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# EMISSION FACTOR DEVELOPMENT FOR THE FEED AND GRAIN INDUSTRY

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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by

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## ABSTRACT

This report contains an evaluation of available data used to develop emission factors for alfalfa dehydration plants, grain elevators and other feed and grain operations.

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Physical Sciences Division

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# INTRODUCTION

The work in this report was performed by MRI for EPA as Task Order No. 22 on Contract No. 68-02-1324. The objective of this work was to develop emission factors for the feed and grain industry by examination and evaluation of available data. Results of that effort are described in this report, which is divided into two sections of two parts each. The major sections are titled

Alfalfa Dehydration Plants
Feed and Grain Plants

The first part of each major section summarizes the emission factors that were developed, describes the processes and describes control methods while the second part of each section presents background and support information for those emission factors.

# ALFALFA DEHYDRATION PLANTS

## EMISSION FACTORS

### General

The dehydration of alfalfa for the production of alfalfa meal is the primary objective of an alfalfa dehydration plant. Dehydrated alfalfa is important for its protein quality, unidentified growth and reproductive factors, pigmenting xanthophylls, and vitamin contributions.

The process carried out at most dehydration plants is essentially that shown in Figure 1. Standing alfalfa is mowed and chopped in the field a and is transported by truck to the dehydrating plant which is located near the field (usually within 10 miles). The truck dumps the chopped alfalfa onto a self feeder which carries it into a drying drum. The drying drum, a direct-fired rotary unit, subjects the alfalfa to high temperature combustion gases (approximately 1800°F at the inlet and 275°F at the outlet) and evaporates the water from about 77% $H_2O$ in green chops down to 8% $H_2O$ in dry chops. From the drying drum, the high moisture gases and dry chops enter the primary cyclone which separates the product from the gases. The material separated in the primary cyclone next enters the grinding machine, normally a hammermill, which reduces the dehydrated chops to a powder referred to as "meal." The meal enters a pneumatic conveyor that discharges into a meal collection cyclone which separates the meal from the conveying air. The collected meal is then usually fed to a pelletizing machine. Product meal or pellets may be stored prior to shipment or they may be loaded out directly from the process.

### Emissions and Controls

Emissions from alfalfa dehydrating plants are indicated in Figure 1 and include dust from the primary cyclone, meal collector cyclone, pellet collector cyclone and pellet cooler. Although these sources are common to many plants there are several process variations in which secondary

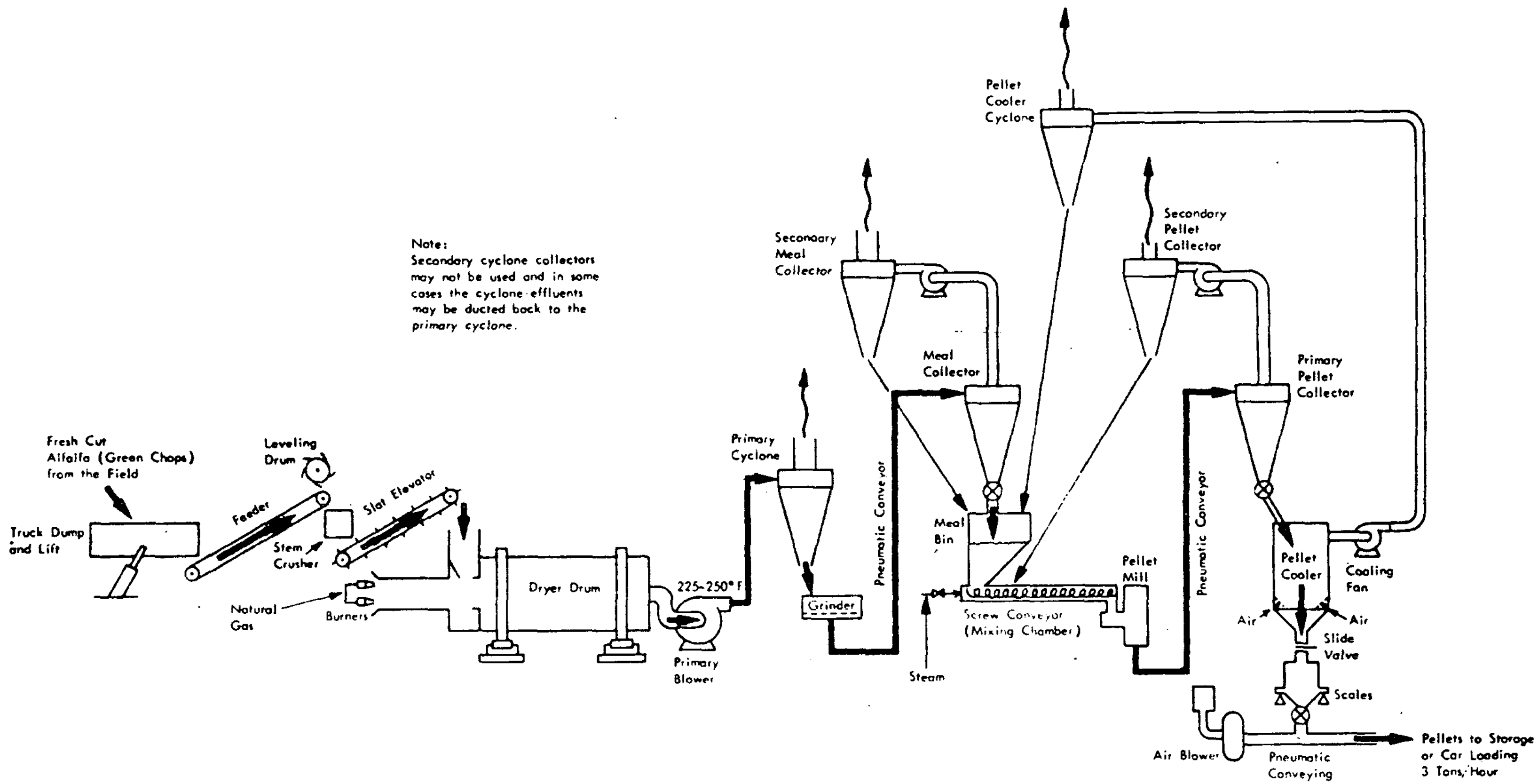


Figure 1. Generalized flow diagram for alfalfa dehydration plant.

cyclones may or may not be used, (e.g., some sources ducted to a common secondary cyclone, or some sources are ducted back to the primary cyclone, etc.). A number of tests have been conducted to measure emissions from alfalfa dehydration plants and included plants that employ some of process variations described above. Results of that testing are summarized in Table 1.

Data shown in Table 1 were obtained from actual source tests at alfalfa dehydration plants. These data, as well as discussions with plant operators and others knowledgeable in the field, have led to the conclusion that the greatest portion of the particulate emissions comes from the drying operation, i.e., the primary cyclone. From this same information it is estimated that the total plant emission factor for an alfalfa dehydration facility would be about 20 lb/ton of product (meal or pellets) as shown in Table 2. However, much of the data used in arriving at this figure was based on testing at plants which reportedly were well "tuned" prior to testing or in some cases operated below capacity.[3/] It is therefore possible that the emission factor of 20 lb/ton may be below the industry average and an individual plant could be emitting considerably more than 20 lb/ton of product.

In the past, control of emissions has been directed to the meal collector cyclone, etc., because of the difficulties involved in controlling the high moisture content effluent from the primary cyclone. These sources have primarily been controlled with cyclones but some plants have installed fabric filters. More recently there has been a concentrated effort by the American Dehydrators Association and individual plants to investigate control methods for the effluent from the primary cyclone. Most of the devices that have been investigated, and full-scale units that have been installed on a few plants, consisted of some type of low-pressure drop wet scrubber. References Nos. 1, 2, and 3 contain descriptions and cost information for some of these control methods.

Table 1. PARTICULATE EMISSION FACTOR DATA FOR ALFALFA DEHYDRATION PLANT EQUIPMENT

| Emission sources | Lb/ton of product | Kg/MT of product |
|---|---|---|
| Primary cyclone (Dryer only) | 14.22[a] | 7.11[a] |
| Primary cyclone (Dryer only) | 15.02[b] | 7.51[b] |
| Primary cyclone (Dryer and Hammermill) | 14.28[a] | 7.14[a] |
| Primary cyclone (Dryer and all other sources) | 17.46[a] | 8.73[a] |
| Meal collection cyclone | 2.6[a] | 1.3[b] |
| Pellet cooler cyclone | 3.2[b] | 1.6[b] |
| Pellet regrind cyclone[c] | 8.0[b] | 4.0[b] |

a/ Reference No. 1.
b/ Reference No. 2.
b/ Pellet regrind is a special operation that is not normally a part of the processing operation.

