data for each grain was carried out to determine any dependency on grain quality (moisture or FM*). There was no discernible indication of any effect of FM on the emission factors and data on the effect of moisture were inconclusive.

* Foreign material.

Information was also obtained in the study that permitted characterization of the total potential dust emissions over weekly, daily, and hourly periods. The total dust collected over these periods varied over the following ranges; for this particular elevator which has a storage capacity of 4 million bushels and receipts plus shipments average about 13,000 tons/week:

| Period | Total Dust Collected (lb) |
|---|---|
| Weekly | 17,484-64,490 |
| Daily | 2,260-6,134 |
| Hourly | 105-2,960 |

Over the long term, significantly, the headhouse generates by far the largest amount of dust, because it operates on a more continuous basis than other operations; all grain must pass through the headhouse for any and all functions performed by the elevator.

## INTRODUCTION

This project was undertaken to investigate dust emissions from terminal elevators. Prior to this project, Midwest Research Institute had conducted a broad program for the Environmental Protection Agency, entitled "Engineering and Cost Study of Emissions Control in the Grain and Feed Industry " (EPA Contract No. 68-02-0213). Included in that study was a collection of available data on emissions from grain elevator operations, which directly reflect emission-control requirements for such operations and the requisite emission control strategy and control equipment selection and costs.

During the course of that study, it became obvious that dust emission data and emission factors for grain elevators were sparse, and the information which was available consisted of gross estimates or material balances for elevator operations as a whole, or were based on a few short-term tests on certain specific operations.

Recognizing the need for more data on emissions and emission factors for grain elevators, EPA authorized MRI to conduct a study to obtain additional data. As proposed by MRI, this study was to be based on continuous weighing of the dust collected by filter systems installed on several grain-handling operations at a terminal elevator in Kansas City. Fabric filters exhibit very high collection efficiency, so it could be assumed that if the quantity of dust collected and then discharged from the filters was determined, one would have an accurate measure of the amount of dust that had entered the dust collector system. The elevator where the study was to be conducted had the advantages that each major grain-handling operation was equipped with a fabric filter dust-collector system, and that each was a separate system (i.e., not ducted to a common control device). These operations included the following:

Truck unloading;

Car unloading;

Car loading;

Corn cleaning;

Gallery belt;

Tunnel belt; and

Headhouse.

After selection of the dust weighers to be used in the study, MRI made arrangements with the elevator to obtain all information regarding the amount and type of each grain processed through each of the grain-handling operations associated with the seven filter systems. These data, together with the quantities of dust weighed, provided the information necessary for the purposes of this study.

## PURPOSE

The primary purpose of this study was to determine emission factors (pound of dust per ton of grain) for seven specific grain-handling operations in a terminal elevator. These factors were to be long-term emission factors. That is, they were to be determined on the basis of the total weight of dust collected by each filter system over weekly periods and the corresponding quantity (and type) of grain processed through the associated grain-handling operation. These determinations were to be repeated each week over a period of 6 months.

Other emission data were also to be collected during the test period, including the following:

1. Short-term emission factors with identification of grain type and grain quality (moisture and FM*).

2. Determination of the quantity of dust collected by each operating system during five separate 8-hr periods.

3. Determination of the quantity of dust collected by each operating system during 16 separate 1-hr periods.

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* Foreign material.

## DESCRIPTION OF THE ELEVATOR

The Kansas City Terminal Elevator No. 1, where we conducted this study, is pictured in Figure 1, and diagrammed schematically in Figure 2. It has a total storage capacity of 4 million bushels and handles wheat, corn, soybeans and milo. Storage of grain is in bins on each side of the headhouse. Those bins on one side are referred to as the "old house" and those on the other as the "new house." This is significant from the standpoint that there are a total of 12 dust collector systems at this elevator, but weigher systems were not installed on any of the five filter systems in the new house. These included the two gallery belt and two tunnel belt systems plus the one on barge loading, which is seldom used. A description of the other seven filter systems, on which weighers were installed, is given below.

### UNLOADING

Grain is received at the elevator by truck, hopper cars, and boxcars. There is only one truck unloading station, consisting of a long shed that encloses the longest semi-truck, and a dump pit that is equipped with undergrate aspiration ducted to a fabric filter. Grain received by truck falls into the receiving pit, and is conveyed by underground belt into either of two legs, one having a capacity of 10,000 bu/hr and the other 25,000 bu/hr. (The elevator is equipped with a total of four legs; two are 10,000 bu/hr capacity and two are 25,000 bu/hr capacity.) The grain is conveyed by these legs to the top of the headhouse, where it may be discharged to any of several locations, although it is usually discharged onto the gallery belt serving the old house or onto either of the two gallery belts serving the new house. From these belts the grain is discharged into the selected storage bins by means of "trippers."

Grain is also received by hopper cars or boxcars. Hopper cars are bottom-unloaded through one dump grate into a receiving pit; from there it is conveyed by an underground belt into either of two legs, which elevates the grain to the top of the headhouse and discharges it onto one of the gallery belts, as in truck unloading.

(Old House) (New House)

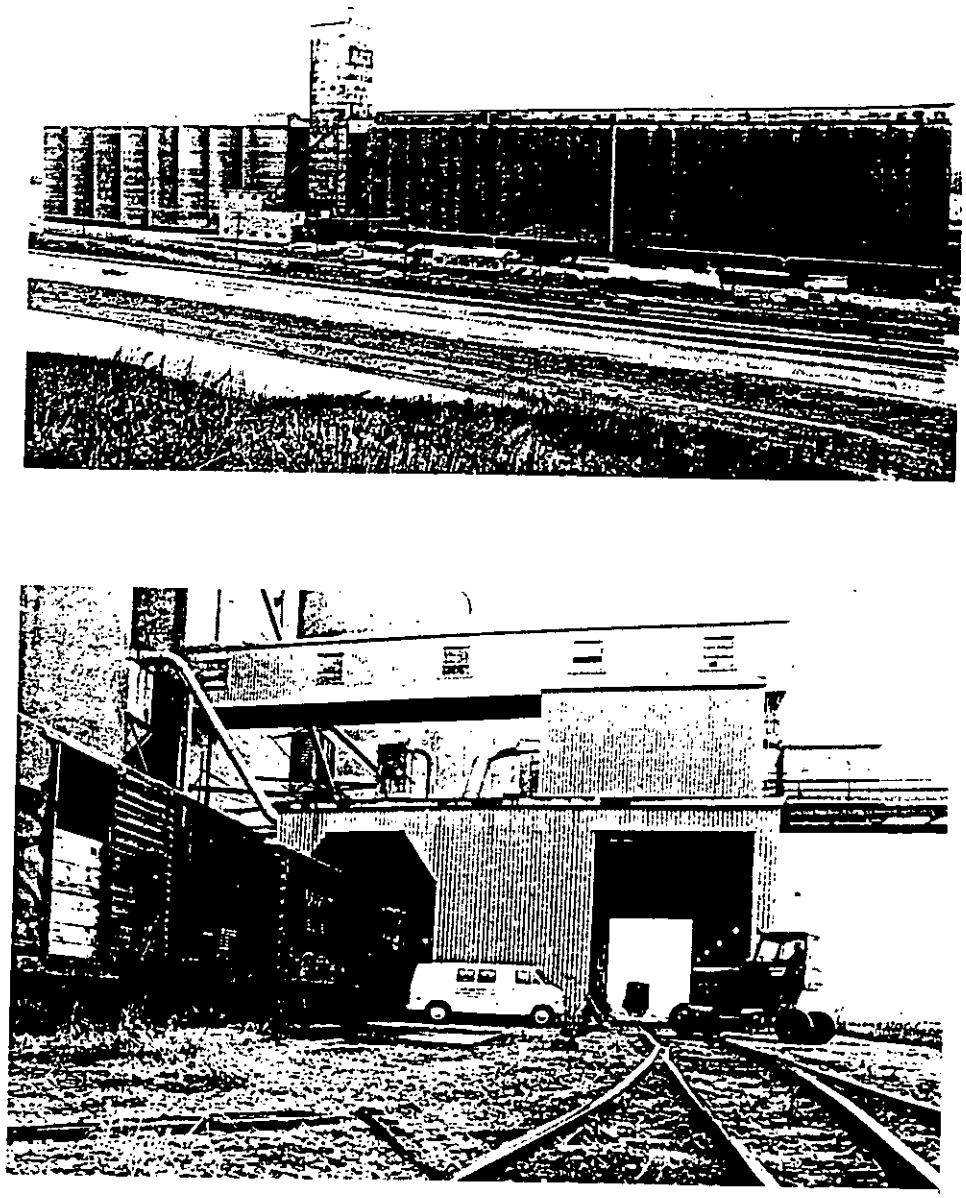
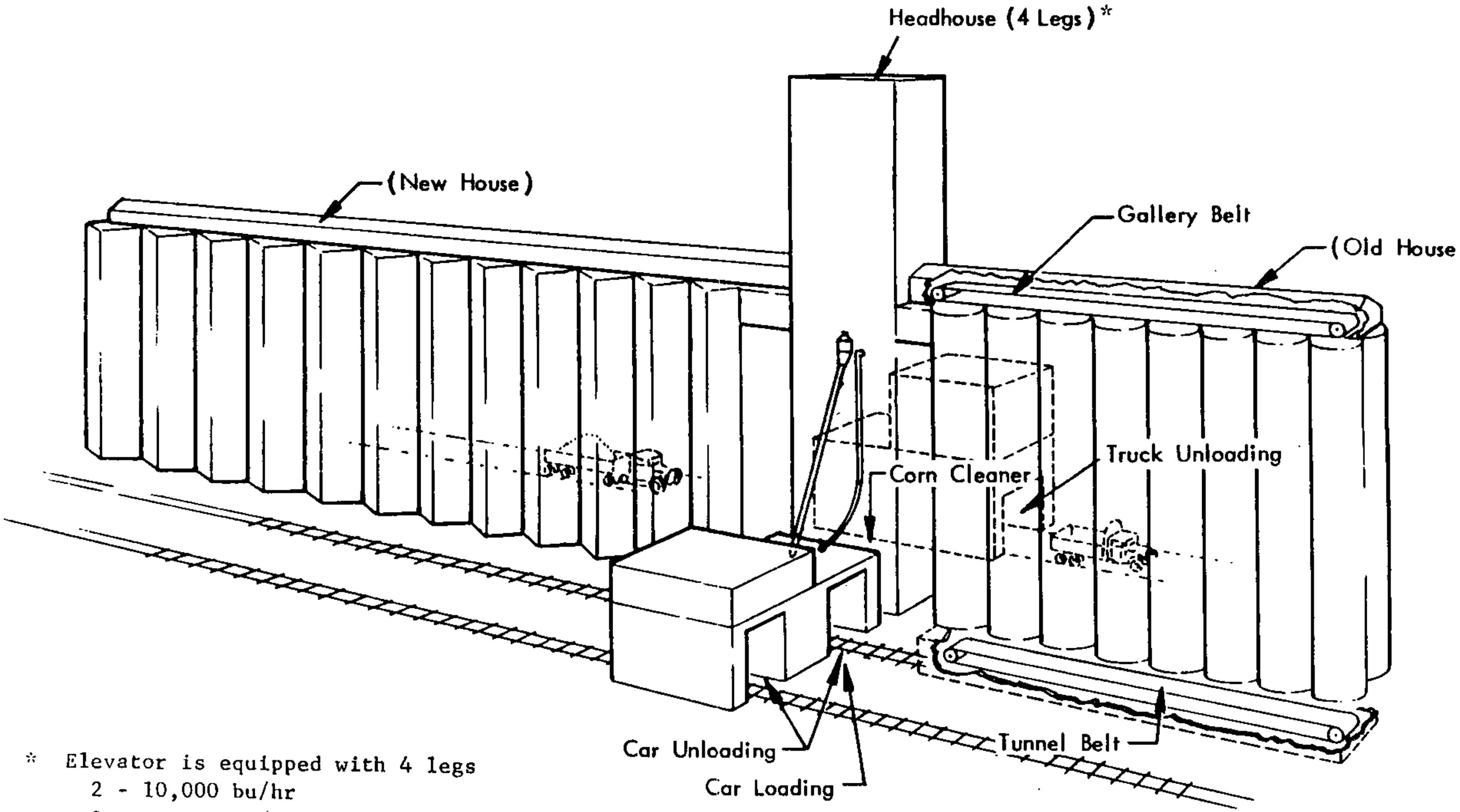


Figure 1. Photograph of elevator--front and back views.




* Elevator is equipped with 4 legs
2 - 10,000 bu/hr
2 - 25,000 bu/hr

Figure 2. Schematic diagram of the elevator.

Boxcars are unloaded by a hydraulically operated mechanical car unloader. This device elevates one end of the car and tilts the car sideways, causing the grain to flow out of the car door and through the trackside grating into a receiving pit below. Grain is conveyed out of this pit by the same underground belt that serves the hopper-car unloading system.

Both the hopper car and boxcar unloading are equipped with undergrate aspiration leading to a common fabric filter. Slide valves are used in the ducting, in order to provide aspiration for unloading hopper cars or boxcars, depending on which is in use. Because both hopper-car unloading and boxcar unloading are served by the same underground belt, only one car can be unloaded at a time even though hopper cars are unloaded on one track while the other track is used exclusively for boxcar unloading.

LOADING

Grain may be loaded into hopper cars, boxcars, or barges. There is no loading of trucks at this elevator, and barge loading is seldom used. Boxcars and hopper cars are loaded on the same track, but not simultaneously. A common fabric filter serves both hopper car and boxcar loading, with a slide valve in the ducting to provide aspiration to one or the other.

The dust-collection system for car loading is described in the next section of this report.

GALLERY BELTS

There are three gallery belts, one serving the old house and two in the new house. Each of these is equipped with a hood and filter system at the point where the grain is discharged onto the belt. However, there is no dust collection on the gallery belt trippers or the storage bins. Therefore, the dust collection hoods actually serve only the transfer point where grain is discharged onto the belt.

TUNNEL BELTS

The tunnel belt in the old house receives grain from the bottom of the bins and discharges it into either of two legs, while the two tunnel belts in the new house discharge grain into either of the other two legs. A weigher system was installed only on the old house tunnel belt, and collected dust from the hoods at each bin drop-point onto the belt as well as from the over and under hoods at the head pulley of the tunnel belt, and from the boot of one leg. Slide valves in the ducting were used to provide aspiration only on those hoods where grain was being discharged onto the tunnel belt.

## CLEANER

The elevator was equipped with one cleaner, having a capacity of 1,000 bu/hr, that utilized air aspiration. It was used for cleaning of corn prior to loadout, but since only a portion of the corn was cleaned, it was used only intermittently, as required. Corn to be cleaned is fed onto the upper end of the cleaner and travels downward over a screen by the oscillating motion of the cleaner. During this process, smaller particles (e.g., seeds, broken kernels, small rocks, etc.) fall through the screen and are rejected. There are also two fans mounted on top of the cleaner which pull air up through the screen and remove dust, chaff and hulls, etc., which are collected by the filter before the air is exhausted to the atmosphere. Material collected by the filter is dropped into a dust storage tank mounted on the side of the building below the filter. This is the only dust-control system at the elevator in which the collected dust is not returned into the grain stream.

## HEADHOUSE

As previously mentioned, the elevator was equipped with four legs. The headhouse also consisted of two scale and garner systems. This arrangement provided good flexibility in that truck unloading could be carried out simultaneously with car loading or unloading.

At the top of the headhouse the grain was discharged from the four legs, and the flow could be directed to any of several locations: including the three gallery belts, the two garner and weigh tank systems, and the headhouse bins. The dust control system in the headhouse consisted of a single large fabric filter, but the suction manifold had many branches to control dust from the four legs, the leg discharge chutes, and the two garner and weigh tank systems.

During the 6-month test period the elevator operated in what would be considered a normal manner. Operation consisted primarily of unloading trucks and of loading and unloading cars. Some corn was cleaned intermittently, and the one grain dryer at the elevator was used on certain occasions, primarily for drying milo.

As expected, the quantity of grain processed each day increased during harvest periods. During these times, the elevator operating hours (8:00 A.M. to 5:00 P.M.) were extended to late in the evening, and the elevator sometimes remained open on Saturdays.

Besides the normal loading and unloading, some in-house transfer of grain was conducted, often on weekends in order not to interfere with loading and unloading. Such transfer operations most often consisted of moving grain from one bin to another bin.

## DESCRIPTION OF DUST CONTROL SYSTEMS

This discussion is restricted to those seven filter systems on which the dust weighers were installed. The other five systems are quite similar to those operations that were equipped with weighers. However, the prime purpose of this study was to obtain data that would permit us to calculate the uncontrolled emission factor for each of the seven grain-handling operations described below (i.e., to determine the weight of dust collected by each system and then be able to assess the quantity of grain processed through the associated grain-handling operation during the same time interval (usually 1 week)). The elevator personnel were very helpful and recorded the information necessary for us to calculate the amount of each type of grain processed through each of the seven operations.

All of the filter systems had been installed at the elevator in 1972 by the Natkin Company of Kansas City, Missouri. They installed Micro-Pul filters that are equipped with pulse-jet bag cleaning mechanisms requiring 80-100 psi cleaning air. Each system has its own cleaning air compressor and air tank. Details of each of the seven dust collection and filter systems are presented below.

### TRUCK UNLOADING

The truck unloading pit is equipped with undergrate aspiration of 12,000 cfm ducted to a Micro-Pul filter. Clean air from the filter is exhausted to atmosphere through a blower. A schematic diagram of the system is shown in Figure 3 and pictured in Figure 4. As shown in the schematic, this system also provides dust control for the truck unloading belt and for the boot of the No. 1 elevator (leg).

Observation of this system during our weekly visits indicated that it does a very good job of controlling emissions from truck unloading. Little or no dust could be observed escaping capture by the undergrate aspirator.

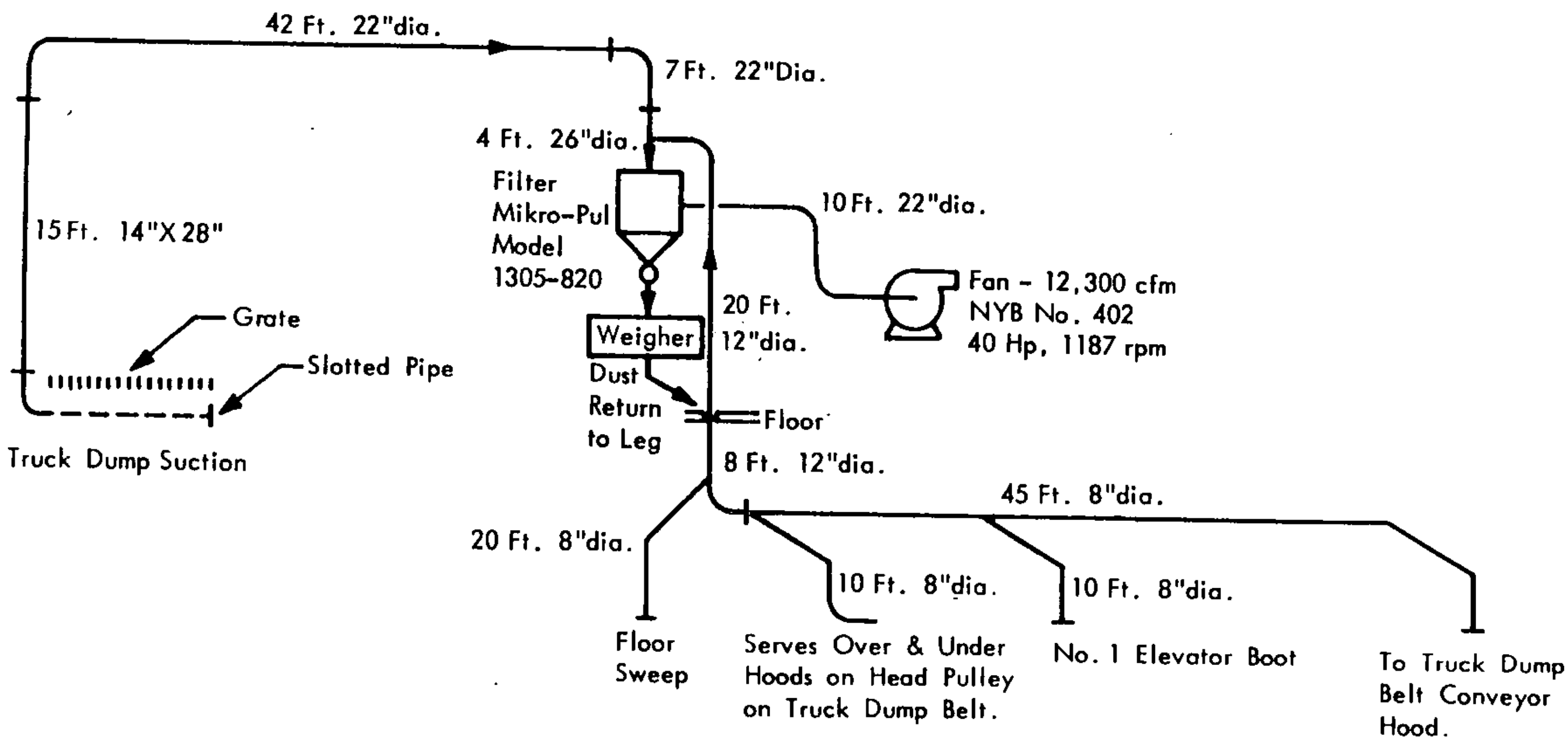
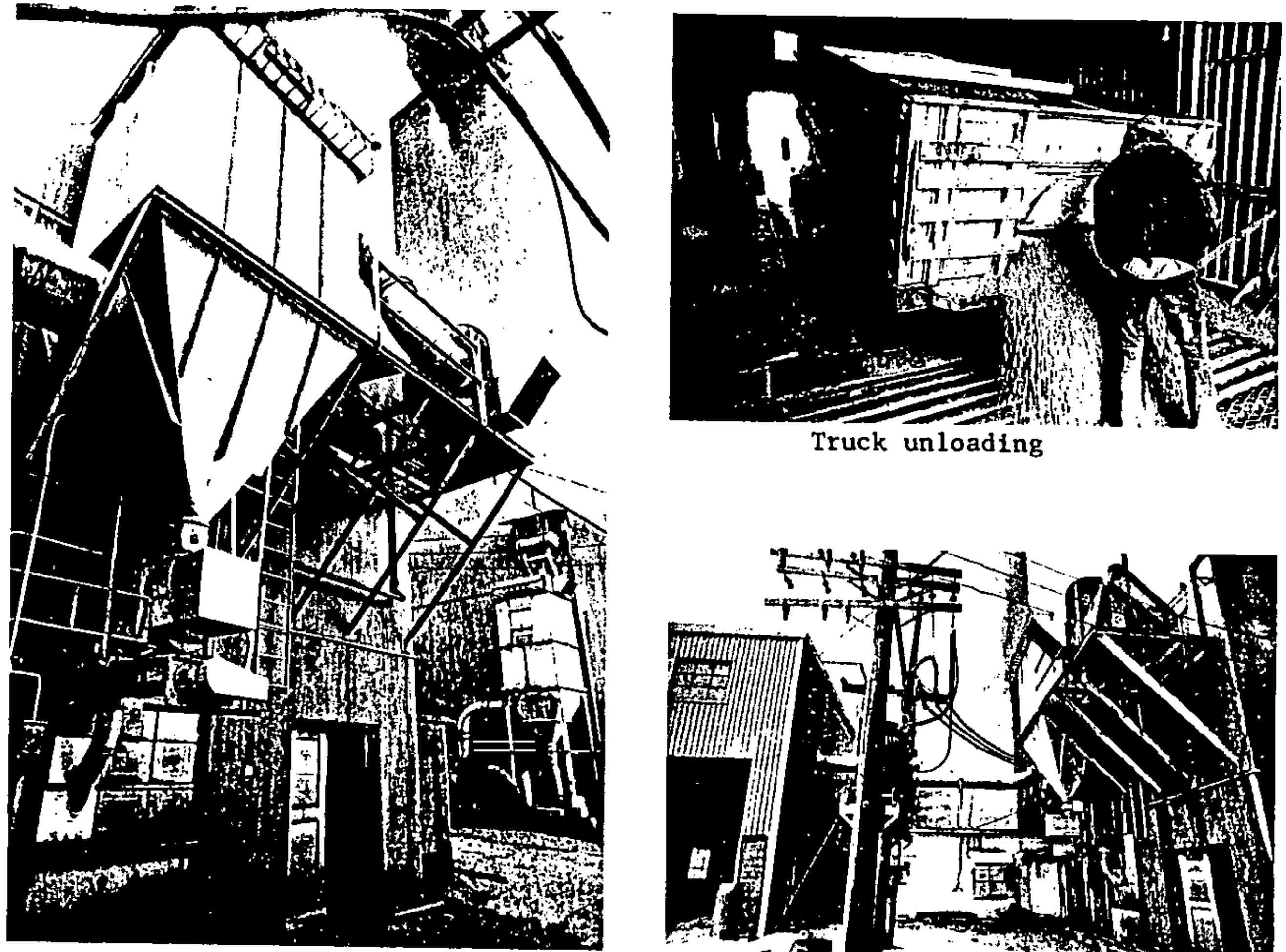



Figure 3. Truck unloading.



Filter, fan and weigher

Truck unloading

Unloading shed and filter

Figure 4. Truck unloading system.

The truck-unloading shed is open at both ends, but the shed is quite long, exceeding the entire length of the largest semi-trucks.

The dust hopper below the filter bags discharges dust through a rotary valve (air lock), and the dust weigher was mounted just below this air lock. Dust was discharged from the air lock into the weigher, and then into a screw conveyor that returned the dust to the unloading leg.

Although the filter did provide good control of truck-unloading emissions, it occasionally plugged, usually from "bridging" of the dust just above the rotary valve. Bridging may have been caused partly by malfunction of the cleaning air pulse valves which fouled at very low temperatures. Pluggage necessitated dismantling of the rotary valve to clean out the filter hopper, so that part of the dust was not weighed and would, therefore, tend to lower the calculated emission factor for that period (week). Also, it was difficult for us to know how long, during the week, the filter was plugged.

Bridging did not occur in either of the two filters which have a screw conveyor at the bottom of the dust-filter hopper; it did occur more than once in each of those tetrahedron-shaped hoppers that connect directly to a rotary valve. It might, therefore, be good practice to avoid using hoppers of this design, even though it would cause some increase in cost due to the added expense of a screw conveyor.

Like the other filter systems, the truck unloading filter also experienced some problem with malfunction of the cleaning air pulse valves, primarily during subfreezing temperatures. Such temperatures occurred only late in the program, but it certainly increased the frequency of the problem with all of the filter systems. Primary indication of this problem was zero air pressure reading in the cleaning air tanks, even though the compressors ran continuously. The problem is evidently caused by condensation and freezing of water vapor from the compressed air, in the pulse valves, which then causes malfunction of the valves resulting in continuous bleed-off of the compressed air. Ambient air that is compressed to 50-100 psig will have a high dewpoint. If the compressed air lines are exposed to subfreezing temperatures, the moisture will condense and freeze in these air lines. Therefore, if this situation may exist, reliable means should be provided for drying the compressed air, or for otherwise preventing condensation or freezing of the water in the compressed air lines. Such precautions would of course be an added expense, but without it, proper operation of the dust-control system in cold weather will be very uncertain.

