Background Report Reference

AP-42 Section Number: 9.9.1

Background Report Section: 4

Reference Number: 29

Title: Emission Control in the Grain and Feed Industry: Volume II

NTIS

September 1974

450/3-73-003b

PB-241 234

EMISSIONS CONTROL IN THE GRAIN AND FEED INDUSTRY: VOLUME II. EMISSION INVENTORY

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Midwest Research Institute

Prepared for:

Environmental Research Center

September 1974

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/3-73-003b	2.
3. PB 241 234	
4. TITLE AND SUBTITLE Emissions Control In The Grain and Feed Industry Volume II - Emission Inventory	5. REPORT DATE September 1974
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Dr. L. J. Shannon, P. G. Gorman	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Midwest Research Institute, 425 Volker Boulevard, Kansas City, Missouri	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO. 68-02-0213
12. SPONSORING AGENCY NAME AND ADDRESS United States Environmental Protection Agency, Office of Air and Waste Management, Office of Air Quality Planning and Standards	13. TYPE OF REPORT AND PERIOD COVERED Final
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The emission information presented in "Volume I - Engineering and Cost Study" was used in this report to calculate particulate emissions for each segment of the industry and project emissions for the years 1975 and 1980. This required (a) identifying those operations within each segment of the industry that represent major emission sources; (b) determining the production rate for each operation; (c) evaluating the emission factors in Volume I and other references; (d) calculating the average control efficiency for each operation.

Emission calculations were made for the latest year for which production data was reported in Volume I (generally 1969-1971). To calculate the current level of control efficiency, cyclones were assumed to be 90% efficient and fabric filters 99% efficient The following assumptions were made concerning the future extent of control when projecting emissions to 1975 and 1980: (1) a linear relationship exists between the present and future level; (2) large operations located mainly in urban areas will reach 100% application of the most efficient control devices (99%) by 1985; (3) smaller operations will reach 100% control by 1990 or 1995; (4) application of control at smal operations in rural areas (e.g., country elevators) will increase at a fixed rate (e.g., 3% per year).

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Grain Elevators Feeding (supplying) Mills Air Pollution Particles Dust	Emission Inventory Emission Projections	

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 100
	20. SECURITY CLASS (This page) Unclassified	22. PRICE $4.75/2.25

EPA-450/3-73-003-b

EMISSIONS CONTROL IN THE GRAIN AND FEED INDUSTRY: VOLUME II - EMISSION INVENTORY

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Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, N. C. 27711

September 1974

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Publication No. EPA-450/3-73-003-b

PREFACE

This report was prepared for EPA/OAQPS under Contract No. 68-02-0213, which was monitored by Mr. Kenneth R. Woodard.

The program was centered in MRI's Physical Sciences Division, Dr. H. M. Hubbard, Director. Dr. L. J. Shannon, Head, Environmental Systems Section, served as program manager. Dr. L. J. Shannon, Mr. P. G. Gorman, and Mr. M. P. Schrag were the principal authors of this report. Mr. D. Wallace also contributed significantly to the program.

Approved for:

MIDWEST RESEARCH INSTITUTE

H. M. Hubbard, Director
Physical Sciences Division

September 1974

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SUMMARY

Volume I of this study reports on Emissions Control in the Grain and Feed Industry and contains much or all available information on emission sources within this industry. In addition, it contains a compilation of questionnaire data on the extent of control that has been applied. The objective in Volume II is to evaluate this information, prepare an emission inventory for this industry, and project emissions for the years 1975 and 1980.

Methodology employed in preparing the emission inventory consisted of the following steps:

a. Identify (using information in Volume I) those operations within each segment of the industry that represent major emission sources.

b. Determine production rate for each segment of the industry and the portion of that rate associated with specific operations.

c. Evaluate data presented in Volume I and other references in order to select the most representative emission factor for each operation.

d. Utilize questionnaire results presented in Volume I to identify application of control on each operation and calculate average efficiency of control.

e. Calculate annual emissions from each operation using factors obtained in the preceding steps.

This sequence of steps, or variations thereof, was employed to calculate emission quantities for all important sources within each segment of the grain and feed industry. A summary of emissions for each segment is presented in Table 1 and indicates the year for which these are applicable. Some segments do not include all source operations because of lack of information.

Table 1. SUMMARY OF ESTIMATED EMISSIONS

Source	Emissions (tons/year)	Confidence Rating[c]
Grain elevators		
Country elevators (1971)	357,000	B
Terminal elevators (1971)	117,000	A
Export elevators (1971)	140,000	B
Feed mills (1969)	174,000	B
Alfalfa dehydration plants (1971)	16,000	B
Wheat mills (1971)	45,600[a]	C
Durum mills (1971)	649[a]	C
Rye mills (1971)	408[a]	C
Dry corn mills (1970)	3,550[a]	B
Oat mills (1970)	875	C
Rice mills (1970)	4,260[a]	C
Commercial rice dryers	b/	
Soybean mills (1970)	117,000	B
Wet corn mills (1970)	11,200	C

a/ Emission quantity does not include all source operations because of lack of information.

b/ No estimate of emissions due to lack of information.

c/ A - Good reliability
B - Fair reliability
C - Poor reliability

The emission estimates are subject to several limitations. Foremost among these is the scarcity of data needed for determination of representative emission factors. In many cases estimates had to be based on only one or two pieces of data and in certain cases controlled emission factors had to be used. Accuracy of the emission calculations is also limited by the reliability of the extent of control information taken from the questionnaires and the fact that these same data were used to calculate the average efficiency of control assuming 90% efficiency for cyclones and 99% efficiency for fabric filters. Reliance on meager data and the uncertainty of assumptions limit the accuracy of results, as indicated by the confidence ratings (Table 1), and emphasizes the need for additional testing and information before more accurate estimates can be obtained.

The emission values given in Table 1 are believed to be the best estimates that can be made within the limitations of the available data. These estimates were prepared for more sources, and in more detail, than was previously possible. They are also based on the most complete information on extent of control obtained from industry questionnaires and should therefore closely represent current status of applied control technology in this industry.

Emission calculations were made for the latest year in which production information was reported in Volume I. This ranged from 1969-1971. These calculations were used as a basis for projecting emissions for 1975 and 1980. The processing rates for those years were estimated and the following assumptions were made concerning the future in the extent of control: (1) larger operations located mainly in urban areas (e.g., export elevators) will be subject to more control pressures so they would reach 100% application of control, using the most efficient devices, by 1985; (2) a linear relationship exists between the present and future level; (3) smaller operations will reach 100% control by 1990 or 1995, depending on the type of operation; (4) small operations in rural areas (e.g., country elevators) should be under less control pressure, so the application of control will increase at a fixed rate (e.g., 3% per year).

The accuracy of emission projections is limited primarily by these assumptions, however, they are considered reasonable at this time.

Results of the emission projections for each segment of the grain and feed industry are shown in Table 2.