Table 2. TOTAL EMISSION FACTOR FOR ALFALFA DEHYDRATION PLANT

| Type of operation | Lb/ton of product[a] | Kg/MT of product[a] |
|---|---|---|
| Total emissions from uncontrolled plant | 20.0[b] | 10.0 |

a/ Product consists of meal and/or pellets.
b/ Reference No. 2.

References

1. Smith, K. D., "Particulate Emissions from Alfalfa Dryers - The Effectiveness and Cost of Control," Interim Report, American Dehydrators Association, Prepared for Environmental Protection Agency (Grant No. R801446), April 1973.

2. Shannon, L. J., R. W. Gerstle, P. G. Gorman, D. M. Epp, T. W. Devitt, and R. Amick, "Emissions Control in the Grain and Feed Industry Volume I - Engineering and Cost Study," Final Report by Midwest Research Institute, Prepared for Environmental Protection Agency Document No. EPA 450/3-73-003a, December 1973.

3. Smith, K. D., "Particulate Emissions from Alfalfa Dehydrating Plants Control Costs and Effectiveness," Final Report by American Dehydrators Association, Prepared for Environmental Protection Agency, Document No. EPA-650/2-74-007, January 1974.

## BACKGROUND AND SUPPORT INFORMATION FOR EMISSION FACTORS FOR ALFALFA DEHYDRATION PLANTS

### Air Pollution Emission Rate from Alfalfa Dehydrators

Emissions from alfalfa dehydrating plants include dust from the various cyclone separators, and odors from the volatile matter driven off the alfalfa.

In comparison to the other segments of the grain and feed industry, a significant amount of source testing has been done to characterize the emissions from dehydration plants.[1,2] Midwest Research Institute has recently completed two source testing programs for the American Dehydrators Association (ADA). References 1 and 2 present the results of the testing programs in detail and a summary is given in the following paragraphs.

Reference 1 describes the field testing program conducted by MRI for the ADA during the Summer of 1971, at four plants which had been selected by ADA as representative of this industry. Particulate emissions and process conditions were measured at the four alfalfa dehydrating mills for both normal and extreme process operating conditions.

Source tests were performed to determine the particulate emission rate from a given source. The emission-rate test consisted of the measurement of effluent flowrate and temperature, dust loading, and carrier gas composition (moisture and Orsat analysis). For these measurements, EPA Method 5 and the Research Appliance Company Model 2343 "Staksamplr" equipment were used. Integrated particulate samples representative of the entire duct cross-section were collected by sampling for equal amounts of time over a network of properly distributed points. For each test the duration of sampling range from 30 to 60 min so that short-term fluctuations in emissions were averaged out.

Process parameters were measured during testing. These parameters have been classified into three groups: (1) raw materials, (2) product (pellets), and (3) process operating conditions relating to drying, grinding and pelleting of the alfalfa. These quantities were measured periodically during testing.

A comparison of available emission factor data, for the particulate sources in the dehydrating process, is shown in Table 3. There are considerable differences in the data from the different information sources. The emission factors for the primary cyclone (which include

Table 3. COMPARISON OF ALFALFA DEHYDRATION PLANT EMISSION FACTOR DATA (lb/ton)[a]

**Primary cyclone**

| Ref. 1 | Ref. 2 | Ref. 3 | Ref. 4 |
|---|---|---|---|
| 4.6[b] | 3.03[c] | 2.25 | 4.8[b] |
| 4.6[d] | 4.99 | 3.25 | 1.9[b] |
| 5.2[b] | 1.72 | | 1.0[b] |
| 4.4 | 1.42 | Avg. 2.75 | 0.8[b] |
| 6.5 | 3.12 | | 1.6[b] |
| 2.6[d] | | | 2.7[b] |
| | Avg. 2.86 | | 3.0[d] |
| Avg. 4.65 | | | 1.2 |
| | | | 0.6[d] |
| | | | Avg. 2.0 |

**Secondary cooling cyclone**

| Ref. 4 |
|---|
| 1.25 |
| 0.72 |
| Avg. 1.0 |

**Meal collection cyclone(s)**

| Ref. 1 | Ref. 4 |
|---|---|
| 0.65 | 2.25 |
| | 12.0 |
| | Avg. 7.1 |

**Pellet cooler cyclone**

| Ref. 1 | Ref. 4 |
|---|---|
| 0.65 | 0.25 |
| 0.53[e] | 1.5 |
| Avg. 0.8 | |

**Pellet regrind**

| Ref. 1 | Ref. 4 |
|---|---|
| 2.0 | 0.5 |

a/ All emission data expressed as pounds per ton of green chops. This may be converted to pounds per ton of meal by the following approximate relationship:[5] (lb/ton of chops) x (4) ≈ lb/ton of meal.

b/ Includes discharge from meal collector cyclone and pellet cooler cyclone.

c/ All sources ducted to primary cyclone.

d/ Includes discharge from meal collector cyclone.

e/ Sum of pellet collector and pellet cooler cyclone discharges.

other significant sources in some cases) are highest for the data in Reference 1, and show a range of 2.6 to 6.5 lb/ton chops and an average of 4.65 lb/ton of chops. However, emissions from the other sources are lower in Reference 1 than Reference 3, especially from the meal collection cyclone. These variations may be due to differences in control equipment, measurement techniques or plant operating conditions. Data in Reference 1, for emissions from the meal collector, were taken at the outlet of the secondary cyclone that is in series with the primary cyclone which should help to reduce the emissions. The emissions from the primary cyclone reported in References 1 and 2 also include, in some cases, the effluents from other sources that are ducted to the primary cyclone. This could add to the effluent from the primary cyclone, but the total emissions may be less than they would be if the effluent from other sources were allowed to vent to atmosphere.

Although the data reported in References 1 and 2 represent relatively well controlled plants, the measurement techniques are significantly different than those used in References 3 and 4. Measurements in References 1 and 2 were according to EPA Method 5 and included duct extensions for the cyclone outlets. At least part of the sampling reported in Reference 3 was performed right at the cyclone outlet which makes it difficult to obtain accurate results. While differences in the emission factors may be partly caused by the type of primary cyclone and the measurement techniques, it is also known that emissions from these plants can vary widely due to quality of the alfalfa (moisture and protein content) and operating conditions (over drying or under drying, etc.).

Examination of the available data plus many plant visits and discussions with plant operators and others knowledgeable in the field have led to the conclusion that the greatest portion of the dust emission from an alfalfa dehydrating plant comes from the drying operation (i.e., the primary cyclone). The data in Table 3 show that the average emission factor for the primary cyclone varies from 2.0 to 4.65 lb/ton of chops. The data reported in References 1 and 2 were obtained using EPA Method 5 procedures so these are probably the most accurate value available. The average of these two values (2.86 and 4.65) indicate that the overall average would be 3.75 lb/ton of green chops. This is approximately equivalent to 15.0 lb/ton of meal,[5/] which is much lower than the emission factor of 60 lb/ton of meal specified in Reference 6. The factor in Reference 6 was apparently based on data from Reference 3. These data were obtained prior to 1960, using techniques that are probably not as accurate as the recent EPA procedures. It is therefore felt that the emission factor of 15 lb/ton of meal is more representative for the primary cyclone and that the total plant emission factor probably does not exceed 20 lb/ton of meal. More complete information on test data and evaluation of results is contained in Reference 5.

References

1. Smith, K.D., "Particulate Emissions from Alfalfa Dryers - The Effectiveness and Cost of Control," Interim Report, American Dehydrators Association, Prepared for Environmental Protection Agency (Grant No. R801446), April 1973.

2. Cowherd, C., "Particulate Emissions and Process Conditions at Representative Alfalfa Dehydrating Mills," Final Report, Midwest Research Institute, Prepared for American Dehydrators Association, 19 November 1971.

3. "Air Pollution from Alfalfa Dehydrating Mills," USDHEW Technical Report A60-4 (1960).

4. Private Communication, Mr. Kenneth Smith, American Dehydrators Association, September 1969.

5. Shannon, L. J., et al., "Emissions Control in the Grain and Feed Industry Volume I - Engineering and Cost Study," Final Report by Midwest Research Institute for EPA under Contract No. 68-02-0213 (EPA Publication 450/3-73-003a), December 1973.