## CAR UNLOADING

The car-unloading filter serves the undergrate aspiration on hopper-car unloading and boxcar unloading. Slide valves in the ducting provide aspiration to one or the other of the two receiving pits. Design air flow is 18,000 cfm through the Micro-Pul filter, and clean air is exhausted through the fan to atmosphere. A schematic diagram of the system is shown in Figure 5 and pictured in Figure 6. This system also provides dust control for the unloading belt and the No. 4 leg.

Dust collected by the filter is conveyed by a screw conveyor to a rotary valve (air lock) that discharges the dust into a chute. This chute dropped the dust into our weigher, from which it was discharged back down into the grain-receiving pit. Pluggage of the dust discharge chute did occur on occasion and some problems were encountered with malfunction of the air pulse valves at low temperatures.

The unloading area is enclosed by a shed that is open at both ends. Observation of this dust collection system indicated that it was not completely effective in capturing the dust emitted during boxcar unloading. However, the undergrate aspiration is quite effective on hopper car unloading.

## CAR LOADING

Loading of hopper cars and boxcars is served by one filter but the hooding system is quite different for each. Again, slide valves in the duct system provide aspiration to either the boxcar loading or hopper car loading, depending on which type of car is to be loaded. Design air flow for the Micro-Pul filter is 4,000 cfm, and clean air from the filter is exhausted to atmosphere by the blower. A schematic diagram of the filter, fan and ducting is shown in Figure 7 and pictured in Figure 8. The car-loading filter system provides dust control exclusively for the loading operation, and no other dust sources are served by this system.

Hooding for the loading operation is unique. Collection of dust emissions during the loading of hopper cars is by means of a hood with flexible hoses that permit it to be raised or lowered, depending on the height of the hopper car. This hood, as shown in Figure 8, is adjacent to the grain-loading spout, and extends about 10 ft along the length of the center of the hopper car to capture the dust as it "boils" up out of the loading door along the top center of the car. This hood is only fairly effective in capturing all of the dust generated during hopper-car loading. Perhaps more air flow would have provided greater capture efficiency, but it certainly is an improvement over no control at all. This specific hood design is not effective for loading round-hole hoppers where the loading holes are not along the top center of the car. However, most of the hopper cars loaded at this elevator were the center-loading type.

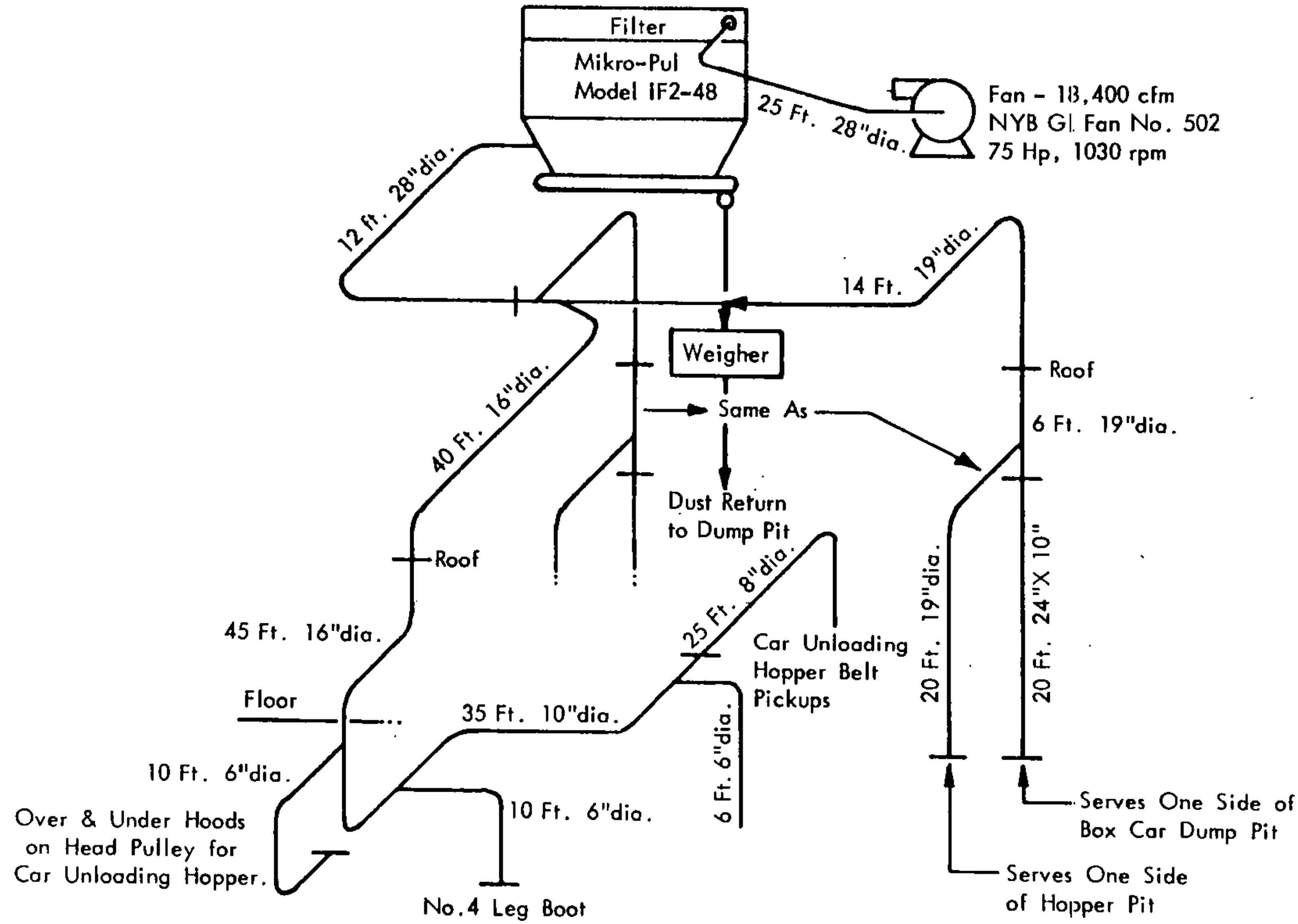
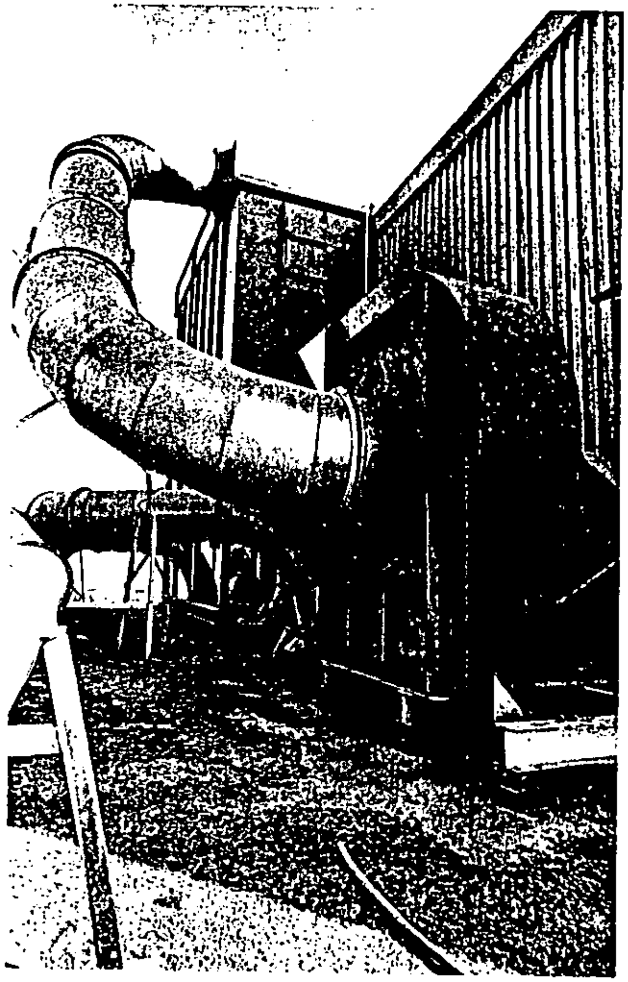



Figure 5. Boxcar and hopper car unloading.



Filter and fan

Dust weigher

Boxcar unloading spot

Figure 6. Photographs of Car Unloading System.

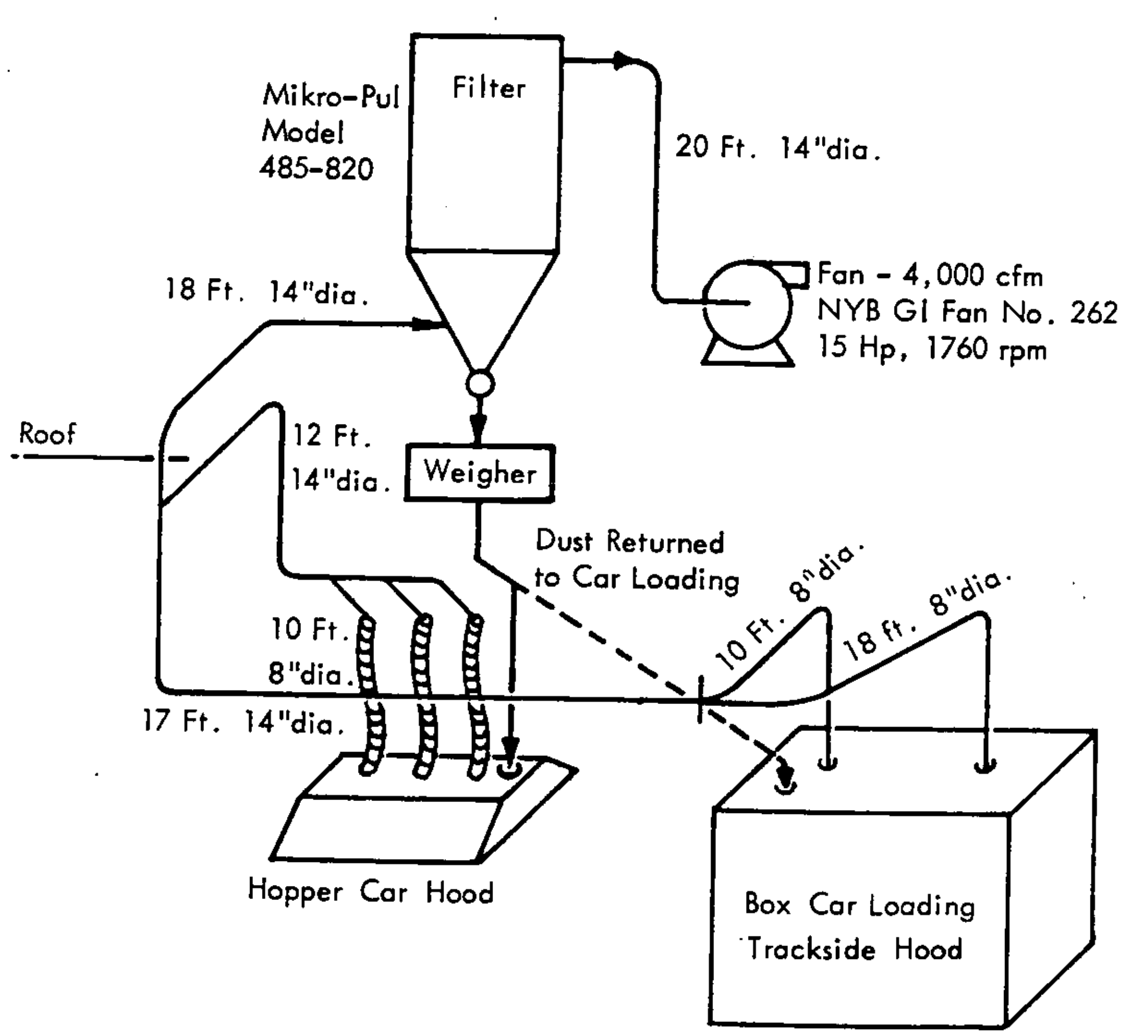
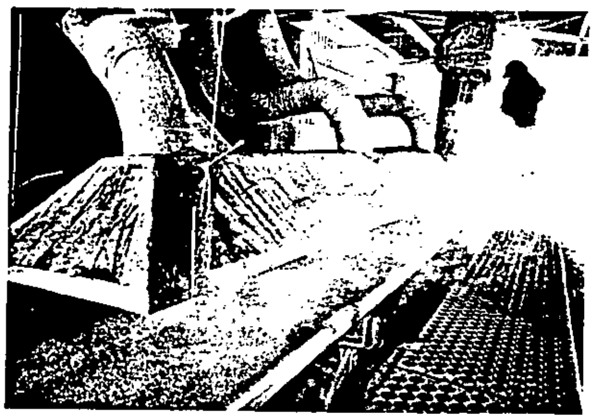



Figure 7. Boxcar and hopper car loading.



Hopper car hood

Boxcar-trackside housing

Hopper car loading

Filter, fan and weigher

Figure 8. Photographs of Car Loading System.

Collection of dust emissions during boxcar loading is by means of a trackside housing with an opening that matches the door of the car above the grain doors, as depicted in Figure 9. Clearance between this dust collection housing and the side of the car is about 1 ft, with flaps extending out from the housing that help to minimize escape of the dust between the car and housing. This arrangement does a fairly good job of capturing the dust generated during loading of boxcars.

Dust-laden air from either the trackside housing (boxcars) or the hood above the hopper cars was aspirated up into the filter mounted on the roof of the car-loading shed, and clean air from the filter was exhausted to atmosphere through the blower. Dust collected by the filter is discharged from the dust hopper through a rotary valve (air lock). The dust weigher was mounted just below this valve, and after passing through the weigher, the dust entered a chute that discharged it back into the car being loaded. Return of the dust into the car was required by state regulations because no part of the material can be removed once it has been weighed for loadout.

The car-loading filter did plug up several times during the first part of the 6-month test period. During the early part of this study, the plugging was usually due to blockage in the chute that returns the dust into the car. Modifications were made in this chute and the problem occurred very seldom thereafter. However, the filter still plugged on occasions because of bridging of dust just above the rotary valve.

CORN CLEANER

The air-aspirated corn cleaner is equipped with two fans that discharge into a common duct leading to the fabric filter shown in Figures 10 and 11. Design air flow for the filter is 12,000 cfm, and the clean air is discharged directly to the atmosphere. Dust is discharged from the filter through a rotary valve (air lock). The dust weigher was mounted just below this valve. The dust passed through the weigher and into the dust tank below. The dust is occasionally emptied from the tank into trucks and hauled away. This is the only dust system in which the dust is not returned to the grain stream.

The corn cleaning operation was in service only intermittently, as needed, and usually for periods of 1/2 to 2 hr on those days when it was used. Some dust does appear to escape from the cleaner during operation, but the primary function of the aspiration provided by the fans is to aid in cleaning of the corn. The nature of the dust collected by the filter system is somewhat different from the other systems in that it appears to contain more hulls and chaff, etc. This difference may have contributed to pluggage of the filter due to bridging above the rotary valve, which seemed to occur on more occasions in this filter than any of the others.

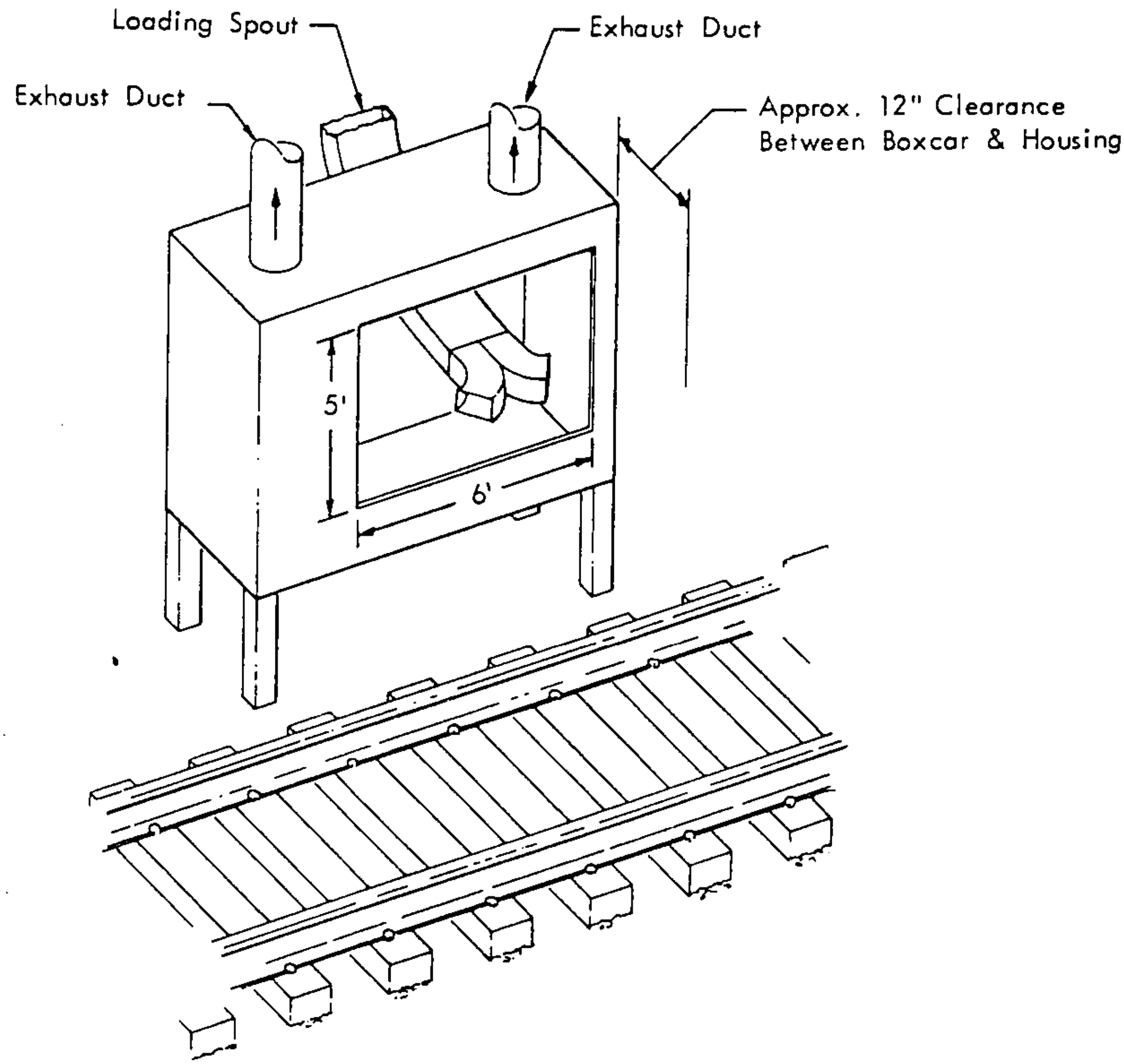



Figure 9. Dust control system for boxcar loading.

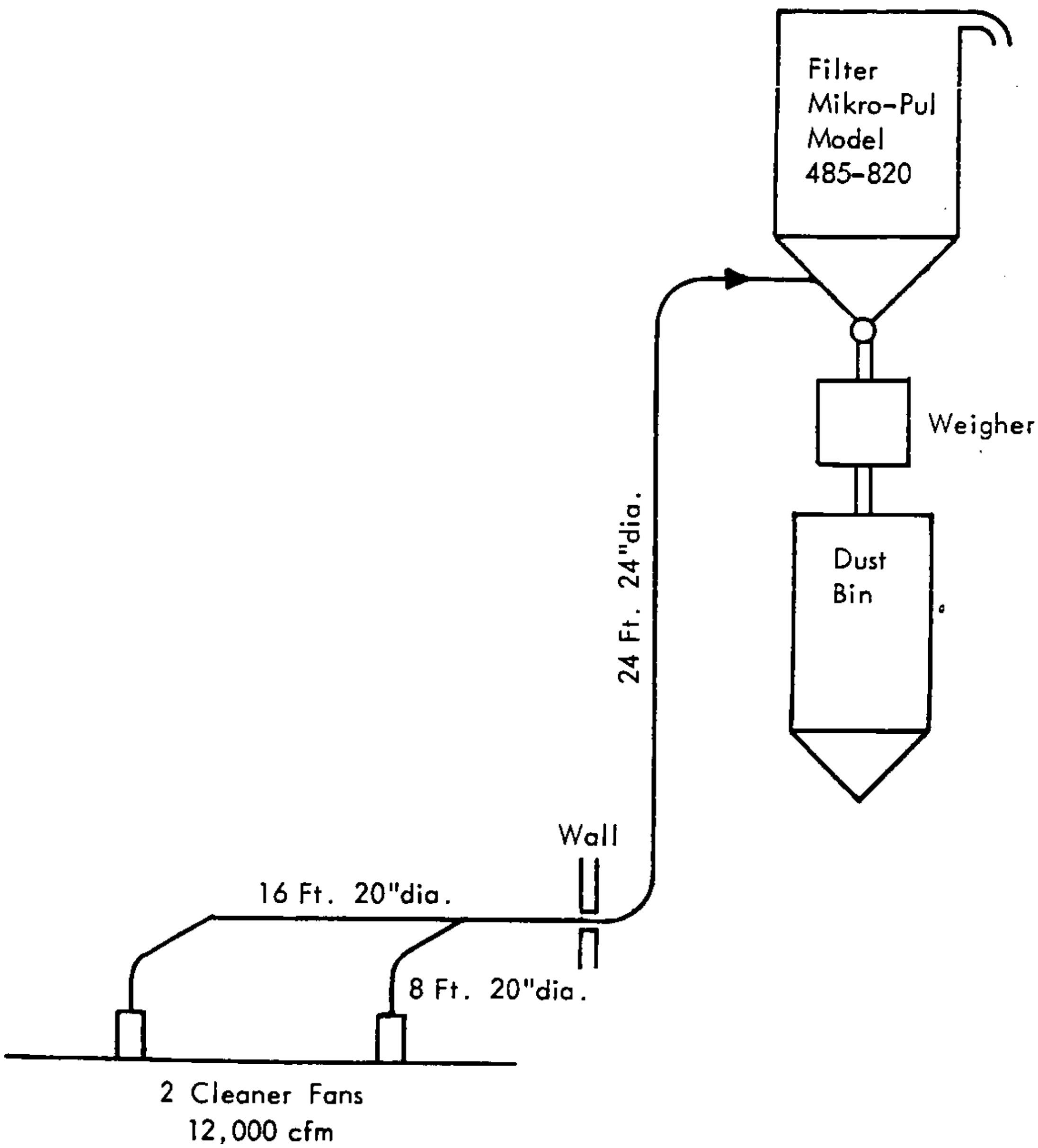
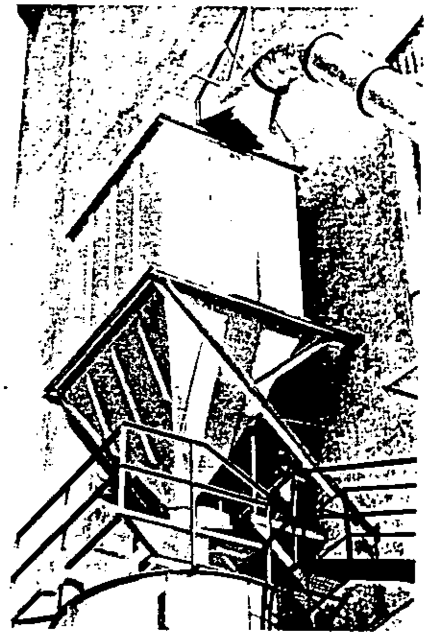
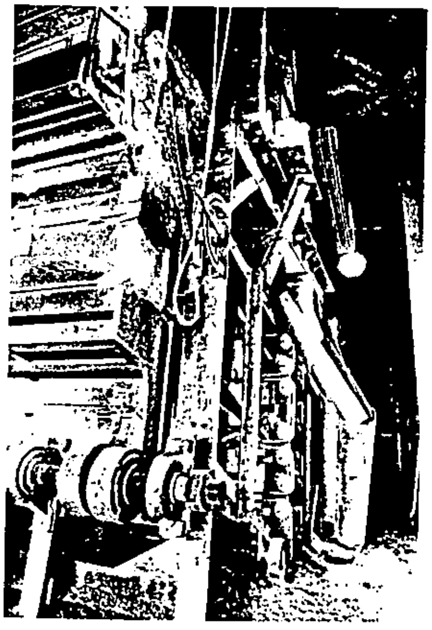



Figure 10. Grain cleaner (corn only).

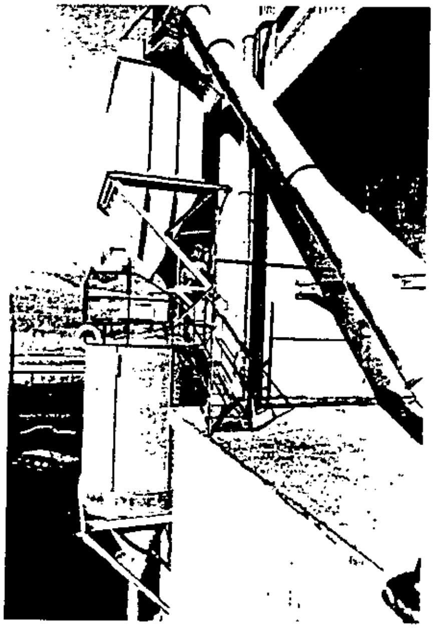
Dust weigher



Filter



Cleaner (and fans)



Filter and dust tank

Figure 11. Photographs of Corn Cleaner System.

## GALLERY BELT

The term "gallery belt" is misleading for this dust-control system because it is in actuality only a transfer-point dust-control system.

Either of two grain chutes discharged grain onto the gallery belt. Both of these transfer points were hooded as shown in Figures 12 and 13. Air was aspirated from the hoods through a fan and into the filter mounted on the roof above. Dust collected by the filter was discharged through a rotary valve into the weigher below, from which it dropped back through one of the hoods onto the gallery belt with the grain.

Visual observation of the system indicated that the system was effective in minimizing the dust escape at these transfer points. However, since there is no dust control on the tripper, the gallery belt area becomes quite dusty when this belt is in service.

This gallery belt system was not in service as much as we had expected during the 6-month test period. The two gallery belts in the new house were used more often, because the new house has greater storage capacity and operations seem to direct most grain to that house. During weekends, grain was often transferred from the new house to the old house; as a consequence, we were not able to observe it in operation nor calibrate the weigher as frequently as we had anticipated.

## TUNNEL BELT

Each of 23 grain drop-points from the old house storage bins onto the tunnel belt are hooded and aspirated into a common exhaust manifold, as shown in Figure 14. Dust control for the head pulley and No. 2 leg are also connected into this exhaust manifold. This manifold is exhausted through a fan into the filter mounted on the roof above the tunnel (see photographs, Figure 15). Dust collected by the filter is discharged through a rotary valve and drops through a chute into the weigher, from which it is returned into the tunnel belt.

It was difficult to assess how effectively the hooding systems captured the dust when the tunnel belt was in use. However, it was observed that it did not completely eliminate dust in the tunnel area. It was also difficult to use the data on the amount of dust passing through the weigher as representative of the quantity of grain transferred by the tunnel belt because the aspiration for the boot of No. 2 leg is connected into this system. This leg was in use a much greater portion of the time than the tunnel belt and dust was often being collected by the tunnel belt dust control system even though no grain was being moved on the tunnel belt.