Table 2. SUMMARY OF PROJECTED EMISSIONS

Industry	Estimated Emissions (tons/year) (and Base Year)	Projected Emissions (tons/year) 1975	Projected Emissions (tons/year) 1980
Grain elevators			
Country elevators	357,000 (1971)	376,000	339,000
Terminal elevators	117,000 (1971)	126,000	115,000
Export elevators	140,000 (1971)	132,000	32,000
Feed mills	174,000 (1969)	156,000	127,000
Alfalfa dehydration	16,000 (1971)	13,000	9,200
Wheat mills a/	45,600 (1971)	37,400	29,000
Durum mills a/	649 (1971)	628	507
Rye mills a/	408 (1971)	338	262
Dry corn mills a/	3,550 (1970)	2,870	1,980
Oat mills	875 (1970)	1,000	1,000
Rice mills a/	4,260 (1970)	3,730	2,420
Commercial rice dryers	b/	b/	b/
Soybean mills	117,000 (1970)	93,000	61,400
Wet corn mills	11,200 (1970)	10,800	9,300

a/ Emission quantities do not include all source operations because of lack of information.

b/ No estimate of emissions due to lack of information.

I. INTRODUCTION

Inventories of particulate emissions for grain and feed operations have been conducted in the past by EPA and others, but the previous inventories were usually directed primarily to grain elevators and were based on very meager data on emission factors and estimates of extent of control. As part of EPA Contract No. 68-02-0213, recent test data as well as previous data were compiled by MRI to up-date information on emissions and emission factors for each operation within each segment of the grain and feed industry. In addition, the emission inventory questionnaires utilized in the study enabled a determination of the extent of control for most industry operations.* The improved data base that resulted was used to prepare an inventory of particulate emissions for the grain and feed industry which is reported herein.

The segments of the grain and feed industry included in this emission inventory are:

A. Grain Elevators

B. Feed Mills

C. Alfalfa Dehydrating Plants

D. Wheat Mills

E. Durum Mills

F. Rye Mills

G. Dry Corn Mills

H. Oat Mills

I. Rice Mills

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* See Appendix C of Ref. 1.

J. Commercial Rice Dryers

K. Soybean Mills

L. Wet Corn Mills

The above industry segments are the same as those covered in Volume I,[1/] which included process descriptions, identification of emission sources, presentation of emission data, and discussion of control methods, etc. Much of that information has been utilized in this report.

The methodology used to make emission estimates and the data and calculations pertinent to each operation are presented in this document. Assumptions used and indications of the reliability of the estimates are included with the calculations. Data required for calculating emissions from some specific operations are still not available, therefore the emission inventory presented is not complete.

The emission inventory is primarily based on amounts of grain processed by each segment of the industry in 1970 or 1971 (the most recent data compiled in Volume I).[1/] Estimates of future grain production and emission control have been used to project emissions for the years 1975 and 1980.

II. GENERAL METHODOLOGY

In order to refine existing emission inventories, it is necessary to upgrade the data base with respect to production rates, emission factors, percentage of production capacity on which control equipment is installed, and control equipment efficiency. Most of the available emission factor data for the operations within each segment of the industry and statistics on the amount of grain processed through each operation are presented in Volume I as well as information on the type and on the number of control devices installed on the various sources of interest.

The computation method used to calculate the emission was, in most cases, the same procedure that had been applied in making the national inventory of particulate emissions for the Particulate Pollutant System Study.[2] The following equation was used to calculate emissions:

$$E = (P)(e.f.)\ (1/2{,}000)\left[1-(a)(e)\right] \qquad (1)$$

where E = Emissions in tons per year.

P = Process rate in tons per year.

e.f. = Emission factor in pounds per ton.

a = Application of control (expressed as the fraction of amount processed that is equipped with control equipment).

e = Efficiency of control (a factor indicating the average efficiency of the control equipment applied to the process).

Details of the calculations and a summary of the calculated emissions are presented in the following sections. All of the data necessary for the calculation using Eq. (1) were not available for every operation in each industry segment. For a few operations, so little information was available that it was not possible to estimate emissions. Some estimates were made by somewhat different methods which are detailed in the text. Also, since more data were available for some sources than for others, a confidence rating was assigned to the emissions quantity for each operation as an indication of the accuracy of the calculated emissions.*

The estimated particulate emissions represent the total potential emissions from handling of grain and other processing operations. Some are generated from interior operations, such as tunnel belts and gallery belts in grain elevators, and may not all reach the exterior of the facility. Those emitted from operations that are primarily external (unloading, loading, drying, etc.) are emitted to the ambient air. Therefore, the particulate emissions which actually enter the atmosphere could range from a minimum of those associated only with external operations up to a maximum of the total emission from all operations.

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* A = Good reliability.
B = Fair reliability.
C = Poor reliability.

III. EMISSION CALCULATIONS

A. Grain Elevators

Grain elevators are one of the major sources of particulate emissions within the grain and feed industry. This segment has been subdivided into the three main categories of country, inland terminal, and export elevators. Many of the grain handling operations or emission sources within these three classes of elevators are similar and include:

Unloading

Loading

Drying

Cleaning

Garner and scale vents

Elevator legs

Transfer points

Bin vents

Emission estimates were made for most of the above sources within the three types of elevators. Emission factors were derived from data compiled in Volume I and were supplemented by data obtained in a recent study conducted by MRI for EPA, at a terminal elevator in Kansas City.[3] An extensive analysis of available data on grain dryer emissions was necessary in order to derive a representative overall emission factor for that source because of the difficulties associated with sampling of dryers, the variations in dryer designs, and the spread in reported sampling results. Our analysis of grain dryer emission factors is presented within the section on country elevators.

One difficulty in making emission calculations for grain elevators was determination of the amount of grain processed through each operation by each type of elevator. The first requirement was to ascertain the amount of grain handled or unloaded in each type of elevator. It was then necessary to analyze available information in order to estimate the amount of grain processed through each operation. This is a complex problem because only part of the grain that is unloaded is cleaned or dryed, while on the other hand, more grain may be transferred internally than is unloaded. The methodology used in estimating the amounts of grain processed through each operation is discussed within the appropriate section of the emission calculations for each type of elevator.

1. Country elevators: The major operations or sources within country elevators for which emission quantities were calculated are:

a. Unloading

b. Turning

c. Loading

d. Drying

e. Cleaning

f. Headhouse

a. Unloading

(1) Processing rate: The annual receipts, or amount of grain unloaded, at country elevators during the 1971-1972 crop year was 5.9×10^9 bushels (177×10^6 tons) (Vol. I, page 21).

(2) Emission factor: An emission factor of 0.64 lb/ton, for truck unloading, was taken from a study at a terminal elevator.3/ This is lower than previous factors for this source but is based on quantitative results that are considered to be the most accurate available. It is possible, however, that the emission factor for country elevators could be higher than similar operations at terminal elevators because of the field dust, etc., but definitive test results for country elevators are not available.

(3) Extent of control: A 31% application of control was determined from Table 177 in Vol. I. This same table was used to calculate a 90% efficiency of control assuming 90% efficiency for cyclones and 99% for fabric filters.

(4) Calculation of emissions: Using Eq. (1) and the factors delineated above, one obtains the following estimate of particulate emissions:

$$(177 \times 10^6 \text{ tons})\ (0.64 \text{ lb/ton})\ (\text{ton}/2{,}000 \text{ lb})\ [1-(0.31)(0.90)]$$

$$= 0.41 \times 10^5 \text{ tons}^B$$

b. Turning

(1) Processing rate: The amount of grain turned was calculated using the amount of grain unloaded (177×10^6 tons). This was multiplied by 1/2.0, which is the ratio of storage capacity to amount received (Vol. I, page 20), and by 1.5, which is the estimated number of times that storage volume is turned based on the country elevator questionnaires discussed in Volume I.