6. Compilation of Air Pollutant Emission Factors, EPA Publication AP-42, February 1972.

# FEED AND GRAIN MILLS AND ELEVATORS

## EMISSION FACTORS

### General

Grain elevators are transfer and storage areas for grain and are usually classified as either country, terminal, or export elevators. Country elevators generally receive grains as they are harvested from fields within a 10- to 20-mile radius of the elevator. The country elevators unload, weigh and store grain as it is received from the farmer. In addition, the country elevator may dry or clean the grain before it is shipped to the terminal elevators or processors.

Terminal elevators receive most of their grain from country elevators and ship to processors, other terminals, and exporters. The primary function of a terminal elevator is to store grain in quantity without deterioration and to bring it to commercial grade so as to conform to the needs of buyers. As with country elevators, terminals dry, clean and sort grain. In addition, they can blend grain to meet buyer specifications.

Export elevators are similar to terminal elevators with the exception that they mainly load grain on ships for export.

The other types of operations involved in the processing of grain, in grain and feed plants, range from very simple mixing steps to complex processes which are characteristic of industrial processing plants. Included are such diverse processes as: (a) simple mixing processes in feed mills; (b) grain milling in flour mills; (c) solvent extracting in soybean processing plants; and (d) a complex series of processing steps in a corn wet-milling plant.

Emissions and Controls

Grain handling, milling and processing include a variety of operations from the initial receipt of the grain at either a country or terminal elevator to the delivery of a finished product. Flour, livestock feed, soybean oil and corn syrup are among the products produced from plants in the grain and feed industry. Emissions from the feed and grain industry can be separated into two general areas, those occurring at grain elevators and those occurring at grain processing operations.

Grain Elevators - Grain elevator emissions can occur from many different operations in the elevator including unloading (receiving), loading (shipping), drying, cleaning, headhouse (legs), tunnel belt, and trippers, etc. Emissions factors for these operations at terminal, country and export elevators are presented in Table 4. The emission factors for unloading operations are assumed to be from trucks for country elevators and trucks and railroad cars for terminal and export elevators. Emission factors for removal of grain from the storage bins (i.e., tunnel belt drop-points) were based on a study done at a terminal elevator.[1/] The headhouse (legs) emission factor is also based on the terminal elevator study.[1/] Drying and cleaning emission factors are based mainly on data reported in References 1, 2, and 3.

The emission factors shown in Table 4 represent the amount of dust generated per ton of grain processed through each of the designated operations (i.e., uncontrolled emission factors). Amounts of grain processed through each of these operations in a given elevator is dependent on such factors as the amount of grain turned (interbin transfer), amount dryed, and amount cleaned, etc. Because the amount of grain passing through each operation is often difficult to determine, it may be more useful to express the emission factors in terms of the amount of grain shipped or received, assuming these amounts are about the same over the long term. Emission factors from Table 4 have been modified accordingly and are shown in Table 5 along with the appropriate multiplier that was used as representative of typical ratios of throughput at each operation to the amount of grain shipped or received. This ratio is an approximate value based on average values for turning, cleaning, and drying in each type of elevator. However, operating practices in individual elevators are different, so these ratios, like the basic emission factors themselves, would be more valid for a group of elevators rather than individual elevators.

Table 4. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS[1-3]

| Type of source | Emission factor (uncontrolled)[a] (lb/ton) | (kg/MT) |
|---|---|---|
| Terminal of elevators | | |
| Unloaded (receiving) | 1.00 | 0.50 |
| Loading (shipping) | 0.27 | 0.14 |
| Removal from bins (tunnel belt) | 1.40 | 0.70 |
| Drying[b] | 1.05 | 0.52 |
| Cleaning | 6.00 | 3.00 |
| Headhouse (legs) | 1.50 | 0.75 |
| Tripper (gallery belt) | 1.00 | 0.50 |
| Country elevators | | |
| Unloading (receiving) | 0.64 | 0.32 |
| Loading (shipping) | 0.27 | 0.13 |
| Removal from bins | 1.40 | 0.70 |
| Drying[b] | 0.68 | 0.34 |
| Cleaning | 6.00 | 3.00 |
| Headhouse (legs) | 1.50 | 0.75 |
| Export elevators | | |
| Unloading (receiving) | 1.00 | 0.50 |
| Loading (shipping) | 1.00 | 0.50 |
| Removal from bins (tunnel belt) | 1.40 | 0.70 |
| Drying[b] | 1.05 | 0.52 |
| Cleaning | 6.00 | 3.00 |
| Headhouse (legs) | 1.50 | 0.75 |
| Tripper (gallery belts) | 1.00 | 0.50 |

a/ Emission factors are in terms of pounds of dust emitted per ton of grain processed by each source.

b/ Emission factors for drying are based on 1.8 lb/ton for rack dryers and 0.3 lb/ton for column dryers prorated on the basis of distribution of these two types of dryers in each elevator category, as discussed in Reference 3.

Table 5. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS BASED ON AMOUNT OF GRAIN RECEIVED OR SHIPPED[a]

| Type of Source | Emission Factor lb/ton processed | x | Typical Ratio of Tons Processed to Tons Received or Shipped[a] | = | Emission Factor lb/ton received or shipped |
|---|---|---|---|---|---|
| **Terminal Elevators** | | | | | |
| Unloading (receiving) | 1.00 | | 1.00 | | 1.00 |
| Loading (shipping) | 0.27 | | 1.00 | | 0.27 |
| Removal from bins (tunnel belt) | 1.40 | | 2.03 | | 2.84 |
| Drying[b] | 1.05 | | 0.10 | | 0.11 |
| Cleaning | 6.00 | | 0.22 | | 1.32 |
| Headhouse (legs) | 1.50 | | 3.03 | | 4.55 |
| Tripper (gallery belt) | 1.00 | | 1.71 | | 1.71 |
| **Country Elevators** | | | | | |
| Unloading (receiving) | 0.64 | | 1.00 | | 0.64 |
| Loading (shipping) | 0.27 | | 1.00 | | 0.27 |
| Removal from bins | 1.40 | | 2.08 | | 2.91 |
| Drying[b] | 0.68 | | 0.25 | | 0.17 |
| Cleaning | 6.00 | | 0.08 | | 0.48 |
| Headhouse (legs) | 1.50 | | 3.08 | | 4.62 |
| **Export Elevators** | | | | | |
| Unloading (receiving) | 1.00 | | 1.00 | | 1.00 |
| Loading (shipping) | 1.00 | | 1.00 | | 1.00 |
| Removal from bins (tunnel belt) | 1.40 | | 1.23 | | 1.72 |
| Drying[b] | 1.05 | | 0.01 | | 0.01 |
| Cleaning | 6.00 | | 0.15 | | 0.90 |
| Headhouse (legs) | 1.50 | | 2.23 | | 3.35 |
| Tripper (gallery belt) | 1.00 | | 1.07 | | 1.07 |

a/ Assumed that over the long term the amount received is approximately equal to amount shipped.
b/ See note b/ in Table 4.

In this same regard, the factors in Tables 4 or 5 should not be added together in an attempt to obtain a single emission factor value for grain elevators because in most elevators some of the operations are equipped with control devices and some are not. Therefore, any estimation of emissions must be directed to each operation and its associated control device, rather than the elevator as a whole, unless the purpose was to estimate total potential (i.e., uncontrolled) emissions. An example of the use of emission factors in making an emission inventory is contained in Reference 3.

Some of the operations listed in the tables, such as the tunnel belt and tripper, are internal or in-house dust sources which, if uncontrolled, might show lower than expected atmospheric emissions because of internal settling of dust. On the other hand, the reduction in emissions via internal settling is not known and it is quite possible that all of this dust is eventually emitted due to subsequent external operations, internal ventilation or other means.

As mentioned above, many elevators utilize control devices on at least some sources. In the past, cyclones have commonly been applied to such sources as legs in the headhouse and tunnel belt hooding systems. More recently, fabric filters have been utilized at many elevators on almost all types of sources. However, some sources in grain elevators do present control problems. Control of loadout operations is one source that is difficult to control because of the problem of containment of the emissions. Probably the most difficult source to control, because of the large flowrate and high moisture content of the exhaust gases, is the dryers. Screen-houses or continuously vacuumed screen systems are available for reducing dryer emissions and have been applied at several facilities. Detailed descriptions of dust control systems for grain elevator operations, and their estimated costs, are contained in Reference 2.

<u>Grain Processing Operations</u> - Grain processing operations include many of the operations performed in a grain elevator in addition to milling and processing of the grain. Emission factors for different grain milling and processing operations are presented in Table 6. Brief discussion of these different operations and the methods used for arriving at the emission factor values shown in Table 6 are presented below.

