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6.4 GRAIN ELEVATORS AND PROCESSING PLANTS

6.4.1 General[1-3]

Grain elevators are facilities at which grains are received, stored, and then distributed for direct use, process manufacturing, or export. They can be classified as either "country" or "terminal" elevators, with terminal elevators further categorized as inland or export (marine) types. Operations other than storage often are performed at elevators, such as cleaning, drying and blending. The principal grains handled include wheat, milo, corn, oats, rice and soybeans.

Country elevators are generally smaller elevators that receive grain by truck directly from farms during the harvest season. These elevators sometimes clean or dry grain before it is transported to terminal elevators or processors. Terminal elevators dry, clean, blend and store grain for shipment to other terminals or processors, or for export. These elevators may receive grain by truck, rail or barge, and they have significantly greater grain handling and storage capacities than do country elevators. Export elevators are terminal elevators that load grain primarily onto ships for export.

The first step at a grain elevator is the unloading of the incoming truck, railcar or barge. A truck discharges its grain into a hopper, usually below grade, from which the grain is conveyed to the main part of the elevator. Barges are unloaded by a bucket elevator (marine leg) that is extended down into the hold. The main building at an elevator, where grain is elevated and distributed, is called the "headhouse". In the headhouse, grain is lifted on one of the elevator legs and discharged onto the gallery belt, which conveys the grain to the storage bins, or silos. A "tripper" diverts grain into the desired bin. Grain is often cleaned and/or dried before storage. When ready for shipping, grain is discharged from bins onto the tunnel belt below, which conveys it to the scale garner and on to the desired loadout location. Figure 6.4-1 illustrates the basic elements of an export terminal elevator.

A grain processing plant (mill) receives grain from an elevator and performs various manufacturing steps that produce a finished food product. Examples of these plants are flour mills, animal feed mills, and producers of edible oils, starch, corn syrup, and cereal products. The elevator operations of unloading, conveying and storing also are performed at mills.

6.4.2 Emissions And Controls[1]

The only pollutant emitted in significant quantities from grain elevators and processing operations is particulate matter. Small amounts of combustion products from natural gas fired grain dryers also may be emitted. Grain elevators and grain processing operations can be considered separate categories of the industry when considering emissions.