(2) Emission factor: A value of 1.40 lb/ton was used for turning, based on expected similarity to the tunnel belt emissions factor determined in Ref. 3 for a terminal elevator.

(3) Extent of control: Because grain is often turned at a country elevator by returning it into the receiving pit, the same extent of control as receiving was assumed.

(4) Calculation of emissions: Particulate emissions from turning operations were estimated using Eq. (1) and the appropriate factors. As shown in the following calculations, emissions are estimated to be about 6.7×10^4 tons/year.

$$(177 \times 10^6 \text{ tons} \times 1/2.0 \times 1.5)(1.40 \text{ lb/ton})(\text{ton}/2{,}000 \text{ lb})[1-(0.31)(0.90)]$$

$$= 6.65 \times 10^4 \text{ tons}^B$$

c. Loading

(1) Processing rate: It was assumed that over the long term, the amount loaded equals the amount unloaded (177×10^6 tons).

(2) Emission factor: A factor of 0.27 lb/ton was applied to loading operations at country elevators. This factor is based on data for car loading at a terminal elevator. No definitive data were available for country elevators so the same factor was used as for terminal elevators (see section on unloading).

(3) Extent of control: Data in Vol. I (Table 177) were utilized to calculate 22% application of control and 90% efficiency of control.

(4) Calculation of emissions: Emissions are estimated to be 19,000 tons/year as indicated by the following calculation.

$$(177 \times 10^6 \text{ tons})(0.27 \text{ lb/ton})(\text{ton}/2{,}000 \text{ lb})[1-(0.22)(0.90)] = 0.19 \times 10 \text{ tons}^B$$

d. Drying

(1) Processing rate: Data in Volume I (page 23) indicated that 25.4% of grain receipts are dried at country elevators. The survey questionnaires used in deriving this figure also indicated that about half of the dryers at country elevators were rack type and the other half were column type. Based on this information, it was assumed that 12.7% of grain receipts are dried in each type of dryer.

(2) Emission factor: A quantitative assessment of emissions from grain dryers is difficult. The emission rate from any given installation is probably 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.

There are two main types of grain dryers (rack or column type) and because the emissions from these two types are different, they have been considered separately. Available data on rack dryer emissions have been tabulated as shown in Table 3. Some of the data in Table 3 are results of emission tests on dryers equipped with control devices employing some type of screen to reduce the emissions. The data and information from Table 3 are depicted graphically in Figure 1. This figure indicates that there may be a relationship between control device screen size and the emission factor. The figure also indicates that the uncontrolled emission factor for rack dryers may approach an average value of about 3.0 lb/ton. For this reason, the value of 3.0 lb/ton has been selected as the uncontrolled emission factor for rack dryers, for the purpose of estimating emissions from rack dryers.

Table 3. GRAIN DRYER EMISSION DATA--RACK DRYERS

	Dryer Throughput (bu/hr)	Control Device Screen Size	Emissions (lb/ton)	
			Controlled	Uncontrolled
A[a]	2,750	34 mesh	1.3	-
B[b]	1,000	100 mesh	0.1 to 0.38	-
C[c]	1,033	None	-	3.9
D[c]	4,000	50 mesh	0.86	-
E[d]	2,000	None	-	2.3
F[e]	1,000	24 mesh	0.34	3.1

a/ Volume I, p. 134.
b/ Volume I, p. 136.
c/ Volume I, p. 137.
d/ Volume I, p. 139.
e/ Test report received from EPA.

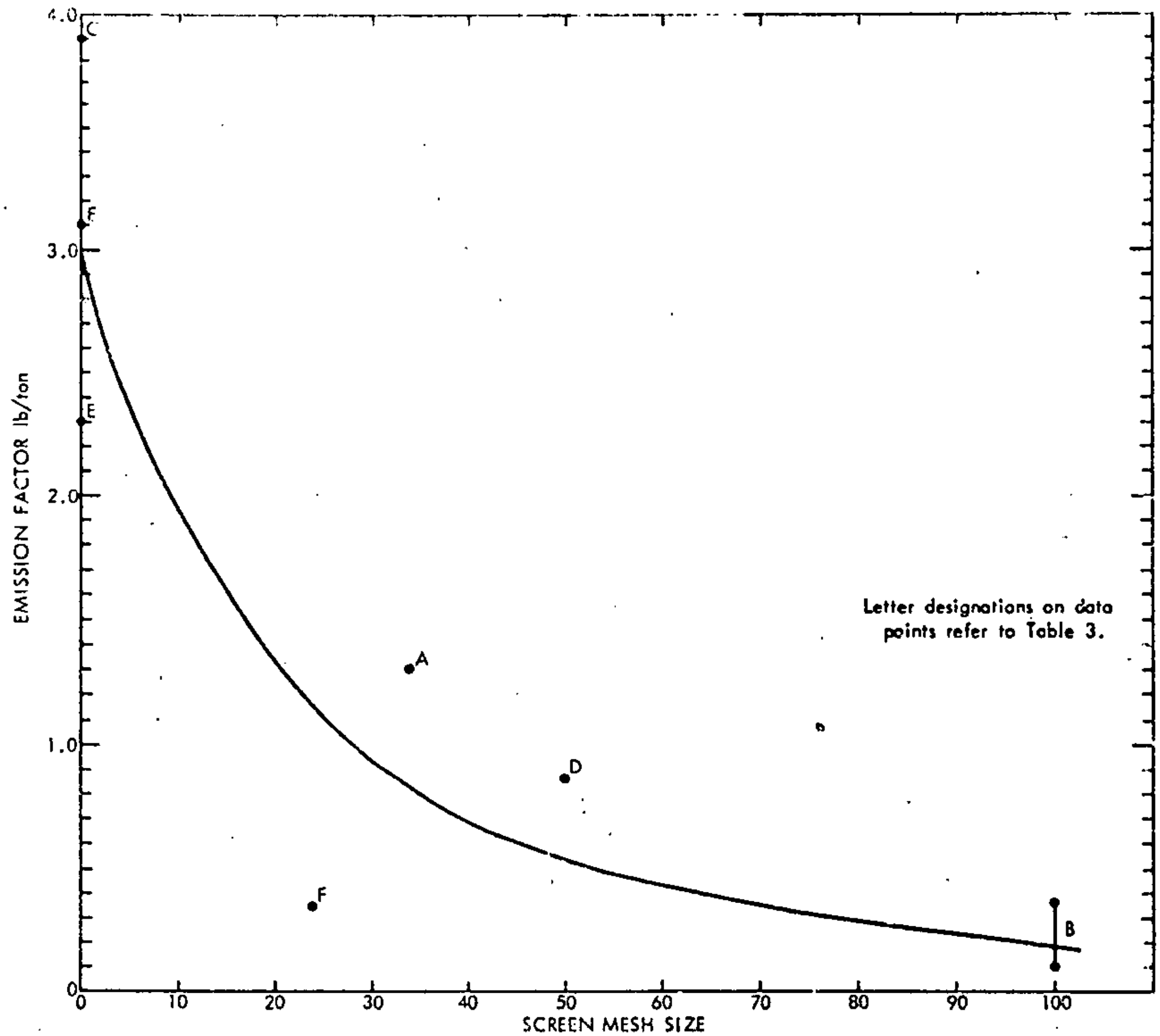

Figure 1 - Emission Factor Data for Rack Dryers as a Function of Control Device Screen Size

Emission test data for column dryers are sparse, as can be seen by the tabulation of data in Table 4. Only two sets of data were available but they are in close agreement with an average of 0.22 lb/ton. However, other unpublished data for a column dryer (noncirculating) showed an emission factor of 0.45 lb/ton.* Therefore, these three pieces of data were considered together and an emission factor of 0.3 lb/ton was used for the purpose of estimating emissions from column dryers.