Table 6. PARTICULATE EMISSION FACTORS FOR GRAIN PROCESSING OPERATIONS[1,2,3]

| Type of source | Emission factor[a,c] (uncontrolled except where indicated) (lb/ton) | (kg/MT) |
|---|---|---|
| **Feed Mills** | | |
| Receiving | 1.30 | 0.65 |
| Shipping | 0.50 | 0.25 |
| Handling | 3.00 | 1.50 |
| Grinding | 0.10[b] | 0.05[b] |
| Pellet coolers | 0.10[b] | 0.05[b] |
| **Wheat Mills** | | |
| Receiving | 1.00 | 0.50 |
| Precleaning and handling | 5.00 | 2.50 |
| Cleaning house | -- | -- |
| Millhouse | 70.00 | 35.00 |
| **Durum Mills** | | |
| Receiving | 1.00 | 0.50 |
| Precleaning and handling | 5.00 | 2.50 |
| Cleaning house | -- | -- |
| Millhouse | -- | -- |
| **Rye Milling** | | |
| Receiving | 1.00 | 0.50 |
| Precleaning and handling | 5.00 | 2.50 |
| Cleaning house | -- | -- |
| Millhouse | 70.00 | 35.00 |
| **Dry Corn Milling** | | |
| Receiving | 1.00 | 0.50 |
| Drying | 0.50 | 0.25 |
| Precleaning | 5.00 | 2.50 |
| Cleaning house | 6.00 | 3.00 |
| Degerming and milling | -- | -- |

a/ Emission factors are expressed in terms of pounds of dust emitted per ton of grain entering the plant (i.e., received), which is not necessarily the same as the amount of material processed by each operation.

b/ Controlled emission factors.

c/ --Blanks indicate insufficient information.

Table 6. (Concluded)

| Type of source | Emission factor[a,c] (uncontrolled except where indicated) (lb/ton) | (kg/MT) |
|---|---|---|
| Oat Milling | | |
| Total | 2.50[b] | 1.25[b] |
| Rice Milling | | |
| Receiving | 0.64 | 0.32 |
| Handling and precleaning | 5.00 | 2.50 |
| Drying | -- | -- |
| Cleaning and millhouse | -- | -- |
| Soybean Mills | | |
| Receiving | 1.60 | 0.80 |
| Handling | 5.00 | 2.50 |
| Cleaning | -- | -- |
| Drying | 7.20 | 3.60 |
| Cracking and dehulling | 3.30 | 1.65 |
| Hull grinding | 2.00 | 1.00 |
| Bean conditioning | 0.10 | 0.05 |
| Flaking | 0.57 | 0.29 |
| Meal dryer | 1.50 | 0.75 |
| Meal cooler | 1.80 | 0.90 |
| Bulk loading | 0.27 | 0.14 |
| Corn Wet Milling | | |
| Receiving | 1.00 | 0.50 |
| Handling | 5.00 | 2.50 |
| Cleaning | 6.00 | 3.00 |
| Dryers | -- | -- |
| Bulk loading | -- | -- |

Emission factor data for feed mill operations are sparse. This is partly due to the fact that many ingredients; whole grain and other dusty materials (bran, dehy alfalfa, etc.) are received by both truck and rail and several unloading methods are employed. However, some operations (handling, shipping, and receiving) for a feed mill are similar to operations in a grain elevator, so an emission factor for each of these different operations was estimated on this basis. The remaining operations were estimated from the best information available.[2/]

Three emission areas for wheat mill processing operations are grain receiving and handling, cleaning house, and milling operations. Data from a grain elevator study[1/] were used to estimate emission factors for grain receiving and handling. Data for the cleaning house were insufficient to estimate an emission factor and information taken from Reference 2 was used to estimate the emission factor for milling operations. The large emission factor for the milling operation is somewhat misleading because almost all of the sources involved are equipped with control devices to prevent product losses and fabric filters are widely used for this purpose.

Operations for durum mills and rye milling are similar to those of wheat milling. Therefore, most of these emission factors are equal to those for wheat mill operations.

The grain unloading, handling and cleaning operations for dry corn milling are similar to those in other grain mills but the subsequent operations are somewhat different. Also, some drying of corn received at the mill may be necessary prior to storage. An estimate of the emission factor for drying was obtained from Reference 2. Insufficient information was available to estimate emission factors for degerming and milling.

Information necessary to estimate emissions from oat milling was unavailable. It was also felt to be unwise to attempt to use emission factor data for other grains because handling of oats is reported to be dustier than many other grains. The only emissions factor data that were available were for controlled emissions.[2/] An overall controlled emission factor of 2.5 lb/ton was calculated from this data.

Emission factors for rice milling were based on those for similar operations in other grain handling facilities. Insufficient information was available to estimate emission factors for drying, cleaning and mill house operations.

Information taken from Reference 2 was used to estimate emission factors for soybean mills.

Information on corn wet-milling emission factors was unavailable in most cases due to the wide variety of products and the diversity of operations. Receiving, handling and cleaning operations emission factors were assumed to be similar to those for dry corn milling.

Many of the operations performed in grain milling and processing plants are the same as those in grain elevators, so the control methods are similar. As in the case of grain elevators, these plants often use cyclones or fabric filters to control emissions from the grain handling operations (e.g., unloading, legs, cleaners, etc.). These same devices are also often used to control emissions from other processing operations and a good example of this is the extensive use of fabric filters in flour mills. However, there are also certain sources within some milling operations that are not amenable to use of these devices. Therefore, wet scrubbers have found some application, particularly where the effluent gas stream has high moisture content. Certain other sources have been found to be especially difficult to control, and one of these is the rotary dryers in wet corn mills. Descriptions of the emission control systems that have been applied to sources within the grain milling and processing industries are contained in Reference 2.

References


1. Gorman, P. G., "Potential Dust Emission From a Grain Elevator In Kansas City, Missouri," Final Report, prepared for Environmental Protection Agency, May 1974.

2. Shannon, L. J., R. W. Gerstle, P. G. Gorman, D. M. Epp, T. W. Devitt, and R. Anick, "Emission Control In the Grain and Feed Industry Volume I - Engineering and Cost Study," Final Report by Midwest Research Institute prepared for Environmental Protection Agency, Document No. EPA-450/3-73-003a, December 1973.

3. Shannon, L. J., P. G. Gorman, M. P. Schrag, D. Wallace, "Emission Control in the Grain and Feed Industry Volume II - Emission Inventory," Final Report by Midwest Research Institute prepared for Environmental Protection Agency, July 1974.

## BACKGROUND AND SUPPORT INFORMATION FOR EMISSION FACTORS FOR FEED AND GRAIN MILLS AND ELEVATORS

### General

Grain elevators are transfer and storage areas for grain and are usually classified as either country, terminal or export elevators. Country elevators generally receive grain or soybeans as they are harvested from fields within a 10- to 20-mile radius of the elevator. The country elevators unload, weigh and store grain as it is received from the farmer. In addition, the country elevator may dry or clean the grain before it is shipped to the terminal elevators or processors.

Terminal elevators receive most of their grain from country elevators and ship to processors, other terminals, and exporters. The primary function of a terminal elevator is to store grain in quantity without deterioration and to bring it to commercial grade so as to conform to the needs of buyers. As with country elevators, terminals dry, clean and store grain. In addition, they can blend grain to meet buyer specifications.

Export elevators are similar to terminal elevators with the exception that they mainly load grain on ships for export.

The other types of operations involved in the processing of grain in grain and feed plants range from very simple mixing steps to complex processes which are characteristic of industrial processing plants. Included are such diverse processes as: (a) simple mixing processes in feed mills; (b) grain milling in flour mills; (c) solvent extracting in soybean processing plants; and (d) a complex series of processing steps in a corn wet-milling plant.

### Emissions and Controls

Grain handling, milling, and processing include a variety of operations from the initial receipt of the grain at either a country or terminal elevator to the delivery of a finished product. Flour, livestock feed, soybean oil and corn syrup are among the products produced from plants in the grain and feed industry. Emissions from the feed and grain industry can be separated into two general areas, those occurring at grain elevators and those occurring at grain processing operations.

Grain Elevators - Grain elevator emissions can occur from many different operations in the elevator, including unloading (receiving), loading (shipping), drying, cleaning, headhouse (legs), tunnel belt, and trippers (primarily for terminal and export elevators). Emissions factors for several of these operations are presented in Table 7.