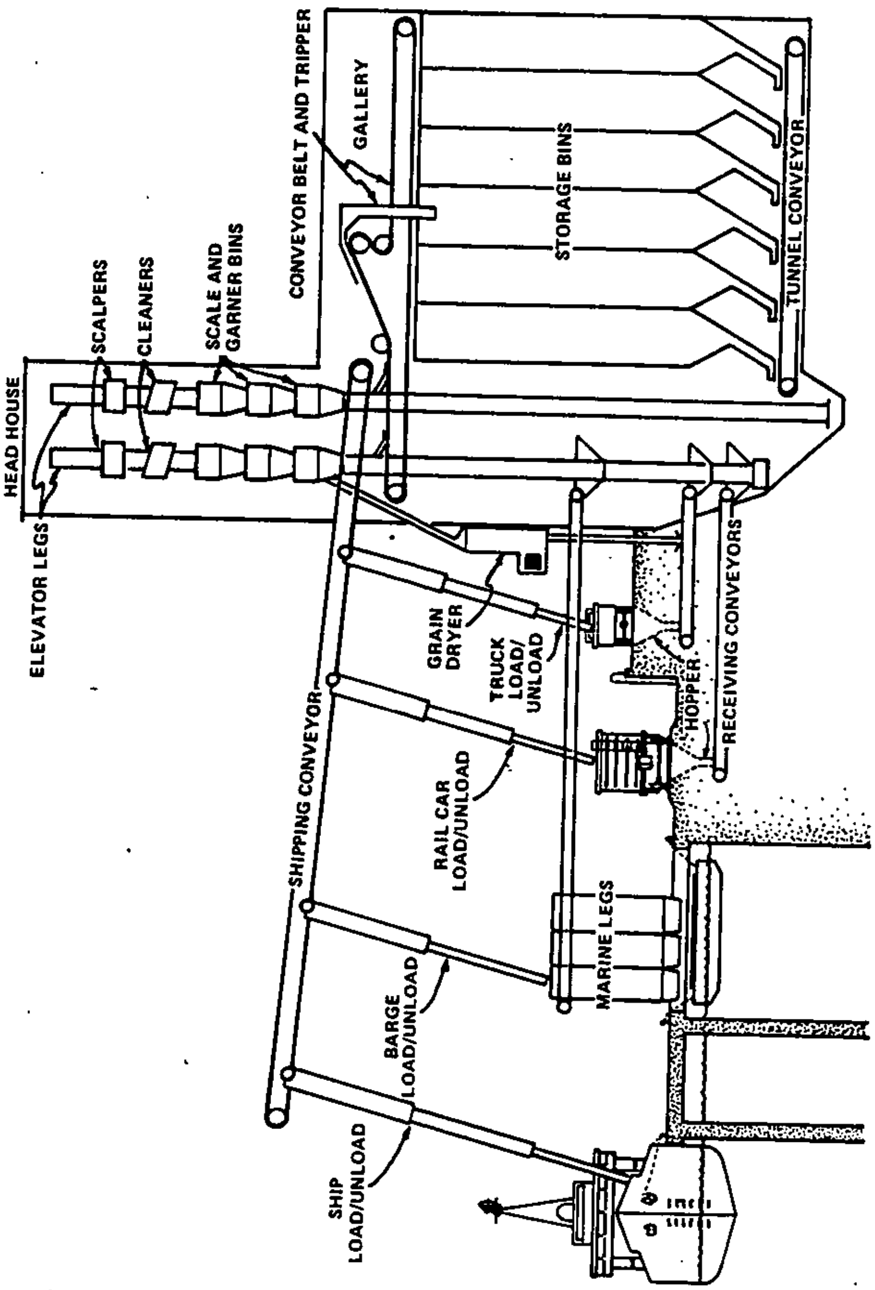

Figure 6.4-1. Typical export terminal grain elevator.

6.4.2.1 Grain Elevators - Emissions of fugitive dust occur whenever quantities of grain are set into motion during loading, conveying, transfer, drying or cleaning operations at a grain elevator. The emission rate can be affected by the quantity of foreign material in the grain (dirt, seeds, sticks, stones, etc., known as "dockage") and by the type of grain. While it is difficult to quantify the effect of dockage, observations indicate that soybeans, oats and sorghum are usually very dusty, whereas wheat and corn are comparatively clean.[4] Total particulate emission factors for the principal operations at grain elevators are presented in Table 6.4-1. Since data differentiating these emission factors by grain type are sparse, all of these factors are approximate average values intended to apply to a variety of grains. Tables 6.4-2, 6.4-3 and 6.4-4, and Figures 6.4-2, 6.4-3 and 6.4-4, show particle size distributions and size specific emission factors for three operations at grain elevators.

The emission factors in Table 6.4-1 represent the amount of dust generated per unit weight of grain processed through each uncontrolled operation. Since the amount of grain passing through each individual operation is often difficult to determine, it is sometimes convenient to express the emission factors in terms of the quantity of grain received or shipped by the elevator. (It is assumed that the amounts shipped and received are equal over the long run.) Therefore, the factors in Table 6.4-1 have been modified and are expressed in Table 6.4-5 as a function of the amount of grain received or shipped. The ratios shown in Table 6.4-5 are approximate values based on averages for bin turning, cleaning and drying in each elevator category. However, because operating practices at individual elevators are different, these ratios, like the emission factors themselves, may lack precision when applied to an individual elevator.

The factors in Tables 6.4-1 and 6.4-5 should not be added together in order to obtain a single overall emission factor for a grain elevator because, in most elevators, the emissions from some operations are controlled and others are not. Therefore, emissions estimations generally should be undertaken for each operation and its associated control device.

