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Pacific Environmental Services, Inc.

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AP-42 Section 9.9.1
Reference 4
Report Sect.
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DOCUMENTATION FOR AP-42 EMISSION FACTORS:

SECTION 6.4, GRAIN ELEVATORS AND PROCESSING PLANTS

by

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A. Introduction

The EPA's Air Management Technology Branch (AMTB) has the responsibility for maintaining the document Compilation of Air Pollutant Emission Factors, AP-42, which is a basic source of emission factor information. This document is used in the preparation of State implementation plans, review of Prevention of Significant Deterioration applications, and a multitude of other emissions estimating efforts. The emission factors are updated periodically to reflect new data that may characterize emissions from an industry or process operation. A recent focus of the Agency has been the characterization of emissions of fine particulate matter, which has specific adverse effects on health related to its respirability. In this revision effort, both total particulate and size-specific emission factors for the grain handling and processing industries have been compiled. Section B discusses the origin of the particle size distributions and size-specific emission factors developed for four operations, and Section C documents the total particulate factors developed for six operations. Appendices A and B contain the reference information from which the emission factors in Sections B and C, respectively, were developed. Appendic C documents the emission factors that were previously in the AP-42 Section. Appendix D contains the revised AP-42 Section 6.4.

In order to impart information on the reliability and accuracy of the emission factors in Section 6.4, the factors and size distribution information have been letter rated to reflect the amount and quality of the data used to develop the factors. In this system, emission factors based on more tests of better quality are given a higher letter, such as A or B. Conversely, factors basei on only one or two tests, or on tests performed using nonstandard methods, are assigned ratings of C, D or E. Generally, factors based on several tests at facilities representing a good cross-section of the industry would receive an A rating. Factors rated B are somewhat less representative of the industry or reflect fewer tests. The emission factor tables in Section 6.4 have been assigned overall ratings reflecting a subjective evaluation of the average rating of all the factors in the table. Individual factors may vary somewhat from this overall rating.

The grain distribution and processing industry moves grain (wheat, corn, soybeans, etc.) from its origin at farms through various storage points (elevators) to the processing plants and mills where grain products (flour, starch, animal feed, etc.) are produced. Grain elevators can be classified as country (near farms), inland terminal, or export (marine) elevators. At elevators, incoming grain is unloaded, transferred on conveyors, and stored in silos. The processes are reversed for outgoing shipments. An elevator may also clean and dry the grain before storage. A mill or processing plant performs most of these same steps, as well as manufacturing some type of final product from the grain. Therefore, the additional steps of grinding, blending, cooling, and pelletizing may occur at these plants. Each step of handling, transfer, and processing of dry grain or grain products generates particulate emissions. These two industry segments, grain elevators and grain processing plants, are presented in two distinct subsections within Section 6.4 of AP-42.

B. Particle Size Distributions

Particulate size distribution data for four grain handling and processing operations have been included in the revised AP-42 Section 6.4. While other distributions were found and examined, none of them was completely enough described, or test methods were inadequate, to justify their incorporation into the Section. The four operations for which sizing data were available are:

1. Barge unloading and conveyor transfer (corn and soybeans)
2. Loading of ships (wheat)
3. Rice dryer
4. Carob kibble roaster

The data for operation no. 1 were located in an EPA test report, and represent the outlet stream from a fabric filter control system at an export elevator. The data for the second export elevator operation were contained in two EPA reports, and reflect a combination of sizing tests performed on three different types of uncontrolled shiploading operations. Tests of the two grain processing operations, rice drying and carob roasting, were performed by KVB, Inc., for the State of California. These data are contained in EPA's computerized Fine Particle Emission Information System (FPEIS). The following subsections describe the sizing data and contain the plots of particle size and size-specific emission factors.

1. Barge Unloading and Conveyor Transfer

These were EPA tests on the outlet of a control system (fabric filter) for unloading of grain from barges. Grain is unloaded from barges by a "marine leg" bucket elevator. The buckets discharge the grain into a surge bin which continuously feeds it onto a conveyor belt. The grain is transferred from two short conveyors to a final conveyor that carries it to the elevator. The control system aspirates dusty air from the front and back of the leg, the surge bin, and the conveyor transfer points. During the testing, corn and soybeans were unloaded.

Reference report: EPA:EMB Test No. 74-GRN-7 (January 1974).

Table 5 of the reference report (see Appendix A) shows Particle Size Results for two test runs.

Run 1

Particulate catch = 22,450 ug (probe & cyclone) + 2,070 ug (sizing stages)

= 24,520 ug.

Stage	Particle size, um	Weight each stage, ug	Cumulative weight, ug	Cumulative weight % < stated size
Total catch	--	--	24,520	100
1	3.14	1,480	2,070	8.44
2	1.63	190	590	2.41
3	1.10	210	400	1.63
4	0.57	120	190	0.77
5	0.33	70	70	0.29

Run 2

Particulate catch = 44,900 ug (probe & cyclone) + 1,440 ug (sizing stages)

= 46,340 ug.

Stage	Particle size, um	Weight each stage, ug	Cumulative weight, ug	Cumulative weight % < stated size
Total catch	--	--	46,340	100
1	3.14	1,260	1,440	3.1
2	1.63	90	180	0.39
3	1.10	30	90	0.19
4	0.57	40	60	0.13
5	0.33	20	20	0.04

The size plot (Figure 1) is based on the average of the two runs. Thus,

Particle size, um	Avg. cumulative wt. % < stated size
0.33	0.17
0.57	0.45
1.10	0.91
1.63	1.4
3.14	5.8

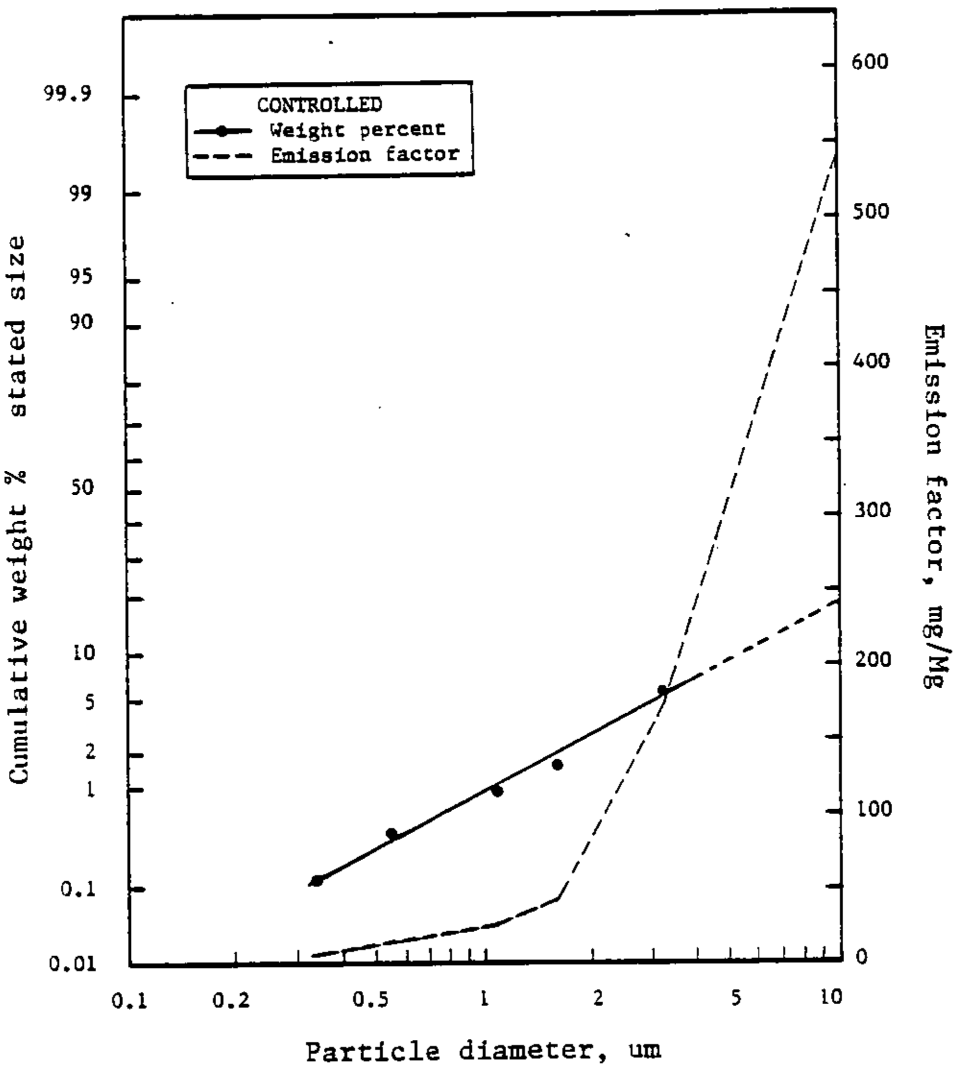

Figure 1. Barge Unloading/Conveying at Export Elevators: Particle Size Distribution and Emission Factor

Emission Factor Table

Parameters measured in tests:

Run No.	Process Rate, Mg/hr	Particulate Rate, kg/hr Control Inlet	Particulate Rate, kg/hr Control Outlet	Emission factor, kg/Mg Uncontrolled	Emission factor, kg/Mg Controlled
1	1,307	362	3.0	a	0.002
2	1,494	1,259	5.0	0.84	0.004
3	1,206	1,045	3.3	0.87	0.003

[a]Run No. 1 inlet test was 19.5% isokinetic; therefore, it was disregarded.