Emissions factors for unloading operations are assumed to be from trucks for country elevators and trucks and railroad cars for terminal and export elevators. Emission factors for removal of grain from storage bins were based on a study done on a terminal elevator[1] and considered the fact that grain is often turned at a country elevator by returning it into the receiving pit. The headhouse (legs) emission factor is also based on the terminal elevator study.[1] Drying and cleaning emission factors are based mainly on data collected from a feed and grain study[2,3] and the previously mentioned elevator study.[1]

The emission factors shown in Table 7 represent the amount of dust generated per ton of grain processed through each of the designated operations (i.e., uncontrolled emission factors). Amounts of grain processed through each of these operations in a given elevator are dependant on such factors as the amount of grain turned (interbin transfer), amount dryed, and amount cleaned, etc. Because the amount of grain passing through each operation is often difficult to determine, it may be more useful to express the emission factors in terms of the amount of grain shipped or received, assuming these amounts are about the same over the long term. Emission factors from Table 7 have been modified accordingly and are shown in Table 10 along with the appropriate mulitiplier that was used as representative of typical ratios of throughput at each operation to the amount of grain shipped or recieved. This ratio is an approximate value based on average values for turning, cleaning, and drying in each type of elevator, as explained in Table 11. However, operating practices in individual elevators are different, so these ratios, like the basic emission factors themselves, would be more valid for a group of elevators rather than individual elevators.

In this same regard, the factors given in the tables should not be added together in an attempt to obtain a single emission factor value for grain elevators because in most elevators some of the operations are equipped with control devices and some are not. Therefore, any estimation of emissions must be directed to each operation and its associated control device, rather than to the elevator as a whole, unless the purpose was to estimate total potential (i.e., uncontrolled) emissions. An example of the use of emission factors in making an emission inventory is contained in Reference 3.

Table 7. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS

| Type of source | Emission factors[a] (uncontrolled) (lb/ton) | (kg/MT) |
|---|---|---|
| Terminal elevators | | |
| Unloading (receiving) | 1.00[b] | 0.50 |
| Loading (shipping) | 0.27[c] | 0.14 |
| Removal from bins (tunnel belt) | 1.40[d] | 0.70 |
| Drying | 1.05[e] | 0.52 |
| Cleaning | 6.00[f] | 3.00 |
| Headhouse (legs) | 1.50[g] | 0.75 |
| Tripper (gallery belt) | 1.00[h] | 0.50 |
| Country elevators | | |
| Unloading (receiving) | 0.64[i] | 0.32 |
| Loading (shipping) | 0.27[j] | 0.13 |
| Removal from bins (tunnel belt) | 1.40[k] | 0.70 |
| Drying | 0.68[l] | 0.34 |
| Cleaning | 6.00[m] | 3.00 |
| Headhouse (legs) | 1.50[n] | 0.75 |
| Export elevators[o] | | |
| Unloading (receiving) | 1.00 | 0.50 |
| Loading (shipping) | 1.00[p] | 0.50 |
| Removal from bins (tunnel belt) | 1.40 | 0.70 |
| Drying | 1.05 | 0.52 |
| Cleaning | 6.00 | 3.00 |
| Headhouse (legs) | 1.50 | 0.75 |
| Tripper (gallery belt) | 1.00 | 0.50 |

a/ Emission factors are in terms of pounds of dust emitted per ton of grain processed by each source.

b/ Emission factor of 1.00 lb/ton for unloading is based on Kansas City elevator study.[1] Table 8 shows the values for truck unloading (0.64) and car unloading (1.30). These data are supported by data in Table 9 taken from Reference 2.

c/ The emission factor for loading was taken from the Kansas City elevator study[1] which shows a value of 0.27 lb/ton for car loading (Table 8). Emission factor for truck loading was not determined but is not expected to be significantly different.

d/ Emission factor of 1.40 lb/ton is based on tunnel belt emission factor of 1.40 determined in the Kansas City elevator study (Table 8).[1]

e/ Emission factor of 1.05 lb/ton for drying was based on dryer emissions, discussed in Appendix A, of 0.3 lb/ton for column dryers and 1.8 for rack dryers. Other survey data indicate ratio of column to rack dryers at terminal elevators is about 1:1, so an average emission factor of 1.05 lb/ton was used.

f/ An emission factor of 6.00 lb/ton for cleaning is based on the Kansas City elevator study[1] which showed a value of 5.78 lb/ton (for corn) in Table 8.

g/ An emission factor for 1.5 lb/ton for the headhouse is from the Kansas City elevator study[1] and is shown by Table 8. This value includes garner and scale.

h/ The emission factor for the tripper, of 1.00 lb/ton, is an estimate based on factors for other sources and observations of tripper emissions.

i/ The emission factor of 0.64 lb/ton for truck unloading was taken from the Kansas City elevator study (Table 8)[1]. This is lower than data in Table 9 and previous editions of AP-42 but is based on quantitative results that are considered to be more accurate than those on which the higher values have been based. It is possible, however, that emission factors for country elevators could be higher than similar operations at a terminal elevator because of field dust, etc., but definitive test results for country elevators are not available.

j/ An emission factor for loading of 0.27 lb/ton at country elevators is the same as that for terminal elevators (see note i).

k/ An emission factor of 1.40 lb/ton for turning is based on expected similarity to the tunnel belt emission factor determined in the Kansas City elevator study (Table 8).[1]

l/ Emission factor of 0.68 lb/ton for drying at country elevators is discussed in Appendix A, which showed 0.3 lb/ton for column dryers and 1.8 lb/ton for rack dryers. Survey data indicated that 75% of dryers at country elevators were column type so an emission factor of 0.68 lb/ton was used.

m/ An emission factor of 6.00 lb/ton for cleaning is based on the Kansas City terminal elevator study[1] which showed an emission factor to be 5.78 lb/ton. A very low emission factor of 0.43 lb/ton for a cleaner was reported by a study performed in North Dakota. However, it is not known if this cleaner operated with air aspiration and it is doubtful that this low value is representative of cleaning operations.

n/ The emission factor of 1.50 lb/ton for headhouse (legs) is based on the assumption that it will be approximately the same as the value of 1.49 lb/ton determined in the Kansas City elevator study (Table 8).[1]

o/ Emission factors for all sources are assumed to be the same as for terminal elevators except ship loading.

p/ An emission factor of 1.0 lb/ton for ship loading is based on one test on ship loading as a port elevator in Seattle (EPA Emission Test Report 73-GRN-3).

Table 8. BEST AVERAGE VALUE OF LONG-TERM COMPOSITE EMISSION FACTORS (LB/TON)[1/]

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

Table 9. PARTICULATE EMISSIONS FROM GRAIN HANDLING AND PROCESSING[2/] (lb/ton of grain processed)

| Emission source | Lb/ton Processed | Range of emissions (lb/ton) |
|---|---|---|
| Terminal Elevators | | |
| Shipping or receiving | | |
| Rail | 1 | (1 - 3) |
| Truck | 1.4 | (0.8 - 3.5) |
| Barge | 1.2 | (1 - 3.5) |
| Transferring, conveying, etc. | 2.0 | (2 - 2.5) |
| Screening and cleaning | 5.0 | (5 - 7) |
| Drying | 5.5 | (4 - 8) |
| Country Elevators | | |
| Shipping or receiving | | |
| Rail | 4 | (3 - 8) |
| Truck | 4.5 | (2 - 8) |
| Barge | 5.5 | (3 - 8) |
| Transferring, conveying, etc. | 3.5 | (2 - 4) |
| Screening and cleaning | 8.5 | (7 - 10) |
| Drying | 7.5 | (4 - 8) |

## Table 10. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS BASED ON AMOUNT OF GRAIN RECEIVED OR SHIPPED[a]

| Type of Source | Emission Factor lb/ton processed | x | Typical ratio of Tons Processed to Tons Received or Shipped[a,b] | = | Emission Factor lb/ton received or shipped |
|---|---|---|---|---|---|
| **Terminal Elevators** | | | | | |
| Unloading (receiving) | 1.00 | | 1.00 | | 1.00 |
| Loading (shipping) | 0.27 | | 1.00 | | 0.27 |
| Removal from bins (tunnel belt) | 1.40 | | 2.03 | | 2.84 |
| Drying | 1.05 | | 0.10 | | 0.11 |
| Cleaning | 6.00 | | 0.22 | | 1.32 |
| Headhouse (legs) | 1.50 | | 3.03 | | 4.55 |
| Tripper (gallery belt) | 1.00 | | 1.71 | | 1.71 |
| **Country Elevators** | | | | | |
| Unloading (receiving) | 0.64 | | 1.00 | | 0.64 |
| Loading (shipping) | 0.27 | | 1.00 | | 0.27 |
| Removal from bins | 1.40 | | 2.08 | | 2.91 |
| Drying | 0.68 | | 0.25 | | 0.17 |
| Cleaning | 6.00 | | 0.08 | | 0.48 |
| Headhouse (legs) | 1.50 | | 3.08 | | 4.62 |
| **Export Elevators** | | | | | |
| Unloading (receiving) | 1.00 | | 1.00 | | 1.00 |
| Loading (shipping) | 1.00 | | 1.00 | | 1.00 |
| Removal from bins (tunnel belt) | 1.40 | | 1.23 | | 1.72 |
| Drying | 1.05 | | 0.01 | | 0.01 |
| Cleaning | 6.00 | | 0.15 | | 0.90 |
| Headhouse (legs) | 1.50 | | 2.23 | | 3.35 |
| Tripper (gallery belt) | 1.00 | | 1.07 | | 1.07 |

a/ Assumed that over the long term the amount received is approximately equal to amount shipped.
b/ See Table 11 for explanation of ratios used.