Several methods are available to reduce or control dust emissions at grain elevators. Since most emissions are generated when air passes swiftly through a mass of grain, measures that slow down grain transfer (conveying) rates or that reduce free fall distances will reduce emissions. Bulk grain, especially when falling through the air, should be protected from significant air currents or wind sources. Many operations at elevators are partially or totally enclosed (e. g., screw conveyors, drag conveyors, elevator legs) to isolate generated dust from the atmosphere. Hooding in the vicinity of some operations (e. g., grain unloading, conveyor transfer points) collects generated dust by creating a negative pressure area (through suction, or air aspiration) near the center of activity and then ducting the dusty air to a control device. Recent developments in the control of ship and barge loading operations include the use of "dead boxes" and tent controls. The dead box is a baffled attachment on the loading spout that serves to reduce the speed of the falling grain before it reaches the open air and strikes the grain pile. Aspiration to a control device often accompanies the use of the dead box. Large flexible covers connected to the loading spout and aspiration ducting, called tents, are used to cover the holds of ships during most of a loading operation. The tent must be removed during topping off (usually

TABLE 6.4-1. TOTAL PARTICULATE EMISSION FACTORS FOR UNCONTROLLED GRAIN ELEVATORS[a]

EMISSION FACTOR RATING: B

Type of Operation	Total particulate kg/Mg	Total particulate lb/ton
Country elevators		
Unloading (receiving)	0.3	0.6
Loading (shipping)	0.2	0.3
Removal from bins (tunnel belt)	0.5	1.0
Drying[b]	0.4	0.7
Cleaning[c]	1.5	3.0
Headhouse (legs)	0.8	1.5
Inland terminal elevators		
Unloading (receiving)	0.5	1.0
Loading (shipping)	0.2	0.3
Removal from bins (tunnel belt)	0.7	1.4
Drying[b]	0.6	1.1
Cleaning[c]	1.5	3.0
Headhouse (legs)	0.8	1.5
Tripper (gallery belt)	0.5	1.0
Export elevators		
Unloading (receiving)	0.5	1.0
Loading (shipping)	0.5	1.0
Removal from bins (tunnel belt)	0.7	1.4
Drying[b]	0.5	1.1
Cleaning[c]	1.5	3.0
Headhouse (legs)	0.8	1.5
Tripper (gallery belt)	0.5	1.0

[a]Expressed as weight of dust emitted/unit weight of grain handled by each operation. For inland terminal and export elevators, Reference 5; for drying, References 2, 6; for country elevators, Reference 5 and additional test data in References 7-10.
[b]References 6, 11. Based on 0.9 kg/Mg for uncontrolled rack dryers and 0.15 kg/Mg for uncontrolled column dryers, prorated on the basis of the distribution of these two types of dryers.
[c]Reference 11. Average of values, from < 0.3 kg/Mg for wheat to 3.0 kg/Mg for corn.

TABLE 6.4-2. PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED RICE DRYERS[a]

EMISSION FACTOR RATING: D

Aerodynamic particle diameter (um)	Cumulative weight % ≤ stated size	Emission factor[b] (kg/Mg)
2.5	0.8	0.0012
6.0	2.6	0.0039
10.0	7.7	0.012
15.0	24.5	0.037
Total particulate		0.15[c]

[a]References 1, 12.
[b]Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of rice dried.
[c]Reference 11.

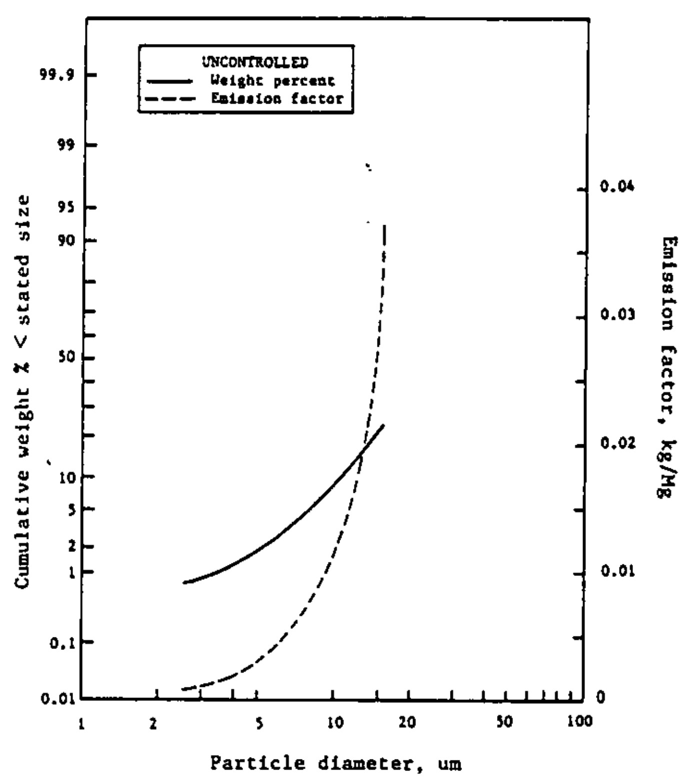

Figure 6.4-2. Cumulative size distribution and emission factors for uncontrolled rice dryers.