Average uncontrolled emission factor = 0.85 kg/Mg.
Average controlled emission factor = 0.003 kg/Mg.

$$\text{Control system collection efficiency} = \frac{0.85 - 0.003}{0.85} \times 100\% = 99.6\%.$$

The measured emission factor of 0.85 kg/Mg for uncontrolled unloading/conveying is similar to the factors in Table 6.4-1 of AP-42 for Unloading (receiving), 0.5 kg/Mg; Removal from bins (tunnel belt), 0.7 kg/Mg; and Headhouse (legs), 0.8 kg/Mg. Therefore, none of these emission factors was revised on the basis of the two inlet test runs. The table below shows size-specific emission factors for the controlled operation, based on a total emission factor of 0.003 kg/Mg. Note that units are mg/Mg (mg = 10^{-6} kg).

Particle diameter, um	Cumulative weight % < stated size	Emission factor, mg/Mg
	Controlled	Controlled
0.33	0.17	5.1
0.57	0.45	13.5
1.10	0.91	27.3
1.63	1.4	42
3.14	5.8	174
10.0[a]	18.0	540

[a]Extrapolated data point.

2. Shiploading of Grain at Export Elevators

The particulate size distributions of dust emissions from grain loading at several export elevators in Portland, Oregon, were measured in 1978. Two types of systems were used to reduce or control emissions: 1) aspirated tent system and 2) dead-box system; and one elevator was uncontrolled at the time of the tests. A probe consisting of an Andersen cascade impactor, a cyclonic pre-separator, and a glass fiber filter was used to determine the size distribution.

Reference reports:

1. W. Battye and R. Hall. Particulate Emission Factors and Feasibility of Emission Controls for Shiploading Operations at Portland, Oregon Grain Terminals - Volume I. GCA Corporation for U.S. EPA. EPA Contract No. 68-01-4143. June 1979.

2. Emission Factor Development for Ship and Barge Loading of Grain. GCA Corporation for U.S. EPA. EPA Contract No. 68-02-3510. October 1984.

Table 2 in Reference 2 shows the impactor size data. Figure 10 (Ref. 2) and Figure 5 (Ref. 1) show plots of these data (see Appendix A for Table 2 and Figure 5). Since these data plot close together and overlap one another, a decision was made in the interest of clarity to not retain these individual plots for AP-42 Section 6.4 Further, no consistent trends differentiating the three loading methods are apparent. Therefore, all six tests were averaged to produce a single size distribution. This distribution represents uncontrolled emissions because measurements were made at the loading point, upstream of the fabric filter used to capture emissions.

Table 1 shows cumulative weight percentages for each particle size, as well as averages for each of these particle sizes. The particle sizes used in this table are the midpoints of the size ranges in the reference Table 2 in Appendix A. Each concentration in Table 2 was first converted to a percentage of the total measured concentration for each test, and then these percentages were cumulated to produce the individual values for Table 1.

Emission Factor Table

The emission factor for loading (shipping) at export elevators is 0.5 kg/Mg, as shown in Table 6.4-1 of AP-42. In order to calculate

Table 1. PARTICLE SIZING DATA FOR SHIPLOADING TESTS

Test	Total Concentration (mg/m^3)	Cumulative Weight % < Stated Size								
		Total	12.8 um	9.4 um	6.9 um	4.2 um	2.5 um	1.4 um	0.9 um	<0.71 um
1. Bunge (tent)	89	100	38.4	33.0	24.7	16.0	8.0	2.4	0.7	0.7
2. Dreyfus (tent)	200	100	33.6	24.3	16.4	11.4	6.2	3.8	2.1	1.6
3. Cargill-1 (dead-box)	9.3	100	36.9	35.0	23.0	21.0	15.3	11.5	5.8	1.9
4. Cargill-2 (dead-box)	95	100	66.5	56.5	43.5	34.5	7.5	3.6	2.4	2.0
5. Columbia-1 (no control)	104	100	61.9	47.9	37.9	22.9	11.9	2.9	0.4	0
6. Columbia-2 (no control)	135	100	54.7	47.3	32.3	22.3	13.4	6.7	2.4	0.5
Average[a]		100	48.7	40.7	29.6	21.4	10.4	5.2	2.3	1.1

[a]These values represent arithmetic averages of the six test values for each particle size.

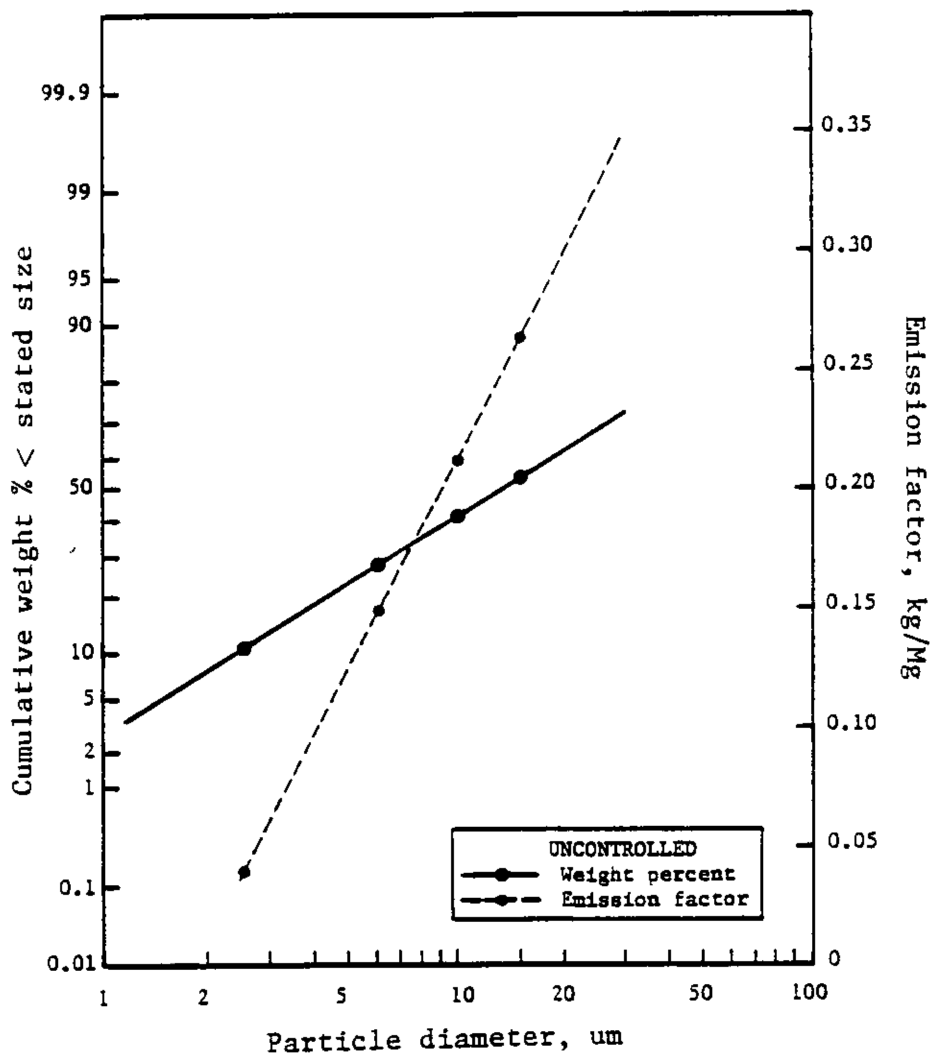

Figure 2. Shiploading at Export Elevators:
Particle Size Distribution and Emission Factor

size-specific emission factors, the cumulative weight percentages at several particle sizes were multiplied by this total factor. The results, which are plotted as a straight line in Figure 2, are shown in the emission factor table following the figure.

Particle diameter, um	Cumulative weight % < stated size	Emission factor, kg/Mg
	Uncontrolled	Uncontrolled
2.5	10.4	0.05
4.2	21.4	0.11
6.0	27.0	0.13
10	42.0	0.21
15	53.0	0.26

3. Rice Dryer

Test by California Air Resources Board, 10/11/77. Appendix A contains pertinent material from FPEIS printout, Series No. 228.

Reference report:

L.J. Shannon, et al., Emissions Control in the Grain and Feed Industry: Volume II - Emission Inventory, EPA-450/3-73-003b, MRI for U.S. EPA, September 1974.

Calculations for Sample 1

Total mass of sample collected = 590.7 mg
Volume of sample collected = 27.9 m^3

Therefore, concentration = 590.7/27.9 = 21.2 mg/m^3
= 21,200 ug/m^3

Also, T = 94°C = 201°F, P = 758 mm Hg = 29.84" Hg, W.V. = 2.3%.

Converting to standard conditions:

$$21{,}200\ ug/m^3 \times \frac{661}{530} \times \frac{29.92}{29.84} \times \frac{100}{100 - 2.3} = 27{,}100\ ug/dnm^3.$$

Size Distribution

Particle diameter, um	Cumulative mass conc. (ug/dnm^3)	Cumulative % < stated size
0.625	missing	--
1.0	missing	--
1.25	missing	--
2.5	202	0.7
6	991	3.7
10	2,950	10.9
15	6,590	24.3
20	10,200	37.6

Calculations for Sample 2

Total mass of sample collected = 190.3 mg
Volume of sample collected = 5.46 m^3

Thus,

Concentration = 34.9 mg/m^3 = 34,900 ug/m^3.

T = 96°C, P = 758 mm Hg, W.V. = 3.3%.

At standard conditions, C = 45,300 ug/dnm^3.