Table 4. GRAIN DRYER EMISSION DATA--COLUMN DRYERS

	Dryer Throughput (bu/hr)	Control Device	Emissions (lb/ton)	
			Controlled	Uncontrolled
A[a]/	1,000	None	-	0.21
B[b]/	400	None	-	0.23

a/ Volume I, p. 139.
b/ Volume I, p. 140.

In summary, the uncontrolled emission factors used in computing dryer emissions are those shown in Table 5 (rack--3.0 lb/ton, column--0.3 lb/ton). However, it must be emphasized that 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.

(3) Extent of control: Data in Volume I (Table 177) showed the application of control on all grain dryers to be 25%. It has been assumed that the controlled dryers are primarily the rack type. As previously mentioned, half of the dryers are rack type, while the other half are column type. Therefore, the application of control on rack type dryers is 50%, while the application of control on column dryers is near 0%. The associated efficiency of control was estimated to be 80% for the devices that are used to control rack dryer emissions.

* Background Information for Federal Performance Standards - Grain Handling and Milling, Report prepared for EPA by PEDCo-Environmental, Cincinnati, Ohio, July 1971.

Table 5. SUMMARY OF EMISSION FACTOR SELECTIONS FOR GRAIN DRYERS

Dryer Type	Selected Emission Factor (uncontrolled)
Rack	3.0 lb/ton
Column	0.3 lb/ton

(4) Calculation of emissions: Based on the above factors, particulate emissions from grain dryers were estimated as follows:

Rack dryers:

$(177 \times 10^6$ tons $\times$ 12.7%)(3.0 lb/ton)(ton/2,000 lb) [1-(0.50)(0.80)]

= 20.23×10^3 tons

Column dryers:

$(177 \times 10^6$ tons $\times$ 12.7%)(0.3 lb/ton)(ton/2,000 lb) [1-(0)]

= 3.37×10^3 tons

Dryer total 23.60×10^3 tons[c]

e. Cleaning

(1) Processing rate: Data in Vol. I (page 23) indicated that 7.8% of receipts at country elevators are cleaned.

(2) Emission factor: An emission factor of 6.0 lb/ton was selected based on data in Ref. 3. This is somewhat lower than the range of 7-10 lb/ton shown in Table 81 of Vol. I, but the former value is considered to be based on more definitive data

(3) Extent of control: Volume I (Table 177) showed 73% application of control on cleaning operations at country elevators.* Data from this same table were used to calculate an efficiency of control of 95%, assuming 90% efficiency for cyclones and 99% for fabric filters.

* In comparison with the application of control for drying in terminal and export elevators, the 73% application figure appears to be quite high. It is possible that data from questionnaires were not representative of the whole industry. Thus the confidence level of this figure is quite low.

(4) Calculation of emissions: Particulate emissions of the order of 10^4 tons/year are estimated to result from grain cleaning as shown in the following calculation:

$$(177 \times 10^6 \text{ tons} \times 7.8\%)(6.0 \text{ lb/ton})(\text{ton}/2{,}000 \text{ lb})[1-(0.73)(0.95)]$$

$$= 1.38 \times 10^4 \text{ tons}^C$$

f. Headhouse

(1) Processing rate: Amount of grain passing through the headhouse (legs) is estimated to be the same as the total of all operations because grain must pass through the headhouse at least once for each operation. Therefore, the amount passing through the headhouse was obtained by summation of the amounts involved in each operation as described in the preceding sections a through e, resulting in a total of 546 x 10^6 tons.

(2) Emission factor: An approximate emission factor of 1.5 lb/ton was used for the headhouse (legs, etc.) based on data in Ref. 3.

(3) Extent of control: Volume I (Table 177) showed 59% application of control on legs at country elevators. Almost all were controlled with cyclones, so efficiency of control was estimated to be 90%.

(4) Calculation of emissions: Using Eq. (1) and the factors delineated for headhouse processes, one obtains the following estimate of particulate emissions:

$$(546 \times 10^6 \text{ tons})(1.5 \text{ lb/ton})(\text{ton}/2{,}000 \text{ lb})[1-(0.59)(0.90)] = 1.92 \times 10^5 \text{ tons}^B$$

g. Summary of estimated particulate emissions for country elevators: A summary of the estimated particulate emissions for the major sources at country elevators is presented below:

Country Elevators	Emission (1971) (ton/year)	Confidence Rating a/
a. Unloading	0.41×10^5	B
b. Turning	6.65×10^4	B
c. Loading	0.19×10^5	B
d. Drying	2.36×10^4	C
e. Cleaning	1.38×10^4	C
f. Headhouse	1.92×10^5	B
Subtotal	3.57×10^5	B

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

2. Inland terminal elevators: The major individual sources within inland terminal elevators for which emission quantities were calculated are:

a. Unloading

b. Turning

c. Loading

d. Drying

e. Cleaning

f. Headhouse

g. Tripper

a. Unloading

(1) Processing rate: The annual receipts or amount of grain unloaded at terminal elevators during the 1971-1972 crop year was 1.8×10^9 bushels (5.4×10^7 tons).1/

(2) Emission factor: An emission factor of 1.00 lb/ton is estimated for unloading in terminal elevators. This is based on the average of the emission factors for truck unloading (0.64 lb/ton) and car unloading (1.30 lb/ton) found in Ref. 2. This estimate is supported by data in Table 81 of Vol. I.

(3) Extent of control: A 59% application of control was determined using Table 178 in Vol. I. This same table was used to determine an efficiency of control of 93%. This is based on a weighted average of the control devices assuming 90% efficiency for cyclones and 99% efficiency for fabric filters.

(4) Calculation of emissions: Particulate emissions calculated from Eq. (1) and the factors selected result in the following estimate:

$$(5.4 \times 10^7 \text{ tons})(1.00 \text{ lb/ton})(1/2{,}000)[1-(0.59)(0.93)] = 1.22 \times 10^4 \text{ tons}^A$$

b. Turning

(1) Processing rate: The amount of grain turned was calculated using the amount of grain unloaded (5.4×10^7 tons). This was multiplied by 1/1.4 which is the ratio of storage capacity to amount received (Vol. I, page 20) and by 1.0 which is the estimated number of times that the storage volume is turned based on questionnaires discussed in Vol. I.

(2) Emission factor: A factor of 1.40 lb/ton was used and was based on the tunnel belt emission factor of 1.40 determined in Ref. 3.