TABLE 6.4-3. PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR CONTROLLED BARGE UNLOADING/CONVEYING[a]

EMISSION FACTOR RATING: D

Aerodynamic particle diameter (um)	Cumulative weight % ≤ stated size	Emission factor[b] (kg/Mg)
2.5	4.0	0.00013
6.0	11.0	0.00037
10.0	18.0	0.00054
Total particulate		0.003[c]

[a]Reference 13. Control is by fabric filter.
[b]Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of grain unloaded/conveyed.
[c]Total mass emission factor is from Reference 1.

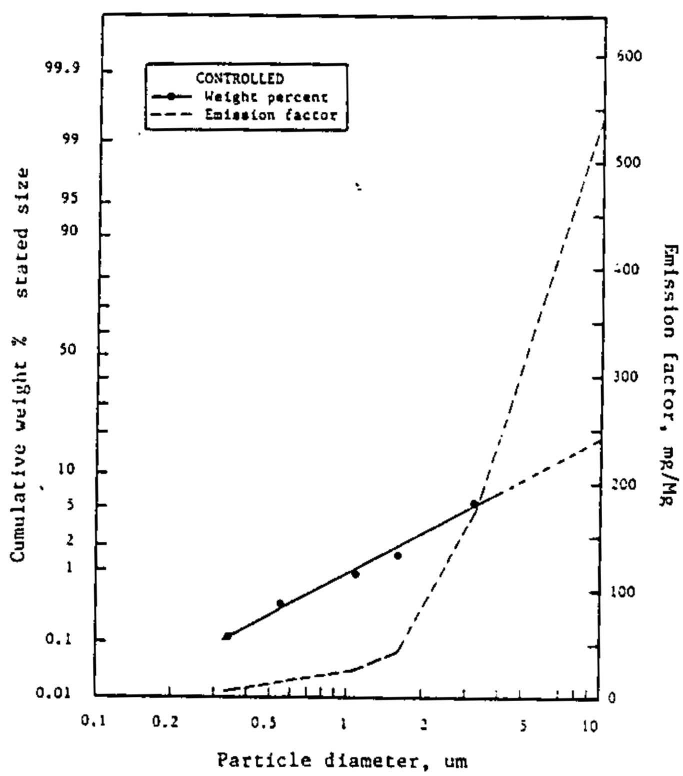

Figure 6.4-3. Cumulative size distribution and emission factors for controlled barge unloading/conveying.

TABLE 6.4-4. PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED SHIPLOADING[a]

EMISSION FACTOR RATING: C

Aerodynamic particle diameter (um)	Cumulative weight % ≤ stated size	Emission factor[b] (kg/Mg)
2.5	10.4	0.05
6.0	27.0	0.13
10.0	42.0	0.21
15.0	53.0	0.26
Total particulate		0.50[c]

[a]References 1, 14-15.
[b]Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of grain loaded onto ships.
[c]Reference 11.