Size Distribution

Particle diameter, um	Cumulative mass conc. (ug/dnm^3)	Cumulative % < stated size
0.625	133	0.3
1.0	195	0.4
1.25	231	0.5
2.5	386	0.9
6	626	1.4
10	2,020	4.5
15	11,200	24.7
20	19,900	43.9

The size plot (Figure 3) is based on the average of the two runs. Therefore,

Particle diameter, um	Avg. cumulative % < stated size
0.625	0.3
1.0	0.4
1.25	0.5
2.5	0.8
6	2.6
10	7.7
15	24.5
20	40.8

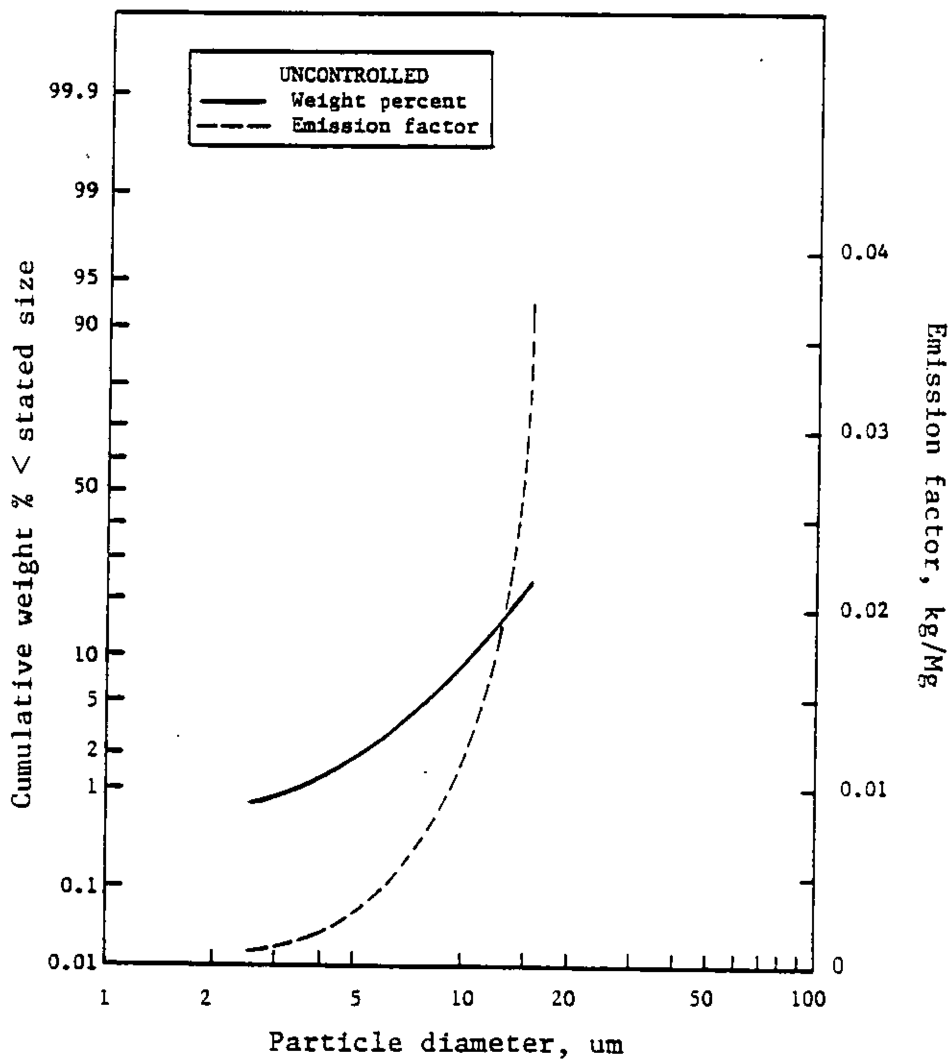

Figure 3. Rice Dryer: Particle Size Distribution and Emission Factor

Emission Factor Table

Total particulate emission factor = 0.15 kg/Mg rice dried (column dryers) from reference report. To obtain size-specific emission factors, multiply the total factor by the cumulative weight percent for each particle size.

Particle diameter, um	Cumulative weight % < stated size	Emission factor, kg/Mg
	Uncontrolled	Uncontrolled
0.625	0.3	0.0004
1.0	0.4	0.0006
1.25	0.5	0.0008
2.5	0.8	0.0012
6	2.6	0.0039
10	7.7	0.012
15	24.5	0.037
20	40.8	0.061

4. Carob Kibble Roaster

Test by KVB, Inc. for California Air Resources Board, 3/23/78. Appendix A contains pertinent material from FPEIS printout, Series No. 229.

Calculation of sample concentration at STD conditions

Total mass of sample collected = 1.07 g
Volume of sample collected = 6.65 m^3

Thus, concentration = 1.07 g/6.65 m^3 = 0.161 g/m^3
= 161,000 ug/m^3

Also, T = 204°C = 399°F, P = 765 mm Hg = 30.12" Hg, W.V. = 8.2%.

Converting to standard conditions:

$$161{,}000\ ug/m^3 \times \frac{859}{530} \times \frac{29.92}{30.12} \times \frac{100}{100 - 8.2} = 282{,}400\ ug/dnm^3.$$

Size Distribution

Particle diameter, um	Cumulative mass conc. (ug/dnm^3)	Cumulative % < stated size
0.625	424	0.2
1.0	1,100	0.4
1.25	1,360	0.5
2.5	1,760	0.6
6	1,870	0.7
10	5,640	2.0
15	32,500	11.5
20	58,400	20.7

Emission Factor Table

Total particulate emission factor = 3.0 kg/Mg carob kibble roasted.* To obtain size-specific emission factors, multiply total factor by the cumulative weight percent for each particle size.

Particle diameter, um	Cumulative weight % < stated size	Emission factor, kg/Mg
	Uncontrolled	Uncontrolled
0.625	0.2	0.006
1.0	0.4	0.012
1.25	0.5	0.015
2.5	0.6	0.018
6	0.7	0.021
10	2.0	0.060
15	11.5	0.35
20	20.7	0.62

Figure 4 shows the size distribution and size-specific emission factors for this category, which has been added to the revised Section 6.4.

*Ref.: H.J. Taback, Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin, PB 293 923/AS, NTIS, Springfield, VA, February 1979.

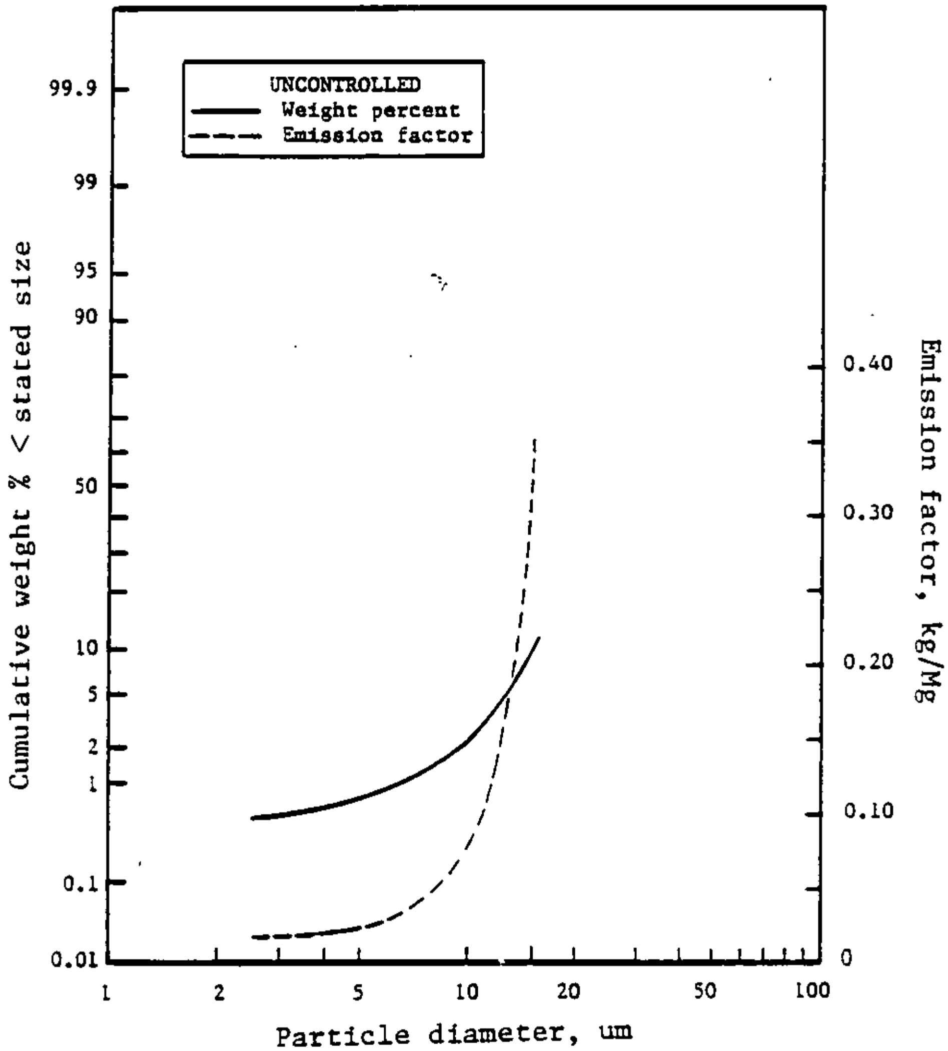

Figure 4. Carob Kibble Roaster: Particle Size Distribution and Emission Factor

C. Emission Factors

Emission factors for six grain processing operations have been added to Table 6.4-3 in AP-42 Section 6.4 (now Table 6.4-6). Of these six, two emission factors replace existing factors in the table. Another factor fills in a blank space in an existing category. The remaining three are entirely new source categories (processing operations) in the table. The six operations for which new or revised emission factors have been developed are:

1. Carob kibble roasting (new category)
2. Wet corn milling - Dryers (new factor in existing category)

Feed mills (cyclone controlled):

3. Pellet coolers (revises previous factor)
4. Corn cracking (new category)
5. Corn hammermills (revises factor for Grinding)
6. Flaking (corn/barley) (new category)

The data for operation no. 1 were located in a 1983 EPA report completed in California that presents fine particle emission data for several source categories. The data for the second operation are from a 1981 EPA Source Category Survey report on animal feed dryers. The remaining emission test data for feed mills are from a test program performed from 1972 to 1980 (Purina Mills). The following subsections describe the basis for the revised emission factors.