Table 11. AVERAGE VALUES USED FOR RATIO OF TONS PROCESSED TO TONS SHIPPED OR RECEIVED

| | Ratio of Grain Throughput to Grain Received or Shipped for basic elevator functions listed below[a] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Emission Sources | Unloading | | Loading | | Turning | | Drying | | Cleaning | | Total[b] |
| Terminal Elevators | | | | | | | | | | | |
| Unloading | 1.00 | | | | | | | | | = | 1.00 |
| Loading | | | 1.00 | | | | | | | = | 1.00 |
| Removal from bins | | | 1.00 | + | 0.71 | + | 0.10 | + | 0.22 | = | 2.03 |
| Drying | | | | | | | 0.10 | | | = | 0.10 |
| Cleaning | | | | | | | | | 0.22 | = | 0.22 |
| Headhouse | 1.00 | + | 1.00 | + | 0.71 | + | 0.10 | + | 0.22 | = | 3.03 |
| Tripper | 1.00 | | | + | 0.71 | | | | | = | 1.71 |
| Country Elevators | | | | | | | | | | | |
| Unloading | 1.00 | | | | | | | | | = | 1.00 |
| Loading | | | 1.00 | | | | | | | = | 1.00 |
| Removal from bins | | | 1.00 | + | 0.75 | + | 0.25 | + | 0.08 | = | 2.08 |
| Drying | | | | | | | 0.25 | | | = | 0.25 |
| Cleaning | | | | | | | | | 0.08 | = | 0.08 |
| Headhouse | 1.00 | + | 1.00 | + | 0.75 | + | 0.25 | + | 0.08 | = | 3.08 |
| Export Elevators | | | | | | | | | | | |
| Unloading | 1.00 | | | | | | | | | = | 1.00 |
| Loading | | | 1.00 | | | | | | | = | 1.00 |
| Removal from bins | | | 1.00 | + | 0.07 | + | 0.01 | + | 0.15 | = | 1.23 |
| Drying | | | | | | | 0.01 | | | = | 0.01 |
| Cleaning | | | | | | | | | 0.15 | = | 0.15 |
| Headhouse | 1.00 | + | 1.00 | + | 0.07 | + | 0.01 | + | 0.15 | = | 2.23 |
| Tripper | 1.00 | | | + | 0.07 | | | | | = | 1.07 |

a/ Values derived from information and data in Reference 3.

b/ "Total" represents the overall average ratio of grain throughput to grain received or shipped for each emission source due to all basic elevator functions which involve that source.

Some of the operations listed in the tables, such as the tunnel belt and tripper, are internal or in-house dust sources which, if uncontrolled, might show lower than expected atmospheric emissions because of internal settling of dust. On the other hand, the reduction in emissions via internal settling is not known and it is quite possible that all of this dust is eventually emitted due to subsequent external operations, internal ventilation or other means.

As mentioned above, many elevators utilize control devices on at least some sources. In the past, cyclones have commonly been applied to such sources as legs in the headhouse and tunnel belt hooding systems. More recently, fabric filters have been utilized at many elevators on almost all sources. However, some sources in grain elevators do present control problems. Control of load-out operation is one of the more difficult sources to control because of the problem of containment of the emissions. Probably the most difficult source to control, because of the large flowrate and high moisture content of the exhaust gases, is the dryers. Screen houses or continuously vacuumed screen systems are available for reducing dryer emissions and have been applied at several facilities. Detailed description of dust control systems for grain elevator operations, and their estimated costs, are contained in Reference 2.

Grain Processing Operations - Grain processing operations include many of the operations performed in a grain elevator in addition to milling and processing of the grain. Emission factors for different grain milling and processing operations are presented in Table 12. Brief discussion of these different operations and the methods used for arriving at the emission factor values shown in Table 12 are presented below. More detailed discussion and derivation of the emission factors shown in Table 12 are presented in Appendix B.

Emission factor data for feed mill operations are sparse. This is partly due to the fact that many ingredients; who grain and other dusty materials (bran, dehy alfalfa, etc.) are received by both truck and rail and several unloading methods are employed. However, some operations (handling, shipping and receiving) for a feed mill are similar to operations in a grain elevator, so an emission factor for each of these different operations was estimated on this basis. The remaining operations were estimated from the best information available.[2/]

Three emission areas for wheat mill processing operations are grain receiving and handling, cleaning house, and milling operations. Data from a grain elevator study[1/] were used to estimate emission factors for grain receiving and handling. Data for the cleaning house were insufficient

Table 12. PARTICULATE EMISSION FACTORS FOR GRAIN PROCESSING OPERATIONS[a]

| Type of source | Emission factors[a,b,d] (uncontrolled except where indicated) (lb/ton) | (kg/MT) |
|---|---|---|
| Feed Mills | | |
| Receiving | 1.30 | 0.65 |
| Shipping | 0.50 | 0.25 |
| Handling | 3.00 | 1.50 |
| Grinding | 0.10[c] | 0.05[c] |
| Pellet coolers | 0.10[c] | 0.05[c] |
| Wheat Mills | | |
| Receiving | 1.00 | 0.50 |
| Precleaning and handling | 5.00 | 2.50 |
| Cleaning house | -- | -- |
| Millhouse | 70.00 | 35.00 |
| Durum Mills | | |
| Receiving | 1.00 | 0.50 |
| Precleaning and handling | 5.00 | 2.50 |
| Cleaning house | -- | -- |
| Millhouse | -- | -- |
| Rye Milling | | |
| Receiving | 1.00 | 0.50 |
| Precleaning and handling | 5.00 | 2.50 |
| Cleaning house | -- | -- |
| Millhouse | 70.00 | 35.00 |
| Dry Corn Milling | | |
| Receiving | 1.00 | 0.50 |
| Drying | 0.50 | 0.25 |
| Precleaning | 5.00 | 2.50 |
| Cleaning house | 6.00 | 3.00 |
| Degerming and milling | -- | -- |

a/ See Appendix B.
b/ Emission factors are expressed in terms of pounds of dust emitted per ton of grain entering the plant (i.e., received), which is not necessarily the same as the amount of material processed by each operation.
c/ Controlled emission factor.
d/ Blanks indicate insufficient information.

Table 12. (Concluded)

| Type of source | Emission factors[a,c] (uncontrolled except where indicated) (lb/ton) | (kg/MT) |
|---|---|---|
| Oat Milling | | |
| Total | 2.50[c] | 1.25[c] |
| Rice Milling | | |
| Receiving | 0.64 | 0.32 |
| Handling and precleaning | 5.00 | 2.50 |
| Drying | -- | -- |
| Cleaning and millhouse | -- | -- |
| Soybean Mills | | |
| Receiving | 1.60 | 0.80 |
| Handling | 5.00 | 2.50 |
| Cleaning | -- | -- |
| Drying | 7.20 | 3.60 |
| Cracking and dehulling | 3.30 | 1.65 |
| Hull grinding | 2.00 | 1.00 |
| Bean conditioning | 0.10 | 0.05 |
| Flaking | 0.57 | 0.29 |
| Meal dryer | 1.50 | 0.75 |
| Meal cooler | 1.80 | 0.90 |
| Bulk loading | 0.27 | 0.14 |
| Corn Wet Milling | | |
| Receiving | 1.00 | 0.50 |
| Handling | 5.00 | 2.50 |
| Cleaning | 6.00 | 3.00 |
| Dryers | -- | -- |
| Bulk loading | -- | -- |

to estimate an emission factor and information taken from Reference 2 was used to estimate the emission factor for milling operations. The large emission factor for the milling operations is somewhat misleading because almost all of the sources involved are equipped with control devices to prevent product losses and fabric filters are widely used for this purpose.