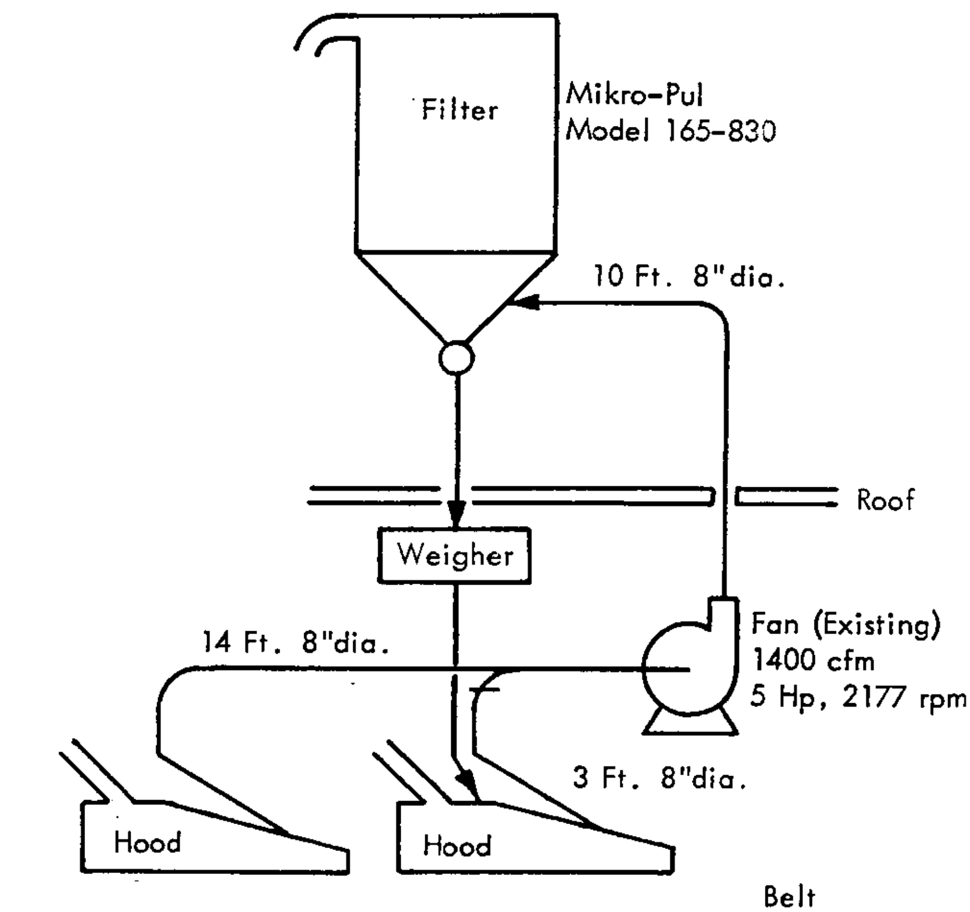
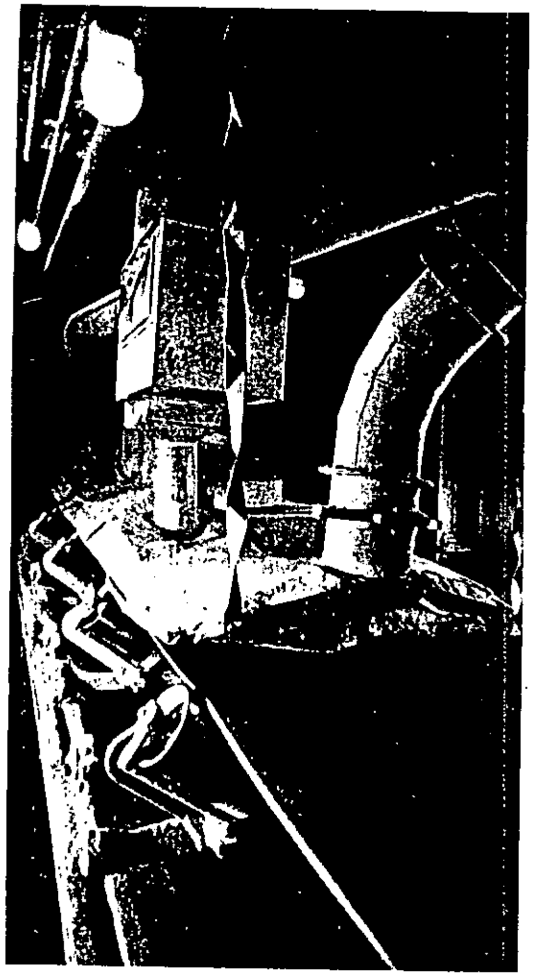
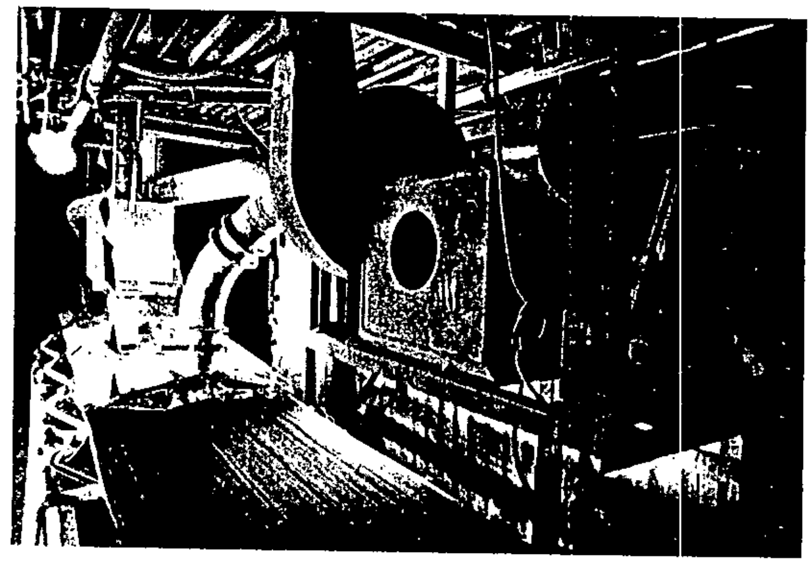



Figure 12. Gallery belt.



Hood and dust weigher



Hood, weigher and fan

Figure 13. Photographs of Gallery Belt System.

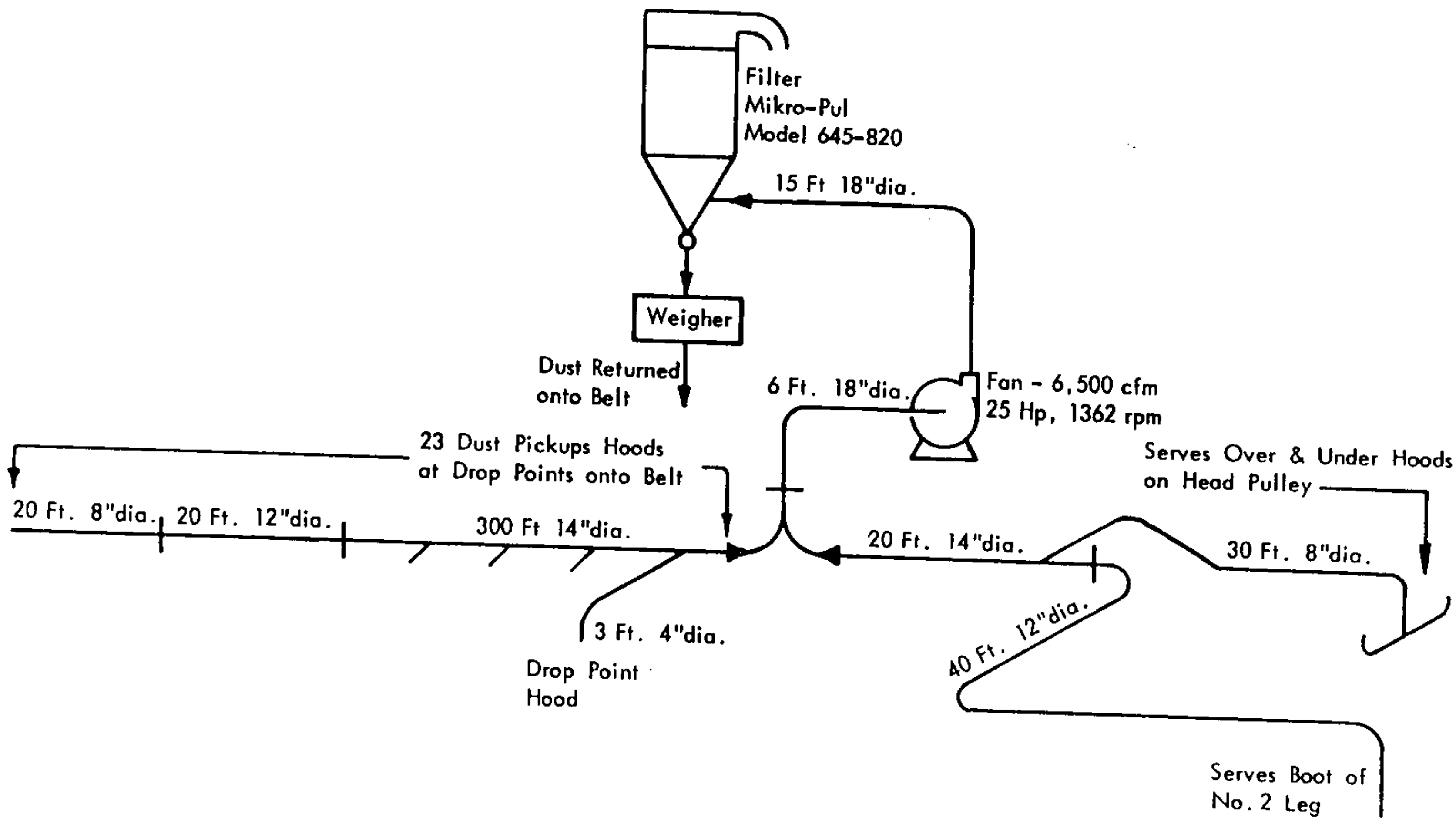
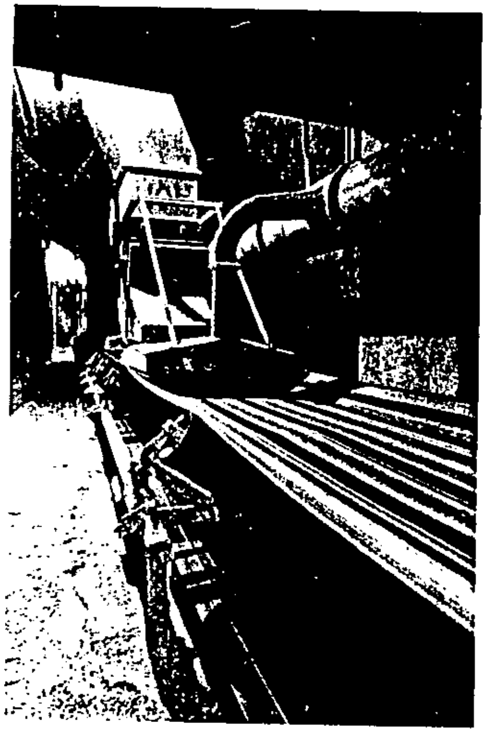
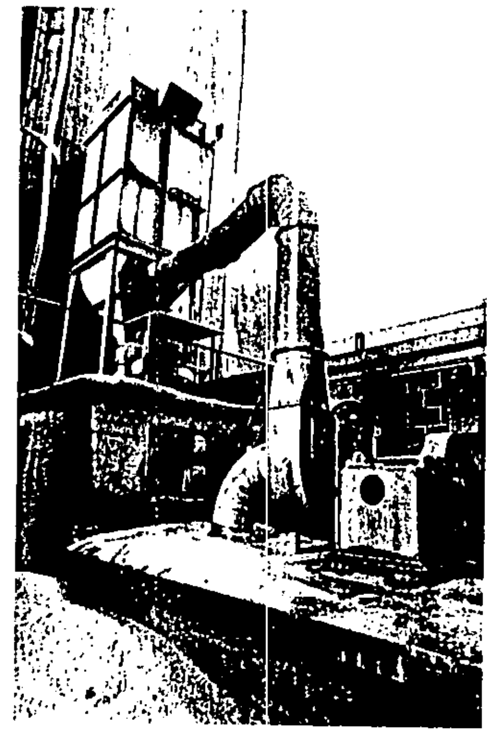



Figure 14. Tunnel belt.



Tunnel belt and hood

Weigher



Filter and fan

Figure 15. Photographs of Tunnel Belt System.

Therefore, the calculated emissions, based on the quantity of grain processed by the tunnel belt, are misleading. This is discussed in more detail in a later section of the report.

Pluggage of the dust filter, due to bridging above the rotary valve, did occur a few times and cold weather again contributed to problems with malfunction of the air pulse valves. It was observed also that when the filter system was first started in the morning, large quantities of dust were discharged through the rotary valve for a period of about 5 min. This might be explained by the fact that when the pulse valves were malfunctioning, the filter bags were not being cleaned properly and probably built up a large cake of dust. This increased the pressure drop across the bags up to 10-12 in. $H_2O$, rather than the normal 4 in. $H_2O$. When the fan system was shut down at night, part of the dust layer on the bag was probably released and fell into the hopper below. Upon startup the next morning, the rotary valve emptied this dust out of the hopper at the maximum rate that the valve was capable of handling until the hopper was emptied. The rapid rotation of the weigher, which was not designed to handle this high rate of dust discharge, certainly affected its accuracy. However, such operation did not last long.

## HEADHOUSE

Dust control for the headhouse was achieved by a common exhaust manifold connected to several dust sources consisting primarily of the top of each of the four legs and their grain discharge chutes and the two garner and weigh tank systems. A schematic diagram of this dust control system is shown in Figure 16 and is pictured in Figure 17. The exhaust manifold was ducted to the filter located on the roof, and clear air from the filter was exhausted to atmosphere through the blower. Dust collected by the filter dropped into a screw conveyor along the bottom of the hopper below the filter, which then discharged the dust into a rotary valve (air lock). After being discharged from the valve, the dust fell down a chute into the weigher, which then discharged it into a chute that returned the dust into either of the two garner bins.

In every operation carried out by the elevator, the grain must pass through the headhouse by means of one of the four legs, and two legs are often in service at the same time. As a result, the dust system in the headhouse is collecting dust almost continuously and, as our data shows, this system collects more dust over any weekly period than all six of the other dust control systems combined. This does not mean that the calculated emission factors are higher for this source; it only reflects the fact that all of the grain must be processed through the headhouse for any operation and it is therefore in service almost continuously.

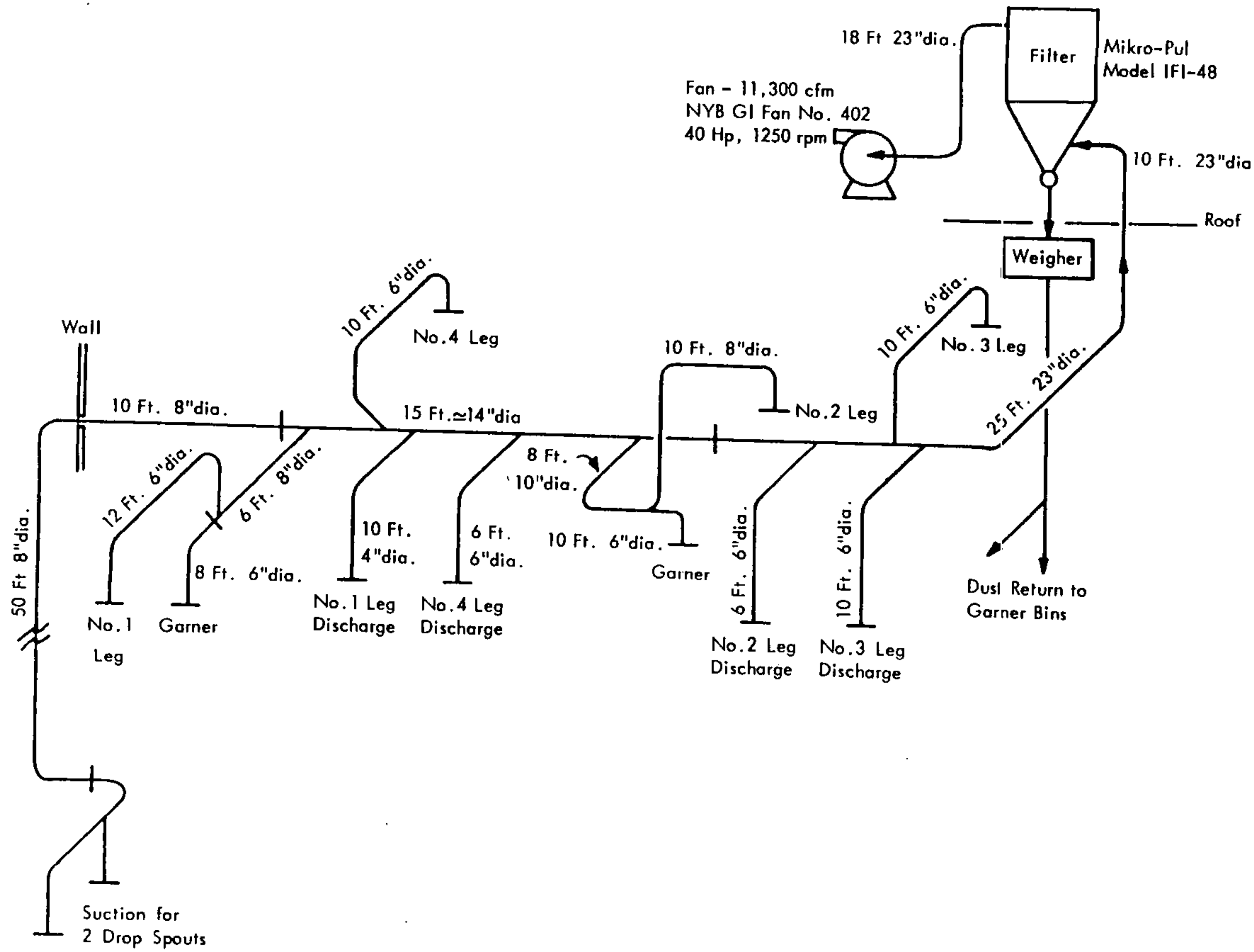
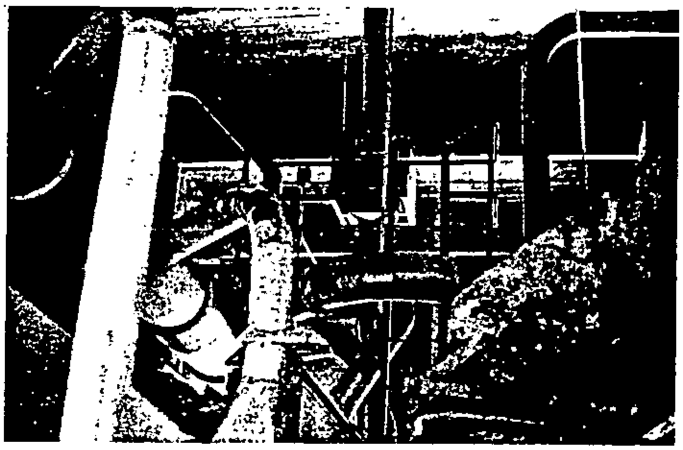
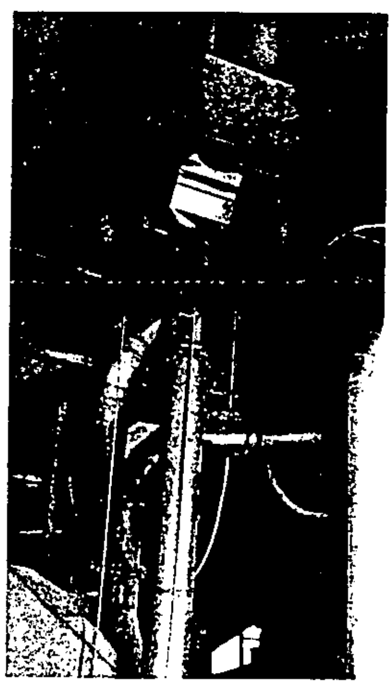


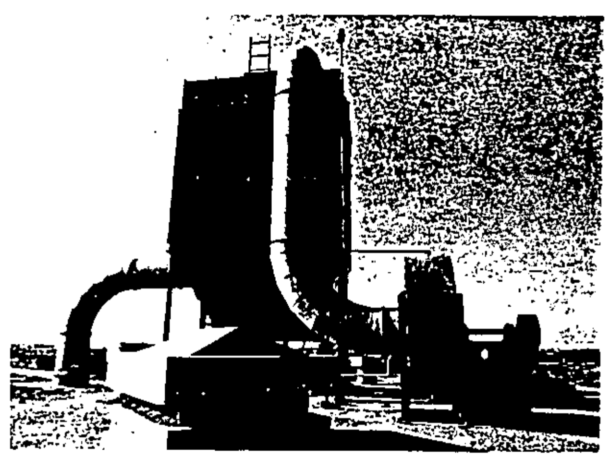

Figure 16. Headhouse.



Dust collection manifold and weigher



Manifold and weigher



Filter and fan

Dust weigher

Figure 17. Photographs of Headhouse System.

The headhouse dust control system does appear to be very effective in controlling emissions from the several sources that it serves. On those occasions when this system was out of service, the headhouse area rapidly became quite dusty.

The only problem experienced in the headhouse dust control system was shutdowns in the earlier part of the program resulting from pluggage of dust in the discharge line between the rotary valve and the dust weigher. These were caused by the dust weigher due to a mechanical problem that intermittently prevented proper operation of the weigher mechanism. This was corrected after the cause of the problem was located, and the system operated very well thereafter.

## DESCRIPTION OF DUST WEIGHERS

The intent of this program was to continuously measure the weight of dust collected by seven filter systems on a weekly basis for a period of 6 months. That data, along with an assessment of the quantity of grain processed by each of the systems, would permit us to calculate emission factors for each operation over the long term and provide much more accurate information on the potential dust emissions.

Continuous, long-term weighing of the dust collected by each filter system was an unusual, but very important part of the proposed study. Because it was impractical to use normal stack sampling procedures to obtain continuous long-term measurement of the emissions from several dust-control systems, suitable means had to be found for continuous weighing of the dust discharged from each filter system. MRI, in investigating this problem, had considered several weighing methods including automatic scales, weigh belts, electronic metering devices, mechanical weighers, and others.

### WEIGHER SELECTION

Weighers to be used were subject to several restrictions imposed by the requirements of this task and the manner in which they were to be used. Most important of course, was that they be capable of handling the dust at the rate at which it was discharged from the filters without becoming overloaded. This also meant that they must be able to weigh the dust, at variable rates because the flow often varied over a wide range. They must also be able to tolerate impact of the dust because the dust flow pulsates, corresponding to its release from each vane of the rotary valve at the bottom of each filter. After release, each "clump" of dust falls a distance of 1-10 ft before entering the weigher, which causes some impact force.

Other factors considered in our evaluation of the weighers were as follows:

1. Capital cost.

2. The quantity of dust held in the weighers during each weighing should not exceed 5 lb. Minimal holdup was desirable to minimize the effect that this could have upon returning the dust to the grain stream.

3. Design of the weighers should be such that they would not tend to plug or cause bridging of the dust in the chutes leading to or from the weigher.

4. They must have an easily adjustable weighing range.

5. They must be designed so that periodic calibrations could be carried out.

6. Space requirements should be minimal, especially vertical height, because of the restricted space at several of the locations where they were to be installed.

7. It was desirable that they operate mechanically, without requiring electrical or compressed air supply.

After investigation of several devices we selected the one which most closely satisfied all of the above requirements, and EPA accepted this selection. The weigher selected was the Holm Model GF weighing mechanism supplied by the Howe Richardson Company of Kansas City.

WEIGHER MECHANISM

The Holm scale mechanism is illustrated in Figure 18 and pictured in Figure 19. It consisted of a three-compartment revolving weigh hopper mounted on one end of a weighing beam with a counterweight on the opposite end of the beam. On the side of each of the three weighing compartments was a stop-pin that controlled the position of each compartment and which also actuated a mechanical counter.