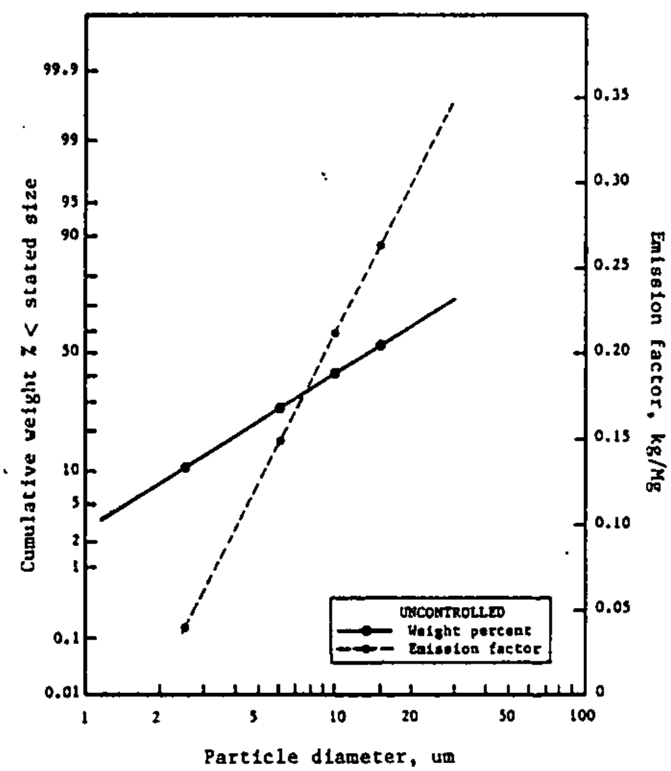

Figure 6.4-4. Cumulative size distribution and emission factors for uncontrolled shiploading.

TABLE 6.4-5. TOTAL PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS, BASED ON AMOUNT OF GRAIN RECEIVED OR SHIPPED[a]

EMISSION FACTOR RATING: C

Type of Operation	Emission factor, kg/Mg handled[b]	x	Typical ratio of grain processed to grain received or shipped[c]	=	Emission factor, kg/Mg received or shipped
Country elevators					
Unloading (receiving)	0.3		1.0		0.3
Loading (shipping)	0.2		1.0		0.2
Removal from bins (tunnel belt)	0.5		2.1		1.0
Drying[d]	0.4		0.3		0.1
Cleaning[e]	1.5		0.1		0.2
Headhouse (legs)	0.8		3.1		2.5
Inland terminal elevators					
Unloading (receiving)	0.5		1.0		0.5
Loading (shipping)	0.2		1.0		0.2
Removal from bins (tunnel belt)	0.7		2.0		1.4
Drying[d]	0.6		0.1		0.1
Cleaning[e]	1.5		0.2		0.3
Headhouse (legs)	0.8		3.0		2.3
Tripper (gallery belt)	0.5		1.7		0.8
Export elevators					
Unloading (receiving)	0.5		1.0		0.5
Loading (shipping)	0.5		1.0		0.5
Removal from bins (tunnel belt)	0.7		1.2		0.8
Drying[d]	0.5		0.01		0.01
Cleaning[e]	1.5		0.2		0.3
Headhouse (legs)	0.8		2.2		1.7
Tripper (gallery belt)	0.5		1.1		0.6

[a]Assumes amount received is approximately equal to the amount shipped.
[b]To obtain units of lb/ton, multiply factors by 2.0.
[c]Reference 6. Average values from a survey of elevators across the U. S. Can be considerably different for any individual elevator or group of elevators in the same locale.
[d]See Note b in Table 6.4-1.
[e]See Note c in Table 6.4-1.

about 25 percent of the total loading), allowing essentially uncontrolled emissions to escape.

Most elevators utilize particulate control devices on at least some of their operations. The traditional form of control at elevators has been mechanical collectors, or cyclones. Cyclones collect particles larger than about 10 microns with only 85 to 95 percent control efficiency, often producing visible emissions. Hence, fabric filters are usually selected in areas having more stringent control requirements. Typical efficiencies for well operated fabric filters exceed 99 percent, with no visible emissions. The air aspirated from enclosed equipment and hoods is ducted to a fabric filter or, in some cases, one or more cyclones. Rarely are other particulate control devices, such as wet scrubbers and electrostatic precipitators, applied at elevators. Grain dryers present a different sort of control problem because of the large volumes of warm, moist air exhausted. Most dryers are enclosed with a continuously vacuumed polyester or stainless steel screening to collect particulate, with the vacuum usually discharged to a cyclone. Two principal dryer configurations, rack and column, are in use. The majority of dryers manufactured today are of the column type, which has considerably lower emissions than the rack type.[16]