1. Carob Kibble Roasting

Reference reports:

1. H.J. Taback, Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin, PB 293 923/AS, National Technical Information Service, Springfield, VA, February 1979.

2. Emission test data from Environmental Assessment Data Systems, Fine Particle Emission Information System, Series No. 229, U.S. EPA, Research Triangle Park, NC, June 1983.

The two reference reports contain results from a test performed by the California ARB on March 23, 1978, on a carob kibble roasting process (uncontrolled emissions). This process is very similar to coffee roasting. Carob pods are air-cleaned, roasted, and then cooled and stored until they are ground in preparation for making carob candies.

Reference 1 shows a calculated emission factor from this test of 6.0 lb/ton (3.0 kg/Mg) carob kibble roasted. It also shows a second factor of 7.6 lb/ton, referencing Section 6.2 of AP-42, Second Edition (Coffee Roasting). This AP-42 emission factor relies on information relating to a different (although similar) industry, whereas these test results directly represent the carob roasting process. Therefore, the calculated emission factor for this test has been included in Table 6.4-3 of AP-42.

Emission Factor: 3.0 kg/Mg (6.0 lb/ton).

2. Wet Corn Milling - Dryers

Reference report:

Source Category Survey: Animal Feed Dryers, U.S. EPA, Emission Standards and Engineering Division, EPA-450/3-81-017, December 1981.

Table 7-1 in the reference report presents emission test data from tests at a wet corn milling plant producing animal feed ('Plant C'), between 1977 and 1981. Uncontrolled emission rates from nine tests (39 runs) on rotary steam tube feed dryers are shown, as well as process weight rates during the tests (see Appendix B). The table below shows how these test parameters are used to calculate the average emission factor for this processing operation.

Plant C tests

Test date	Uncontrolled emission rate, kg/h	Process weight rate, Mg/h	Emission factor, kg/Mg	(lb/ton)
1977	0.60	3.96[a]	0.15	0.30
1977	0.72	4.11	0.18	0.35
1977	0.66	4.16	0.16	0.29
1981	0.69	6.15	0.11	0.22
1977	0.69	4.11	0.17	0.34
1981	0.50	4.22	0.12	0.24
1977	0.97	4.04	0.24	0.48
1981	1.50	4.28	0.35	0.70
1980	0.74	1.02	0.72	1.45
		Average =	0.24	(0.48)

[a]Does not agree with value in Table 7-1. See Appendix B for explanation.

The calculated emission factors are averaged arithmetically to produce an average uncontrolled emission factor for this processing operation.

Emission Factor: 0.24 kg/Mg (0.48 lb/ton).

3. Feed Mills (Pellet coolers, Hammermilling, Flaking, Cracking)

References:

1. Letter and attachment (test data) from Paul Luther, Purina Mills, Inc., St. Louis, MO, to Greg LaFlam, Pacific Environmental Services, Inc., Durham, NC. March 11, 1987.

2. Letter and pellet cooler test data from P. Luther, Purina Mills, to Frank Noonan, U.S. EPA, Research Triangle Park, NC. July 8, 1987.

The reference material contains total particulate test results from four feed mills tested between 1972 and 1980, and from one mill tested in 1987. Pellet coolers at all five mills were tested, and a cracker and hammermill (corn) and a flaking unit (corn/barley) were tested at three of the mills. All process streams tested were controlled by single or multiple cyclones. The table below summarizes the data and shows the calculation of average emission factors (SI units). The data summary sheets from the references are included in Appendix B.

FEED MILL TEST DATA SUMMARY

Pellet Coolers

Plant	A Processed feed rate, Mg/h	B Emission rate, kg/h	C = B ÷ A Controlled emission factor, kg/Mg (lb/ton)
1	10.9	3.0	0.28 (0.55)
	10.9	1.5	0.14 (0.28)
	10.9	5.0	0.46 (0.92)
	10.0	1.8	0.17 (0.32)
2	9.1	0.20	0.02 (0.04)
	16.3	0.84	0.05 (0.10)
3	12.7	3.3	0.26 (0.52)
	13.0	1.8	0.14 (0.28)
	11.4	1.8	0.16 (0.31)
	13.4	3.3	0.25 (0.49)
4	8.8	1.5	0.17 (0.33)
	9.8	1.1	0.11 (0.22)
5	8.4	0.5	0.06 (0.12)
	7.3	0.7	0.10 (0.20)
	5.9	0.5	0.08 (0.16)
		Average =	0.16 (0.32)
		Corn Cracker	
2	3.6	0.04	0.012 (0.024)
		Corn Hammermill	
4	7.3	0.59	0.08 (0.16)
		Flaking Unit (corn/barley)	
1	5.5	0.42	0.08 (0.16)

APPENDIX A

REFERENCE MATERIAL FOR PARTICLE SIZE DISTRIBUTIONS

TABLE 2
Summary of Particulate Results in Metric Units
Inlet

Run Number	1	2	3	Average
Date	10-30-73	10-30-73	10-31-73	
Volume of Gas Sampled - Nm^3 (a)	1.30	2.06	4.16	
Percent Moisture by Volume	0.9	1.0	0.9	
Average Stack Temperature - °C	19.4	20.8	22.3	
Stack Volumetric Flow Rate - Nm^3/min. (b)	1067	1076	1107	1083
Stack Volumetric Flow Rate - m^3/min. (c)	1083	1103	1148	1111
Percent Isokinetic	19.5	92.4	90.7	
Particulates - probe, cyclone, and filter catch				
mg	7,364.0	40,148.0	65,483.0	37,665.0
mg/Nm^3	5,645	19,466	15,706	13,606
mg/m^3	5,561	18,970	15,140	13,224
kg/hr	361	1,256	1,043	887
Particulates - total catch				
mg	7,371.5	40,152.5	65,486.5	37,670.2
mg/Nm^3	5,651	19,469	15,707	13,609
mg/m^3	5,566	18,972	15,141	13,226
kg/hr	362	1,256	1,043	887
Percent impinger catch	0.1	0.0	0.0	0.0

[a] Dry normal cubic meter at 21.1°C, 760mm Hg.

[b] Dry normal cubic meters per minute at 21.1°C, 760mm Hg.

[c] Actual cubic meters per minute

Barge unloading/conveying
From: EPA/EMB Test No. 74-GRN-7

TABLE 4
Summary of Particulate Results in Metric Units
Outlet

Run Number	1	2	3	Average
Date	10-30-73	10-30-73	10-31-73	
Volume of Gas Sampled - Nm^3 (a)	2.38	2.62	2.69	
Percent Moisture by Volume	0.8	0.5	1.1	
Average Stack Temperature - °C	20.4	29.3	29.2	
Stack Volumetric Flow Rate - Nm^3/min. (b)	1024	1069	1097	1063
Stack Volumetric Flow Rate - m^3/min. (c)	1025	1104	1148	1092
Percent Isokinetic	93.5	98.7	98.7	97.0
Particulates - probe, cyclone, and filter catch				
mg	115.5	604.5	135.0	151.7
mg/Nm^3	48.5	77.9	50.1	58.8
mg/m^3	48.4	75.3	47.8	57.2
kg/hr	2.98	5.00	3.30	3.76
Particulates - total catch				
mg	117.0	207.0	137.5	153.8
mg/Nm^3	49.1	78.8	51.0	59.6
mg/m^3	49.0	76.3	48.7	58.0
kg/hr	3.02	5.06	3.36	3.81
Percent impinger catch	1.3	1.2	1.8	1.4

[a] Dry normal cubic meter at 21.1°C, 760mm Hg.

[b] Dry normal cubic meters per minute at 21.1°C, 760mm Hg.

[c] Actual cubic meters per minute

Barge unloading/conveying
From: EPA/EMB Test No. 74-GRN-7

TABLE 5

Particle Size Results

Run 1

Stage	Characteristic Diameter, Dn µm	µg	Weight Percent	Cumulative Weight Percent, <Dn
Probe & cyclone		22,450		
1	3.14	1,480	71.5	28.5
2	1.63	190	9.2	19.3
3	1.10	210	10.1	9.2
4	0.57	120	5.8	3.4
5	0.33	70	3.4	
	TOTAL	2,070		

Run 2

Stage	Characteristic Diameter, Dn µm	µg	Weight Percent	Cumulative Weight Percent, <Dn
Probe & cyclone		44,900		
1	3.14	1,260	87.5	12.6
2	1.63	90	6.3	6.3
3	1.10	30	2.1	4.2
4	0.57	40	2.8	1.4
5	0.33	20	1.4	
	TOTAL	1,440		

Note: Totals indicate sums of numbered impactor stages only, and weight percents are based on these totals. The cumulative values should be shifted as indicated by the dashed lines.