Dust first fell into the upper compartment, thereby increasing the weight until it was sufficient to overcome that of the counterweight. When this occurred, the weigh beam tilted a small amount, thereby releasing the stop-pin. Weight of material in the (dust) hopper compartment then caused it to rotate downward and the dust fell out of the compartment. As soon as the dust fell out of this compartment the weigh beam tilted

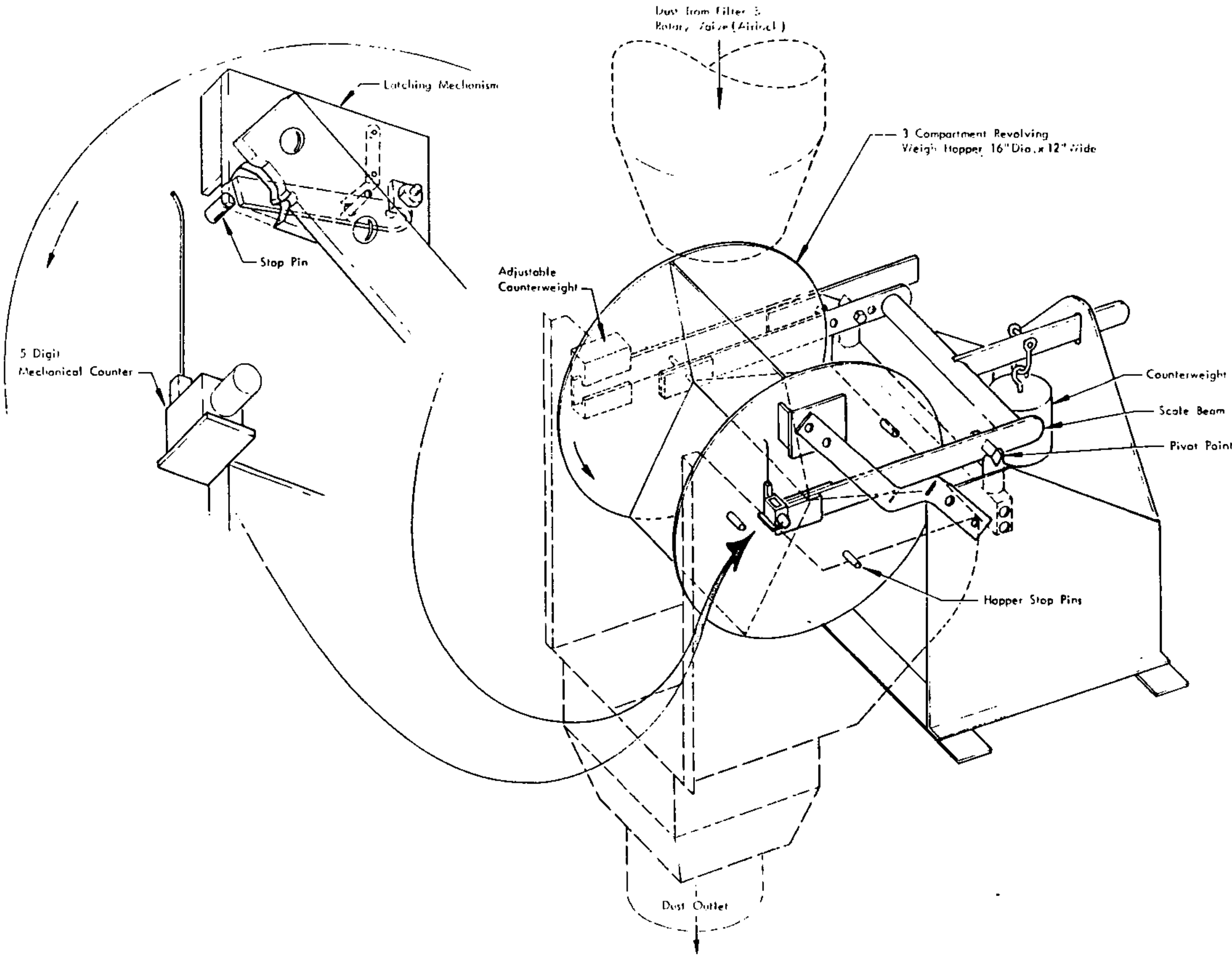



Figure 18. Illustration of dust weighing device

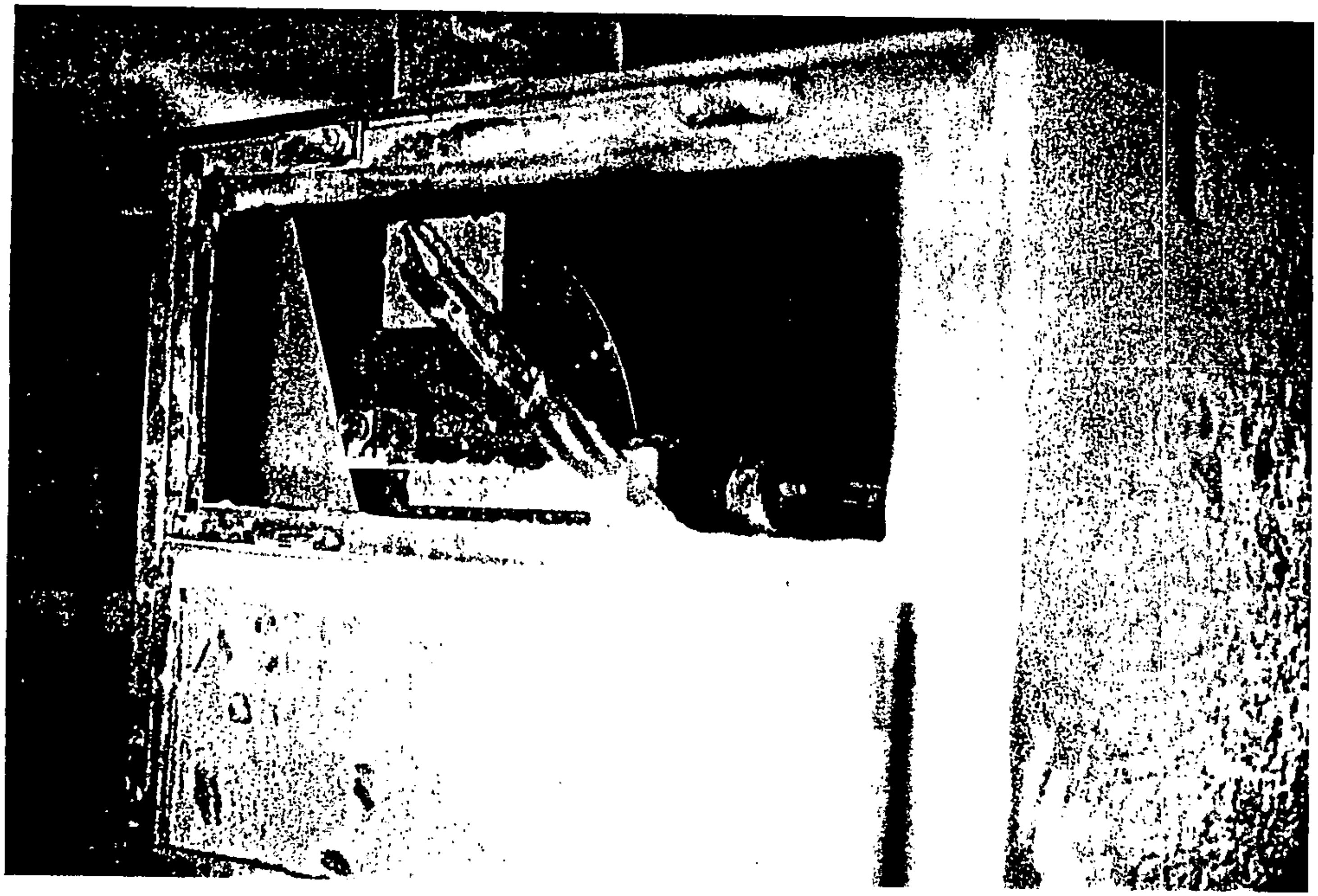


Figure 19. Photograph of dust weigher.

back into its original position and the partial revolution of the hopper caused the stop-pin of the next empty compartment to contact the latching mechanism, automatically positioning the empty compartment so that it was ready to receive more dust.

Each time a compartment rotated, one count was recorded by the mechanical counter. Therefore, in order to determine the weight of dust corresponding to one or more "counts" it was necessary to calibrate the weighers as described later in this section of the report. Basically, however, the calibration was carried out by collecting and weighing the dust discharged by the weigher each time the revolving hopper changed position (i.e., one count). This was then repeated several times and the average weight of dust discharged for each count was calculated and used as the calibration factor expressed in "pounds per count."

Each weigher was enclosed in a sheet metal housing that was open at the bottom. Access doors were provided for reading the counter and for changing the position of the adjustable counterweight. Another access door, below the revolving hopper, was provided so that a drawer could be inserted to collect dust discharged from the weigher. This was used to carry out the calibration procedure mentioned above.

Dust entered the weighers at the top, in most cases through a 6-8 in. diameter pipe. Inside the top of the weigher a tapered nozzle directed the dust into the compartment of the revolving weigh hopper. The nozzle was designed to direct the dust into the revolving hopper so that none could bypass the hopper. The nozzles were modified somewhat during the program to adjust the direction of the dust as it fell into the hopper compartment. This was necessary because, when dust fell directly into the center of the hopper the weight would build up until it tilted the weigh beam, releasing the hopper stop-pin, but the hopper would not rotate. Therefore, if the dust were made to fall more toward the outside of the hopper compartment, rather than in the center, the weight of dust did provide the impetus for causing the hopper to rotate.

WEIGHER OPERATION

Throughout the course of this study, the weigher's performance was satisfactory but there were a few problems. For the most part, these problems resulted from the fluctuations in dust flow from the filters. The quantity of dust discharged by the filters varies depending on how much dust is being generated by the source. As the dust rate increases, the amount of dust dropped from each vane of the rotary valve below the filters also increases. Accordingly, the amount of dust entering the weigh hopper increases. Therefore, the flow of dust was noncontinuous; and the dust fell in loose clumps that varied in amount depending on the emission source. The effect of this on the weighers was that the weight of dust discharged from the weigher for each count would vary. For this reason it was necessary to make dust weighings for several counts in order to obtain good average calibration factors (pounds per count).

Another effect of the variations in dust flow was the impact of the dust as it entered the weighers. As the dust flow rate increased, the impact as it fell into the weigh hopper was greater and tended to cause the weigh hopper to rotate prematurely. Also, this sometimes caused the hopper to rotate a second or third time before the stop-pin could properly contact the latching mechanism.

Although the pulsating dust flow and variability of dust flow rate did tend to affect the operation of the weighers, the problems were not serious because they were, for the most part, taken into account by the calibration procedures, as discussed in the next section.

## WEIGHER CALIBRATION AND ACCURACY

During the course of the study our goal was to calibrate all weighers at least once a month. We were not able to accomplish this on every weigher because of problems with the filters and because some operations were seldom in use during our trips to the elevator one day each week.

As mentioned earlier, the calibration procedure consisted of collecting the dust discharged by the weigher, which was then manually weighed with a portable scale. This weight was recorded, along with the number of counts registered while the dust was being collected. This was repeated several times and the total weight of dust collected, divided by the total number of counts, yielded the calibration factor expressed as "pounds per count." The amount of dust collected for each manual weighing ranged from 1-5 lb and the associated number of counts was on the order of 1-4 depending on the dust source and the setting on the adjustable counterweight. Weighings were repeated from 10-30 times for each calibration, based on the time available or the length of time the source was in operation.

During the course of the project it was sometimes necessary to change the setting on the adjustable counterweight or to modify the position of the dust inlet chute in order to improve the operation of the weigher or to prevent dust pluggage problems. Such changes necessitated recalibration of the weigher and changed the calibration factor. Results of the weigher calibrations are given in Appendix A. These results are important because they are the basis on which all the emissions and emission factors were calculated. Examination of the calibration factors given in Appendix A shows that there is more variability in the factors, at a given counterweight setting, than was expected. These variations are discussed below for each individual weigher.

Truck Unloading

The five calibration factors for truck unloading ranged from 0.566-1.028 lb/count. Ideally, one would anticipate that each factor would be the same and that any variations would be indicative of their accuracy. On this basis, the average factor would be 0.720 with a deviation of 0.320 (± 45%). However, the last four factors show that each factor is larger than the preceding one. The reason for this is not known but might have been due to buildup of dust on the weigher pivot points or a result of wear on some components of the weigher. We therefore tend to believe that any error in accuracy is not nearly as large as the computed average might indicate because emissions were always calculated on the basis of the most current calibration factor.

Car Unloading

Calibration factors for car unloading, at the counterweight setting of Mark 2, ranged from 1.51-1.65 if the first factor of 3.11 was neglected. We believe this is justified because buildup of dust in the weigher housing at that time almost certainly retarded proper operation of the weighing mechanism. The last two factors of 0.98 and 1.03 are in close agreement, and we, therefore, conclude that the factors for this weigher are accurate to within ± 10%.

Car Loading

Calibration factors for car loading ranged from 1.44-1.65, again eliminating the first factor of 2.32 because of dust build-up problems in the weigher housing. On this basis the average would be 1.51 ± 0.14 or ± 10%.

Corn Cleaner

Four calibration factors for the cleaner varied from 0.75-1.15 lb/ton, although the value of 1.15 may be high because of dust buildup in the weighers. Some error may be included in these factors because of the difficulty in preventing wind loss of some of the collected dust during calibration procedures and the limitation on the number of weighings that could be made because of the short periods of time that the cleaner was in operation. Even so, the data indicates a maximum error in accuracy on the order of 25%,which is considerably less than the variation in the calculated emission factors for this source.

Gallery Belt

Because the gallery belt was seldom in operation during our trips to the elevator, we were able to obtain only two calibration factors, both of which were identical: 0.562 lb/count.

Tunnel Belt

Eight calibration factors were obtained and ranged from 0.58-1.30 lb/ton. The average of these is 0.93 ± 0.37 indicating a rather poor accuracy of ± 40%. The reason for this is not known and would be of more concern were it not for the fact that the arrangement of the dust control system on this source caused much larger variations in the calculated emission factors.

Headhouse

Calibration factors for the headhouse weigher ranged from 0.79-1.69 (at Mark 3). However, the last three factors are lower than preceding ones as a result of a required change in the position of the deflector plate which controls the direction of the dust falling into the weigh hopper. Because of the comparatively large flow rate of dust handled by this weigher, the position of this deflector plate does affect the calibration factor. Comparison of the error in the first four factors (± 15%) with that of the last three factors (± 11%) leads us to believe that the results are accurate to within less than ± 15%.

# RESULTS

One of the primary purposes of this study was determination of long-term (weekly) emission factors for each of seven grain-handling operations within the terminal elevator. Another primary purpose was an assessment of the total potential emissions and the relative significance of each operation to this total. A secondary objective was evaluation of the effect of grain type on the emissions, as well as possible effect of moisture content, FM, etc., on the emissions. The presentation of results is organized as follows:

- Long-term emission factors
  - Analysis of experimental results
  - Comparison of results
  - Effect of grain types (statistical)
- Short-term emission factors
  - Average short-term emission factors
  - Effect of grain type
  - Effect of $H_2O$, FM, etc.
- Total emissions
  - Cumulative emission factors
  - Daily
  - Hourly

## LONG-TERM EMISSION FACTORS

Probably the most important results of this study were the long-term composite emission factors determined over the 6-month period of this project for each of the seven grain-handling operations. The best average value of the long-term composite emission factor for each of the seven sources is presented in Table 1. These are based on the actual weekly emission factors shown in Table 2. Analysis of these actual weekly emission factors to determine the best average values is presented in the next section of this report. The data used to calculate the actual weekly emission factors, including quantity of dust collected and the amount of each type of grain handled, are contained in Appendix B.

The data used in computing the emission factors were obtained during our trips to the elevator one time each week. On those weekly visits we recorded the "count" reading as shown on the mechanical counter attached to each weigher. This reading (counts) multiplied by the latest calibration factor (pounds per count) gave the weight of dust collected by each filter system during that week.

We then obtained the information from the elevator operating records that showed the amount of each type of grain handled by each of the respective grain-handling operations and its associated dust-filter system. Thus, the weight of dust (pounds) divided by the total weight of grain processed (tons) yielded the emission factor (pounds per ton). Most of the systems handled more than one type of grain during each week, so the factors are composite emission factors for all types of grains handled. As such, they may reflect the fact that one type of grain may emit more dust than another type. This matter is discussed more fully in a later section of this report.

Even though the factors shown in Table 1 are composite factors, they are based on long-term data that we believe are more accurate than any that have been obtained to date. Any inaccuracies are primarily on the low side. That is, we think that the calculated factors would tend to be lower than the actual emission factor (if it could be determined), for two reasons.

1. The calculated emission factors are based on the dust collected by the filter system, so they will not include dust that may have escaped capture by the aspiration systems or hoods.

2. Most malfunctions in the filters or the weighers (e.g., plugups, etc.) would decrease the quantity of dust weighed and, therefore, decrease the calculated emission factor. This is true for all systems, but a special case is the tunnel-belt system. The tunnel belt dust-collector

Table 1. BEST AVERAGE VALUE OF LONG-TERM COMPOSITE EMISSION FACTORS (LB/TON)

| Truck Unloading | Car Unloading | Car Loading | Corn Cleaner | Gallery Belt | Tunnel Belt | Headhouse |
|---|---|---|---|---|---|---|
| 0.64 | 1.30 | 0.27 | 5.78 | 0.11 | 1.40 | 1.49 |

Table 2. SUMMARY OF WEEKLY COMPOSITE EMISSION FACTORS $\left(\frac{\text{pounds of dust}}{\text{ton of grain}}\right)$

| Week of | Truck Unloading | Car[a/] Unloading | Car[a/] Loading | Corn Cleaner | Gallery[b/] Belt | Tunnel[c/] Belt | Headhouse |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 0.547 | 0.310 | 0.263 | Filter plugged | 0.034 | Not calculated | 0.804 |
| 7/16/73 | 0.678 | 0.440 | 0.174 | 12.95 | 0.032 | 2.80 | 1.349 |
| 7/23/73 | 0.656 | 0.437 | 0.230 | 4.10 | 0.035 | 2.80 | 1.425 |
| 7/30/73 | 0.602 | 0.363 | 0.136 | 7.42 | 0.126 | 3.75 | 1.188 |
| 8/6/73 | 0.554 | 0.284 | 0.185 | 5.68 | 0.059 | 1.89 | 1.000 |
| 8/13/73 | 0.556 | 1.63 | 0.173 | Filter plugged | 0.110 | 8.18 | 0.930 |
| 8/20/73 | 0.597 | 0.922 | 0.184 | Filter plugged | 0.152 | 1.09 | Dust collector not operating |
| 8/27/73 | 0.567 | Dust collector not operating | 0.213 | Filter plugged | 0.088 | 1.76 | Dust collector not operating |
| 9/4/73 | 0.826 | Dust collector not operating | 0.245 | Not used | 0.010 | 2.08 | Dust collector not operating |
| 9/10/73 | 0.642 | 1.89 | 0.320 | 2.76 | Not used | Not calculated | 1.653 |
| 9/17/73 | 0.471 | 1.44 | 0.379 | 6.96 | 0.052 | 4.26 | 3.029 |
| 9/24/73 | 0.835 | 1.94 | 0.368 | 8.82 | 0.100 | 11.49 | 1.903 |
| 10/1/73 | 0.541 | 1.01 | 0.282 | 4.47 | 0.084 | 3.80 | 1.464 |
| 10/7 and 10/15/73 | 0.249 | 0.983 | 0.272 | 5.07 | 0.030 | 8.04 | 1.678 |
| 10/22/73 | 0.607 | 0.925 | 0.201 | 4.41 | 0.048 | 8.37 | 1.469 |
| 10/29/73 | 0.883 | Dust collector not operating | 0.291 | 6.40 | 0.093 | 2.21 | 0.982 |
| 11/5/73 | 0.771 | d/ | 0.110 | 4.93 | 0.085 | h/ | 1.602 |
| 11/12/73 | 0.625 | d/ | 0.318 | 2.35 | 0.099 | 4.03 | 1.410 |
| 11/19/73 | 0.564 | 0.715 | 0.357 | f/ | 0.145 | 1.83 | 1.544 |
| 11/26/73 | 0.829 | e/ | 0.400 | 8.13 | 0.044 | 2.18 | 1.939 |
| 12/3/73 | 0.638 | 1.60 | 0.285 | 4.03 | 0.361 | 1.43 | 2.748 |
| 12/10/73 | 0.864 | 4.51 | 0.479 | -- | 0.164 | 4.96 | 3.777 |
| 12/17/73 to 12/21/73 | 0.395 | 3.80 | 0.723 | 1.79 | 0.337 | 15.1 | 3.514 |
| 12/21/73 to 12/28/73 | 1.26 | 2.76 | 0.158 | 5.11 | 0.239 | 1.81 | 5.067 |
| 12/28/73 to 1/7/74 | 0.252 | 2.44 | 0.100 | 8.68 | g/ | i/ | 3.169 |

a/ Loading and unloading of cars includes both hopper cars and boxcars.
b/ The gallery belt dust collector is connected to only one hood where grain is fed onto the belt.
c/ The emission factor values may be unusually high and show large variation because dust is continually collected from one leg, even though little or no grain may be moved through the tunnel belt.
d/ Dust collector out of service all or part of week; fan motor repairs.
e/ No emission factor calculated because counter-wire on weigher was broken.
f/ No emission factor calculated because unable to determine quantity of grain cleaned.
g/ Not calculated because of low air pressure in cleaning air tank.
h/ No emission factor could be calculated because filter was plugged.
i/ Emission factor not calculated because fan was out of service part of week.

system is connected to the grain drop hoods and to one of the legs. This leg is used to transfer grain (i.e., truck unloading), which occurs much more frequently than movement of grain on the tunnel belt. Therefore, the dust-collector system was often discharging dust even though no grain was being moved on the tunnel belt. As a result, the computed emission factor (pounds of dust per ton of grain) is not representative of the amount of dust generated per ton of grain moved by the tunnel belt. Analysis of the emission factors computed for this source as well as each of the other sources is discussed below.

## Analysis of Experimental Results

Truck Unloading - Weekly emission factors for truck unloading are shown in Table 2 (column 2). These factors vary from 0.249 lb/ton to 1.26 lb/ton and the average is 0.640 lb/ton.

The range of computed emission factors for truck unloading (0.249-1.26 lb/ton) shows more variation than might have been expected. The maximum error in the weigher calibration factor, ± 45% as previously discussed, could account for much of this variation, but the actual calibration error is not believed to be that large. Variation in the emission factors could also be due to the suspected variation in the emission factor for each type of grain; but statistical analysis of the data as discussed in another section of this report does not support that argument. Therefore, the range of the calculated emission factors must be due either to some unknown variability in the dust control system or weigher mechanism, or to natural variation in the amount of dust emitted in truck unloading of grain. The latter reason is more plausible.

Car Unloading - The emission factors for car unloading as shown in column 3 of Table 2 vary from 0.284 lb/ton up to 3.80 lb/ton and the average is 1.49 lb/ton. This range is quite large and certainly is not due to error in the calibration factor (± 10%), nor can it be attributed to different types of grain or variations that occur between unloading boxcars and hopper cars, as discussed in a later section of the report.

Examination of the emission factors for car unloading in Table 2 brings out two facts relative to the range of the data. First, the calculated emission factors were lowest in the first 5 weeks, and significantly higher after that period. Second, the factors for the last 4 weeks were higher than any previous factors. Such changes are not random, and must have been due to the weighers or the dust control system.

During the early weeks of the study there were some problems with the weigher installation and related pluggages of the dust system. During that period, the weigher location was changed because the angle of dust fall into the weigher was opposite to the weigher's direction of rotation. This tended to hinder rotation, sometimes resulting in plugging of the dust chute leading into the weigher. At the time, observation of weigher operation did not indicate that this was a serious problem, but the weigher location was changed during the week of 7/23, which is not coincidental with the increase in emission factors after the fifth week, but does create some doubt about the first 3 weeks of data.

Increase in the emission factors for the last 4 weeks is believed to have been due to the colder weather, which caused malfunction of the pulse valve-cleaning mechanism as discussed earlier. It was observed that during this period the cleaning-air tank-pressure was often down to zero, which would result in poor cleaning of the bags (as confirmed by an observed high-pressure drop across the bags). It is suspected that when this condition occurs, large amounts of dust fall off the bags after the system has been shut off. When the system is turned back on, this dust would be discharged rapidly through the rotary valve into the weigher. We did observe that when the dust system was turned on, large amounts of dust were suddenly discharged through the dust chute and weigher, causing rapid rotation of the weigher. This prevents proper "latching" of the weigher, thereby causing it to revolve more than it otherwise would and undoubtedly causing some error.

The periods of change in the emission factors (i.e., after the fifth week and the last 4 weeks) almost surely resulted from changes in the weigher and dust control system. The best interpretation of the data would be made if the first 5 weeks of data and the last 4 weeks were excluded. Remaining data would include that which ranged from 0.715-1.94 lb/ton, with an average of 1.30 lb/ton rather than the overall average of 1.49 lb/ton.

Car Loading - Weekly emission factors for car loading ranged from 0.100 lb/ton to 0.723 lb/ton with an average of 0.274 lb/ton (see Table 2, column 4). These emission factors also show a rather wide range, but unlike car unloading, these seem to be random variations. We have no evidence that there were any specific reasons for these variations, and, like truck-unloading emission factors, probably are due primarily to the natural variation in the amount of dust emitted in loading of grain.

We did attempt to obtain data for comparing emission during hopper-car loading with boxcar loading, but little data were obtained for boxcars because much of the loading is in hopper cars rather than boxcars.

Corn Cleaner - Emission factors for corn cleaning vary from 1.79-12.95 with an average of 5.78 lb/ton (Table 2, column 5). Again, the range of the emission factors is quite wide, but the random variation in these factors was not entirely unexpected, considering the type of operation involved. The air aspirated from the corn cleaner contains large amounts of chaff, hulls and beeswing as well as dust, and the amount of such material released during cleaning could vary considerably from one batch of corn to the next. The wide range of the data reflects this fact, and is not due to error or changes in the filter or weigher system.

Cleaning of corn is an intermittent operation because only a small portion of the corn is cleaned. Therefore, even though this source has the largest emission factor, it does not account for a large portion of the total emissions from the elevator. One must remember this fact if the emission data are to be applied to some other elevator or elevators in general, for the average emission factor can only be applied to that amount of corn that is cleaned using air aspiration, and not to all corn or to corn that is screened without air aspiration.

Gallery Belt - This dust system is composed of two hoods where grain is dropped onto the gallery belt from either of two spouts. It therefore represents a transfer point, and does not include any dust control on the tripper or bins, etc.

The data for this gallery transfer point show a wide range of 0.010-0.361, with an average of 0.110 lb/ton (Table 2, column 6). It is hard to imagine that the wide range in the data could be due to any natural variation in dust generated by this source, or to different types of grain. Examination of the data shows rather consistent values of about 0.03 lb/ton the first 3 weeks, and a series of high values in the last 4 weeks. Even if these data points were disregarded, the range is still quite wide (0.030-0.152). If this broadness of range were due to some change in the filter or weigher, our weekly examination of the system should have identified the cause.

The only other factor that may be related to this problem is the intermittent operation of the system. Most of the grain unloaded at the elevator is initially stored in the new house. Therefore, when this gallery belt in the old house is used, it may only be operated for a short time whenever one or two cars are unloaded and sent directly to the old house; or it may be operated for longer periods when grain is transferred from the new house to the old house. Therefore, there could be a wide range in the number of times the system was operated each week without necessarily being related to the quantity of grain entering the old house. However, we can see no reason why the number of times the system was operated would cause such wide variation in the amount of dust collected per ton of grain handled.

Even though the wide range in the data has no obvious explanation, we believe that the average value (0.110 lb/ton) is representative of emissions from this source and, as would be expected, this emission factor is smaller than that of any of the other operations measured, and is very small in comparison with some (e.g., unloading or headhouse).

Tunnel Belt - The tunnel-belt emission factors given in Table 2 are not representative of this source because the dust-collection systems also served one of the legs, which was in operation a much greater portion of the time than was the tunnel belt. Therefore, the data must be corrected in order to account for this fact. Since the amount of grain carried by the tunnel belt varied from week to week, we assumed that as the amount of grain increases, the closer we would approach the actual emission factor for this source alone, because the influence of dust collected from the leg should decrease. On this premise, a plot was made of the calculated emission factors versus the quantity of grain moved by the tunnel belt (Figure 20). This graph does verify that the emission factor decreased as quantity of grain increased, and that the emission factor approaches a value of about 1.4 lb/ton. Based on the data obtained in this study, the emission factor of 1.4 lb/ton is the best value that could be applied to the tunnel belt emissions.

Headhouse - Calculated emission factors for the headhouse dust control system varied from 0.804 lb/ton to 5.067 lb/ton (Table 2, column 8). This range in data is not as wide as the ranges for some of the other sources, and the variations appear to be random except for the fact that higher values occurred primarily in the last 4-5 weeks of the program. It might be suspected that the colder weather during the last weeks of the program may have again affected the filter system, and caused the dust-weigher readings to be inaccurate. However, this filter system seemed to be much less subject to problems that occurred with the other filter systems in cold weather; this is probably not a valid explanation for the higher emission factors in the last weeks of the program. On the other hand, it is possible that because the cold weather was hampering proper operation of several of the other filter systems, the dust load for the headhouse system may have increased as a consequence. In either case, we believe that the best average emission factor for the headhouse would be based on data that ignore the last 5 weeks of data. This procedure gives a more conservative value for the average headhouse emission factor of 1.49 lb/ton.