(3) Extent of control: A 92% application of control was determined using Table 178 of Vol. I. The same table was used to determine an efficiency of control of 93%, assuming 90% efficiency for cyclones and 99% efficiency for fabric filters.

(4) Calculation of emissions: Particulate emissions on the order of 4,000 tons are estimated using Eq. (1) and the preceding factors:

$$(5.4 \times 10^7 \text{ tons} \times 1/1.4 \times 1.0)(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.92)(0.93)]$$

$$= 3.78 \times 10^3 \text{ tons}^A$$

c. Loading

(1) Processing rate: It is assumed that the amount loaded is equal to the amount unloaded (5.4×10^7 tons).

(2) Emission factor: The emission factor of 0.27 lb/ton for loading into cars was taken from Ref. 3.

(3) Extent of control: A 30% application of control was obtained from Table 178 of Vol. I. Data from the same table were used to calculate an efficiency of control of 92%.

(4) Calculation of emissions: Emissions of the order of 5,000 tons/year were estimated using Eq. (1).

$$(5.4 \times 10^7 \text{ tons})(0.27 \text{ lb/ton})(1/2{,}000)[1-(0.30)(0.92)] = 5.25 \times 10^3 \text{ tons}^A$$

d. Drying

(1) Processing rate: Data in Vol. I (page 23) indicated that 9.6% of the grain unloaded is dried in terminal elevators. It was also assumed that like country elevators half of the dryers at terminal elevators were rack type and the other half were column type. On this basis, it follows that 4.8% of the amount unloaded is dried in each type of dryer (i.e., 2.59×10^6 tons).

(2) Emission factor: An emission factor of 0.3 lb/ton was used for column dryers and 3.0 lb/ton for rack dryers (see Section 1.d.).

(3) Extent of control: A 24% application of control was obtained from Table 178 of Vol. I and the efficiency of control was estimated to be about 80% for the devices that are used to control dryer emissions. However, the 24% application of control covers all dryers, half of which were assumed to be column type and half rack type. As in the case of country elevators, it was also assumed that the controlled dryers are primarily the rack type. It therefore follows that the application of control on rack type dryers is 48%, while the application of control on column dryers is near 0%.

(4) Calculation of emissions: Emissions have been calculated based on the factors delineated above and in Eq. (1) as follows:

Rack dryers:

$$(2.59 \times 10^6 \text{ tons})(3.0 \text{ lb/ton})(\text{ton}/2{,}000 \text{ lb})[1-(0.48)(0.80)]$$

$$= 2.39 \times 10^3 \text{ tons}$$

Column dryers:

$$(2.59 \times 10^6 \text{ tons})(0.3 \text{ lb/ton})(\text{ton}/2{,}000 \text{ lb})[1-(0)]$$

$$= \underline{0.39 \times 10^3 \text{ tons}}$$

Dryer total 2.78×10^3 tons[C]

e. Cleaning

(1) Processing rate: From Vol. I (page 23) it was determined that terminal elevators clean 22.1% of their receipts. Using the amount of grain unloaded (5.4×10^7 tons) it was determined that the amount of grain cleaned was 1.19×10^7 tons.

(2) Emission factor: An emission factor of 6.00 lb/ton is based on data from Ref. 3, which showed an emission factor of 5.78 lb/ton for corn cleaning.

(3) Extent of control: A 43% application of control was obtained from Table 178 of Vol. I. Data from this same table were used to determine the efficiency of control of 92%.

(4) Calculation of emissions: The emissions from the cleaning process were calculated to be 2.18×10^4 tons.

$$(1.19 \times 10^7 \text{ tons})(6.00 \text{ lb/ton})(1/2{,}000)[1-(0.43)(0.92)] = 2.18 \times 10^4 \text{ tons}^{A}$$

f. Headhouse

(1) Processing rate: The amount of grain passing through the headhouse is estimated to be the total of all operations (16.4×10^7 tons).

(2) Emission factor: The emission factor of 1.50 lb/ton was determined from Ref. 3 (1.49 lb/ton) which included garner and scale.

(3) Extent of control: A 78% application of control was obtained from Table 178 of Vol. I. This same table was used to determine an efficiency of control of 92%.

(4) Calculation of emissions: Below are the calculations of total emissions from the headhouse process in terminal elevators (primarily legs).

$(16.4 \times 10^7 \text{ tons})(1.50 \text{ lb/ton})(1/2{,}000)[1-(0.78)(0.92)] = 3.44 \times 10^4 \text{ tons}^A$

g. Tripper

(1) Processing rate: The amount of grain crossing the tripper is assumed to be at least equal to the amount unloaded plus the amount turned (9.3×10^7 tons).

(2) Emission factor: The emission factor for the tripper of 1.00 lb/ton is a gross estimate based on factors for other sources and observations of tripper emissions. No data are available for this source.

(3) Extent of control: A 22% application of control was taken from Vol. I (Table 178). An efficiency of control of 94% was determined using data from the same table.

(4) Calculation of emissions: Emissions from the tripper have been approximated at 3.67×10^4 tons as calculated below:

$(9.3 \times 10^7 \text{ tons})(1.00 \text{ lb/ton})(1/2{,}000)[1-(0.22)(0.94)] = 3.67 \times 10^4 \text{ tons}^B$

h. Summary of the calculated emissions for terminal elevators: A summary of the calculated emissions for the major sources at terminal elevators is presented below:

Terminal Elevators	Emissions (1971) (tons/year)	Confidence Rating[a/]
a. Unloading	1.22×10^4	A
b. Turning	3.78×10^3	A
c. Loading	5.25×10^3	A
d. Drying	2.78×10^3	C
e. Cleaning	2.18×10^4	A
f. Headhouse	3.44×10^4	A
g. Tripper	3.67×10^4	B
Subtotal	1.17×10^5	A

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

3. Export elevators: The major individual sources within export elevators for which emissions quantities were calculated are:

a. Unloading

b. Turning

c. Loading

d. Drying

e. Cleaning

f. Headhouse

g. Tripper

a. Unloading

(1) Processing rate: The annual receipts or amount of grain unloaded at export elevators during the 1971-1972 crop year was 2.7×10^9 bushels (8.1×10^7 tons) (Vol. I, page 21).

(2) Emission factor: The emission factor for export elevators is assumed to be the same as that for terminal elevators, 1.0 lb/ton.

(3) Extent of control: An application of control of 76% was obtained from Table 179 of Vol. I. This same table was used to calculate an efficiency of control of 95%. This was based on a weighted average of the control devices, assuming 90% efficiency for cyclones and a 99% efficiency for fabric filters.

(4) Calculation of emissions: Using Eq. (1) and the factors delineated above, emissions from the unloading operation were determined as follows:

$$(8.1 \times 10^7 \text{ tons})(1.00 \text{ lb/ton})(1/2,000)[1-(0.76)(0.95)] = 1.13 \times 10^4 \text{ tons}^A$$

b. Turning

(1) Processing rate: The amount of grain turned was calculated using the amount of grain unloaded (8.1×10^7 tons). This was multiplied by the ratio of the storage capacity to the amount received (1/7.6) from Vol. I (page 20) and by the estimated number of times that the storage volume is turned (0.5) based on data from the associated questionnaires.