6.4.2.2 Grain Processing Plants - Several grain milling operations, such as receiving, conveying, cleaning and drying, are similar to those at grain elevators. In addition to these, breaking down (milling) the grain or grain by-products for processing through various types of grinding operations is a further source of emissions. The hammermill is the most widely used grinding device at feed mills. Product is recovered from the hammermill with a cyclone collector, which can be a major source of dust emissions. Again, like elevators, mills use a combination of cyclones and fabric filters to conserve product and to control emissions. Drying at a grain mill is accomplished using several types of dryers, including fluidized bed dryers (soybean processing) and flash fired or direct fired dryers (corn milling). These newer dryer types might have lower emissions than the traditional rack or column dryers, but data are insufficient at this time to quantify the difference. The grain pre-cleaning often performed before drying also likely serves to reduce emissions. Emission factors for various grain milling and other processing operations are presented in Table 6.4-6, and the particle size distribution and size specific emission factor for a roaster operation are shown in Table 6.4-7 and Figure 6.4-5. The origins of these emission factors are discussed below.

Emission factor data for feed mill operations are sparse. The factors for receiving, shipping and handling are based on estimates made by experts within the feed industry.[17] The remaining feed mill factors are based on test data in References 2, 18 and 19.

The roasting of carob kibble (or pods), which are ground and used as a chocolate substitute, is similar to coffee roasting. The emission factor and particle size distribution for this operation were derived from References 20 and 21.

Three emission areas for wheat mill processing operations are grain receiving and handling, cleaning house and milling operations. Data from Reference 5 were used to estimate emission factors for grain receiving and

TABLE 6.4-6. TOTAL PARTICULATE EMISSION FACTORS FOR UNCONTROLLED GRAIN PROCESSING OPERATIONS[a]

EMISSION FACTOR RATING: D

Type of Operation	Emission factor kg/Mg	Emission factor lb/ton
Feed mills		
Receiving	1.3	2.5
Shipping	0.5	1.0
Handling	2.7	5.5
Grinding		
Hammermilling[b]	0.1[c,d]	0.2[c,d]
Flaking[b]	0.1[c]	0.2[d]
Cracking[b]	0.01[c,d]	0.02[c,d]
Pellet cooler[b]	0.2[c]	0.4[c]
Carob kibble roasting	3.0	6.0
Wheat milling		
Receiving	0.5	1.0
Precleaning and handling	2.5	5.0
Cleaning house	-	-
Mill house	35.0	70.0
Durum milling		
Receiving	0.5	1.0
Precleaning and handling	2.5	5.0
Cleaning house	-	-
Mill house	-	-
Rye milling		
Receiving	0.5	1.0
Precleaning and handling	2.5	5.0
Cleaning house	-	-
Mill house	35.0	70.0
Oat milling[e]	1.25	2.5
Rice milling		
Receiving	0.32	0.64
Precleaning and handling	2.5	5.0
Drying[f]	0.15	0.30
Cleaning and mill house	-	-

TABLE 6.4-6 (concluded).

Type of Operation	Emission factor kg/Mg	Emission factor lb/ton
Soybean milling		
Receiving	0.8	1.6
Handling	2.5	5.0
Cleaning	-	-
Drying[g]	3.6	7.2
Cracking and dehulling	1.7	3.3
Hull grinding	1.0	2.0
Bean conditioning	0.05	0.1
Flaking	0.29	0.57
Meal dryer	0.75	1.5
Meal cooler	0.9	1.8
Bulk loading	0.14	0.27
Dry corn milling		
Receiving	0.5	1.0
Drying[g]	0.25	0.5
Precleaning and handling	2.5	5.0
Cleaning house	3.0	6.0
Degerming and milling	-	-
Wet corn milling		
Receiving	0.5	1.0
Handling	2.5	5.0
Cleaning	3.0	6.0
Drying[h]	0.24	0.48
Bulk loading	-	-

[a]Most emission factors are expressed as weight of dust emitted/unit weight of grain entering the plant, not necessarily the same as amount of material processed by each operation. Dash = no data.
[b]Expressed as weight of dust emitted/unit weight of grain processed.
[c]With cyclones.
[d]Measured on corn processing operations at feed mills.
[e]Represents several sources at one plant, some controlled with cyclones and others with fabric filters.
[f]Average for uncontrolled column dryers; see Table 6.4-2.
[g]Dryer types unknown.
[h]For rotary steam tube dryers.