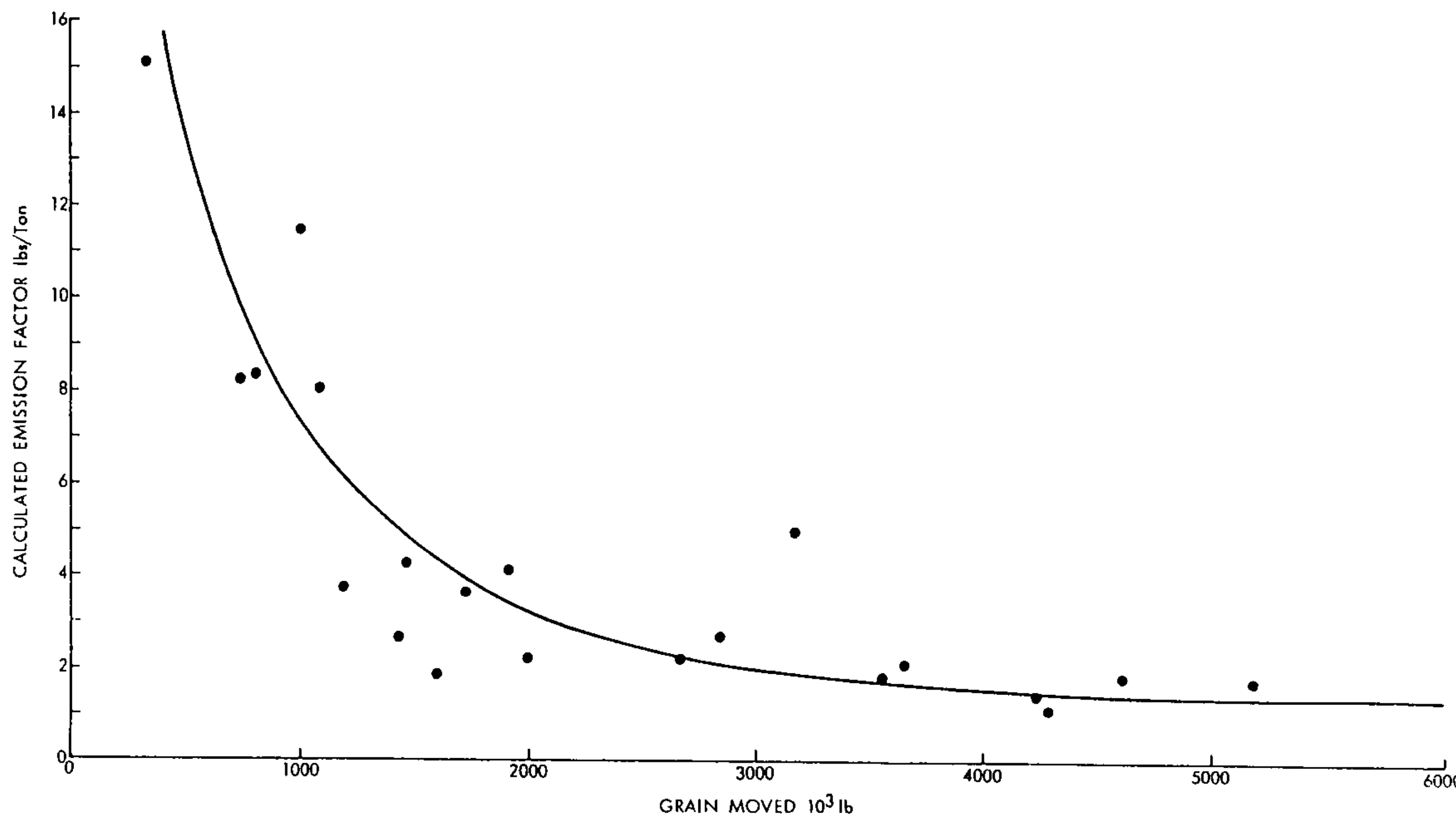



Figure 20. Tunnel belt emission factors versus quantity of grain moved.

## Comparison of Experimental Results with Other Published Information

Best values of the long-term composite emission factors experimentally determined in this study were as follows:

| Operation | Emission Factor (lb/ton) |
|---|---|
| Truck unloading | 0.64 |
| Car unloading | 1.30 |
| Car loading | 0.27 |
| Corn cleaner | 5.78 |
| Gallery belt (transfer) | 0.11 |
| Tunnel belt | 1.40 |
| Headhouse | 1.49 |

The emission factors experimentally determined by MRI can be compared with those of other published sources (Table 3), bearing in mind that they are not strictly identical situations, as shown by appropriate footnotes.

Examination of the data in Table 3 shows that the experimentally determined emission factors agree fairly well with published data for some dust sources (e.g., car unloading, cleaning, tunnel belt). However, the MRI factors are lower in some cases (truck unloading and car loading), and higher in other cases (e.g., headhouse).

This comparison indicates that the MRI data are certainly not grossly different than other emission factor information. However, none of the other published information was obtained by direct experimental methods, as were the data obtained in this study.

## Effect of Grain Type and Grain Quality on Emission Factors

It is commonly believed in the grain industry that different types of grain emit different amounts of dusts. This idea is primarily based on visual observation of emissions, which can be misleading, but it certainly seems reasonable to those that have experience in grain elevator operations.

MRI obtained data in this study in an attempt to determine if this belief is true. The effect on dust emissions of different types of grains was investigated using both the long-term and the short-term emission factor data. The short-term emission factors are discussed in another section of this report, so this discussion will be confined to the long-term factors.

Table 3. COMPARISON OF EMISSION FACTOR DATA

| Operation | MRI Data | Published Data Ref. 1 | Ref. 2 | Ref. 3 |
|---|---|---|---|---|
| Truck unloading | 0.64 | 2.0 | 1 | 0.8 |
| Car unloading | 1.30 | 1.0 | 1 | 0.7 |
| Car loading | 0.27 | 1.0 | 1 | 1.1 |
| Cleaning | 5.78 (corn only) | 5.0 | 5 | 6.0 |
| Transfer point (gallery belt) | 0.11 | -- | -- | -- |
| Tunnel belt | 1.40 | 1.5[a/] | 2[b/] | 1.0[c/] |
| Headhouse | 1.49 | 0.5 | -- | -- |

Ref. 1 - Thimsen, D. J. and P. W. Aften, "A Proposed Design for Grain Elevator Dust Collection", Journal of the Air Pollution Control Assn., November 1968.

Ref. 2 - Compilation of Air Pollutant Emission Factors, USEPA, April 1973. Values specified in this EPA document for terminal elevators are at least partially based on those of Thimsen (Ref. 1 above).

Ref 3. - Private Communication, Results reported for Cargill Chicago elevator based on calculated material balances ("shrink") over a period of 18 years.

a/ Value of 1.5 was for transferring or turning bins for cooling and may therefore include sources other than just the tunnel belt.

b/ Value of 2 lb/ton is for transferring, conveying, etc.

c/ Identified in Ref. 3 as "transferring".

Determination of the long-term emission factors was based on weekly amounts of dust collected from each of seven operations within the elevator, and on the quantity of each type of grain handled (Appendix B). Because different amounts of each type of grain were handled by each operation every week, it was presumed that the quantity of dust collected would have been a result of the amount of each type of grain handled and the emission factor for each type of grain. We knew the total quantity of dust collected, and the amount of each type of grain handled each week, but not the amount of dust collected for each type of grain. However, because the amount of each type of grain handled by each operation did vary from week to week, it appeared that a statistical analysis of the weekly data could be used to determine an emission factor for each type of grain for each of the seven grain-handling operations (except the corn cleaner and tunnel belt). Using the data for the remaining five operations, a statistical evaluation, using regression analyses to determine the best-fit emission factor for each type of grain was conducted to predict the total amount of dust generated. That is, an equation was setup for each operation as follows:

$$\text{Total Dust (lbs)} = a \times (\text{tons wheat}) + b \times (\text{tons corn}) + c \times (\text{tons SB}) + d \times (\text{tons milo})$$

where $a$ = emission factor for wheat, lb/ton,

$b$ = emission factor for corn, lb/ton,

$c$ = emission factor for SB, lb/ton, and

$d$ = emission factor for milo, lb/ton.

The total dust collected each week, as well as the amount of each type of grain handled, was known for each operation. All sets of weekly data were entered into a computerized regression analysis to determine the values of a, b, c and d that gave the best fit (least squares) for the known total amount of dust collectdd.

A second regression analysis was also performed to determine how well the total quantity of dust generated can be predicted, based only on the total amount of grain handled. In this case, the equation becomes:

Total Dust (lb) = e x (tons wheat + tons corn + tons SB + tons milo)

where e = composite emission factor, lb/ton.

Results of the two regression analyses were compared to determine the improvement in accuracy for predicting dust emissions when the amount of each type of grain is considered rather than just the total amount of all grain. Of course, there is always some improvement when considering the types of grain because the regression analysis has more degrees of freedom. However, the extent of the improvement would indicate just how dependent the emissions are on grain type.

Results of the two regression analyses are presented in Table 4. The multiple correlations for each operation show that there is not much improvement in determining total dust emissions on the basis of grain type. That is, dust generation can be predicted on the basis of total amount of grain about as well as on the bases of amount and type of each grain. Also, Table 4 shows that the best-fit emission factors for each grain type are very inconsistent (e.g., in some cases wheat has the largest emission factor while in another case it has the smallest emission factor), and the standard error of regression in some cases is as large as (or larger than) the emission factor.

Although these results would seem to indicate that grain type has little effect on dust emissions, this is not necessarily true. Actually, it may only reflect the fact that the emission factors for each type of grain vary over a wide range; i.e., when one considers the large amounts of grain handled over a weekly period, the effect of grain type is masked out and is not an important factor. Our investigation of short-term emission factors verified the wide range in emission factors for each grain type but on the average, did show a dependence on grain types as discussed in a later section of this report.

Regression analyses of the long-term emission data do support use of the average emission factors given in Table 1 to calculate dust generated by an elevator over the long term. However, these composite factors are for an elevator handling four types of grain; their accuracy would probably not be as good if they were applied to an elevator handling only one or two types of grain.

Grain quality, meaning moisture content, FM, etc., is also thought to affect the emission for each type of grain, although the type of grain itself is commonly believed to be the most important factor that influences dust emissions. We were not able to use the long-term emission factor

Table 4. REGRESSION ANALYSIS

| | Multiple Correlation (%) | Grain | Emission Factors | Standard Error of Regression |
|---|---|---|---|---|
| Truck unloading | 86.7 | Wheat | -0.42 | 0.55 |
| | | Corn | 0.93 | 0.14 |
| | | SB | 0.80 | 0.34 |
| | | Milo | -0.01 | 0.56 |
| | 81.4 | All | 0.58 (0.64)[a/] | 0.04 |
| Car unloading | 93.3 | Wheat | 2.19 | 0.40 |
| | | Corn | 0.33 | 0.43 |
| | | SB | 1.82 | 0.43 |
| | | Milo | 0.87 | 0.12 |
| | 78 | All | 1.04 (1.30)[a/] | 0.10 |
| Car loading | 80 | Wheat | 0.13 | 0.04 |
| | | Corn | 0.29 | 0.04 |
| | | SB | 0.62 | 0.21 |
| | | Milo | 0.31 | 0.05 |
| | 65 | All | 0.27 (0.27)[a/] | 0.02 |
| Gallery belt | 61 | Wheat | 0.04 | 0.04 |
| | | Corn | 0.12 | 0.02 |
| | | SB | 0.04 | 0.03 |
| | | Milo | 0.05 | 0.02 |
| | 51 | All | 0.07 (0.11)[a/] | 0.01 |
| Headhouse | 80 | Wheat | 1.24 | 0.68 |
| | | Corn | 1.10 | 0.66 |
| | | SB | 0.72 | 0.81 |
| | | Milo | 2.42 | 0.64 |
| | 74 | All | 1.48 (1.49)[a/] | 0.10 |

a/ Numbers in parentheses are the arithmetic average emission factors shown in Table 1.

data to analyze the effect of grain quality on emissions because we did not know the amount of dust attributable to each type of grain. Even if we had known the amount of dust generated by each type of grain over each weekly period, the weekly information on each grain type was too voluminous, and covered such a wide range of the various grain quality factors, that it is doubtful that any type of analysis of the data could have been used to determine the effect of these factors on dust emissions. However, the short-term emission factors were used to attempt an analyses of the effect of grain quality on emissions.

## SHORT-TERM EMISSION FACTORS

A second objective of this study was to obtain short-term emission factors to supplement the long-term factors previously discussed. These short-term factors were also determined by means of the mechanical weighers, but they were based on the amount of dust collected during the period when one truck was unloaded or one car was loaded/unloaded (i.e., short term). Thus, on the basis of knowledge of the weight of dust collected and the quantity of grain loaded or unloaded, a short-term emission factor could be calculated. This had the advantage of providing an emission factor for a particular operation, with knowledge of the type of grain and its quality. However, it was feasible to obtain this data only for three operations: truck unloading, car unloading and car loading.

During our weekly visits to the elevator, we conducted short-term tests when possible, so that we could obtain data for each of the three above operations for all four types of grain. The results of these tests are presented in Tables 5, 6, and 7. Some discussion of these results, i.e., overall average of short-term factors and emissions by grain type, is presented below.

### Average Short-Term Emission Factors

Overall average short-term emission factors for truck unloading, car unloading and car loading were computed, irrespective of grain type, as included in Tables 5, 6, and 7. A comparison of these average short-term factors with the average long-term factors given in Table 1 is presented below.

| | Average Short-Term Emission Factor (lb/ton) | Average Long-Term Emission Factor (lb/ton) |
|---|---|---|
| Truck Unloading | 0.83 | 0.64 |
| Car Unloading | 0.76 | 1.30 |
| Car Loading | 0.30 | 0.27 |

Table 5. TRUCK UNLOADING, EMISSION FACTORS BY GRAIN TYPE (LB/TON)

| | Wheat | Corn | SB | Milo |
|---|---|---|---|---|
| | 0.081 | 0.128 | 1.15 | 0.280 |
| | 0.217 | 0.130 | 1.63 | 1.090 |
| | 1.06 | 0.234 | 1.85 | 0.610 |
| | 0.73 | 0.115 | 2.20 | 1.23 |
| | | 0.670 | 0.87 | 0.88 |
| | | 0.70 | 2.06 | 0.96 |
| | | 0.49 | | 1.60 |
| | | 0.67 | | |
| | | 0.42 | | |
| | | 0.71 | | |
| | | 0.56 | | |
| | | 0.80 | | |
| Avg. | 0.52 | 0.47 | 1.63 | 0.95 |
| Range | 0.081-1.06 | 0.115-0.80 | 0.87-2.20 | 0.28-1.60 |

Average of all data = 0.83

Table 6. CAR UNLOADING, EMISSION FACTORS BY GRAIN TYPES (LB/TON)

| Wheat | | Corn | | SB | | Milo | |
|---|---|---|---|---|---|---|---|
| Hopper | Box | Hopper | Box | Hopper | Box | Hopper | Box |
| 0.11 | 0.50 | 0.77 | 0.84 | | 1.51 | 0.12 | 1.42 |
| | | 0.88 | 0.38 | | | 0.41 | 2.08 |
| | | | 0.65 | | | 0.59 | 0.26 |
| | | | | | | | 0.98 |
| | | | | | | | 0.64 |
| 0.11 | 0.50 | 0.83 | 0.62 | - | 1.51 | 0.37 | 1.08 |
| Avg. 0.31 | | 0.70 | | 1.51 | | 0.81 | |

Average of all data = 0.76

Table 7. CAR LOADING, EMISSION FACTORS BY GRAIN TYPE (LB/TON)

| Wheat | Corn | SB | Milo | |
|---|---|---|---|---|
| 0.12 | 0.34 | 0.33 | 0.26 | 0.38 |
| 0.15 | 0.20 | 0.21 | 0.14 | 0.34 |
| 0.54 | 0.18 | 0.41 | 0.24 | 0.36 |
| 0.25 | 0.31 | 0.95 | 0.24 | 0.39 |
| 0.15 | 0.31 | 0.56 | 0.26 | 0.37 |
| 0.07 | 0.27 | 0.44 | 0.32 | 0.39 |
| 0.07 | 0.36 | 0.48 | 0.41 | 0.22 |
| 0.07 | | 0.59 | 0.34 | 0.42 |
| 0.12 | | 0.31 | 0.35 | 0.39 |
| | | 0.12 | 0.35 | 0.51 |
| | | | 0.30 | 0.27 |
| | | | 0.09 | 0.21 |
| | | | 0.02 | 0.32 |
| | | | 0.19 | 0.34 |
| | | | 0.11 | 0.34 |
| | | | 0.08 | 0.31 |
| | | | | 0.28 |
| Avg. 0.17 | 0.28 | 0.44 | 0.29 | |
| Range 0.07-0.54 | 0.18-0.36 | 0.12-0.95 | 0.02-0.51 | |

Average of all data = 0.30

It could be assumed that both factors should be in agreement or that the average short-term factors might be better estimates because we could be certain that no filter pluggage problems, etc., had occurred, as may have been the case for some of the long-term (weekly) data. However, the amount of short-term data is not sufficient to consider the average short-term emission factors as more valid than the long-term factors. Also, because the short-term data do indicate a dependence of emissions of grain type as discussed below, the overall average short-term emission factors probably would not coincide with the average long-term factor for each operation unless they were both based on the same proportions of each type of grain.

Effect of Grain Type

Truck Unloading - The emission factor for each grain type, as presented in Table 5, again indicates that the ranges for each grain type are rather wide. However, the average values do confirm the belief that different types of grain emit different amounts of dust, with soybeans and milo being considerably more "dusty" than corn and wheat. A rank ordering of these grains based on the average of the short-term emission factors is as follows:

| | |
|---|---|
| Soybeans | 1.63 lb/ton |
| Milo | 0.95 lb/ton |
| Wheat | 0.52 lb/ton |
| Corn | 0.47 lb/ton |

Car Unloading - An attempt was made to obtain short-term emission factors for each type of grain as it was unloaded from boxcars and hopper cars, because it was expected that boxcar unloading would generate more dust than hopper car unloading. We were unable to obtain sufficient data for this operation to support definite conclusions, but more data were obtained for milo (Table 6) than for the other grains and indicate that the average emission factor for boxcar unloading of milo is about three times greater than hopper car unloading of this grain. However, the small amount of data cannot be considered conclusive.

Examination of the data in Table 6 relative to boxcar unloading again confirms the dependence of emissions on grain type:

| | |
|---|---|
| Soybeans | 1.51 lb/ton |
| Milo | 1.08 lb/ton |
| Corn | 0.62 lb/ton |
| Wheat | 0.50 lb/ton |

This listing is in good agreement with the values obtained for truck unloading.

Car Loading - We were able to obtain considerably more data for the car-loading operation, which consists primarily of hopper car loading (Table 7). Rank ordering of the grain types, based on the short-term emission factors, again indicates that soybeans produce the most dust, followed by milo and corn, which are quite close; wheat produces the least dust.

| | |
|---|---|
| Soybeans | 0.44 lb/ton |
| Milo | 0.29 lb/ton |
| Corn | 0.28 lb/ton |
| Wheat | 0.17 lb/ton |

Although the grains are in the same order as for car unloading, the magnitude of the emission factors for car loading is considerably lower, which shows that the amount of dust collected during car loading is lower than that collected during truck or boxcar unloading, as might be expected.

## Effect of Grain Quality

Short-term emission factor data were also used in an attempt to determine the effect of grain quality on the emission factors for each type of grain. The short-term data for truck unloading, car unloading, and car loading were used for this purpose, but we were not able to obtain information on grain quality for all of the short-term emission factors. In addition, the only information that was available on grain quality was moisture content and FM (foreign material). Available information on grain quality associated with the short-term emission factors is presented in Tables 8, 9, and 10. For those operations and grain types where sufficient information was available, a plot of the emission factors versus moisture content and FM was made in an attempt to discern any relationship between grain quality (moisture or FM) and the short-term emission factors.

Table 8. TRUCK UNLOADING, SHORT-TERM EMISSION FACTORS AND GRAIN QUALITY

| Wheat | | | Corn | | | SB | | | Milo | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM |
| 0.81 | 15.5 | 4 | 0.128 | 13.5 | 3.0 | 1.15 | 12.6 | 1-2 | 0.280 | 13.6 | 7 |
| 0.217 | 12.0 | ? | 0.130 | 15.0 | 2.4 | 1.63 | 13.5 | 1 | 1.09 | 15.0 | 6 |
| 1.06 | 13.5 | ? | 0.234 | 13.0 | 4.0 | 1.85 | 12.8 | 1 | 0.61 | 14.5 | 5 |
| 0.73 | 12.8 | ? | 0.115 | 14.0 | 3.0 | 2.20 | 12.8 | 1 | 1.23 | 15.0 | 7 |
| | | | 0.67 | 16.0 | 3.0 | 0.87 | 17.3 | 2 | 0.88 | 15.0 | 7 |
| | | | 0.70 | 16.5 | 2.0 | 2.06 | 15.1 | 8 | 0.96 | 14.7 | 7 |
| | | | 0.49 | 15.8 | 2.4 | | | | 1.60 | 13.5 | 7 |
| | | | 0.66 | 16.5 | 3.0 | | | | | | |
| | | | 0.42 | 14.1 | 2.5 | | | | | | |
| | | | 0.71 | 15.5 | 3.0 | | | | | | |
| | | | 0.56 | 16.5 | 2.5 | | | | | | |
| | | | 0.80 | 17.5 | 3.0 | | | | | | |

a/ Emission factor in pounds per ton.

Table 9. CAR UNLOADING, SHORT-TERM EMISSION FACTORS AND GRAIN QUALITY

| Wheat | | | Corn | | | SB | | | Milo | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM |
| 0.11 | 12.8 | 2 | 0.77 | 20 | 3 | 1.51 | 12.7 | 1 | 0.12 | 13 | 7 |
| 0.50 | 13.0 | ? | 0.88 | 18.7 | 2 | | | | 0.41 | 15.5 | 7 |
| | | | 0.84 | 18.7 | 1.7 | | | | 0.26 | 16.0 | 7 |
| | | | 0.38 | 18.0 | 1.7 | | | | 0.98 | 15.8 | 4.2 |
| | | | 0.65 | 19.2 | 1.7 | | | | 0.64 | 15.5 | 7.8 |
| | | | | | | | | | 0.59 | 11.5 | 6.8 |

a/ Emission factor in pounds per ton.

Table 10. CAR LOADING, SHORT-TERM EMISSION FACTORS AND GRAIN QUALITY

| Wheat | | | Corn | | | SB | | | Milo | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM | EF[a] | $H_2O$ | FM |
| 0.15 | 13.4 | 0.5 | 0.31 | 14 | 2.3 | 0.21 | 12.8 | 1.7 | 0.26 | 13.0 | 6.5 |
| 0.54 | 12.0 | 0.4 | 0.27 | 13.7 | 2.4 | | | | 0.32 | 14.0 | 5 |
| 0.25 | 13.0 | 0.36 | 0.36 | 13.0 | 5.0 | | | | 0.41 | 14.0 | 5.8 |
| | | | | | | | | | 0.34 | 14.0 | 6 |
| | | | | | | | | | 0.35 | 13.8 | 5 |
| | | | | | | | | | 0.35 | 13.7 | 7 |
| | | | | | | | | | 0.30 | 13.0 | 8 |
| | | | | | | | | | 0.38 | 13.8 | 6.0 |
| | | | | | | | | | 0.34 | 13.9 | 5.5 |
| | | | | | | | | | 0.36 | 14.3 | 6.5 |
| | | | | | | | | | 0.39 | 14.0 | 6.0 |
| | | | | | | | | | 0.37 | 14.8 | 6.0 |
| | | | | | | | | | 0.39 | 13.0 | 6.0 |
| | | | | | | | | | 0.22 | 13.4 | 8.0 |
| | | | | | | | | | 0.42 | 13.3 | 7.7 |
| | | | | | | | | | 0.39 | 13.5 | 7.3 |
| | | | | | | | | | 0.51 | 13.7 | 7.8 |
| | | | | | | | | | 0.27 | 13.9 | 7.4 |
| | | | | | | | | | 0.21 | 13.7 | 5.8 |
| | | | | | | | | | 0.32 | 13.5 | 5.0 |
| | | | | | | | | | 0.34 | 13.5 | 5.0 |
| | | | | | | | | | 0.34 | 14.0 | 5.7 |
| | | | | | | | | | 0.31 | 14.0 | 6.5 |
| | | | | | | | | | 0.28 | 14.0 | 6.0 |

a/ Emission factor in pounds per ton.

Figures 21, 22, and 23 for truck unloading of corn, SB and milo do not indicate any relationship between the emission factor and FM. However, Figure 21 for corn does indicate that higher emission factors were associated with higher moisture content. There appears to be a similar but less pronounced relationship for SB and milo (Figures 22 and 23) although the number of data points is not at all conclusive. It is somewhat surprising that the emission factor for corn would increase with higher moisture content, and this increase should not be considered reliable without other supporting data.

Data for car unloading of corn and milo are shown in Figures 24 and 25, but the spread in the few data points available are inconclusive.

Car loading of milo is shown in Figure 26. Although there were several data points, they are grouped too closely together to show any effect of moisture on the emission factor. However, the data indicate wide variation in FM without effect on emission factors.

The only conclusions that can be made regarding the observed effect of moisture and FM on short-term emission factors are: (1) Increasing moisture content (of corn) may be associated with higher emission factors; and (2) The data do not indicate any dependency of the emission factors on FM.

## TOTAL EMISSIONS

The dust weighers were used to obtain long-term and short-term emission factor data, and to provide data on total potential dust emissions from the elevator on weekly, daily, and hourly bases. Such information is of interest in order to ascertain the actual quantity of dust (i.e., pounds) that may be emitted over these periods of time.

### Cumulative Emission Factors

Total dust collected during each weekly period throughout this study was obtained by compiling the information for each of the seven grain-handling operations (see Appendix B). This compilation is presented in Table 11 and also shows the amount of grain unloaded and loaded each week. The last column in Table 11 shows the emission factor calculated for the total pounds of dust collected per ton of throughput where:

$$\text{Throughput} = \frac{\text{Amount Loaded} + \text{Amount Unloaded}}{2} \; .$$

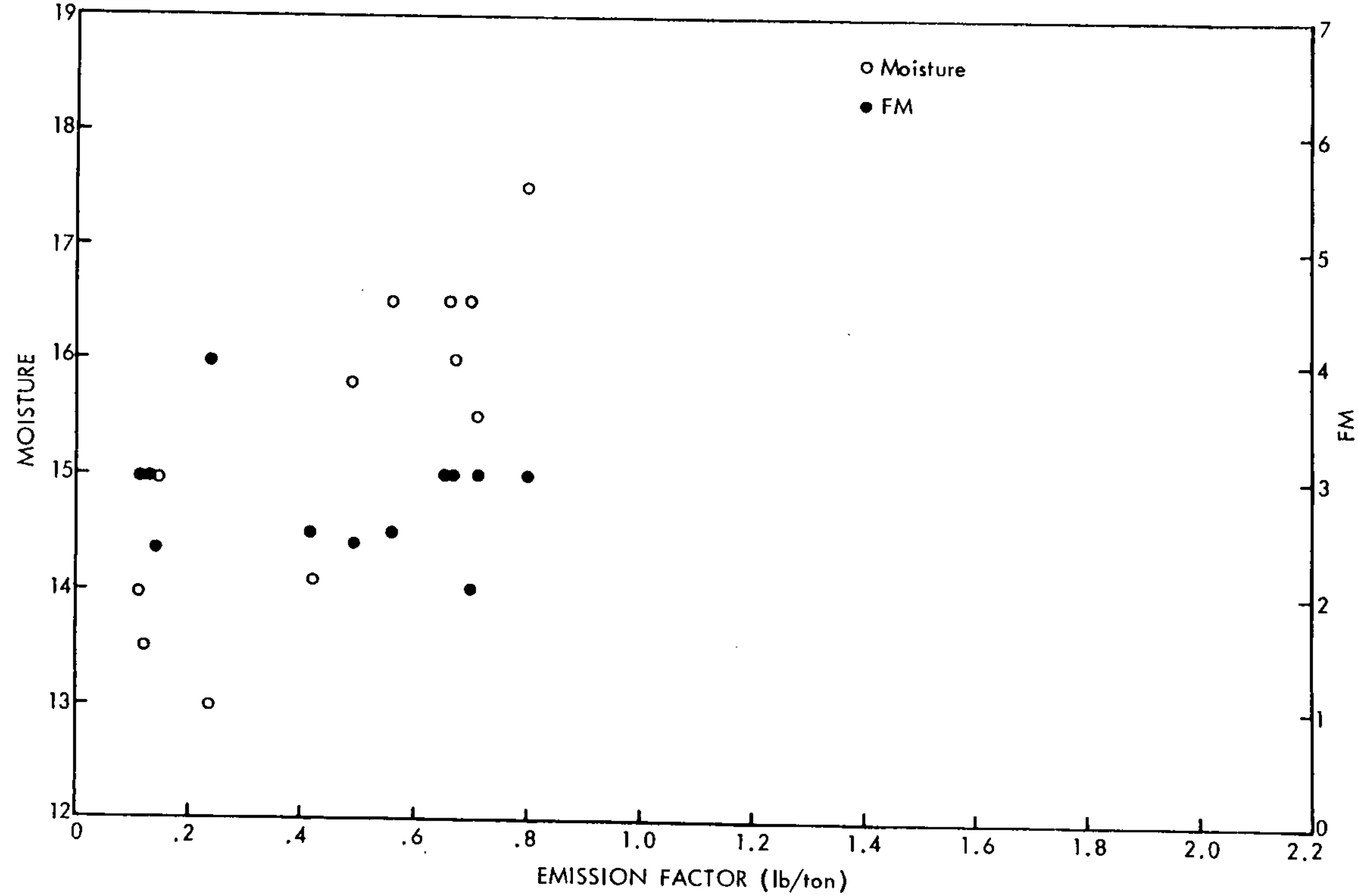



Figure 21. Short-term emission factors versus grain quality, truck unloading of corn.