(2) Emission factor: The emission factor for turning is assumed to be the same as that for terminal elevators (1.40 lb/ton).

(3) Extent of control: An 82% application of control was determined by using Table 179 of Vol. I. This table was also used to determine an efficiency of control of 93%.

(4) Calculation of emissions: The total emissions from the turning of grain in export elevators has been determined to be about 900 tons.

$$(8.1 \times 10^7 \text{ tons} \times 1/7.6 \times 0.5)(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.82)(0.93)] = 8.95 \times 10^2 \text{ tons}^A$$

c. Loading

(1) Processing rate: It is assumed that the amount loaded is equal to the amount unloaded (8.1×10^7 tons).

(2) Emission factor: The emission factor of 1.0 lb/ton for ship loading is based on one test of ship loading at a port elevator in Seattle (EPA Emission Test Report 73-GRN-8).

(3) Extent of control: A 26% of application of control is based on data in Table 179 of Vol. I. This same table was used to determine an efficiency of control of 90%.

(4) Calculation of emissions: Emissions for the loading operations were calculated using Eq. (1) and the factors determined above to be 3.12×10^4 tons.

$$(8.1 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.26)(0.90)] = 3.12 \times 10^4 \text{ tons}^B$$

d. Drying

(1) Processing rate: Data in Vol. I (page 23) indicated that 1.0% of the grain unloaded is dried in export elevators. Using the amount of 8.1×10^7 tons unloaded, the total amount dried is 8.1×10^5 tons. However, it was again assumed that half the dryers are rack type and half are column type. It was thus estimated that about 4.0×10^5 tons are dried in each type dryer.

(2) Emission factor: The emission factor and the assumptions on which it is based are the same for export elevators as for country and terminal elevators (i.e., 3.00 lb/ton for rack dryers and 0.3 lb/ton for column dryers).

(3) Extent of control: Based on the previously described extent of control derived for country and terminal elevators, it was estimated that the extent of control for rack type dryers in export elevators is about 50%, while that for column dryers is nearer 0%. The efficiency of control was also estimated to be about 80%.

(4) Calculation of emissions: The emissions from drying amount to about 400 tons.

Rack dryers:

$(4.0 \times 10^5$ tons)(3.0 lb/ton)(ton/2,000 lb)[1-(0.50)(0.80)] = 360 tons

Column dryers:

$(4.0 \times 10^5$ tons)(0.3 lb/ton)(ton/2,000 lb)[1-(0)] = 60 tons

Dryer total 420 tons[c]

e. Cleaning

(1) Processing rate: From Vol. I (page 23) it was determined that export elevators clean 14.6% of their receipts (8.1×10^7 tons). It was thus calculated that the amount of grain cleaned was 1.18×10^7 tons.

(2) Emission factor: The emission factor for cleaning in export elevators is assumed to be the same as that in terminal eleators (6.00 lb/ton).

(3) Extent of control: A 37% application of control was obtained from Table 179 of Vol. I. Data from this same table indicated the efficiency of control was 94%.

(4) Calculation of emissions: Emissions have been calculated to be 2.3×10^4 tons using Eq. (1) and the factors determined above.

$(1.18 \times 10^7$ tons)(6.00 lb/ton)(1/2,000)[1-(0.37)(0.94)] = 2.30×10^4 tons[A]

f. Headhouse

(1) Processing rate: The amount of grain passing through the headhouse is estimated to be the total of the amounts involved in the preceding five operations (18.0×10^7 tons).

(2) Emission factor: The emission factor of 1.5 lb/ton was assumed to be the same as that for the headhouse of a terminal elevator.

(3) Extent of control: A 63% application of control was determined from Table 179 Vol. I. 1. This same table was used to calculate an efficiency of control of 96%.

(4) Calculation of emissions: The emissions total of 5.34×10^4 tons calculated below was determined using Eq. (1) and the factors delineated above. The calculations are as follows:

$$(18.0 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.63)(0.96)] = 5.34 \times 10^4 \text{ tons}^A$$

g. Tripper

(1) Processing rate: The amount of grain crossing the tripper was assumed to be at least equal to the amount unloaded plus the amount turned (8.6×10^7 tons).

(2) Emission factor: The emission factor of 1.0 was assumed to be equal to the emission factor used for the tripper in a terminal elevator.

(3) Extent of control: A 57% application of control was obtained from Table 179 of Vol. I. An efficiency of control of 90% was determined using data from this same table.

(4) Calculation of emissions: Tripper emissions of 2.02×10^4 tons have been calculated below.

$$(8.6 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.57)(0.93)] = 2.02 \times 10^4 \text{ tons}^B$$

h. Summary of calculated emissions for export elevators: A summary of the calculated emissions for the major sources at export elevators is presented below:

h. Summary of calculated emissions for export elevators: A summary of the calculated emissions for the major sources at export elevators is presented below:

Export elevators	Emissions (1971) (tons/year)	Confidence Rating[a/]
a. Unloading	1.13×10^4	A
b. Turning	8.95×10^2	A
c. Loading	3.12×10^4	B
d. Drying	4.20×10^2	C
e. Cleaning	2.30×10^4	A
f. Headhouse	5.34×10^4	A
g. Tripper	2.02×10^4	B
Subtotal	1.40×10^5	B

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

B. Feed Mills

Feed mills convert grain and other ingredients into a mixed feed by first changing the constituents to a desired form and size, then mixing, and finally forming the feed into the desired shape and consistency. The basic forms of the feed are mash, pellets, and crumbles. The operations which are possible sources of emission in this process are as follows:

a. Receiving

b. Shipping

c. Handling operations (transfer points, garner and scale)

d. Grinding

e. Pellet coolers

The mixing stage and the pellet milling stage are not considered to be major sources of emissions, thus they are not included in the calculations of emissions.

a. Receiving

(1) Processing rate: The total feed production for 1969 was reported to be 104×10^6 tons (Vol. I, page 29).

(2) Emission factor: Emission factor data for this operation are sparse, owing partly to the fact that many ingredients, whole grain and other more dusty materials (bran, dehydrated 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, if not impossible, to determine. However, the recovery operations are similar to those in a grain elevator, at least as far as whole grains are concerned. Therefore, an emission factor for the unloading operation only has been estimated as 1.30 lb/ton. This was the value determined for car unloading (Ref. 3) and may be representative of feed mills since questionnaire indicate that the majority of ingredients are received by rail cars. The value hopefully reflects the fact that some ingredients tend to be more dusty than whole grains.

(3) Extent of control: Data in Vol. I (Table 188) indicated an average application of control of about 32%. From this table the weighted average of efficiency of control was calculated to be about 96%.

(4) Calculation of emissions: Receiving operation emissions in feed mills have been determined to be 4.66×10^4 tons using the calculations below:

$$(104 \times 10^6 \text{ tons})(1.30 \text{ lb/ton})(1/2{,}000)[1-(0.32)(0.96)] = 4.66 \times 10^4 \text{ tons}^B$$

b. Shipping

(1) Processing rate: The amount of feed shipping in 1969 was 104×10^6 tons and data in Fef. 4 indicate that about 78%, or 81×10^6 tons, is bulk shipment.