TABLE 6.4-7. PARTICLE SIZE DISTRIBUTION AND EMISSION FACTORS FOR UNCONTROLLED CAROB KIBBLE ROASTERS[a]

EMISSION FACTOR RATING: E

Aerodynamic particle diameter (um)	Cumulative weight % ≤ stated size	Emission factor[b] (kg/Mg)
2.5	0.6	0.018
6.0	0.7	0.021
10.0	2.0	0.060
15.0	11.5	0.35
Total particulate		3.0[c]

[a]Reference 18.
[b]Expressed as cumulative weight of particulate ≤ corresponding particle size/unit weight of carob kibble roasted.
[c]Reference 21.

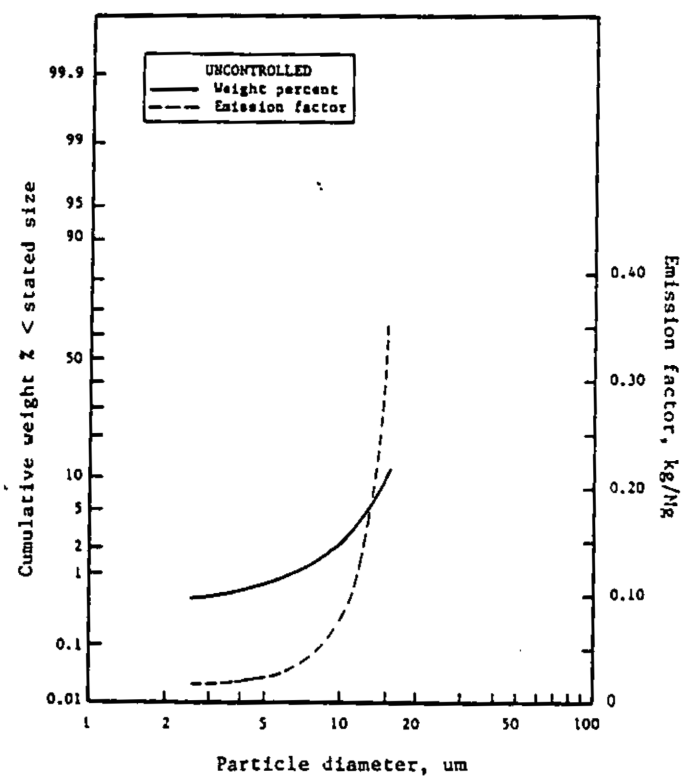

Figure 6.4-5. Cumulative size distribution and emission factors for uncontrolled carob kibble roasters.

handling. Data for the cleaning house are insufficient to estimate an emission factor, and information contained in Reference 2 was used to estimate the emission factor for milling operations. The large emission factor for the milling operation applies to uncontrolled operations. Almost all of the sources involved, however, are equipped with control devices to prevent product losses. Fabric filters are widely used for this purpose.

Durum and rye milling operations are similar to those for wheat milling. Therefore, most of these emission factors are assumed 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 before storage. An estimate of the emission factor for drying was obtained from Reference 2. Insufficient information is available to estimate emission factors for degerming and milling.

Information necessary to estimate emissions from oat milling is unavailable, and no emission factors for other grains are considered applicable because oats are reported to be dustier than many other grains. The only emission factor data available are for controlled emissions.

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

Information contained in Reference 2 is used to estimate emission factors for soybean mills.

Emissions information on wet corn milling is generally unavailable, in part because of the wide variety of products and the diversity of operations. Receiving, handling and cleaning operations emission factors are assumed to be similar to those for dry corn milling. The drying emission factor is from tests at a wet corn milling plant producing animal feed.[22]

Due to operational similarities between grain milling and processing plants and grain elevators, the control methods used are similar. Both 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. A good example of this is the extensive use of fabric filters in flour mills. However, there are also certain operations within some milling operations that are not amenable to the use of these devices. Therefore, wet scrubbers have found some application, particularly where the effluent gas stream has a high moisture content. Certain other operations have been found to be especially difficult to control, such as rotary dryers in wet corn mills. The various emission control systems that have been applied to operations within the grain milling and processing industry are described in Reference 2.

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