Barge unloading/conveying
From: EPA/EMB Test No. 74-GRN-7

TABLE 2. RESULTS OF ANDERSEN IMPACTOR MEASUREMENTS IN PLUMES GENERATED BY GRAIN LOADING

Test	Test duration (min)	Total measured concentration (mg/m^3)	Size distribution (concentration in size range, mg/m^3) > 13.5 µm	11.2-13.5 µm	7.7-11.2 µm	5.2-7.7 µm	3.3-5.2 µm	1.67-3.3 µm	1.04-1.67 µm	0.71-1.04 µm	< 0.71 µm
Bunge	37	89	54.8	4.8	7.4	7.7	7.1	5.0	1.5	0.0	0.6
Dreyfus	32	200	142	18.6	15.8	10.0	10.4	4.8	3.4	1.0	3.2
Cargill-1	62	9.3	5.9	0.18	1.1	0.19	0.53	0.35	0.53	0.36	0.18
Cargill-2	62	95	33.8	9.7	12.1	8.6	25.4	3.7	1.1	0.38	1.9
Columbia-1	25.4	104	39.3	14.4	10.4	15.6	11.8	9.6	2.6	0.42	0.0
Columbia-2	34	135	60.5	10.0	20.9	13.5	12.0	9.0	5.8	2.6	0.68

Shiploading

From: Emission Factor Development
(GCA Corp. for EPA)

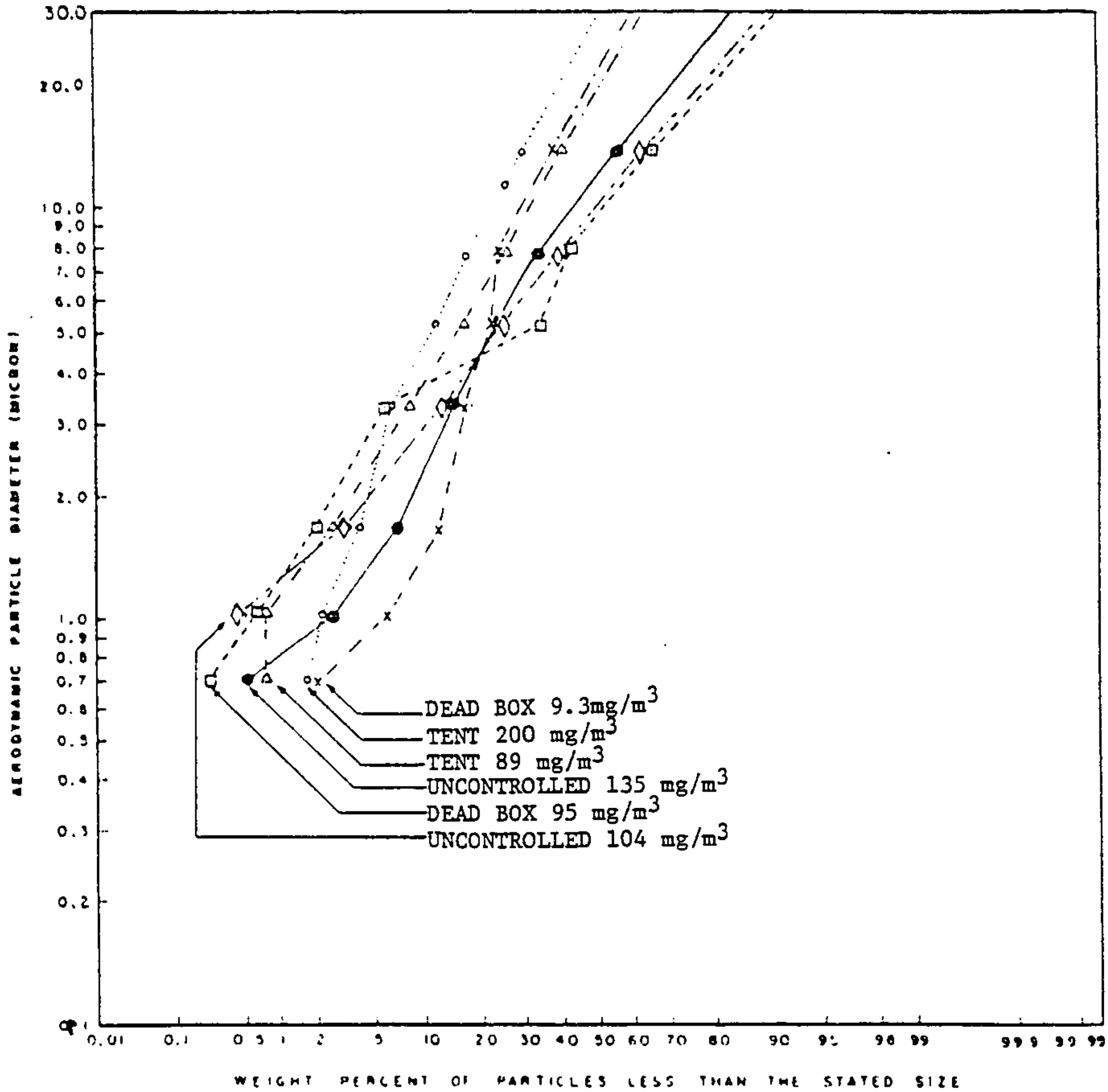

Figure 5. Size distribution of particulate emissions from shiploading, primarily topping-off.

Shiploading

From: Emission Factor Development ...
(GCA Corp. for EPA)

FPEIS TEST SERIES NO: 228 DESCRIBES SAMPLING AT SITE FROM 10/11/77 TO 10/11/77 BY KVB, INC.

SPONSOR ORGANIZATION: CALIFORNIA AIR RESOURCES BOARD
CONTRACT NUMBER: A6-191-30 PURPOSE OF TEST: ENVIRONMENTAL ASSESSMENTS (MULTIMEDIA)
TASK/DIRECTIVE NUMBER: 000

SOURCE DESCRIPTION------------------------------

SOURCE CATEGORY:	FOOD INDUSTRY	SOURCE NAME:	CONFIDENTIAL
SOURCE TYPE:	GRAIN MILL PRODUCTS	SITE NAME:	
PRODUCT/DEVICE:	RICE	ADDRESS:	
PROCESS TYPE:	PROCESSING		LOS ANGELES ,CA 00000
DESIGN PROCESS RATE:	90800 KG/HR		
FEED MATERIAL CATEGORY:	AGRI FEED		
PRIMARY CONTROL DEVICE:		SIC CODE:	2044

EADS WASTE STREAM DATA BASES--------------------

WASTE STREAM DATA FROM OTHER MEDIA WHICH WERE COLLECTED CONCURRENTLY WITH THIS TEST SERIES ARE AS FOLLOWS(TEST SERIES NUMBER-TSN):

LEDS TSN: GEDS TSN: 00080 SDDS TSN: FEIS TSN: CMDS TSN:

REFERENCE REPORT--------------------------------

TITLE
AUTHOR
SPONSOR REPORT NUMBER NTIS NUMBER PUBLICATION DATE

FINE PARTICLE EMISSIONS FROM STATIONARY AND MISCELLANEOUS SOURCES IN THE SOUTH COAST AIR BASIN.
TABACK H.J.
KVB REPORT 5806-783 PB 293 923/AS FEBRUARY 1979

TEST SERIES COMMENTS----------------------------

PROGRAM OBJECTIVES TO INVENTORY TSP EMISSIONS,TO PREPARE A COMPREHENSIVE INVENTORY OF EMISSIONS(I.E. BY SIZE DISTRIBUTION AND CHEMICAL COMPOSITION),AND TO DESCRIBE ALT. METHODS OF CONTROL. RICE DRYER IS A HOLLOW,DOUBLE-WALL CYLINDER ENCLOSED IN A BLDG. VENTED THRU 6-4.1M DIA. SCREENS & HEATED BY 4-9.54KJ/HR BURNERS

Rice Dryer

PARTICLE DIAMETERS BASED ON CLASSIC AERODYNAMIC DEFINITION (TASK GROUP ON LUNG DYNAMICS)

PARTICLE SIZE SUMMARY

SAMPLE NO.	SAMPLE LOCATIONS DEVICE	SYSTEM	UG/DNM3	PARTICLE DIAMETER IN MICROMETERS 20.0	15.0	10.0	6.0	2.5	1.25	1.0	0.625
01	INLET	I	CUM MASS CONC	1.02E+04	6.59E+03	2.95E+03	9.91E+02	2.02E+02	0.00E+00	0.00E+00	0.00E+00
			DM/DLOG D	2.89E+04	2.72E+04	1.15E+04	6.24E+03	5.85E+02	0.00E+00	0.00E+00	0.00E+00
				EXTRAPOL	EXTRAPOL	EXTRAPOL	INTERPOL	INTERPOL	MISSING	MISSING	MISSING
02	INLET	I	CUM MASS CONC	1.99E+04	1.12E+04	2.02E+03	6.26E+02	3.86E+02	2.31E+02	1.95E+02	1.33E+02
			DM/DLOG D	7.01E+04	6.68E+04	2.99E+04	6.29E+02	6.29E+02	3.97E+02	3.53E+02	0.00E+00
				EXTRAPOL	EXTRAPOL	EXTRAPOL	INTERPOL	INTERPOL	INTERPOL	INTERPOL	INTERPOL

Rice Dryer

SAMPLING ACTIVITY DESCRIPTION-------------------

MEASUREMENT INSTRUMENT/METHOD TYPE: I   NAME: SASS TRAIN-WITH CYCLONES   SAMPLING START TIME: 1702   DURATION: 199 MIN

SAMPLING CONDITIONS-- MASS/VOLUMETRIC FLOWRATE= 59.7 M3/SEC   FLOWRATE METHOD: ANEMOMETER   TEMPERATURE= 31 C

MOISTURE CONTENT= 2.3 PCT   VELOCITY= 5.8 M/SEC   PRESSURE= 758 MM HG

SAMPLE DENSITY= 1.0 G/CM3   DENSITY DETERMINATION: ASSUMED

DEVICE SAMPLING LOCATION=INLET   DEVICE/PROCESS NUMBER= 1 SAMPLING LOCATION DESCRIPTION: AT SCREEN OUTLET

SYSTEM SAMPLING LOCATION= INLET OR UNCONTROLLED   CORRESPONDING SAMPLE NUMBER:

VOLUME OF SAMPLE COLLECTED= 27.90 M3   TOTAL MASS OF SAMPLE COLLECTED= 590.70 MG

MEASUREMENT INSTRUMENT: TEMPERATURE= 94 C   INLET PRESSURE= 758 MM HG FLOW RATE= 180.0 L/MIN

ESTIMATED TIME BETWEEN SAMPLING AND CHEM ANALYSIS: DAYS   -SAMPLING AND RADIOASSAY: DAYS

COLLECTION SURFACE/SUBSTRATE:

PERCENT ISOKINETIC SAMPLING= 117   GAS ANALYSIS (PCT BY VOLUME)-- CO2= 7.00   CO= .   O2= 16.00   N2= 77.00

OTHER TRACE GASES (IN PPM):   DILUTION FACTOR= 1.0

PARTICLE MEASUREMENTS WERE MADE ON THE BASIS OF MASS   UPPER BOUNDARY DIAMETER= 30.00 UM

PARTICLE DIAMETERS ARE DEFINED ACCORDING TO THE FOLLOWING DEFINITION: CLASSIC AERODYNAMIC

PARTICLE DIAMETERS WERE DETERMINED FROM CALIBRATION

COMMENTS ON THE SAMPLING ACTIVITY---------------

OF TOTAL SAMPLE MASS 57.6 MG IS INORGANIC & 94.3 IS ORGANIC
CAUGHT IN THE IMPINGERS, SEE GEDS TSN 80.

Rice Dryer

Rice Dryer

SAMPLING ACTIVITY DESCRIPTION-------------------

MEASUREMENT INSTRUMENT/METHOD TYPE: I NAME: OTHER CYCLONES   SAMPLING START TIME: 1703 DURATION: MIN

SAMPLING CONDITIONS-- MASS/VOLUMETRIC FLOWRATE=   FLOWRATE METHOD: TEMPERATURE= C

MOISTURE CONTENT= 3.3 PCT   VELOCITY= M/SEC   PRESSURE= MM HG

SAMPLE DENSITY= G/CM3   DENSITY DETERMINATION:

DEVICE SAMPLING LOCATION=INLET   DEVICE/PROCESS NUMBER= 1 SAMPLING LOCATION DESCRIPTION:

SYSTEM SAMPLING LOCATION= INLET OR UNCONTROLLED   CORRESPONDING SAMPLE NUMBER:

VOLUME OF SAMPLE COLLECTED= 5.46 M3   TOTAL MASS OF SAMPLE COLLECTED= 190.30 MG

MEASUREMENT INSTRUMENT: TEMPERATURE= 96 C   INLET PRESSURE= 758 MM HG FLOW RATE= 35.8 L/MIN

ESTIMATED TIME BETWEEN SAMPLING AND CHEM ANALYSIS: DAYS   -SAMPLING AND RADIOASSAY: DAYS

COLLECTION SURFACE/SUBSTRATE:

PERCENT ISOKINETIC SAMPLING= 11.   GAS ANALYSIS (PCT BY VOLUME)-- CO2= .   CO= .   O2= .   N2= .

OTHER TRACE GASES (IN PPM):   DILUTION FACTOR=

PARTICLE MEASUREMENTS WERE MADE ON THE BASIS OF MASS   UPPER BOUNDARY DIAMETER= UM

COMMENTS ON THE SAMPLING ACTIVITY---------------

OF TOTAL SAMPLE MASS 6.8 MG IS INORGANIC & 1.9 MG IS ORGANIC
CAUGHT IN THE IMPINGERS, SEE GEDS TSN 80.
THREE CYCLONES WERE FABRICATED AND USED IN SERIES WITH A
JOY TRAIN.

Carob Kibble Roasting

FPEIS TEST SERIES NO: 229 DESCRIBES SAMPLING AT SITE FROM 03/23/78 TO 03/23/78 BY KVB, INC.

SPONSOR ORGANIZATION: CALIFORNIA AIR RESOURCES BOARD
CONTRACT NUMBER: A6-191-30 PURPOSE OF TEST: ENVIRONMENTAL ASSESSMENTS (MULTIMEDIA)
TASK/DIRECTIVE NUMBER: 000

SOURCE DESCRIPTION

SOURCE CATEGORY:	FOOD INDUSTRY	SOURCE NAME:	CONFIDENTIAL
SOURCE TYPE:	GRAIN MILL PRODUCTS	SITE NAME:	
PRODUCT/DEVICE:	CAROB KIBBLE	ADDRESS:	
PROCESS TYPE:	ROASTING		LOS ANGELES ,CA 00000
DESIGN PROCESS RATE:	300 KG/HR		
FEED MATERIAL CATEGORY:	AGRI FEED		
PRIMARY CONTROL DEVICE:		SIC CODE:	2041

EADS WASTE STREAM DATA BASES

WASTE STREAM DATA FROM OTHER MEDIA WHICH WERE COLLECTED CONCURRENTLY WITH THIS TEST SERIES ARE AS FOLLOWS(TEST SERIES NUMBER-TSN):

LEDS TSN: GEDS TSN: 00081 SDDS TSN: FEIS TSN: CMDS TSN:

REFERENCE REPORT

TITLE / AUTHOR / SPONSOR REPORT NUMBER	NTIS NUMBER	PUBLICATION DATE
FINE PARTICLE EMISSIONS FROM STATIONARY AND MISCELLANEOUS SOURCES IN THE SOUTH COAST AIR BASIN.		
TABACK H.J.		
KVB REPORT 5806-783	PB 293 923/AS	FEBRUARY 1979

TEST SERIES COMMENTS

PROGRAM OBJECTIVES TO INVENTORY TSP EMISSIONS,TO PREPARE A COMPREHENSIVE INVENTORY OF EMISSIONS(I.E. BY SIZE DISTRIBUTION AND CHEMICAL COMPOSITION),AND TO DESCRIBE ALT. METHODS OF CONTROL. ROASTER HEAT INPUT IS 795M KJ/HR OF NATURAL GAS.

FPEIS TEST SERIES NUMBER: 00229 STREAM NO: 001 TEST ID NO: 1

SERIES FORM C6 PAGE 5 DATE 10/02/86

PARTICLE DIAMETERS BASED ON CLASSIC AERODYNAMIC DEFINITION (TASK GROUP ON LUNG DYNAMICS)

PARTICLE SIZE SUMMARY

SAMPLE NO.	SAMPLE LOCATIONS DEVICE	SYSTEM	UG/DNM3	20.0	15.0	10.0	6.0	2.5	1.25	1.0	0.625
				PARTICLE DIAMETER IN MICROMETERS							
01	INLET	I	CUM MASS CONC	5.84E+04	3.25E+04	5.64E+03	1.87E+03	1.76E+03	1.36E+03	1.10E+03	4.24E+02
			DM/DLOG D	2.07E+05	1.97E+05	8.72E+04	2.65E+02	2.65E+02	2.45E+03	2.87E+03	0.00E+00
				EXTRAPOL	EXTRAPOL	EXTRAPOL	INTERPOL	INTERPOL	INTERPOL	INTERPOL	INTERPOL

Carob Kibble Roasting

SAMPLING ACTIVITY DESCRIPTION-------------------

MEASUREMENT INSTRUMENT/METHOD TYPE: I NAME: OTHER CYCLONES   SAMPLING START TIME: 1036 DURATION: 233 MIN

SAMPLING CONDITIONS-- MASS/VOLUMETRIC FLOWRATE= 799.0 L/SEC   FLOWRATE METHOD: PITOT TUBE   TEMPERATURE= 46 C

MOISTURE CONTENT= 8.2 PCT   VELOCITY= 12.4 M/SEC   PRESSURE= 758 MM HG

SAMPLE DENSITY= 1.0 G/CM3   DENSITY DETERMINATION: ASSUMED

DEVICE SAMPLING LOCATION=INLET   DEVICE/PROCESS NUMBER= 1 SAMPLING LOCATION DESCRIPTION: 2.5 M FROM AFTERBURNER INLET.

SYSTEM SAMPLING LOCATION= INLET OR UNCONTROLLED   CORRESPONDING SAMPLE NUMBER:

VOLUME OF SAMPLE COLLECTED= 6.65 M3   TOTAL MASS OF SAMPLE COLLECTED= 1.07 G

MEASUREMENT INSTRUMENT: TEMPERATURE= 204 C   INLET PRESSURE= 765 MM HG FLOW RATE= 44.5 L/MIN

ESTIMATED TIME BETWEEN SAMPLING AND CHEM ANALYSIS: DAYS   -SAMPLING AND RADIOASSAY: DAYS

COLLECTION SURFACE/SUBSTRATE:

PERCENT ISOKINETIC SAMPLING= 122   GAS ANALYSIS (PCT BY VOLUME)-- CO2= 0.40   CO= .   O2= 20.20   N2= 79.40

OTHER TRACE GASES (IN PPM): NO CO OR HCN DETECTED   DILUTION FACTOR= 1.0

PARTICLE MEASUREMENTS WERE MADE ON THE BASIS OF MASS   UPPER BOUNDARY DIAMETER= 30.00 UM

PARTICLE DIAMETERS ARE DEFINED ACCORDING TO THE FOLLOWING DEFINITION: CLASSIC AERODYNAMIC

PARTICLE DIAMETERS WERE DETERMINED FROM CALIBRATION

COMMENTS ON THE SAMPLING ACTIVITY---------------

OF TOTAL MASS, 319 MG IS INORGANIC & 174 MG IS ORGANIC CAUGHT IN IMPINGERS, GEDS 81. THREE CYCLONES WERE USED WITH A JOY TRAIN. SASS TRAIN DATA FOR THE AFTERBURNER OUTLET CONDITION WAS UNUSABLE DUE TO A HIGH AFTERBURNER TEMPERATURE OF 360 DEG C.