(2) Emission factor: Load out is a major source of dust emissions but little emission factor data are available (Vol. I, page 166). However, it is known that of the feed shipped from feed mills, most of the bulk feed is shipped by truck. As a basis, an emission factor of 0.27 lb/ton was determined from car loading of grain in Ref. 3. However, because it is assumed that bulk loading of feed mill products would tend to be more dusty than whole grain, an emission factor of 0.5 lb/ton has been assumed for this operation.

(3) Extent of control: A 5% application of control is indicated in Table 188 of Vol. I. This same table was used to calculate an efficiency of control of 90% (most controlled by cyclones).

(4) Calculation of emissions: The calculations below have been used to determine a yearly particulate emissions total for shipping of 19,500 tons.

$$(81 \times 10^6 \text{ tons})(0.5 \text{ lb/ton})(1/2{,}000)[1-(0.05)(0.90)] = 1.95 \times 10^4 \text{ tons}^C$$

c. Handling operations

(1) Processing rate: The amount of material handled was assumed to be the same as the amount received (104×10^6 tons).

(2) Emission factor: No emission factor data were available for the internal handling operations in feed mills. However, it would be expected that they are somewhat similar to those of grain elevators. Reference 3 showed that the most significant of these operations was the legs, having an emission factor of 1.49 lb/ton. The tunnel belt emission factor of 1.40 lb/ton is comparable but feed mill operations are such that this may not be a comparable operation. However, all material would be expected to pass through a leg at least twice so an overall emission factor for feed mills has been estimated at 3.00 lb/ton.

(3) Extent of control: A 35% application of control was indicated by Table 188 of Vol. I. Data from this same table were used to determine a 95% efficiency of control.

(4) Calculation of emissions: Particulate emissions in the handling process were calculated as follows:

$$(104 \times 10^6 \text{ tons})(3.0 \text{ lb/ton})(1/2{,}000)[1-(0.35)(0.95)] = 1.05 \times 10^5 \text{ tons}^B$$

d. Grinding

(1) Processing rate: Data in Ref. 4 indicate that about 47% of feed ingredients are whole grains that require grinding. It was therefore estimated that 47% of the total ingredients (104 x 10 tons) is ground, which amounts to 49 x 10^6 tons.

(2) Emission factor: Because of the wide variation in grains and grinders used, an average emission factor would be difficult to determine. A small amount of data indicate that controlled emissions may range from 0.02-0.2 lb/ton (Vol. I, page 163). Data from Table 188 of Vol. I indicate 56.3% application of control with some plants using fabric filters to control grinder emissions. Considering these facts, and a lack of other data, an average controlled emission factor of 0.1 lb/ton has been estimated.

(3) Extent of control: Since the emission factor is for controlled emissions, the extent of control is not applicable.

(4) Calculation of emissions: Particulate emissions for grinding were calculated as follows:

$$(49 \times 10^6 \text{ tons})(0.1 \text{ lb/ton})(1/2{,}000) = 2.44 \times 10^3 \text{ tons}^C$$

e. Pellet coolers

(1) Processing rate: Data in Ref. 4 indicate that about 17% of the feed is pelletized so the amount pelletized was calculated to be 18 x 10^6 tons.

(2) Emission factor: The only available emission factor data for this operation indicated that the uncontrolled emission factor was quite high (5-50 lb/ton) but that the cyclones were very efficient (92-99.9%, Vol. I, page 164). The data also show considerable difference in controlled emission factors for horizontal and column coolers. Distribution of these two coolers within the industry is not known but observations indicated that column coolers are quite common. For this reason, a controlled emission factor of 0.1 lb/ton has been estimated for the industry as a whole.

(3) Extent of control: Since the emissions factor was for controlled emissions the extent of control is unnecessary.

(4) Calculation of emissions: Pellet cooler emissions were calculated to be 900 tons/year, as shown below:

$(18 \times 10^6 \text{ tons})(0.1 \text{ lb/ton})(1/2{,}000) = 0.90 \times 10^3 \text{ tons}^c$

f. Summary of emissions for feed mills: A summary of the calculated emissions for the major sources in the feed milling industry is presented below:

	Emissions (1969) (tons/year)	Confidence Rating[a]
a. Receiving	4.66×10^4	B
b. Shipping	1.95×10^4	C
c. Handling	1.05×10^5	B
d. Grinding	2.44×10^3	C
e. Pellet coolers	0.90×10^3	C
Total	1.74×10^5	B

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

C. Alfalfa Dehydration

Alfalfa dehydration plants are relatively small operations that receive fresh cut alfalfa from the fields and dehydrate it in rotary gas-fired dryers. The most significant source of emissions in this process is the primary drying cyclone, which accounts for about 75% of the emissions. Since this one source is so dominant, emissions will be calculated on a total rather than a source basis.

1. Processing rate: Data in Vol. I (page 45), indicated that the dehydrated alfalfa production for the 1971-1972 crop year amounted to 1.6 x 10^6 tons of meal.

2. Emission factors: The emission factors for alfalfa dehydration plants are discussed extensively in Vol. I (pages 171-202). It was concluded that the plant emission factor probably does not exceed 20 lb/ton. However, much of the data used in arriving at this figure were based on testing at plants which were reportedly well "tuned" prior to testing or in some cases were operated below rated capacity.* If the above emission factor is too low, it means that the emission inventory calculation results are too low. Nonetheless, this emission factor has been used because it is based on analysis of all the data presently available.

3. Extent of control: Even though a few plants have now installed control devices, the application of control was assumed to be 0%.

4. Calculation of emissions: The total yearly emissions for the alfalfa dehydrating industry have been calculated below to be 1.6 x 10^4 tons.

$$(1.6 \times 10^6 \text{ tons meal})(20 \text{ lb/ton})(1/2{,}000)[1-0] = 1.6 \times 10^4 \text{ tons}^B$$

* Smith, Ken D., EPA Report 650/2-74-007, based on Grant No. R801446 (January 1974).

D. Wheat Mills

Processing operations in wheat mills are discussed in Vol. I (pages 203-213) and three major emission areas are identified: grain receiving and handling, grain cleaning, and milling operations. These areas have been divided into the following sources for which emissions were calculated:

a. Receiving

b. Precleaning and handling

c. Cleaning house

d. Mill house

a. Receiving

(1) Processing rate: Volume I (page 53), indicated that in 1971 the amount of wheat received at mills was 555 x 10^6 bushels (16.6 x 10^6 tons).

(2) Emission factor: It would be expected that receiving of wheat for wheat milling would be similar in emissions to that for terminal grain elevators (0.64 and 1.30 lb/ton).[3/] Data in Vol. I, page 182, for flour mills present controlled emission factors for fabric filters but it is difficult to use these data for estimating uncontrolled emission factor. Therefore, the data from Ref. 3 were used to estimate an emission factor of 1.0 lb/ton for receiving by trucks, cars, and barges.

(3) Extent of control: An application of control of 75% was obtained from Table 201 of Vol. I. Data from this same table were used to calculate a weighted average efficiency of control of 95%.