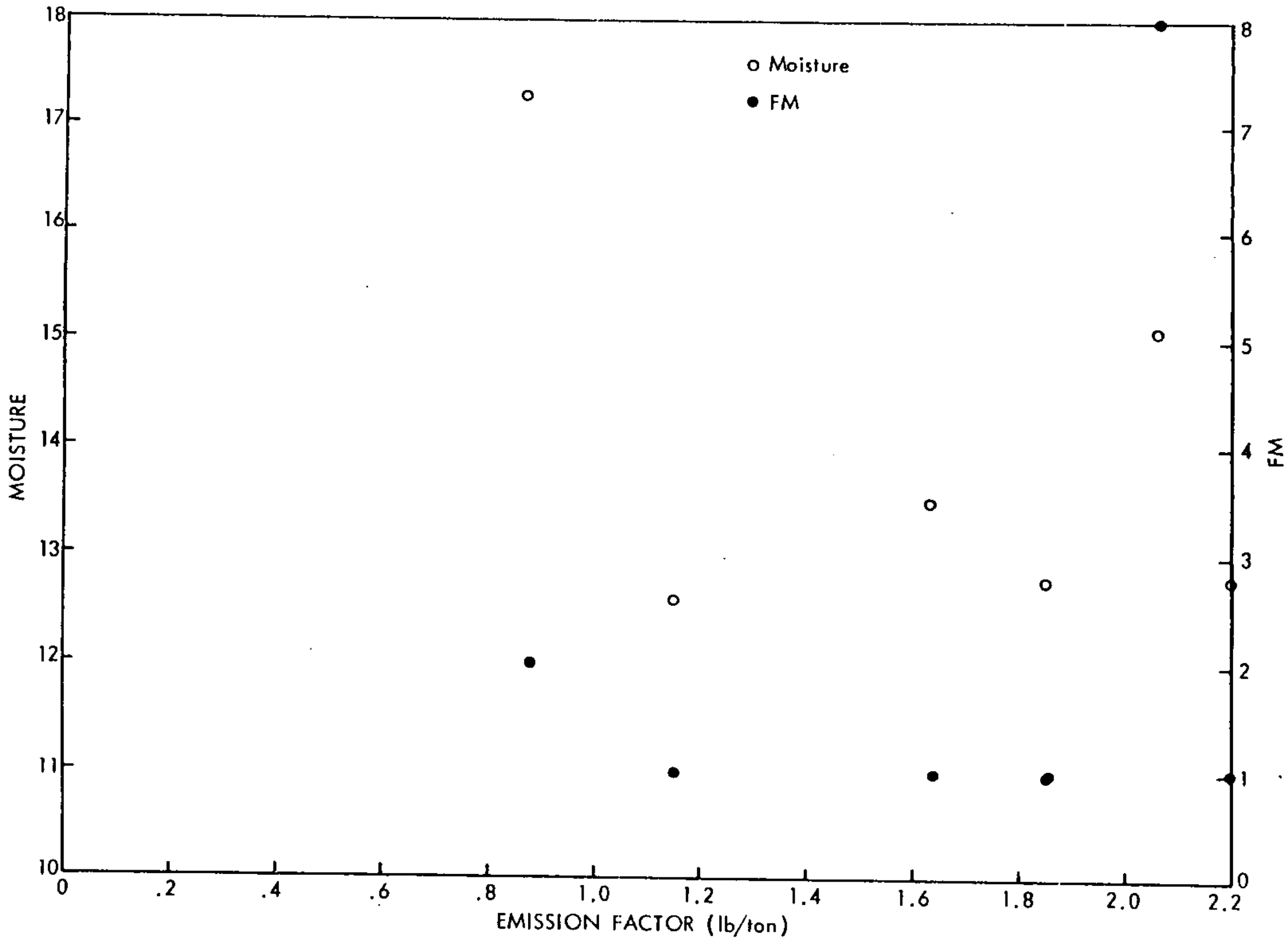



Figure 22. Short-term emission factors versus grain quality, truck unloading of soybeans.

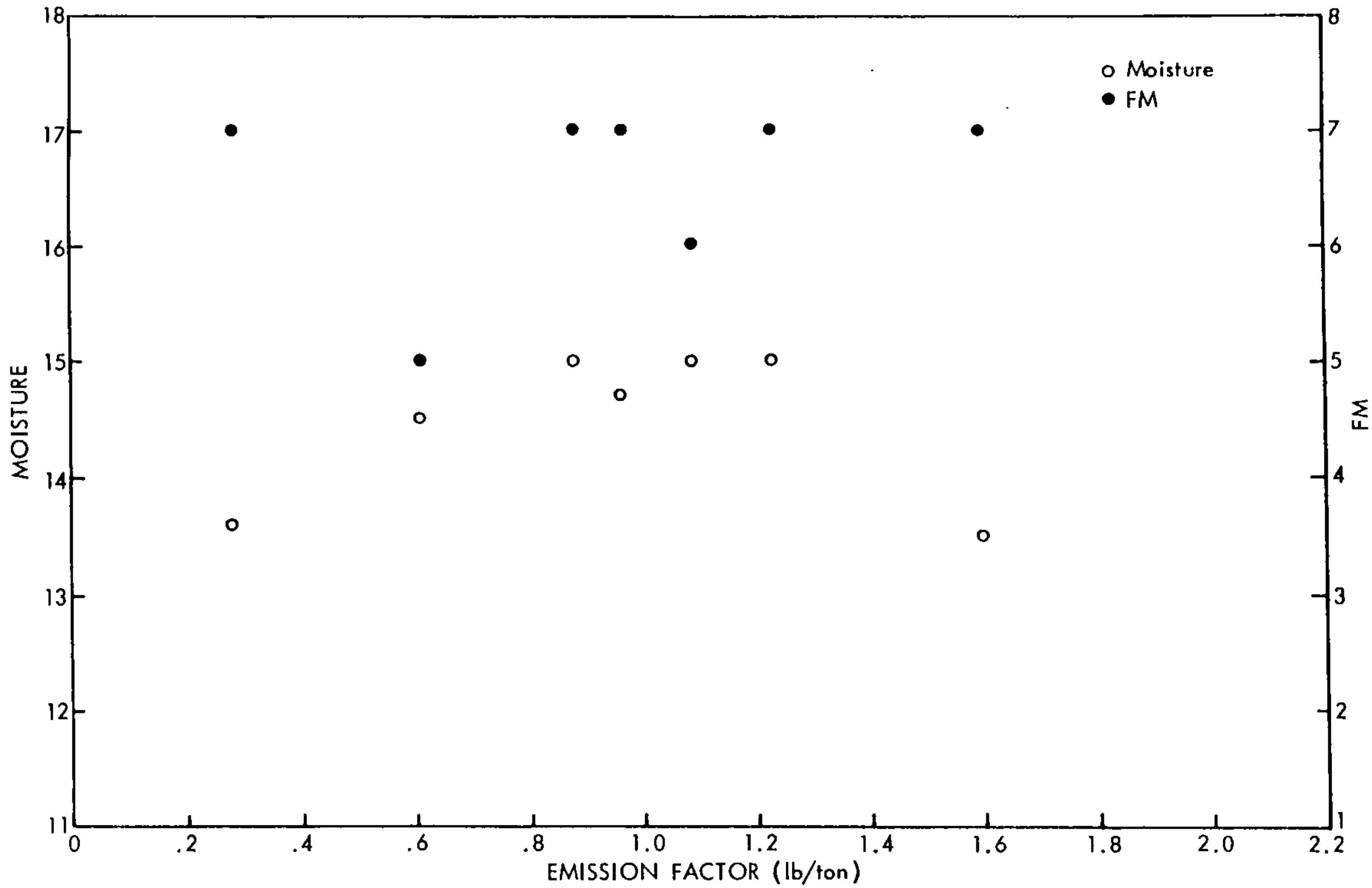



Figure 23. Short-term emission factors versus grain quality, truck unloading of milo.

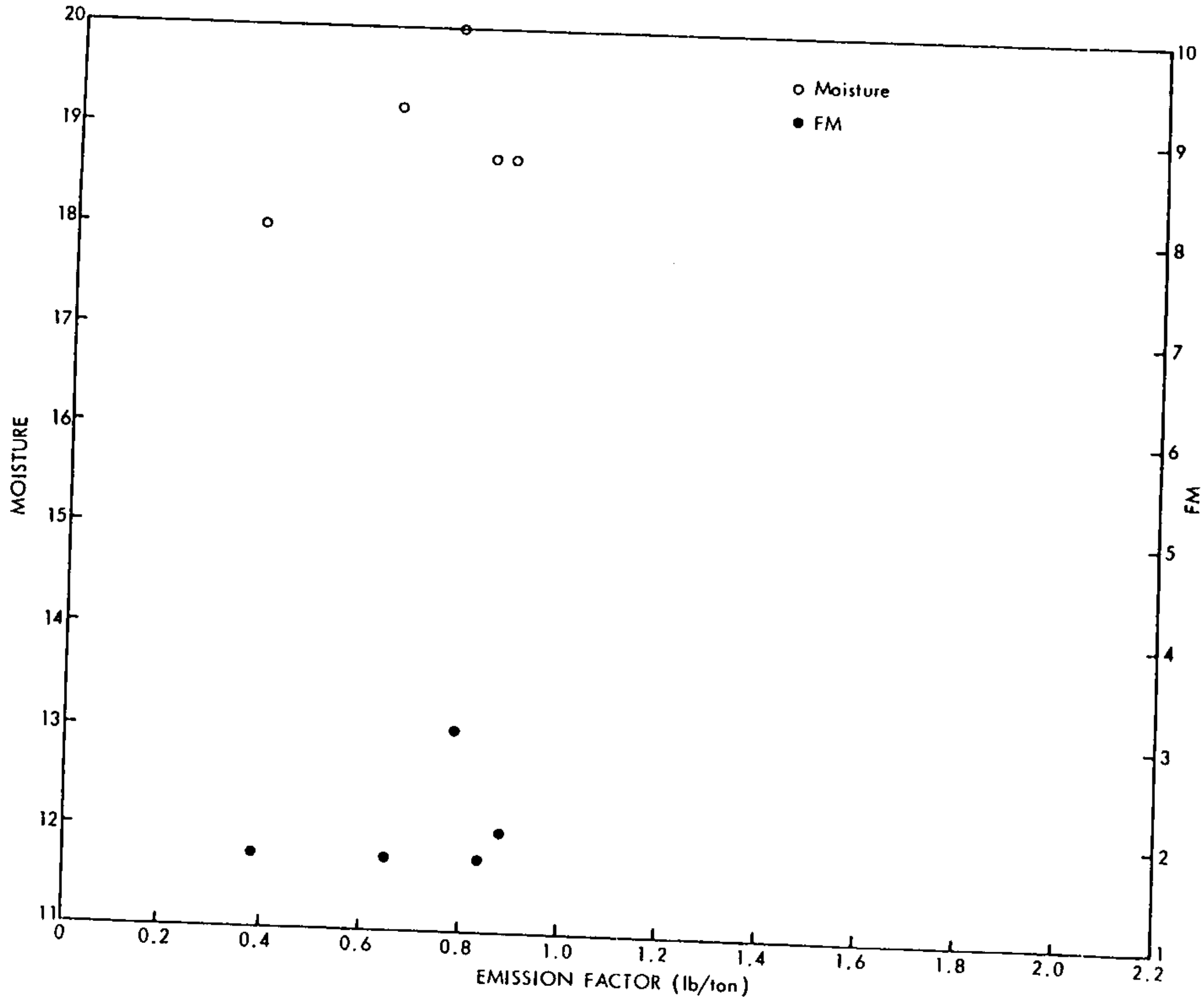



Figure 24. Short-term emission factors versus grain quality, car unloading of corn.

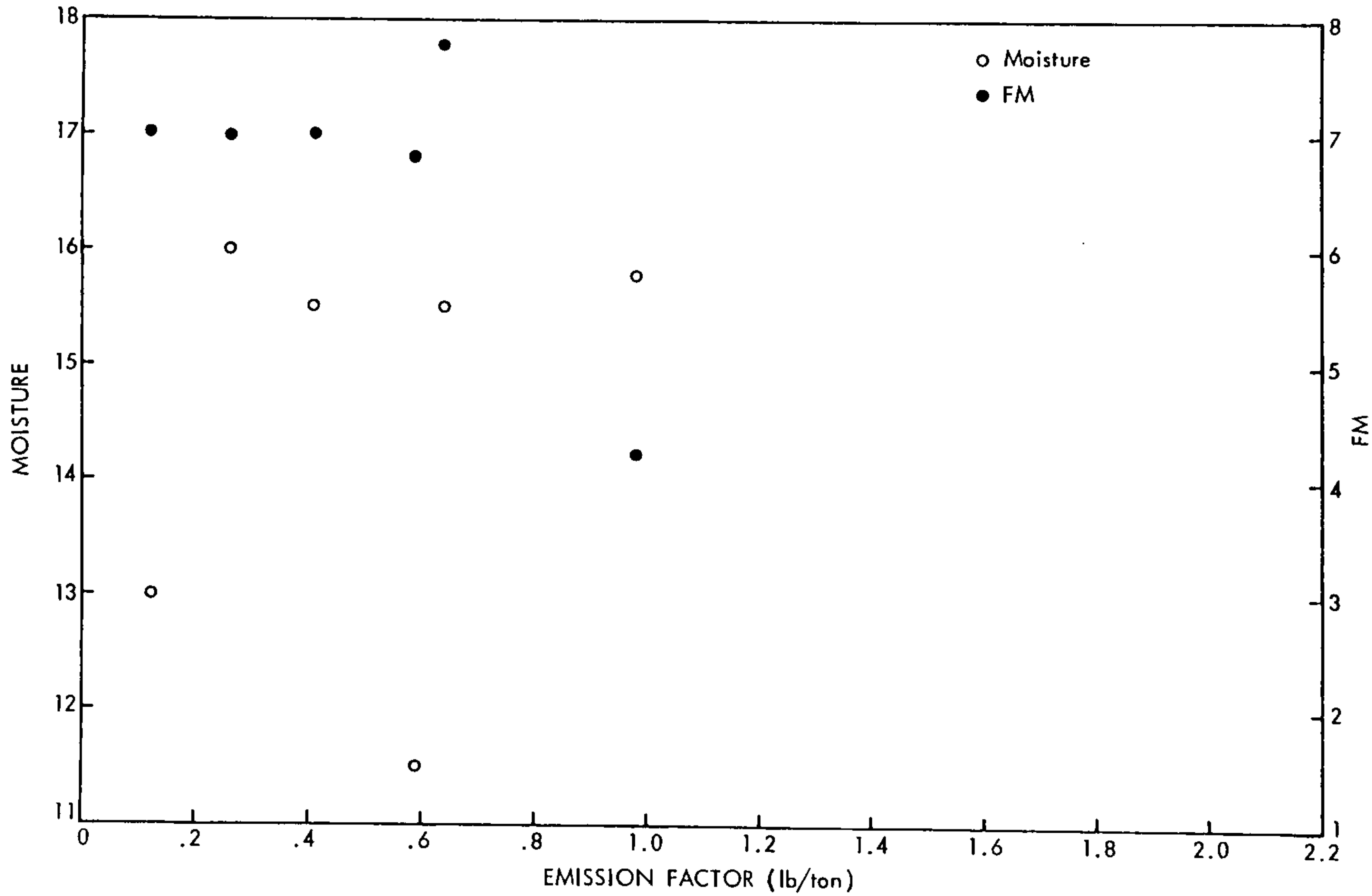



Figure 25. Short-term emission factors versus grain quality, car unloading of milo.

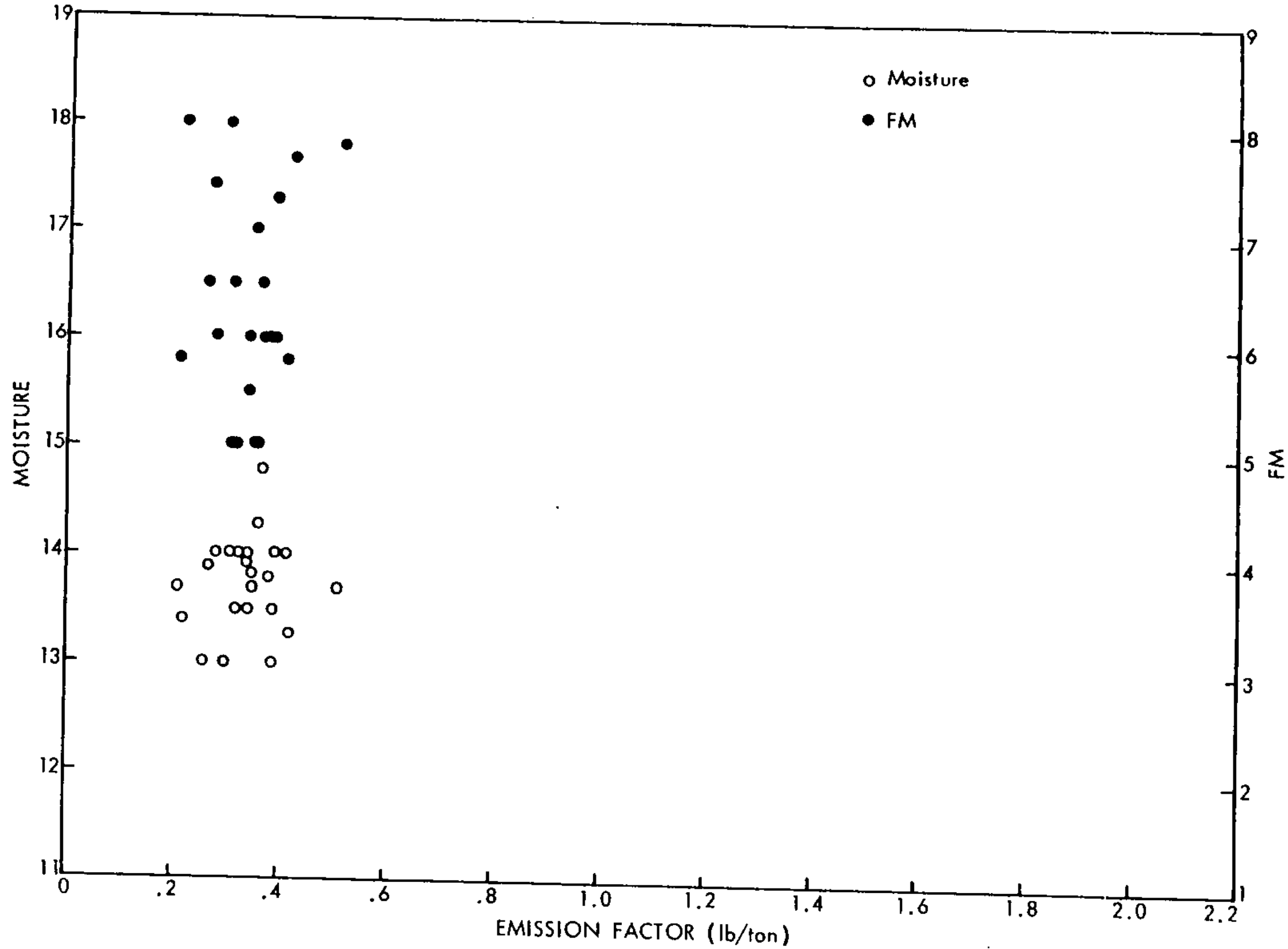



Figure 26. Short-term emission factors versus grain quality, car loading of milo.

Table 11. COMPILATION OF WEEKLY QUANTITIES OF DUST COLLECTED

| Week | Grain Receipts and Shipments (1,000 lb): Unloaded Trucks | Unloaded Cars | Loaded (Cars) | Total | Amount of Dust Collected (lb)[a]: Truck Unloading | Car Unloading | Car Loading | Corn Cleaner | Gallery Belt | Tunnel Belt | Headhouse | Total | Dust Collected Per Ton of Throughput[b] (lb/ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/9/73 | 8,183 | 19,163 | 7,945 | 35,291 | 2,240 | 2,970 | 1,046 | No Data | 82 | 2,685 | 15,627 | 24,650 | 2.80 |
| 7/16/73 | 6,899 | 12,012 | 11,905 | 30,816 | 2,338 | 2,646 | 1,037 | 3,016 | 17 | 3,995 | 24,649 | 37,698 | 4.90 |
| 7/23/73 | 7,197 | 13,417 | 5,259 | 25,873 | 2,362 | 2,931 | 604 | 1,135 | 66 | 1,889 | 20,287 | 29,274 | 4.52 |
| 7/30/73 | 8,693 | 5,663 | 6,425 | 20,781 | 2,616 | 1,029 | 438 | 564 | 142 | 2,244 | 16,246 | 23,279 | 4.48 |
| 8/6/73 | 7,243 | 7,076 | 9,035 | 23,354 | 2,006 | 1,004 | 836 | 358 | 91 | 1,509 | 11,680 | 17,484 | 3.00 |
| 8/13/73 | 8,802 | 2,922 | 7,860 | 19,584 | 2,446 | 2,383 | 681 | No Data | 440 | 3,037 | 14,142 | 23,129 | 4.72 |
| 8/20/73 | 8,489 | 1,952 | 12,960 | 23,401 | 2,534 | 898 | 1,195 | No Data | 367 | 2,326 | No Data | NC | NC |
| 8/27/73 | 7,531 | 2,401 | 8,930 | 18,862 | 2,135 | No Data | 950 | No Data | 202 | 4,535 | No Data | NC | NC |
| 9/4/73 | 3,989 | 2,726 | 10,242 | 16,957 | 1,648 | No Data | 1,254 | 0 | 25 | 3,800 | No Data | NC | NC |
| 9/10/73 | 4,960 | 4,364 | 9,850 | 19,174 | 1,593 | 4,124 | 1,576 | 511 | 0 | 3,696 | 21,894 | 33,394 | 6.96 |
| 9/17/73 | 6,606 | 5,103 | 5,939 | 17,648 | 1,556 | 3,664 | 1,124 | 833 | 153 | 3,109 | 43,453 | 53,892 | 12.20 |
| 9/24/73 | 753 | 2,707 | 6,923 | 10,383 | 628 | 2,623 | 1,276 | 1,645 | 250 | 5,963 | 16,039 | 28,424 | 10.96 |
| 10/1/73 | 2,560 | 5,506 | 7,013 | 15,079 | 693 | 2,775 | 989 | 1,524 | 199 | 3,295 | 16,639 | 26,114 | 6.92 |
| 10/7 and 10/15/73 | 25,529 | 15,956 | 14,324 | 55,809 | 3,178 | 7,838 | 1,945 | 1,065 | 148 | 4,452 | 53,150 | 71,776 | 5.14 |
| 10/22/73 | 19,761 | 9,265 | 10,504 | 39,530 | 5,994 | 4,287 | 1,054 | 278 | 445 | 3,405 | 40,347 | 55,810 | 5.64 |
| 10/29/73 | 18,069 | 9,420 | 8,372 | 35,861 | 7,980 | No Data | 1,220 | 480 | 171 | 2,210 | 20,813 | 32,874 | 3.66 |
| 11/5/73 | 19,086 | 8,433 | 17,214 | 44,733 | 7,359 | No Data | 575 | 542 | 263 | No Data | 39,162 | 47,901 | 4.28 |
| 11/12/73 | 15,222 | 10,729 | 10,446 | 36,397 | 4,756 | No Data | 1,663 | 434 | 441 | 3,879 | 31,821 | 42,994 | 4.72 |
| 11/19/73 | 8,636 | 9,403 | 11,240 | 29,279 | 2,435 | 3,363 | 2,005 | 198 | 405 | 3,253 | 27,579 | 42,888 | 5.86 |
| 11/26/73 | 6,606 | 11,475 | 10,043 | 28,124 | 2,740 | No Data | 2,006 | 610 | 176 | 2,904 | 33,346 | 41,782 | 5.96 |
| 12/3/73 | 4,088 | 5,420 | 15,005 | 24,513 | 1,304 | 4,346 | 2,140 | 1,037 | 192 | 3,042 | 37,167 | 49,228 | 8.04 |
| 12/10/73 | 5,017 | 3,787 | 5,666 | 14,470 | 2,168 | 8,534 | 1,357 | 0 | 388 | 7,905 | 44,138 | 64,490 | 17.82 |
| 12/17 - 12/21/73 | 2,861 | 2,306 | 2,361 | 7,528 | 564 | 4,385 | 854 | 109 | 370 | 2,498 | 24,063 | 32,843 | 17.46 |
| 12/21 - 12/28/73 | 2,218 | 984 | 10,367 | 13,569 | 1,398 | 1,357 | 821 | 1,221 | 90 | 4,167 | 42,323 | 51,377 | 15.14 |
| 12/28 - 1/7/74 | 737 | 4,260 | 16,719 | 21,716 | 93 | 5,196 | 839 | 1,432 | No Data | 2,791 | 38,623 | 48,974 | 9.02 |
| | | | | | | | | | | | | Average = | 7.[illegible] |

Note: NC means "not calculated."

a/ Dust emissions are only for those sources that were measured, which does not include all dust sources in the elevator.

b/ $\text{Throughput} = \frac{\text{Receipts + Shipments}}{2}$

The above definition implies that throughput is equivalent to receipts or shipments. That is, over the long term the amount of grain received will approach or equal the amount shipped. This, of course, is generally true over long periods such as a year or more but, as shown in Table 11, the amounts loaded and unloaded may be quite different over short periods such as a week or even several months.

Examination of the data in Table 11 shows that the total weekly quantity of dust collected for the seven operations varied from 17,484 lb up to 64,490 lb. Perhaps the most interesting aspect of the data in Table 11 is that it shows that by far the largest amount of dust was collected by the headhouse dust-collection system. This is somewhat unexpected because it is usually thought that loading and unloading operations generate the most dust. However, these are more intermittent operations than the headhouse operation. That is, grain is always moving through the headhouse if any operation is being carried out (i.e., loading, unloading, transferring, etc.). Therefore, the headhouse is collecting dust on a more continuous basis than any of the other operations, and the data certainly indicate that, over the long term, it is the largest source of dust within the elevator.