APPENDIX B

REFERENCE MATERIAL FOR REVISED EMISSION FACTORS

TABLE 7-1. EMISSION TEST DATA[a]

Industry/Plant	Date of test	No. of tests	Dryer type	Control type	Dryer process weight rate Mg/h (tons/h)	Stack gas flow rate m³/s (acfm)	Uncontrolled emission rate g/m³ (gr/dscf)	Uncontrolled emission rate kg/h (lb/h)	Controlled emission rate g/m³ (gr/dscf)	Controlled emission rate kg/h (lb/h)	Allowable emissions kg/h (lb/h)
Wet corn milling (SIC 2046)											
Plant A	1976	3	Direct-fired rotary	Cyclone[b]	9.4 (10.4)	8.44 (17,880)	0.055 (0.024)	1.25 (2.76)	--	--	8.99 (19.7)
Plant B[c]	1979	3	4 Direct-fired rotary	Scrubber-venturi	N/A	82.54 (174,900)	--	--	0.163 (0.0713)	27.2 (60)	72.6 (160)[d]
	1979	3	4 Direct-fired rotary	Scrubber-venturi	N/A	94.24 (199,700)	--	--	0.185 (0.0809)	37.2 (82)	72.6 (160)[d]
	1980	3	4 Direct-fired rotary	Scrubber-venturi	N/A	75.27 (159,500)	--	--	0.195 (0.085)	33.1 (73)	472.6 (160)[d]
	1980	3	3 Direct-fired rotary)	Scrubber-venturi	N/A	75.36 (159,700)	--	--	0.146 (0.064)	24.9 (55)	54.4 (120)[e]
Plant C[c]	1977	3	Rotary steam tube (No. 7)	--	40[g] (4.36)	3.12 (6,621)	0.140 (0.061)	0.60 (1.33)	--	--	5.0 (11.0)
	1977	3	Rotary steam tube (No. 8)	--	4.11 (4.53)	3.08 (6,517)	0.167 (0.167)	0.72 (1.59)	--	--	5.2 (11.4)
	1977	3	Rotary steam tube (No. 9)	--	4.16 (4.59)	3.36 (7,119)	0.144 (0.063)	0.66 (1.33)	--	--	52.2 (11.4)
	1981	3	Rotary steam tube (No. 5)	--	6.15 (6.78)	2.73 (5,785)	0.220 (0.096)	0.69 (1.53)	--	--	6.7 (14.8)
	1977	9	Rotary steam tube	Mill cyclone,[b]	4.11 (4.53)	5.68 (12,032)	0.014 (0.006)	0.69 (0.53)	--	--	5.1 (11.3)
	1981	3	Rotary steam tube	Mill cyclone,[b]	4.22 (4.66)	5.39 (11,431)	0.003 (0.013)	0.50 (1.10)	--	--	5.2 (11.5)
	1977	9	Rotary steam tube (+ Hammermill)	Product cyclone,[b]	4.04 (4.45)	5.40 (11,437)	0.055 (0.024)	0.97 (2.14)	--	--	5.0 (11.1)
	1981	3	Rotary steam tube (+ Hammermill)	Product cylone,	4.28 (4.72)	4.79 (10,154)	0.096 (0.042)	1.50 (3.30)	--	--	5.3 (11.6)
	1980	3	Rotary steam tube	--	1.02 (1.12)	2.06 (4,366)	0.215 (0.094)	0.74 (1.63)	--	--	2.0 (4.4)
Alfalfa dehydrators (SIC 2048-9)											
Plant D	1976	2	Direct-fired rotary + hammermill	Cyclones[b]	3.10 (3.42)	10.24 (21,690)	0.616 (0.269)	20.55 (45.3)	--	--	5.8 (12.7)
Plant E	1974-1976	57	Direct-fired rotary	Multiple configurations	--	--	--	2.1-13.7 (4.6-30.2)	--	--	5.0-15.0 (11.0-33.1)

(continued)

Wet corn milling - Dryers

From: EPA-450/3-81-017

TABLE 7-1. (continued)

Industry/Plant	Date of test	No. of tests	Dryer type	Control type	Dryer process weight rate Mg/h (tons/h)	Stack gas flow rate rate m³/s (acfm)	Uncontrolled emission rate g/m³ (gr/dscf)	Uncontrolled emission rate kg/h (lb/h)	Controlled emission rate g/m³ (gr/dscf)	Controlled emission rate kg/h (lb/h)	Allowable emissions kg/h (lb/h)
Beet sugar (SIC 2063)											
Plant F	1977	5	Rotary kiln (lignite-fired)	Cyclone, skimmer[b]	200 (211)	6.47 (13,700) (dscfm)	0.149 (0.065)	3.45 (7.6)	--	--	19.5 (43.0)
Plant G	1980	3	Direct-fired rotary drum	--	65.5 (72.2)	13.07 (27,700)	0.311 (0.136)	7.53 (16.6)	--	--	13.9 (30.4)
	1980	3		--	41.9 (46.2)	13.35 (28,300)	0.389 (0.170)	9.03 (19.9)	--	--	11.1 (24.4)
Plant H	1980	3	Direct-fired rotary drum	--	30.4 (33.5)	14.06 (29,800)	0.254 (0.111)	6.1 (13.5)	--	--	13.7 (30.3)
	1980	3		--	20.3 (22.4)	15.86 (33,600)	0.215 (0.094)	6.8 (15.1)	--	--	11.2 (24.6)
Plant I	1980	3	Direct-fired rotary drum	--	43.9 (48.4)	12.88 (27,300)	0.366 (0.160)	7.7 (17.0)	--	--	14.6 (32.1)
	1980	3		--	43.9 (48.4)	9.25 (19,600)	0.378 (0.165)	5.7 (12.5)	--	--	14.6 (32.2)
Plant J	1977	4	Indirect-fired rotary	Cyclone	22.7 (25)	N/A	--	--	0.183 (0.08)	11.8 (26.1)	16.1 (35.4)
Animal and marine fats and oils (SIC 2077)											
Plant K	1978	N/A	1 Ring; 1 Rotary steam tube	2 cyclones in parallel[b]	3.7 (4.1)	N/A	0.641 (0.28)	1.1 (2.5)	--	--	3.9 (8.5)
Malt beverages (SIC 2082)											
Plant L	1978	3	2 direct-fired rotary drums	2 wet fan collectors	3.8 (4.2)	6.8 (13,300)	--	--	0.112 (0.049)	1.23[f] (2.72)	4.9 (10.8)

N/A = Data not available.
[a]Source sampling reports provided by the plants and by State and local air pollution control agencies.[1]
[b]Based on process description or manufacturing practice, this control equipment is used primarily for product recovery.
[c]Emission rate calculated using front-half and back-half catch, as per Iowa regulation.
[d]Allowable emissions for the 4 dryers.
[e]Allowable emissions for the 3 dryers.
[f]Each dryer.
[g]The value of 40 Mg/h appears to be an error. Assuming 4.36 ton/h for this test is correct, then the equivalent in SI units is 4.36 x 0.908 = 3.96 Mg/h.

PELLET MILL/COOLER STACK TEST SUMMARY

Plant	Feed	Collector	Processed Feed Rate lb/hr	Air Flow SCFM	Emission Rate lb/hr
No. 1	Steer	Longhorn Cyclone	24,000	10,100	6.6
	Steer	Carter Day Cyclone	24,000	10,850	3.4
	Poultry	Cyclones	24,00	10,450	11.0
	Poultry	Cyclones	24,000	14,325	3.9
No. 2	Mixed	Cyclone	20,000	16,735	0.44
	Mixed	Cyclone	36,000	25,580	1.85
No. 3	Poultry	Cyclone	27,900	25,240	7.2
	Poultry	Cyclone	28,700	25,350	4.0
	Steer	Cyclone	25,200	21,850	3.9
	Steer	Cyclone	29,500	30,430	7.3
No. 4	Dairy	Single Cyclone	19,300	16,130	3.2
	Turkey	Single Cyclone	21,600	16,060	2.4

CRACKER STACK TEST SUMMARY

No. 2	Corn	Cyclone	8,000	3,130	0.097

HAMMERMILL STACK TEST SUMMARY

No. 4	Corn	Dual Cyclone	16,000	5,760	1.3

FLAKING STACK TEST SUMMARY

No. 1	Corn/Barley	Single Cyclone	12,000	3,910	0.93

Feed mills (Pellet coolers, Cracking, Grinding and Flaking)

From: Purina Mills, Inc. test data, March 11, 1987

Pellet Mill/Cooler Stack Test Results

Plant	Feed	Collector	Processed Feed Rate lb/hr	Air Flow SCFM	Emission Rate lb/hr
No. 5	Hog	Triple Cyclone	18,500	19,900	1.1
	Horse	Triple Cyclone	16,000	20,000	1.6
	Horse	Triple Cyclone	13,000	19,700	1.1

From: Purina Mills, Inc. test data, July 8, 1987

APPENDIX C

SUPPORT INFORMATION FOR EXISTING EMISSION
FACTORS IN SECTION 6.4

The information in this appendix is copied directly from:

Source Test Evaluation for Feed and Grain Industry, EPA-450/3-76-043, MRI for U.S. EPA, Research Triangle Park, NC, Contract No. 68-02-1403, December 1976.