Operations for durum mills and rye milling are similar to those of wheat milling. Therefore, most of these emission factors are equal to those for wheat mill operations.

The grain unloading, handling and cleaning operations for dry corn milling are similar to those in other grain mills but the subsequent operations are somewhat different. Also, some drying of corn received at the mill may be necessary prior to storage. An estimate of the emission factor for drying was obtained from Reference 2. Insufficient information was available to estimate emission factors for degerming and milling.

Information necessary to estimate emissions from oat milling was unavailable. It was also felt to be unwise to attempt to use emission factor data for other grains because handling of oats is reported to be dustier than many other grains. The only emissions factor data that were available were for controlled emissions.[2/] An overall controlled emission factor of 2.5 lb/ton was calculated from this data.

Emission factors for rice milling were based on those for similar operations in other grain handling facilities. Insufficient information was available to estimate emission factors for drying, cleaning and mill house operations.

Information taken from Reference 2 was used to estimate emission factors for soybean mills.

Information on corn wet milling emission factors was unavailable in most cases due to the wide variety of products and the diversity of operations. Receiving, handling and cleaning operations emission factors were assumed to be similar to those for dry corn milling.

## References

1. Gorman, P. G., "Potential Dust Emission From a Grain Elevator In Kansas City, Missouri," Final Report, prepared for Environmental Protection Agency, May 1974.

2. Shannon, L. J., R. W. Gerstle, P. G. Gorman, D. M. Epp, T. W. Devitt, and R. Anick, "Emission Control In the Grain and Feed Industry Volume I - Engineering and Cost Study," Final Report by Midwest Research Institute prepared for Environmental Protection Agency, Document No. EPA-450/3-73-003a, December 1973.

3. Shannon, L. J., P. G. Gorman, M. P. Schrag, D. Wallace, "Emission Control in the Grain and Feed Industry Volume II - Emission Inventory," Final Report by Midwest Research Institute prepared for Environmental Protection Agency, July 1974.

# APPENDIX A

## EMISSION FACTORS FOR GRAIN DRYERS AT GRAIN ELEVATORS

### GRAIN DRYER EMISSION FACTORS

A quantitative assessment of emissions from grain dryers is difficult, primarily because of lack of available data. However, these data and other information have indicated that the emission rate from any given installation is dependent upon the dryer configuration, i.e., rack or column; the type of grain being processed, i.e., corn, soybeans, wheat; the foreign material present in the incoming grain, i.e., dust, chaff, "beeswing" hulls, etc.; and the amount of moisture removed which affects throughput.

The large volumes of air passed through the grain, the large cross-sectional area through which the air is exhausted and the wide particle size distribution of the effluent contribute to sampling difficulties. The absence of an acceptable test method makes comparisons between reported dryer emission tests highly uncertain.

A compilation of the available data on emissions test for rack and column type dryers is presented in Table A-1 and, based on these data, average values for the uncontrolled emission factors were selected:

Rack Dryers - 1.8 lb/ton
Column Dryers - 0.3 lb/ton

Because of the small amount of available data, spread in these data, inadequate information regarding specific test methods, use of different sampling trains, and the lack of complete information regarding foreign material and moisture differential, these emission factors should only be considered as indicative of possible average emissions and not absolute numbers for individual dryers.

Table A-1. SUMMARY OF AVAILABLE EMISSION FACTOR DATA FOR GRAIN DRYERS (UNCONTROLLED)

| Rack dryers | | Column dryers | |
|---|---|---|---|
| Throughput (bu/hr) | Emission factor (lb/ton) | Throughput (bu/hr) | Emission factor (lb/ton) |
| 1,000 | 3.7[a/] | 400 | 0.23[a/] |
| 2,000 | 2.3[a/] | 1,000 | 0.21[a/] |
| 500 | 1.2[b/] | 3,000 | 0.6[b/] |
| 1,500 | 0.9[b/] | | Avg. = 0.3 lb/ton |
| 1,800 | 1.0[b/] | | |
| | Avg. = 1.8 lb/ton | | |

a/ Reference 2.
b/ Private communication.

## APPENDIX B

## DERIVATION OF EMISSION FACTORS FOR GRAIN PROCESSING OPERATIONS (as shown in Table 12)

### FEED MILLS

#### Receiving

As stated in Reference 2 (p. 159) the ingredient receiving area represents the most serious dust emission problem in most feed mills. Emission factor data for this operation are sparse, owing partly to the fact that many ingredients; whole grain and other more dusty materials (bran, dehy alfalfa, etc.), are received, by both truck and rail and several unloading methods are employed. For these reasons, an average emission factor would be difficult to determine, at least as far as whole grains are concerned, so an emission factor for the unloading operation only has been estimated as 1.30 lb/ton. This was the value determined in the Kansas City elevator study[1/] for car unloading and may be representative of feed mills and hopefully reflects the fact that some ingredients tend to be more dusty than whole grains.

#### Shipping

Most feed mills ship the bulk feed by truck, but some are also shipped in bags by rail and truck. Reference 2 (p. 166) states that loadout is a major source of dust emissions but little emission factor data are available. An emission factor of 0.27 lb/ton was determined for car loading of grain in the Kansas City elevator study.[1/] It is assumed that bulk loading of feed mill products would tend to be more dusty than whole grain loading. Therefore, an emission factor of 0.5 lb/ton has been estimated for this operation.

#### Handling Operations (transfer points, garner and scale, legs)

No data were available for the internal handling operations in feed mills. However, it would be expected that they are somewhat similar to those in grain elevators. The Kansas City elevator study[1/] showed that the most significant of these operations was the legs, having an emission factor of 1.49 lb/ton. The tunnel belt factor of 1.40 lb/ton is similar but feed mill operations are such that this may not be a comparable operation. However, all material in a feed mill would be expected to pass through a leg at least twice from unloading to shipping. Therefore, an overall average emission factor for feed mill handling operations has been estimated as 3.0 lb/ton.

Grinding

Whole grains received at feed mills must be ground and the associated product recovery cyclone is the major dust source in this grain preparation operation. Because of the wide variation in grains and grinders used, an average emission factor would be difficult to determine. A small amount of data presented in Reference 2 (p. 163) indicated that controlled emissions may range from 0.02 to 0.2 lb/ton. Considering these facts, and lack of other data, an average controlled emission factor of 0.1 lb/ton has been estimated, assuming it is to be representative of the industry as a whole.

Pellet Coolers

The only available emission factor data for this operation was contained in Reference 2 (pp. 164-167) and indicated that the uncontrolled emission factor was quite high (5 to 50 lb/ton) but that the cyclones were very efficient (92 to 99.9%). The data on p. 164 show considerable difference in controlled emission factors for horizontal coolers and column coolers. Distribution of these two types of coolers within the industry is not known but our observations indicate that column coolers are quite common. For this reason, a controlled emission factor of 0.1 lb/ton has been estimated.

WHEAT MILLS

Processing operations were discussed in Reference 2 (p. 207) and identified three emission areas: grain receiving and handling, cleaning house, and milling operations. Emission factors and calculation of emissions for sources within each of these operations is discussed below.

Receiving

It would be expected that receiving of wheat would be similar in emissions to that for terminal grain elevators (0.64 and 1.30 lb/ton).[1/] Data on

p. 182 of Reference 2 for one flour mill presents controlled emission factors for fabric filters but it is difficult to use these data in estimating an uncontrolled factor. Therefore, the data from Reference 1 had to be used, and an average factor of 1.0 lb/ton was selected for receiving by trucks, cars and barges.

Precleaning and Handling

Very little data on uncontrolled emissions from precleaning were available, but it is assumed to consist primarily of scalping type operations, which should be a minor source in comparison with handling operations. Handling consists of legs, transfer points, garner and scale and tripper, etc. Usable data on uncontrolled emission factors for these sources in flour mills were lacking, so the data from Reference 1 had to be used, even though it was for a grain elevator and did not include a tripper. However, it did include a tunnel belt and it is also known that in a flour mill the grain would pass through the leg twice (once when received and once when transferred to cleaning house). Therefore, a cumulative emission factor of 5.0 lb/ton was estimated for all precleaning and handling operations.