As mentioned earlier, the last column in Table 11 is the calculated emission factor for total dust collected per ton of throughput, with a final average value of 7.46 lb/ton. The purpose in obtaining this number was to compare it with a hypothetical value using the average composite emission factors given in Table 1. Considering the fact that it would be important to be able to predict the total potential dust emissions based on grain throughput, one can use the average composite emission factor for this purpose. For example, if 1 ton of grain were received (unloaded) and stored, and an equal amount loaded out, the throughput [(receiving + shipping)/2] would be 1 ton. The potential dust emissions from this throughput can be predicted, using the average emission factors, as follows:

<u>Receiving</u>

| | |
|---|---|
| Truck unloading | 0.64 lb/ton |
| Elevated through headhouse | 1.49 lb/ton |
| Transferred onto gallery belt | 0.11 lb/ton |

<u>Shipping</u>

| | |
|---|---|
| Dropped from bins onto tunnel belt | 1.40 lb/ton |
| Elevated through headhouse | 1.49 lb/ton |
| Loaded into a car | 0.27 lb/ton |
| Total | 5.40 lb/ton |

The value of 5.40 lb of dust per ton of throughput is a conservative value that could be used to predict potential dust emissions, assuming the grain is not cleaned or relocated (transferred) from one bin to another. This value is smaller than the value of 7.46 lb/ton shown on Table 11 because the data in Table 11 include associated cleaning and transfer operations, etc.

Although the preceding factor of 5.40 lb/ton could be used to predict the minimum potential dust emissions, it would be more accurate to use cumulative emission factors for specific elevator functions, that can be calculated in the same manner. Therefore, such cumulative emission factors have been computed for unloading (from trucks or cars), loading (into cars), corn cleaning, and turning. These are presented in Table 12 and an example calculation using the cumulative factors is shown in Table 13.

As stated above, use of the cumulative factors is a more accurate method of estimating total potential emissions from an elevator; but it does require knowledge of the quantity of grain processed through each elevator function; i.e., one must know the amount of grain unloaded (and whether from cars or trucks), the amounts loaded (to cars), the amount cleaned (corn) and the amount turned, during the time period of interest (e.g., per week or per month, etc.).

Daily Emissions

During some of our visits to the elevator, readings on the dust weighers were taken in order to assess the potential dust emissions on a daily basis. A total of 11 such daily periods were surveyed in the study. These did not always cover the entire operating day but did comprise the major portion of an 8-hr working period. As expected, not all of the elevator functions were always in service during these periods. Also, the filter systems were sometimes out of service on certain operations because of dust pluggages or other problems.

Data on dust emissions during the daily periods (Appendix C) show the quantity of dust collected for each system, and the types of grain being processed. This information is summarized in Table 14 to show the total dust emissions for each daily period, excluding those days in which the headhouse dust-collector was out of service.

Daily potential dust-emission data in Appendix C again indicates that the largest single source of dust was the headhouse and the data summarized in Table 14 indicates that the amount of dust collected from all sources that were in operation ranged from 2,260 lb up to 6,134 lb.

Table 12. CUMULATIVE EMISSION FACTORS FOR ESTIMATION OF POTENTIAL DUST EMISSIONS FROM A TERMINAL ELEVATOR

| | |
|---|---|
| Unloading | |
| From trucks | $(0.64^{a/} + 1.49^{g/} + 0.11^{e/})$ = 2.24 lb/ton |
| From cars | $(1.30^{b/} + 1.49^{g/} + 0.11^{e/})$ = 2.90 lb/ton |
| Loading | |
| To cars | $(1.40^{f/} + 1.49^{g/} + 0.27^{c/})$ = 3.16 lb/ton |
| Cleaning (and car loadout) | |
| Corn | $(1.40^{f/} + 1.49^{g/} + 5.78^{d/} + 1.49^{g/} + 0.27^{c/})$ = 10.43 lb/ton |
| Turning | |
| | $(1.40^{f/} + 1.49^{g/} + 0.11^{e/})$ = 3.00 lb/ton |

Individual emission factors (from Table 1):

a/ Truck unloading 0.64 lb/ton.
b/ Car unloading 1.30 lb/ton.
c/ Car loading 0.27 lb/ton
d/ Corn cleaning 5.78 lb/ton.
e/ Gallery belt 0.11 lb/ton.
f/ Tunnel belt 1.40 lb/ton.
g/ Headhouse 1.49 lb/ton.

Table 13. EXAMPLE CALCULATION

Example Calculation

Problem: Calculate total potential dust emissions from a terminal elevator from the following information:

| | | |
|---|---|---|
| Amount unloaded from trucks | - | 160,000 tons/year |
| Amount unloaded from cars | - | 100,000 tons/year |
| Amount loaded to cars | - | 200,000 tons/year |
| (no turning or cleaning) | | |

Solution (using factors in Table 12):

| | | |
|---|---|---|
| Truck unloading | 160,000 tons/year x (2.24 lb/ton) = | 358,000 lb dust |
| Car unloading | 100,000 tons/year x (2.90 lb/ton) = | 290,000 lb dust |
| Car loading | 200,000 tons/year x (3.16 lb/ton) = | 632,000 lb dust |
| | | 1,280,000 |

∴ Total potential dust emissions = $\boxed{\text{1,280,000 lb/year}}$

Table 14. SUMMARY OF DAILY POTENTIAL DUST EMISSIONS

| Date | Period Covered | Total Potential Dust Emissions (lb) |
|---|---|---|
| 8/20/73 | 9:30 a.m.-3:30 p.m. | 2,260 |
| 9/24/73 | 9:00 a.m.-3:30 p.m. | 4,651 |
| 10/22/73 | 10:00 a.m.-6:00 p.m. | 3,627 |
| 11/26/73 | 8:30 a.m.-4:30 p.m. | 6,134 |
| 12/3/73 | 8:30 a.m.-4:00 p.m. | 3,676 |
| 12/10/73 | 8:40 a.m.-3:30 p.m. | 4,172 |

Hourly Emissions

Data on hourly potential dust emissions were also obtained during this study (see Appendix D). Again, a summary of the total dust collected for those 1-hr periods is presented in Table 15, excluding those in which the headhouse dust collector was out of service.

As expected, the hourly quantities of dust collected show wide variability, ranging from 105 lb up to 2,960 lb. This at least partially reflects the fact that in any particular hourly period, several systems may not be in use, and the rate at which grain is being processed covers a broad range. However, the largest values shown in Table 15 occurred during December, when cold weather was causing improper operation of several of the filter systems. The representativeness of these latter values may be suspect. On the other hand, the values in Table 15 do not include emissions from the new house section of the elevator, where no dust weighers were installed. In several instances the data do not include dust generated from certain operations where the filters were plugged or otherwise inoperative. Therefore, even though the total amount of dust collected over each hourly period covers a broad range, it probably does typify the characteristics of potential dust emissions from this terminal elevator operation.

Table 15. SUMMARY OF HOURLY POTENTIAL DUST EMISSIONS

| Date | Period Covered | Total Potential Dust Emissions (lb) |
|---|---|---|
| 8/13/73 | 1:00-2:00 p.m. | 373 |
| 8/20/73 | 1:30-2:30 p.m. | 371 |
| 8/20/73 | 2:30-3:30 p.m. | 228 |
| 9/24/73 | 1:00-2:00 p.m. | 629 |
| 11/26/73 | 8:30-9:30 a.m. | 1,157 |
| 11/26/73 | 1:45-2:45 p.m. | 1,054 |
| 12/3/73 | 1:00-2:00 p.m. | 304 |
| 12/3/73 | 2:00-3:00 p.m. | 879 |
| 12/10/73 | 10:00-11:00 a.m. | 105 |
| 12/10/73 | 1:00-2:00 p.m. | 879 |
| 12/17/73 | 2:00-3:00 p.m. | 1,421 |
| 12/28/73 | 10:30-11:30 a.m. | 2,960 |
| 12/28/73 | 2:00-3:00 p.m. | 2,697 |

# FINAL NOTES

With the possible exception of hopper-car loading and boxcar unloading, the dust-aspiration systems at this elevator when operating properly generally provide good control of dust emissions. However, the fabric filter systems experience problems that seriously hamper their effective on-line time. Most such problems are caused by dust plugging in the dust hopper or tail-line below the filter, or by malfunction of the cleaning air pulse valves, especially during cold weather when moisture can freeze in the high-pressure cleaning air lines or pulse valves.

We therefore recommend that dust hoppers below the filter bags be designed to minimize plugging, using screw conveyors or other means; avoiding use of tetrahedron-shaped hoppers.

We also strongly recommend that special attention be given to preventing the possibility of moisture freezing in the pulse valves and air lines.

Because the data obtained in this study represent testing at only one terminal elevator handling four types of grain, comparative data should be obtained at other elevators, including those that process only one or two types of grain.

If additional testing is conducted at other elevators, more extensive short-term test data should be obtained to determine emission factors as a function of grain quality as well as grain type.

Finally, it must be emphasized that all the data and results reported in this study were based on amounts of dust collected, which is not necessarily equivalent to the amount generated. Although some of the results have been reported as "emission factors," the use of this term is not absolutely consistent with the usual meaning that denotes amount generated. The difference in these meanings is related to the capture efficiency of the enclosure or hooding systems that collect the dust as it is generated by the source.

Many of the dust sources that were the subject of this study were fugitive type sources and some dust does escape capture, notably the car loading and unloading operations. The filter systems can collect only that portion of the generated dust that is captured by the aspiration or hooding systems, assuming that the collection efficiency of the fabric filters is greater than 99%. Consequently, our results and reported "emission factors" must be considered conservative because they do not include any dust that escaped capture. If any additional testing of this is conducted, it would, of course, provide more accurate results if the total amount of dust generated could be determined, rather than just the amount collected.

# APPENDIX A

## WEIGHER CALIBRATION FACTORS

Table A-1. CALIBRATIONS - TRUCK UNLOADING

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor $\left(\frac{\text{lb}}{\text{count}}\right)$ Mark 1-1/2[a] |
|---|---|---|---|
| 6/29/73 | 50 | 30.43 | 0.609 |
| 8/20/73 | 65 | 36.80 | 0.566 |
| 9/10/73 | 45 | 28.50 | 0.633 |
| 10/29/73 | 77 | 58.69 | 0.762 |
| 12/3/73 | 55 | 56.56 | 1.028 |

a/ Mark number refers to position of counterweight.

Table A-2. CALIBRATIONS - CAR UNLOADING

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor (lb/count) Mark 1-1/2[a] | Mark 2[a] | Mark 3[a] |
|---|---|---|---|---|---|
| 6/19/73 | 13 | 40.50 | | 3.11[b] | |
| 7/30/73 | 8 | 20.12 | | | 2.52 |
| 7/30/73 | 22 | 35.69 | | 1.62 | |
| 8/13/73 | 54 | 88.31 | | 1.63 | |
| 10/1/73 | 40 | 66.06 | | 1.65 | |
| 11/19/73 | 24 | 36.30 | | 1.51 | |
| 12/10/73 | 9 | 8.81 | 0.98 | | |
| 12/17/73 | 25 | 25.69 | 1.03 | | |

a/ Mark number refers to position of counterweight.

b/ First calibration factor was much larger than succeeding factors determined. We suspect that reason for this was buildup of dust in weigher housings, prior to modifications to the bottom of weighers.

Table A-3. CALIBRATIONS - CAR LOADING

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor $\left(\frac{\text{lb}}{\text{count}}\right)$ Mark 2[a] |
|---|---|---|---|
| 6/19/73 | 18 | 41.69 | 2.32[b] |
| 7/30/73 | 21 | 32.44 | 1.54 |
| 8/6/73 | 9 | 13.44 | 1.49 |
| 8/27/73 | 30 | 44.06 | 1.47 |
| 10/1/73 | 22 | 31.69 | 1.44 |
| 11/12/73 | 20 | 33.06 | 1.65 |
| 12/10/73 | 7 | 10.38 | 1.48 |

a/ Mark number refers to position of counterweight.

b/ First calibration factor was much larger than succeeding factors. We suggest that reason for this was buildup of dust in weigher housings, prior to modifications to the bottoms of weighers.

Table A-4. CALIBRATIONS - CORN CLEANER

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor $\left(\frac{\text{lb}}{\text{count}}\right)$ Mark 2[a] |
|---|---|---|---|
| 8/6/73 | 13 | 14.94 | 1.15 |
| 9/17/73 | 19 | 14.20 | 0.75 |
| 9/24/73 | 51 | 45.06 | 0.88 |
| 12/10/73 | 12 | 9.56 | 0.80 |

a/ Mark number refers to position of counterweight.

Table A-5. CALIBRATIONS - GALLERY BELT

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor $\left(\frac{lb}{count}\right)$ Mark 1/2[a] |
|---|---|---|---|
| 6/29/73 | 8 | 4.5 | 0.562 |
| 12/3/73 | 2 | 1.12 | 0.562 |

a/ Mark number refers to position of counterweight.

Table A-6. CALIBRATIONS - TUNNEL BELT

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor $\left(\frac{\text{lb}}{\text{count}}\right)$ Mark 2[a] |
|---|---|---|---|
| 7/23/73 | 48 | 62.60 | 1.30 |
| 8/6/73 | 21 | 24.19 | 1.15 |
| 9/4/73 | 12 | 13.56 | 1.13 |
| 10/8/73 | 36 | 26.05 | 0.73 |
| 10/22/73 | 57 | 33.06 | 0.58 |
| 11/26/73 | 6 | 3.88 | 0.65 |
| 12/17/73 | 15 | 14.12 | 0.94 |

a/ Mark number refers to position of counterweight.

TABLE A-7. CALIBRATIONS - HEADHOUSE

| Date | Number of Counts | Total Weight of Dust Collected (lb) | Calibration Factor (lb/count) Mark 2[a] | Mark 3[a] |
|---|---|---|---|---|
| 7/9/73 | 32 | 54.08 | | 1.69 |
| 7/30/73 | 33 | 17.44 | 0.53 | |
| 7/30/73 | 25 | 39.94 | | 1.60 |
| 9/24/73 | 131 | 54.20 | 0.41 | |
| 9/24/73 | 54 | 81.62 | | 1.51 |
| 10/29/73 | 20 | 22.12 | | 1.11 |
| 11/5/73 | 94 | 84.12 | | 0.895[b] |
| 11/26/73 | 113 | 89.75 | | 0.794 |
| 12/21/73 | 15 | 14.81 | | 0.987 |

a/ Mark number refers to position of counterweight.

b/ Calibration factor is lower because deflector plate position was changed to minimize possibility of plug-up problems.

# APPENDIX B

## WEEKLY EMISSION FACTOR DATA

Table B-1. SUMMARY OF WEEKLY COMPOSITE EMISSION FACTORS $\left(\frac{\text{pounds of dust}}{\text{ton of grain}}\right)$

| Week of | Truck Unloading | Car[a/] Unloading | Car[a/] Loading | Corn Cleaner | Gallery[b/] Belt | Tunnel[c/] Belt | Headhouse |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 0.547 | 0.310 | 0.263 | Filter plugged | 0.034 | Not calculated | 0.804 |
| 7/16/73 | 0.678 | 0.440 | 0.174 | 12.95 | 0.032 | 2.80 | 1.349 |
| 7/23/73 | 0.656 | 0.437 | 0.230 | 4.10 | 0.035 | 2.80 | 1.425 |
| 7/30/73 | 0.602 | 0.363 | 0.136 | 7.42 | 0.126 | 3.75 | 1.188 |
| 8/6/73 | 0.554 | 0.284 | 0.185 | 5.68 | 0.059 | 1.89 | 1.000 |
| 8/13/73 | 0.556 | 1.63 | 0.173 | Filter plugged | 0.110 | 8.18 | 0.930 |
| 8/20/73 | 0.597 | 0.922 | 0.184 | Filter plugged | 0.152 | 1.09 | Dust collector not operating |
| 8/27/73 | 0.567 | Dust collector not operating | 0.213 | Filter plugged | 0.088 | 1.76 | Dust collector not operating |
| 9/4/73 | 0.826 | Dust collector not operating | 0.245 | Not used | 0.010 | 2.08 | Dust collector not operating |
| 9/10/73 | 0.642 | 1.89 | 0.320 | 2.76 | Not used | Not calculated | 1.653 |
| 9/17/73 | 0.471 | 1.44 | 0.379 | 6.96 | 0.052 | 4.26 | 3.029 |
| 9/24/73 | 0.835 | 1.94 | 0.368 | 8.82 | 0.100 | 11.49 | 1.903 |
| 10/1/73 | 0.541 | 1.01 | 0.282 | 4.47 | 0.084 | 3.80 | 1.464 |
| 10/7 and 10/15/73 | 0.249 | 0.983 | 0.272 | 5.07 | 0.030 | 8.04 | 1.678 |
| 10/22/73 | 0.607 | 0.925 | 0.201 | 4.41 | 0.048 | 8.37 | 1.469 |
| 10/29/73 | 0.883 | Dust collector not operating | 0.291 | 6.40 | 0.093 | 2.21 | 0.982 |
| 11/5/73 | 0.771 | d/ | 0.110 | 4.93 | 0.085 | h/ | 1.602 |
| 11/12/73 | 0.625 | d/ | 0.318 | 2.35 | 0.099 | 4.03 | 1.410 |
| 11/19/73 | 0.564 | 0.715 | 0.357 | f/ | 0.145 | 1.83 | 1.544 |
| 11/26/73 | 0.829 | e/ | 0.400 | 8.13 | 0.044 | 2.18 | 1.939 |
| 12/3/73 | 0.638 | 1.60 | 0.285 | 4.03 | 0.361 | 1.43 | 2.748 |
| 12/10/73 | 0.864 | 4.51 | 0.479 | -- | 0.164 | 4.96 | 3.777 |
| 12/17/73 to 12/21/73 | 0.395 | 3.80 | 0.723 | 1.79 | 0.337 | 15.1 | 3.514 |
| 12/21/73 to 12/28/73 | 1.26 | 2.76 | 0.158 | 5.11 | 0.239 | 1.81 | 5.067 |
| 12/28/73 to 1/7/74 | 0.252 | 2.44 | 0.100 | 8.68 | g/ | i/ | 3.169 |

a/ Loading and unloading of cars includes both hopper cars and boxcars.
b/ The gallery belt dust collector is connected to only one hood where grain is fed onto the belt.
c/ The emission factor values may be unusually high and show large variation because dust is continually collected from one leg, even though little or no grain may be moved through the tunnel belt.
d/ Dust collector out of service all or part of week; fan motor repairs.
e/ No emission factor calculated because counter-wire on weigher was broken.
f/ No emission factor calculated because unable to determine quantity of grain cleaned.
g/ Not calculated because of low air pressure in cleaning air tank.
h/ No emission factor could be calculated because filter was plugged.
i/ Emission factor not calculated because fan was out of service part of week.

Table B-2. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Truck Unloading)

| Week of | Dust Collected (lb) | Grains Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 2,240 | 2,115 | 5,848 | 141 | 79 | 8,183 | 0.547 |
| 7/16/73 | 2,338 | 1,382 | 5,027 | 400 | 90 | 6,899 | 0.678 |
| 7/23/73 | 2,362 | 813 | 6,115 | 217 | 52 | 7,197 | 0.656 |
| 7/30/73 | 2,616 | 788 | 7,432 | 275 | 198 | 8,693 | 0.602 |
| 8/6/73 | 2,006 | 539 | 6,119 | 304 | 281 | 7,243 | 0.554 |
| 8/13/73 | 2,446 | 1,354 | 6,358 | 313 | 777 | 8,802 | 0.556 |
| 8/20/73 | 2,534 | 782 | 7,065 | 74 | 568 | 8,489 | 0.597 |
| 8/27/73 | 2,135 | 1,105 | 5,429 | 29 | 968 | 7,531 | 0.567 |
| 9/4/73 | 1,648 | 482 | 3,152 | 0 | 355 | 3,989 | 0.826 |
| 9/10/73 | 1,593 | 1,878 | 2,135 | 0 | 947 | 4,960 | 0.642 |
| 9/17/73 | 1,556 | 2,965 | 2,452 | 15 | 1,174 | 6,606 | 0.471 |
| 9/24/73 | 628 | 513 | 605 | 187 | 200 | 753 | 0.835 |
| 10/1/73 | 693 | 321 | 1,124 | 144 | 971 | 2,560 | 0.541 |
| 10/7 and 10/15/73 | 3,178 | 1,666 | 4,217 | 11,188 | 8,458 | 25,529 | 0.249 |
| 10/22/73 | 5,994 | 217 | 1,310 | 12,915 | 5,319 | 19,761 | 0.607 |
| 10/29/73 | 7,980 | 160 | 5,429 | 7,315 | 5,165 | 18,069 | 0.883 |
| 11/5/73 | 7,359 | 542 | 7,394 | 6,089 | 5,061 | 19,086 | 0.771 |
| 11/12/73 | 4,756 | 293 | 7,735 | 3,184 | 4,010 | 15,222 | 0.625 |
| 11/19/73 | 2,435 | 435 | 5,826 | 853 | 1,522 | 8,636 | 0.564 |
| 11/26/73 | 2,740 | 237 | 5,030 | 709 | 630 | 6,606 | 0.829 |
| 12/3/73 | 1,304 | 378 | 2,255 | 888 | 567 | 4,088 | 0.638 |
| 12/10/73 | 2,168 | 383 | 3,125 | 775 | 734 | 5,017 | 0.864 |
| 12/17/73 to 12/21/73 | 564 | 356 | 1,854 | 252 | 399 | 2,861 | 0.395 |
| 12/21/73 to 12/28/73 | 1,398 | 314 | 1,459 | 192 | 253 | 2,218 | 1.26 |
| 12/28/73 to 1/7/74 | 93 | 303 | 190 | 48 | 196 | 737 | 0.252 |

Table B-3. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Car Unloading[a])

| Week of | Dust Collected (lb) | Grains Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 2,970 | 14,454 | 4,476 | 0 | 233 | 19,163 | 0.310 |
| 7/16/73 | 2,646 | 10,448 | 1,204 | 0 | 360 | 12,012 | 0.440 |
| 7/23/73 | 2,931 | 10,710 | 2,062 | 0 | 645 | 13,417 | 0.437 |
| 7/30/73 | 1,029 | 4,326 | 524 | 0 | 813 | 5,663 | 0.363 |
| 8/6/73 | 1,004 | 2,272 | 0 | 0 | 4,804 | 7,076 | 0.284 |
| 8/13/73 | 2,383 | 1,298 | 318 | 0 | 1,306 | 2,922 | 1.63 |
| 8/20/73 | 898 | 285 | 0 | 0 | 1,667 | 1,952 | 0.922 |
| 8/27/73 | Dust collector system not operable. | | | | | | |
| 9/4/73 | Dust collector down part of the week. | | | | | | |
| 9/10/73 | 4,124 | 1,314 | 275 | 0 | 2,775 | 4,364 | 1.89 |
| 9/17/73 | 3,664 | 3,261 | 475 | 0 | 1,385 | 5,103 | 1.44 |
| 9/24/73 | 2,623 | 1,343 | 112 | 0 | 1,252 | 2,707 | 1.94 |
| 10/1/73 | 2,775 | 1,799 | 315 | 0 | 3,392 | 5,506 | 1.01 |
| 10/7 and 10/15/73 | 7,638 | 1,334 | 1,326 | 0 | 13,296 | 15,956 | 0.983 |
| 10/22/73 | 4,287 | 209 | 0 | 1,289 | 7,767 | 9,265 | 0.925 |
| 10/29/73 | b/ | 309 | 735 | 2,645 | 5,731 | 9,420 | b/ |
| 11/5/73 | b/ | 95 | 1,533 | 2,467 | 4,338 | 8,433 | b/ |
| 11/12/73 | b/ | 247 | 3,079 | 1,872 | 5,531 | 10,729 | b/ |
| 11/19/73 | 3,363 | 0 | 4,290 | 1,159 | 3,954 | 9,403 | 0.715 |
| 11/26/73 | c/ | 0 | 4,317 | 6,100 | 1,058 | 11,475 | c/ |
| 12/3/73 | 4,346 | 335 | 1,112 | 3,875 | 98 | 5,420 | 1.60 |
| 12/10/73 | 8,534 | 224 | 2,258 | 975 | 330 | 3,787 | 4.51 |
| 12/17/73 to 12/21/73 | 4,385 | 273 | 1,387 | 0 | 646 | 2,306 | 3.80 |
| 12/21/73 to 12/28/73 | 1,357 | 223 | 640 | 0 | 121 | 984 | 2.76 |
| 12/28/73 to 1/7/74 | 5,196 | 474 | 3,441 | 0 | 345 | 4,260 | 2.44 |

a/ Car unloading dust collector system also serves one of the legs.
b/ Dust collector out of service all or part of week; fan motor repairs.
c/ Counter wire broken on weigher.

Table B-4. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Car Loading)

| Week of | Dust Collected (lb) | Grain Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 1,046 | 0 | 7,085 | 300 | 560 | 7,945 | 0.263 |
| 7/16/73 | 1,037 | 0 | 5,450 | 370 | 6,085 | 11,905 | 0.174 |
| 7/23/73 | 604 | 495 | 4,204 | 180 | 380 | 5,259 | 0.230 |
| 7/30/73 | 438 | 5,145 | 1,280 | 0 | 0 | 6,425 | 0.136 |
| 8/6/73 | 836 | 6,310 | 1,995 | 540 | 190 | 9,035 | 0.185 |
| 8/13/73 | 681 | 5,410 | 1,520 | 360 | 570 | 7,860 | 0.173 |
| 8/20/73 | 1,195 | 8,425 | 4,155 | 0 | 380 | 12,960 | 0.184 |
| 8/27/73 | 950 | 4,595 | 3,642 | 525 | 168 | 8,930 | 0.213 |
| 9/4/73 | 1,254 | 2,942 | 4,500 | 0 | 2,800 | 10,242 | 0.245 |
| 9/10/73 | 1,576 | 3,090 | 6,760 | 0 | 0 | 9,850 | 0.320 |
| 9/17/73 | 1,124 | 160 | 5,779 | 0 | 0 | 5,939 | 0.379 |
| 9/24/73 | 1,276 | 510 | 5,293 | 0 | 1,120 | 6,923 | 0.368 |
| 10/1/73 | 989 | 1,230 | 2,983 | 0 | 2,800 | 7,013 | 0.282 |
| 10/7 and 10/15/73 | 1,945 | 4,980 | 3,084 | 720 | 5,540 | 14,324 | 0.272 |
| 10/22/73 | 1,054 | 6,850 | 924 | 1,440 | 1,290 | 10,504 | 0.201 |
| 10/29/73 | 1,220 | 2,000 | 1,684 | 900 | 3,788 | 8,372 | 0.291 |
| 11/5/73 | 575 | 2,920 | 3,725 | 2,355 | 8,214 | 17,214 | 0.110 |
| 11/12/73 | 1,663 | 0 | 3,343 | 1,440 | 5,663 | 10,446 | 0.318 |
| 11/19/73 | 2,005 | 1,000 | 979 | 0 | 9,261 | 11,240 | 0.357 |
| 11/26/73 | 2,006 | 1,400 | 2,225 | 1,080 | 5,338 | 10,043 | 0.400 |
| 12/3/73 | 2,140 | 1,600 | 6,038 | 900 | 6,467 | 15,005 | 0.285 |
| 12/10/73 | 1,357 | 0 | 168 | 2,340 | 3,158 | 5,666 | 0.479 |
| 12/17/73 to 12/21/73 | 854 | 819 | 890 | 540 | 112 | 2,361 | 0.723 |
| 12/21/73 to 12/28/73 | 821 | 0 | 3,752 | 180 | 6,435 | 10,367 | 0.158 |
| 12/28/73 to 1/7/74 | 839 | 1,120 | 7,330 | 1,820 | 6,449 | 16,719 | 0.100 |

Table B-5. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Cleaner)

| Week of | Dust Collected (lb) | Grain Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | | | Filter Plugged - No Data | | | | |
| 7/16/73 | 3,016 | 0 | 467 | 0 | 0 | 467 | 12.95 |
| 7/23/73 | 1,135 | 0 | 554 | 0 | 0 | 554 | 4.10 |
| 7/30/73 | 564 | 0 | 152 | 0 | 0 | 152 | 7.42 |
| 8/6/73 | 358 | 0 | 127 | 0 | 0 | 127 | 5.68 |
| 8/13/73 | | | Filter Plugged - No Data | | | | |
| 8/20/73 | | | Filter Plugged - No Data | | | | |
| 8/27/73 | | | Filter Plugged - No Data | | | | |
| 9/4/73 | | | Cleaner Not Used | | | | |
| 9/10/73 | 511 | 0 | 369 | 0 | 0 | 369 | 2.76 |
| 9/17/73 | 833 | 0 | 239 | 0 | 0 | 239 | 6.96 |
| 9/24/73 | 1,645 | 0 | 373 | 0 | 0 | 373 | 8.82 |
| 10/1/73 | 1,524 | 0 | 682 | 0 | 0 | 682 | 4.47 |
| 10/7/73 and 10/15/73 | 1,065 | 0 | 421 | 0 | 0 | 421 | 5.07 |
| 10/22/73 | 278 | 0 | 126 | 0 | 0 | 126 | 4.41 |
| 10/29/73 | 480 | 0 | 151 | 0 | 0 | 151 | 6.40 |
| 11/5/73 | 542 | 0 | 220 | 0 | 0 | 220 | 4.93 |
| 11/12/73 | 434 | 0 | 371 | 0 | 0 | 371 | 2.35 |
| 11/19/73 | 198 | 0 | a/ | 0 | 0 | a/ | a/ |
| 11/26/73 | 610 | 0 | 149 | 0 | 0 | 149 | 8.13 |
| 12/3/73 | 1,037 | 0 | 515 | 0 | 0 | 515 | 4.03 |
| 12/10/73 | 0 | 0 | 0 | 0 | 0 | 0 | -- |
| 12/17/73 to 12/21/73 | 109 | 0 | 122 | 0 | 0 | 122 | 1.79 |
| 12/21/73 to 12/28/73 | 1,221 | 0 | 478 | 0 | 0 | 478 | 5.11 |
| 12/28/73 to 1/7/74 | 1,432 | 0 | 329 | 0 | 0 | 329 | 8.68 |

a/ No emission factor calculated because unable to determine quantity of grain cleaned.