This material describes the development of emission factors in the previous Section 6.4 dated 4/77.

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 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 belt trippers (primarily for terminal and export elevators). Emissions factors for several of these operations are presented in Table 4.

Table 4. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS

Type of source	Emission factor[a] (uncontrolled) lb/ton	kg/mg
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	3.00[f]	1.50
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)	1.00[k]	0.50
Drying	0.68[l]	0.34
Cleaning	3.00[m]	1.50
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	3.00	1.50
Headhouse (legs)	1.50	0.75
Tripper (gallery belt)	1.00	0.50

References

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 5 shows the values for truck unloading (0.64) and car unloading (1.30). These data are supported by other data in 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 5). 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 5).[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 5.78 lb/ton for cleaning of corn is shown in Table 5, whereas data in Table 6 show a much lower value of 0.34 lb/ton for wheat and smaller grains. Therefore, an average value of 3.00 lb/ton was selected. Because the actual emission factor is dependent on the type of grain, it would be more accurate to use the appropriate value for wheat or corn when possible.

g/ An emission factor of 1.5 lb/ton for the headhouse is from the Kansas City elevator study[1] and is shown by Table 5. 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 5).[1] The value of 0.09 lb/ton shown in Table 6 is lower but was for only one grain (wheat). This is consistent with other data in Reference 1 in which short-term tests showed that the emission factor for unloading of wheat may vary from 0.08 to 1.06 lb/ton.

j/ It was assumed that the emission factor for loading at country elevators would be the same as that for terminal elevators, because no other data was available.

k/ An emission factor of 1.00 lb/ton is based on the average of data for country elevators shown in Table 6.

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 3.00 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 5.

n/ There is a large disparity in the data shown in Table 6 for headhouse (leg) emission factors. However, the average of these data (1.98 lb/ton) is reasonably close to the long-term value of 1.50 lb/ton shown in Table 5.

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 78-GRN-8).

Meager specific emission test data are available from which uncontrolled emission factors could be computed. Therefore most of the factors for terminal and export elevators are based on results reported in Ref. 1, as summarized in Table 5. Recent EPA test results and some emission test reports from North Dakota (Table 6) were used in deriving emission factors for country elevators. These test reports are short-term emission measurements at a few country elevators, which were compared with the long-term test data for the terminal elevator[1/] in order to select emission factors that may be appropriate for country elevators. The emission factor for drying is based mainly on data contained in Refs. 2 and 3, as discussed in Appendix A of this report. All of these emission factors are approximate average values intended to be representative of a variety of grain types but, as noted in Table 4 and in the references, actual emission factors for a specific source could be different, depending on the type of grain (e.g., cleaning) and many other factors.

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 are dependent on such factors as the amount of grain turned (interbin transfer), amount dryed, and amount cleaned. 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 7 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, as explained in Table 8. 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.

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 Ref. 3.

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

Table 5. BEST AVERAGE VALUE OF LONG-TERM COMPOSITE EMISSION FACTORS FOR A TERMINAL ELEVATOR (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 6. SUMMARY OF UNCONTROLLED EMISSION FACTOR DATA FROM TESTS AT COUNTRY ELEVATORS

Source	Emission factor (lb/ton) and grain type
Unloading (trucks)	0.09[4] (wheat)
Removal from bins (tunnel belt hoods and leg boots, etc.)	0.68, 0.37[5] (wheat) 2.72[5] (soybeans) 0.91[5] (corn) 0.63[5] (milo) 1.06 avg.
Cleaning	0.18[6] (wheat) 0.40[7] (not identified) 0.43[8] (wheat and rye) 0.34 avg.
Headhouse (distributor and legs, but also including dump pits)	0.14[9] (wheat) 0.10[7] (not identified) 0.48[8] (wheat, oats, barley)
(legs only)	1.52[4] (wheat) 3.47[4] (milo) 6.15[4] (soybeans) 1.98 avg.

Table 7. 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	3.00		0.22		0.66
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	1.00		2.08		2.08
Drying	0.68		0.25		0.17
Cleaning	3.00		0.08		0.24
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	3.00		0.15		0.45
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 8 for explanation of ratios used. These are typical values based on averages taken from a survey of many elevators across the U.S. and can be considerably different for any individual elevators or group of elevators in the same locale.

Table 8. AVERAGE VALUES USED FOR RATIO OF TONS PROCESSED TO TONS SHIPPED OR RECEIVED

Emission Sources	Unloading		Loading		Turning		Drying		Cleaning		Total[b]
	Ratio of Grain Throughput to Grain Received or Shipped for basic elevator functions listed below[a]										
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 and are based on a survey of many elevators across the U.S. These ratios may therefore be considerably different for an individual elevator or group of elevators in the same locale.

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.

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 flow rate and high moisture content of the exhaust gases, is the dryers. Screenhouses 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 Ref. 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 9. Brief discussions of these different operations and the methods used for arriving at the emission factor values shown in Table 9 are presented below. More detailed discussion and derivation of the emission factors shown in Table 9 are presented in Appendix B (p. C-14 through C-21).

Emission factor data for feed mill operations are limited. The operations of receiving, shipping and handling are similar to operations in a grain elevator, except that many dustier materials (grain by-products, etc.) are handled at feed mills, leading to greater emissions. Factors for these operations were supplied by experts within the feed mill industry.[10] Factors for the remaining operations of grinding and pelleting (pellet cooling) were developed from data in References 2, 11 and 12.

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 the emission factor and information taken from Ref. 2 was used to estimate the emission factor for milling operations. The large emission factor for the milling operation applies to uncontrolled emissions; however, 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.

TABLE 9. TOTAL PARTICULATE EMISSION FACTORS FOR GRAIN PROCESSING OPERATIONS

EMISSION FACTOR RATING: D

Type of Operation	Emission factor[a,b] (uncontrolled except as indicated) kg/Mg	lb/ton
Feed mills		
Receiving	1.3	2.5
Shipping	0.5	1.0
Handling	2.7	5.5
Grinding		
Hammermilling[c]	0.1[d,e]	0.2[d,e]
Flaking[c]	0.1[d]	0.2[d]
Cracking[c]	0.01[d,e]	0.02[d,e]
Pellet cooler[c]	0.2[d]	0.4[d]
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		
Total	1.25[f]	2.5[f]
Rice milling		
Receiving	0.32	0.64
Precleaning and handling	2.5	5.0
Drying	0.15[g]	0.30[g]
Cleaning and mill house	-	-

(continued)

TABLE 9. TOTAL PARTICULATE EMISSION FACTORS FOR GRAIN PROCESSING OPERATIONS (concluded)

EMISSION FACTOR RATING: D

Type of Operation	Emission factor[a,b] (uncontrolled except as indicated)	
	kg/Mg	lb/ton
Soybean milling		
Receiving	0.8	1.6
Handling	2.5	5.0
Cleaning	-	-
Drying[h]	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[h]	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	0.24[i]	0.48[i]
Bulk loading	-	-

[a]Most emission factors are expressed in terms of weight of dust emitted per unit weight of grain entering the plant (i.e., received), which is not necessarily the same as the amount of material processed by each operation.
[b]Dashes indicate information is insufficient.
[c]These factors are in terms of weight of dust emitted per unit weight of grain processed.
[d]Controlled emission factor (cyclones).
[e]These factors were measured on corn processing operations at feed mills.
[f]Controlled emission factor representing several sources at one plant, some controlled with cyclones and others with fabric filters.
[g]Average uncontrolled emission factor for column dryers; see Note c in Table 6.4-2.
[h]Data are insufficient to determine the types of dryers tested.
[i]Factor applies to rotary steam tube dryers.

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 Ref. 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 Ref. 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.

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4. W. H. Maxwell, Stationary Source Testing of a Country Grain Elevator at Overbrook, Kansas, MRI for U.S. EPA, Research Triangle Park, NC, Contract No. 68-02-1403, February 1976.

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9. F.J. Belgea, Cyclone Emissions and Efficiency Evaluation, Report on tests at an elevator in Thompson, North Dakota, Pollution Curbs, Inc., St. Paul, MN, March 10, 1972.

10. Letter from D. Bossman, American Feed Industry Association, Arlington, VA, to F. Noonan, U.S. EPA, Research Triangle Park, NC, July 24, 1987.

11. Emission test data attached to letter from P. Luther, Purina Mills, Inc., St. Louis, MO, to G. LaFlam, PES, Inc., Durham, NC, March 11, 1987.

12. Emission test data attached to letter from P. Luther, Purina Mills, Inc., St. Louis, MO, to F. Noonan, U.S. EPA, Research Triangle Park, NC, July 8, 1987.

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.

Note: The derivation of the new emission factors for feed mills was discussed previously (see p. C-7). The discussion here pertains to the factors in the previous edition of Section 6.4. It has been left in here to provide a complete record of the rationale for current as well as previous emission factors.

APPENDIX B

DERIVATION OF EMISSION FACTORS FOR GRAIN PROCESSING OPERATIONS (as shown in Table 9)

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. 122 of Reference 2 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 (cyclones and fabric filters), are 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

Although no specific supporting data for rice drying were available, the emission factor of 0.30 lb/ton for column dryers was assumed to apply.

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

Tests on an animal feed dryer indicate an average emission factor of 0.48 lb/ton (Reference 24 in Section 6.4; see Appendix D).

Bulk Loading

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