Cleaning House

Cleaning is accomplished by a variety of means but often includes air aspiration to remove lighter impurities (dust) as well as disc separators and scourers. Each of these can be a source of dust emissions but only a small amount of emission data on cyclone controlled sources were available in Reference 2 (p. 210). Therefore, it was not feasible to calculate an emission factor for the cleaning house.

Mill House

Operations in the mill house are complex, and again, very little emission data are available. Reference 2 (p. 209) cites one report which indicated that dust generated in roller mills may average 2.1 lb/bu (70 lb/ton). This source and the purifiers might therefore account for more than 70 lb/ton. This emission factor is larger than the one for precleaning and handling and may be erroneously high but it was the only data available. It should be noted that because of the product value these emissions are controlled, primarily with fabric filters.

DURUM MILLS

The sources of air pollution in a durum mill parallel those of a flour mill and fall into the three main categories of receiving and handling operations, cleaning-house, and milling operations. Rate of emission for durum mill operations are limited but since the processing operations are similar to those of a flour mill, the rates are expected to be similar (Reference 2, p. 215). However, in the mill section one of the primary purposes is to produce middlings rather than flour so the break rolls are different. Because of this, it is assumed that the emission factor of 70 lb/ton used for the mill house in flour mills may not be applicable to durum mills. Therefore, the same emission factors for flour mills were assumed to apply, but the emission factor for milling operations was not estimated.

RYE MILLING

The milling procedure for rye consists of the same processing steps as wheat milling (Reference 2, p. 221) and air pollution sources parallel those in a wheat mill. Very little emission factor data were available for rye milling. Some data on certain milling operations (Reference 2, p. 226) indicate a controlled emission factor of about 1 lb/ton. This is equivalent to an uncontrolled emission factor of 10 lb/ton, assuming cyclone efficiencies of 90%. However, these data do not include break rolls and other operations so the factor of 70 lb/ton used for wheat milling was assumed to be applicable to rye. This factor, and the others for wheat milling were assumed to be the same for rye milling.

DRY CORN MILLING

The grain unloading, handling, and cleaning operations are similar to those in other grain mills but the subsequent operations are somewhat different (Reference 2, p. 216). Very little emission factor data were available for dry corn milling, except for some controlled emission factors tabulated in Reference 2 (pp. 222, 223).

Receiving

As in the case of flour mills, an average emission factor of 1.00 lb/ton has been used for the receiving operation.

Drying

Some drying of corn received at the mill may be necessary prior to storage. Types of dryers used (rack or column) is not known, but about 50% use the

Day-Vac system. For this reason, an emission factor of 0.5 lb/ton was used based on dryer emission factors discussed in Appendix A.

Precleaning and Handling

As explained in the section on flour mills, an average emission factor of 5.0 lb/ton was used for the precleaning and handling operations.

Cleaning House

An emission factor of 5.78 lb/ton was determined for a grain elevator corn cleaning operation.1/ Also, Reference 2 (p. 222) shows an emission factor of 0.0015 lb/bu (0.06 lb/ton) for a cleaning house controlled by a fabric filter. If the FF were 99% efficient, the equivalent uncontrolled factor would be 6.0 lb/ton, which agrees closely with the previous factor of 5.78 lb/ton.

Degerming and Milling

Emission factor data were not available.

OAT MILLING

Most of the information necessary for estimating emission factors was not available. It was felt to be unwise to attempt to use emission factor data for other grains because handling of oats is reported to be dustier than many other grains. The only emission factor data that were available contained controlled emission factors only (Reference 2, p. 236) which can be used to calculate an overall factor of 0.04 lb/bu or 2.5 lb/ton. It is not known if these data, for one mill, included most major dust sources nor is it known if this plant, and the control devices used, is representative of the industry. However, both of the above were assumed to be true, and the total controlled emission factor of 2.5 lb/ton was used.

RICE MILLING

Emission factor data for rice milling operations are meager. Emission sources associated with receiving, cleaning and storage are similar to those involved with all grain processing but it is not known if rice emits more or less dust than other grains in these operations. However, emission factors for other grains were used.

Receiving

Data in Reference 2 (p. 471) indicate that most rice is received by truck. An emission factor for truck unloading of 0.64 lb/ton was assumed based on data for a terminal grain elevator.[1/]

Handling and Precleaning

As was explained in the section on wheat mills, a cumulative emission factor of 5.0 lb/ton has been assumed for the similar operations in a rice mill.

Drying

Observation of rice dryers indicates that the emission factor may be considerably higher than for drying of other grains but supporting data were not available.

Cleaning and Mill House

Because of the lack of data, no estimate of the emission factor could be made.

## SOYBEAN MILLS

Receiving

Data in Reference 2 (p. 251) indicate an average controlled emission factor for a truck dump pit of 0.017 lb/ton, or an uncontrolled factor of 1.5 lb/ton assuming 99% efficiency for the fabric filter control device. This is in good agreement with data in Reference 1 for soybeans which showed 1.63 lb/ton for truck unloading and 1.51 lb/ton for car unloading. Therefore, an emission factor of 1.6 lb/ton was used for soybean receiving.

Handling

No specific information was available on emission factors for soybean handling operations. Even though the emissions from soybeans may be higher than other grains the cumulative factor of 5.00 lb/ton, as discussed in the wheat milling section, was used.

Cleaning

No information was available on the cleaning of soybeans although it is suggested that it would be at least as much as the 6.00 lb/ton discussed in the section on dry corn milling.

Drying

Soybean plants do dry the feed to the flaking mill and observations have indicated that the emission factor for drying of soybeans at soybean mills may be higher than the average factors discussed in Appendix A. The only data available on soybean dryers are contained in Reference 2 (p. 255) and have been used to calculate uncontrolled emission factors ranging from 4.2 to 80 lb/ton. The value of 80 lb/ton is very high but even disregarding this value, the average factor is 7.2 lb/ton.

Cracking (and dehulling)

Data presented in Reference 2 (p. 256) show that the controlled emission factor for cracking and dehulling operations is on the order of 0.01 lb/bu, or 0.33 lb/ton. If one assumes 90% efficiency for the cyclone control devices, the uncontrolled emission factor would be 3.3 lb/ton.

Hull Grinding

Controlled emission factors for hull grinding in Reference 2 (p. 256) show an average, for three reported values, of 0.0055 lb/bu or 0.18 lb/ton. Again assuming 90% efficiency for the cyclone control devices, the uncontrolled emission factor would be approximately 2.0 lb/ton.

Bean Conditioning

Reference 2 (p. 256) shows a cyclone controlled emission factor of 0.0003 lb/bu or 0.01 lb/ton. Assuming 90% cyclone efficiency, the uncontrolled emission factor is 0.1 lb/ton.

Flaking

A total of four controlled emission factors for flaking are presented in Reference 2 (pp. 252, 256) and show an average of 0.0017 lb/bu or 0.057 lb/ton. These were each cyclone controlled, so assuming 90% efficiency, the uncontrolled emission factor would be 0.57 lb/ton.

Meal Dryer

Cyclone controlled emission factor for meal dryers was presented in Reference 2 (pp. 252, 256) and showed a range of 0.003 to 0.0128 lb/bu with an average of 0.0045 lb/bu or 0.15 lb/ton. Again assuming 90% efficiency for the cyclones, the uncontrolled factor would be 1.5 lb/ton.

Meal Cooler

Only one cyclone controlled emission factor was available (Reference 2, p. 252); 0.0056 lb/bu or 0.18 lb/ton. Assuming 90% efficiency for the cyclone, the uncontrolled factor would be 1.8 lb/ton.

Bulk Loading

No emission factor data were available for meal loading. However, observation of these operations indicates that it may be about the same as loading grain at elevators or about 0.27 lb/ton.[1/]

CORN WET MILLING

Receiving

Corn is received by cars and trucks and, as was done for dry corn mills, an average emission factor of 1.0 lb/ton was used.

Handling

Emission factors specifically applicable to handling of corn at wet corn mills are not available. However, as was done on dry corn mills, an average cumulative emission factor of 5.0 lb/ton was used.

Cleaning

An emission factor of 6.0 lb/ton for corn cleaning, as developed in the section on dry corn mills, was used.

Dryers

Feed, gluten and germ dryers are a major source of emissions from wet corn mills but emission factor d ta are lacking.

Bulk Loading

Bulk loading of products is another potential source of emissions but no emission factor data are available.

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16. ABSTRACT

This report contains an evaluation of available data used to develop emission factors for alfalfa dehydration plants, grain elevators and other feed and grain operations.

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