Table B-6. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Gallery Belt)[a/]

| Week of | Dust Collected (lb) | Grain Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 82 | 4,692 | 199 | 0 | 0 | 4,891 | 0.034 |
| 7/16/73 | 17 | 938 | 0 | 0 | 120 | 1,058 | 0.032 |
| 7/23/73 | 66 | 3,203 | 0 | 0 | 540 | 3,743 | 0.035 |
| 7/30/73 | 142 | 94 | 1,141 | 0 | 1,011 | 2,246 | 0.126 |
| 8/6/73 | 91 | 0 | 0 | 0 | 3,082 | 3,082 | 0.059 |
| 8/13/73 | 440 | 0 | 7,386 | 0 | 590 | 7,976 | 0.110 |
| 8/20/73 | 367 | 0 | 4,272 | 0 | 563 | 4,835 | 0.152 |
| 8/27/73 | 202 | 0 | 4,150 | 0 | 473 | 4,593 | 0.088 |
| 9/4/73 | 25 | 0 | 0 | 0 | 4,760 | 4,760 | 0.010 |
| 9/10/73 | 0 | 0 | 0 | 0 | 0 | 0 | -- |
| 9/17/73 | 153 | 1,080 | 0 | 0 | 4,760 | 5,840 | 0.052 |
| 9/24/73 | 250 | 129 | 4,872 | 0 | 0 | 5,001 | 0.100 |
| 10/1/73 | 199 | 0 | 4,760 | 0 | 0 | 4,760 | 0.084 |
| 10/7/73 to 10/15/73 | 148 | 1,440 | 0 | 0 | 8,422 | 9,862 | 0.030 |
| 10/22/73 | 445 | 0 | 3,640 | 10,200 | 4,706 | 18,546 | 0.048 |
| 10/29/73 | 171 | 3,360 | 0 | 0 | 324 | 3,684 | 0.093 |
| 11/5/73 | 263 | 0 | 0 | 1,598 | 4,620 | 6,218 | 0.085 |
| 11/12/73 | 441 | 660 | 4,928 | 360 | 2,983 | 8,931 | 0.099 |
| 11/19/73 | 405 | 0 | 5,600 | 0 | 0 | 5,600 | 0.145 |
| 11/26/73 | 176 | 0 | 0 | 0 | 7,931 | 7,931 | 0.044 |
| 12/3/73 | 192 | 0 | 504 | 0 | 560 | 1,064 | 0.361 |
| 12/10/73 | 388 | 0 | 672 | 385 | 3,690 | 4,747 | 0.164 |
| 12/17/73 to 12/21/73 | 370 | 72 | 0 | 1,800 | 322 | 2,194 | 0.337 |
| 12/21/73 to 12/28/73 | 90 | 183 | 310 | 0 | 261 | 754 | 0.239 |
| 12/28/73 to 1/7/74 | b/ | 0 | 0 | 0 | 1,680 | 1,680 | b/ |

a/ The gallery belt dust collector serves only one hood where grain is fed onto the belt.

b/ No emission factor calculated because of low dust weight due to low pressure in cleaning air tank.

Table B-7. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Tunnel Belt)[a]

| Week of | Dust Collected (lb) | Grain Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated[a] Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 2,685 | 114 | 0 | 0 | 28 | 142 | Not Calculated[a] |
| 7/16/73 | 3,995 | 663 | 162 | 0 | 2,027 | 2,852 | 2.80[a] |
| 7/23/73 | 1,889 | 1,068 | 78 | 0 | 285 | 1,431 | 2.64[a] |
| 7/30/73 | 2,244 | 101 | 1,094 | 0 | 0 | 1,195 | 3.75[a] |
| 8/6/73 | 1,509 | 1,560 | 0 | 0 | 38 | 1,598 | 1.89[a] |
| 8/13/73 | 3,037 | 171 | 0 | 0 | 570 | 741 | 8.18[a] |
| 8/20/73 | 2,326 | 3,938 | 0 | 0 | 342 | 4,280 | 1.09 |
| 8/27/73 | 4,535 | 1,634 | 3,175 | 0 | 358 | 5,167 | 1.76 |
| 9/4/73 | 3,800 | 524 | 0 | 0 | 3,136 | 3,660 | 2.08 |
| 9/10/73 | 3,696 | 150 | 0 | 0 | 0 | 150 | Not Calculated[a] |
| 9/17/73 | 3,109 | 1,080 | 381 | 0 | 0 | 1,461 | 4.26 |
| 9/24/73 | 5,963 | 0 | 701 | 0 | 336 | 1,037 | 11.49 |
| 10/1/73 | 3,295 | 600 | 407 | 0 | 727 | 1,734 | 3.80 |
| 10/7 and 10/15/73 | 4,452 | 0 | 0 | 0 | 1,108 | 1,108 | 8.04 |
| 10/22/73 | 3,405 | 0 | 0 | 0 | 813 | 813 | 8.37 |
| 10/29/73 | 2,210 | 0 | 200 | 0 | 1,798 | 1,998 | 2.21 |
| 11/5/73 | b/ | 0 | 100 | 0 | 2,737 | 2,837 | b/ |
| 11/12/73 | 3,879 | 0 | 224 | 0 | 1,699 | 1,923 | 4.03 |
| 11/19/73 | 3,253 | 0 | 0 | 0 | 3,560 | 3,560 | 1.83 |
| 11/26/73 | 2,904 | 0 | 0 | 0 | 2,669 | 2,669 | 2.18 |
| 12/3/73 | 3,042 | 520 | 514 | 0 | 3,205 | 4,239 | 1.43 |
| 12/10/73 | 7,905 | 0 | 0 | 936 | 2,250 | 3,186 | 4.96 |
| 12/17/73 to 12/21/73 | 2,498 | 246 | 0 | 0 | 84 | 330 | 15.1[a] |
| 12/21/73 to 12/28/73 | 4,167 | 0 | 450 | 0 | 4,167 | 4,617 | 1.81 |
| 12/28/73 to 1/7/74 | 2,791 | 60 | 70 | 0 | 7,487 | 7,617 | c/ |

a/ The emission factor values may be high and show large variation because dust is continually collected from one leg, even though little or no grain may be moved through the tunnel belt.

b/ No emission factor could be calculated because filter was plugged.

c/ Emission factor not calculated because fan was out of service for part of week.

Table B-8. WEEKLY QUANTITIES OF DUST COLLECTED AND GRAINS PROCESSED (Headhouse)

| Week of | Dust Collected (lb) | Grain Processed (1,000 lb) Wheat | Corn | SB | Milo | Total | Calculated Emission Factor (lb/ton) |
|---|---|---|---|---|---|---|---|
| 7/9/73 | 15,627 | 19,067 | 18,501 | 441 | 872 | 38,881 | 0.804 |
| 7/16/73 | 24,649 | 17,004 | 12,226 | 770 | 6,535 | 36,535 | 1.349 |
| 7/23/73 | 20,287 | 14,378 | 12,628 | 397 | 1,077 | 28,480 | 1.425 |
| 7/30/73 | 16,246 | 15,073 | 10,996 | 275 | 1,011 | 27,355 | 1.188 |
| 8/6/73 | 11,680 | 9,121 | 8,114 | 844 | 5,275 | 23,354 | 1.000 |
| 8/13/73 | 14,142 | 10,212 | 16,865 | 673 | 2,653 | 30,403 | 0.930 |
| 8/20/73 | Dust collection system not operating. | | | | | | -- |
| 8/27/73 | Dust collection system not operating. | | | | | | -- |
| 9/4/73 | Dust collection system not operating. | | | | | | -- |
| 9/10/73 | 21,894 | 7,662 | 15,106 | 0 | 3,722 | 26,490 | 1.653 |
| 9/17/73 | 43,453 | 11,186 | 9,948 | 15 | 7,543 | 28,692 | 3.029 |
| 9/24/73 | 16,039 | 2,366 | 11,398 | 187 | 2,908 | 16,859 | 1.903 |
| 10/1/73 | 16,639 | 3,950 | 10,069 | 144 | 8,563 | 22,726 | 1.464 |
| 10/7 and 10/15/73 | 53,150 | 9,492 | 8,995 | 11,908 | 32,944 | 63,339 | 1.678 |
| 10/22/73 | 40,347 | 7,276 | 6,045 | 25,844 | 15,776 | 54,941 | 1.469 |
| 10/29/73 | 20,813 | 8,409 | 8,160 | 10,860 | 14,964 | 42,393 | 0.982 |
| 11/5/73 | 39,162 | 3,557 | 12,752 | 11,811 | 20,749 | 48,869 | 1.602 |
| 11/12/73 | 31,821 | 1,284 | 19,309 | 6,856 | 17,724 | 45,173 | 1.410 |
| 11/19/73 | 27,579 | 1,435 | 16,695 | 2,012 | 15,577 | 35,719 | 1.544 |
| 11/26/73 | 33,346 | 1,637 | 11,684 | 7,889 | 13,186 | 34,396 | 1.939 |
| 12/3/73 | 37,167 | 3,213 | 10,485 | 5,663 | 7,692 | 27,053 | 2.748 |
| 12/10/73 | 44,138 | 607 | 9,471 | 4,090 | 9,206 | 23,374 | 3.777 |
| 12/17/73 to 12/21/73 | 24,063 | 1,448 | 6,259 | 2,592 | 3,397 | 13,696 | 3.514 |
| 12/21/73 to 12/28/73 | 42,323 | 537 | 8,035 | 372 | 7,761 | 16,705 | 5.067 |
| 12/28/73 to 1/7/74 | 38,623 | 1,897 | 11,941 | 1,868 | 8,670 | 24,376 | 3.169 |

Table C-1. DAILY EMISSION DATA

Date: 8/13/73

| | Dust Collected - (lb) 9:30a.m.- 1:00p.m. | 1:00 p.m.- 3:00 p.m. | Type of Grains Processed |
|---|---|---|---|
| Truck unloading | 114.7 | 55.5 | Mostly corn, some wheat |
| Car unloading | 208.6 | 252.7 | Mostly milo, some wheat |
| Car loading | Not operating | | -- |
| Corn cleaner | Plugged | | -- |
| Gallery belt | 36.4 | 1.1 | Milo |
| Tunnel belt | Not operating | | -- |
| Headhouses | 961.6 | 363.2 | Corn, milo and wheat |

Table C-2. DAILY EMISSION DATA

Date: 8/20/73

| | Dust Collected - (lb) 9:30 a.m.- 1:30 p.m. | 1:30 p.m.- 3:30 p.m. | Type of Grain Processed |
|---|---|---|---|
| Truck unloading | 204.1 | 110.6 | Mostly corn, some wheat, soybean, milo |
| Car unloading | 207.0 | 133.7 | Mostly milo, some wheat |
| Car loading | 65.6 | 29.8 | Wheat |
| Corn cleaner | Plugged | | |
| Gallery belt | 87.9 | 1.1 | Milo |
| Tunnel belt | 150.6 | 55.2 | Wheat |
| Headhouse | 843.2 | 374.4 | Corn, milo and wheat |

Table C-3. DAILY EMISSION DATA

Date: 8/27/73

| | Dust Collected - (lb) 9:00 a.m. - 3:30 p.m. | Type of Grains Processed |
|---|---|---|
| Truck unloading | 347 | Mostly corn |
| Car unloading | Not in operation | |
| Car loading | 123 | Corn and wheat |
| Corn cleaner | Plugged | |
| Gallery belt | Not in operation | |
| Tunnel belt | 176 | Wheat |
| Headhouse | Dust collector not operating | |

Table C-4. DAILY EMISSION DATA

Date: 9/10/73

| | Dust Collected (lb) 9:00 a.m. - 4:00 p.m.[a] | Types of Grain Processed |
|---|---|---|
| Truck unloading | 412.7 | Mostly corn, some wheat and milo |
| Car unloading | 19.6 | No cars unloaded |
| Car loading | 470.4 | Milo and corn |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 497.2 | No grain moved on the belt |
| Headhouse | Dust collector out of service | |

a/ Mid-day quantities of dust collected were not determined.

Table C-5. DAILY EMISSION DATA

Date: 9/24/73

| | Dust Collected (lb) 9:00 a.m.- 1:00 p.m. | Dust Collected (lb) 1:00 p.m.- 3:30 p.m. | Type of Grain Processed |
|---|---|---|---|
| Truck unloading | 164.0 | 34.0 | Corn, wheat and milo |
| Car unloading | 130.4 | 353.7 | Wheat and milo |
| Car loading | 296.9 | 0 | Corn only |
| Corn cleaner | 151.4 | 0 | Corn only |
| Gallery belt | Not in operation | | |
| Tunnel belt | Not in operation | | |
| Headhouse | 3,061 | 460 | Corn, wheat and milo |

Table C-6. DAILY EMISSION DATA

Date: 10/22/73

| | Dust Collected (lb)[a/] 10:00 a.m. - 6:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 416 | Milo, soybean, and corn |
| Car unloading | Not in operation | |
| Car loading | 153 | Wheat and milo |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 644 | Wheat and milo |
| Headhouse | 2,414 | Milo, soybean, and corn |

a/ Not able to obtain mid-day readings.

Table C-7. DAILY EMISSION DATA

Date: 10/29/73

| | Dust Collected (lb) 8:15 a.m.-1:30 p.m. | Dust Collected (lb) 1:30 p.m.-5:15 p.m. | Type of Grain Processed |
|---|---|---|---|
| Truck unloading | 494 | 356 | Milo, soybean, and corn |
| Car unloading | 978 | 381 | Milo and soybean (hoppers and boxcars) |
| Car loading | 69 | 56 | Wheat--mostly hopper cars |
| Corn cleaner | Not in operation | | |
| Gallery belt | Not in operation | | |
| Tunnel belt | 758 | 2 | No grain moved on tunnel belt, dust collected from leg |
| Headhouse | No readings because of low cleaning air pressure on filter. | | |

Table C-8. DAILY EMISSION DATA

Date: 11/26/73

| | Dust Collected (lb) 8:30 a.m.-1:45 p.m. | Dust Collected (lb) 1:45 p.m.-4:30 p.m. | Type of Grain Processed |
|---|---|---|---|
| Truck unloading | 376 | 141 | Corn, milo, SB, wheat |
| Car unloading | 36 | 338 | Milo, corn |
| Car loading | 668 | 139 | Milo |
| Corn cleaner | 149 | 5 | Corn |
| Gallery belt | Not in operation | | -- |
| Tunnel belt | 315 | 534 | Milo |
| Headhouse | 4,240 (total) | | Corn, milo, wheat, SB |

Table C-9. DAILY EMISSION DATA

Date: 12/3/73

| | Dust Collected (lb) | | |
|---|---|---|---|
| | 8:25 a.m.-1:00 p.m. | 1:00 p.m.-4:00 p.m. | Type of Grain Processed |
| Truck unloading | 283 | 156 | Corn, milo, SB |
| Car unloading | No readings - counterwire broken on weigher | | |
| Car loading | Not in operation | | |
| Corn cleaner | Not in operation | | |
| Gallery belt | 64 | 24 | Milo |
| Tunnel belt | Not in operation | | |
| Headhouse | 1,634 | 1,515 | Milo, corn, SB |

Table C-10. DAILY EMISSION DATA

Date: 12/10/73

| | Dust Collected (lb) | | |
|---|---|---|---|
| | 8:40 a.m.- 1:00 p.m. | 1:00 p.m.- 3:30 p.m. | Type of Grains Processed |
| Truck unloading | NA[a/] | NA[a/] | Corn, SB, wheat and milo |
| Car unloading | NA[a/] | NA[a/] | Corn and milo |
| Car loading | 154 | 75 | Milo and corn |
| Corn cleaner | NA[a/] | NA[a/] | Corn |
| Gallery belt | 34 | 0 | Milo and wheat |
| Tunnel belt | 34 | 1 | Milo |
| Headhouse | 1,894 | 1,980 | Milo, wheat, Corn and SB |

a/ Filter not operating properly; low cleaning air pressure.

Table C-11. DAILY EMISSION DATA

Date: 12/17/73

| | Dust Collected (lb) | | |
|---|---|---|---|
| | 8:30 a.m.- 12:00 | 12:00 - 4:00 p.m. | Type of Grains Processed |
| Truck unloading | NA[a/] | 516 | Corn, wheat, milo and SB |
| Car unloading | 0 | 836 | Corn |
| Car loading | 440 | 0 | SB |
| Corn cleaner | 0 | 0 | Not in operation |
| Gallery belt | 0 | 40 | Milo |
| Tunnel belt | 45 | 0 | SB |
| Headhouse | NA[a/] | 2,677 | Corn, milo, SB and wheat |

a/ Filter not operating properly; low cleaning air pressure.

Table D-1. HOURLY EMISSION DATA

Date: 8/13/73

| | Dust Collected - (lb) 1:00 p.m. - 2:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 37.8 | Corn |
| Car unloading | 153.2 | Milo |
| Car loading | Not in operation | |
| Corn cleaner | Plugged | |
| Gallery belt | Not in operation | |
| Tunnel belt | Not in operation | |
| Headhouse | 182.4 | Corn, milo, and wheat |

Table D-2. HOURLY EMISSION DATA

Date: 8/20/73

| | Dust Collected - (lb) 1:30 p.m. - 2:30 p.m. | Type of Grain Processed |
| --- | --- | --- |
| Truck unloading | 67.8 | Mostly corn |
| Car unloading | Not in operation | |
| Car loading | 25.3 | Wheat only |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 36.8 | Wheat only |
| Headhouse | 241.6 | Corn and wheat |

Table D-3. HOURLY EMISSION DATA

Date: 8/20/73

| | Dust Collected - (lb) 2:30 p.m. - 3:30 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 42.8 | Mostly corn |
| Car unloading | 133.7 | Milo |
| Car loading | Not in operation | |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 18.4 | No grain processed, but getting dust from elevator leg |
| Headhouse | 132.8 | Corn and milo |

Table D-4. HOURLY EMISSION DATA

Date: 9/10/73

| | Dust Collected (lb) 9:00 a.m. - 10:00 a.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 86.3 | Mostly corn |
| Car unloading | Not in operation | |
| Car loading | 50.0 | Milo only, hopper cars |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 56.5 | No grain moved on belt |
| Headhouse | Dust collector out of service | |

Table D-5. HOURLY EMISSION DATA

Date: 9/24/73

| | Dust Collected (lb) 1:00 p.m. - 2:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 12 | Corn and milo |
| Car unloading | 194 | Milo and wheat |
| Car loading | Not in operation | |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 51 | No grain moved on belt |
| Headhouse | 372 | Corn, milo and wheat |

Table D-6. HOURLY EMISSION DATA

Date: 10/29/73

| | Dust Collected (lb) 1:30 p.m. - 2:30 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 137 | Soybean and milo |
| Car unloading | 97 | Milo (hoppers and boxcars) |
| Car loading | 33 | Wheat (hopper cars) |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 1 | No grain moved on belt |
| Headhouse | No readings because of low cleaning air pressure on filter | |

Table D-7. HOURLY EMISSION DATA

Date: 11/26/73

| | Dust Collected (lb) 8:30 a.m. - 9:30 a.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 85 | Milo, corn, wheat |
| Car unloading | Not in operation | |
| Car loading | 205 | Milo |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | 129 | Milo |
| Headhouse | 738 | Corn, wheat, milo |

Table D-8. HOURLY EMISSION DATA

Date: 11/26/73

| | Dust Collected (lb) 1:45 p.m. - 2:45 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 68 | SB, corn, wheat |
| Car unloading | Not in operation | |
| Car loading | 109 | Milo |
| Corn cleaner | 4 | Corn |
| Gallery belt | Not in operation | |
| Tunnel belt | Not in operation | |
| Headhouse | 873 | SB, corn, wheat, milo |

Table D-9. HOURLY EMISSION DATA

Date: 12/3/73

| | Dust Collected (lb) 1:00 p.m. - 2:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 29 | Milo, corn |
| Car unloading | Counter-wire broken on weigher | |
| Car loading | Not in operation | |
| Corn cleaner | Not in operation | |
| Gallery belt | Not in operation | |
| Tunnel belt | Not in operation | |
| Headhouse | 275 | Milo, corn |

Table D-10. HOURLY EMISSION DATA

Date: 12/3/73

| | Dust Collected (lb) 2:00 p.m. - 3:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 56 | Milo, corn |
| Car unloading | Counter-wire broken on weigher | |
| Car loading | Not in operation | |
| Corn cleaner | Not in operation | |
| Gallery belt | 22 | Milo |
| Tunnel belt | Not in operation | |
| Headhouse | 801 | Milo, corn |

Table D-11. HOURLY EMISSION DATA

Date: 12/10/73

| | Dust Collected (lb) 10:00 a.m. - 11:00 a.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | NA[a/] | Corn, SB, wheat, and milo |
| Car unloading | 0 | Not in operation |
| Car loading | 34 | Milo |
| Corn cleaner | 0 | Not in operation |
| Gallery belt | 0 | Not in operation |
| Tunnel belt | NA[a/] | Milo |
| Headhouse | 71 | Milo, corn, SB and wheat |

a/ Filter not operating properly; low cleaning air pressure.

Table D-12. HOURLY EMISSION DATA

Date: 12/10/73

| | Dust Collected (lb) 1:00 p.m. - 2:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | NA[a] | Corn, SB, wheat and milo |
| Car unloading | NA[a] | -- |
| Car loading | 28 | Corn |
| Corn cleaner | NA[a] | Corn |
| Gallery belt | 0 | Not in operation |
| Tunnel belt | 0 | Not in operation |
| Headhouse | 851 | Corn, SB, wheat and milo |

a/ Filter not operating properly; low cleaning air pressure.

Table D-13. HOURLY EMISSION DATA

Date: 12/17/73

| | Dust Collected (lb) 11:00 a.m. - 12:00 | Type of Grains Processed |
|---|---|---|
| Truck unloading | NA[a/] | Corn, milo and wheat |
| Car unloading | 0 | Not in operation |
| Car loading | 59 | SB |
| Corn cleaner | 0 | Not in operation |
| Gallery belt | 0 | Not in operation |
| Tunnel belt | 25 | SB |
| Headhouse | NA[a/] | |

a/ Filter not operating properly; low cleaning air pressure.

Table D-14. HOURLY EMISSION DATA

Date: 12/17/73

| | Dust Collected (lb) 2:00 p.m. - 3:00 p.m. | Type of Grain Processed |
|---|---|---|
| Truck unloading | 125 | Corn, wheat, milo and SB |
| Car unloading | 162 | Corn |
| Car loading | 0 | Not in operation |
| Corn cleaner | 0 | Not in operation |
| Gallery belt | 0 | Not in operation |
| Tunnel belt | 0 | Not in operation |
| Headhouse | 1,134 | Corn, wheat, milo and SB |

Table D-15. HOURLY EMISSION DATA

Date: 12/28/73

| | Dust Collected (lb) 10:30 a.m. - 11:30 a.m. | Type of Grains Processed |
|---|---|---|
| Truck unloading | 43 | Corn and milo |
| Car unloading | 0 | Not in operation |
| Car loading | 157 | Milo |
| Corn cleaner | 0 | Not in operation |
| Gallery belt | 0 | Not in operation |
| Tunnel belt | 526 | Milo |
| Headhouse | 2,234 | Milo and corn |

Table D-16. HOURLY EMISSION DATA

Date: 12/28/73

| | Dust Collected (lb) 2:00 p.m.-3:00 p.m. | Type of Grains Processed |
|---|---|---|
| Truck unloading | 10 | Corn |
| Car unloading | 0 | Not in operation |
| Car loading | NA[a] | Milo |
| Corn cleaner | 0 | Not in operation |
| Gallery belt | 0 | Not in operation |
| Tunnel belt | 219 | Milo |
| Headhouse | 2,468 | Corn and milo |

a/ Filter not operationg properly; low cleaning air pressure.

SELECTED WATER
RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

W

Potential Dust Emissions From a Grain Elevator in Kansas City, Missouri

Paul G. Gorman

Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

68-02-0228, Task No. 24

A program was conducted at a terminal elevator in Kansas City to obtain information on the quantity of dust collected by each of seven filter systems associated with specific operations in the elevator.

Determination of the amount of dust collected by each system was made by mechanical weighers installed on the dust chutes from each filter to continuously monitor the amount of dust being discharged. Readings were taken on the mechanical weighers once each week, and the amount of each type of grain processed by the seven grain-handling operations was obtained from the elevator operating records for the corresponding weekly period. Long-term (weekly) composite emission factors were calculated for each operation.

In addition to determining long-term emission factors, the weighers were also used to obtain short-term emission data so that emission factors could be calculated according to grain type and grain quality, and to characterize the total potential dust emissions from the elevator on a weekly, daily, and hourly basis. Average emission factors were used to compute cumulative emission factors that can be used to project potential dust emissions from a terminal elevator on the basis of the amount of grain handled.

Air Pollution
Grain Industry
Processes
Emissions
Control Systems

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WASHINGTON, D.C. 20240

Paul G. Gorman | Midwest Research Institute