(4) Calculation of emissions: Equation (1) and the factors explained above were used to calculate particulate emissions of about 3,000 tons/year in the equation below:

$$(16.6 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2,000)[1-(0.70)(0.95)] = 2.78 \times 10^3 \text{ tons}$$

b. Precleaning and handling

(1) Processing rate: The amount of grain involved in this process is assumed to be the same as the amount received (16.6 x 10^6 tons). The fact that some grain is handled more than once is taken into account as part of the emission factor estimate.

(2) Emission factor: Very little data on uncontrolled emissions from precleaning were available. Precleaning was assumed to consist of scalping type operations which should be a minor source in relation to handling. Since usable data on uncontrolled emissions from handling sources were lacking, data from handling sources in grain elevators in Ref. 3 were used even though it does not include an emission factor for the tripper. However, it did include a tunnel belt (1.40 lb/ton) and legs (1.49 lb/ton). It is known that the grain passes through the leg at least twice in a flour mill. Therefore, a cumulative emission factor of 5.0 lb/ton was estimated for all handling operations.

(3) Extent of control: An 85% application of control was determined in Table 201 of Vol. I. These same data were used to calculate an efficiency of control of 95%.

(4) Calculation of emissions: The yearly emissions have been calculated below to be about 8,000 tons.

$$(16.6 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.85)(0.95)] = 7.89 \times 10^3 \text{ tons}^B$$

c. Cleaning house

(1) Processing rate: The amount processed was assumed to be the same as amount received (16.6×10^6 tons).

(2) Emission factor: Cleaning is accomplished by a variety of means but often includes air aspiration to remove lighter impurities as well as disc separators and scourers. Each of these can be a source of dust emission but only a small amount of data on controlled sources were available. Therefore, it was not possible to determine an emission factor.

(3) Extent of control: Data were insufficient to determine extent of control. However, Vol. I did infer that it is probably quite high with controlled houses using 75% fabric filter and 25% cyclones.

(4) Calculation of emissions: Emissions could not be estimated because of insufficient information.

d. Mill house

(1) Processing rate: The amount of grain processed is again assumed to be 16.6×10^6 tons.

(2) Emission factor: Operations in the mill house are complex and again very little emission data are available. However, Vol. 1, page 209, cites one report which indicated that dust generated in roller mills may average 70 lb/ton. This source and the purifiers might, therefore, account for more than 70 lb/ton.

(3) Extent of control: Due to the economic value of the products, the extent of control is quite high. Table 201 of Vol. I indicated a 96% application of control and was used to calculate 98% efficiency of control.

(4) Calculation of emissions: Mill house emissions were determined to be 3.49×10^4 tons. The calculations are:

$$(16.6 \times 10^6 \text{ tons})(70 \text{ lb/ton})(1/2{,}000)[1-(0.96)(0.98)] = 3.49 \times 10^4 \text{ tons}^B$$

e. Summary of calculated emissions for wheat mills: The emission figure for milling is higher than that for precleaning and handling and may be erroneously high. However, the loading of bran and shorts, which have not been included in any calculations, also is a source of emissions. Therefore, the total emissions for wheat mills summarized below may not be greatly exaggerated, but confidence in the calculated quantities is low.

	Emissions (1971) (tons/year)	Confidence Rating[a/]
a. Receiving	2.78×10^3	B
b. Precleaning and handling	7.89×10^3	B
c. Cleaning house	Insufficient information	C
d. Mill house	3.49×10^4	B
Total	4.56×10^4	C

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

E. Durum Mills

The sources of emissions in durum mills can be categorized into the same three areas as wheat mills. The four sources of emissions which will be discussed are:

a. Receiving

b. Precleaning and handling

c. Cleaning house

d. Mill house

a. Receiving

(1) Processing rate: Volume I (page 57), indicates that the amount of durum wheat ground at mills in 1971 was 32×10^6 bushels or about 1×10^6 tons.

(2) Emission factor: Data on the rates of emissions for durum mills are limited. However, since the process is so similar to that of wheat milling, it was assumed that the same emission factors are applicable. Therefore the emission factor of 1.0 lb/ton was used.

(3) Extent of control: The extent of control was assumed to be the same as that for wheat mills. The application of control was thus assumed to be 70% and the efficiency of control 95%.

(4) Calculation of emissions: The yearly emissions from the receiving operation in durum mills have been calculated below to be 168 tons.

$$(1 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2,000)[1-(0.70)(0.95)] = 1.63 \times 10^2 \text{ tons}^B$$

b. Precleaning and handling

(1) Processing rate: The amount of grain handled is assumed to be the same as that received (1×10^6 tons).

(2) Emission factor: Since so little data are available on emissions from durum mills, it is assumed that the factor is the same as that for wheat milling (5.0 lb/ton).

(3) Extent of control: Again the extent of control is assumed to be the same as that for wheat milling; an 85% application of control and 95% efficiency of control.

(4) Calculation of emissions: Below are the calculations which set the yearly emissions for precleaning and handling at 481 tons.

$$(1 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.85)(0.95)] = 4.81 \times 10^2 \text{ tons}^B$$

c. Cleaning house

(1) Processing rate: The processing rate was again assumed to be the same as the amount received (1×10^6 tons).

(2) and (3) Emission factor and extent of control: The same problems were encountered at this point as those in the wheat milling industry. Therefore, it was not possible to determine emission factors or extent of control.

(4) Calculation of emissions: Emissions were not estimated because of insufficient data.

d. Mill house

(1) Processing rate: The amount of grain milled is assumed to be 1×10^6 tons.

(2) Emission factor: There are insufficient data to determine an emission factor for the mill house in a durum mill. It could not be assumed to be the same as in wheat mills because the purpose of durum mills is to produce middlings rather than flour. For this reason, the break rolls are different than in wheat mills and the 70 lb/ton figure cannot be used. Therefore, no emission factor could be estimated.

(3) Extent of control: Since it is impossible to determine emissions factors there was no estimate made.

(4) Calculation of emissions: Emissions were not estimated because of insufficient data.

e. Summary of calculated emissions for durum mills: Due to insufficient information it was not possible to calculate emissions for all significant sources within durum mills. Those emissions that could be calculated are summarized in the table below:

	Emissions (1971) (tons/year)	Confidence Rating[a/]
a. Receiving	1.68×10^2	B
b. Precleaning and handling	4.81×10^2	B
c. Cleaning house	Insufficient information	C
d. Mill house	Insufficient information	C
Total	6.49×10^2	C

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

F. Rye Milling

There is a great deal of similarity between wheat milling and rye milling and the processing steps for rye milling are the same as those for wheat milling. Major emission sources are listed below:

a. Receiving

b. Precleaning and handling

c. Cleaning house

d. Mill house

a. Receiving

(1) Processing rate: Volume I (page 58) indicates that in 1971, the amount of rye ground for flour was 5.3×10^6 bushels or 1.5×10^5 tons.

(2) Emission factor: Very little emission factor data are available for rye milling. Therefore, it was assumed that the emission factor was the same as in wheat milling (1.0 lb/ton).

(3) Extent of control: Again, little data were available about rye milling, but it was considered reasonable to assume that the extent of control is about the sameas for wheat milling (70% application of control and 95% efficiency of control).

(4) Calculations of emissions: The emissions resulting from the receiving operation in rye mills have been calculated below to be 25 tons.

$$(1.5 \times 10^5 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.70)(0.95)] = 2.55 \times 10^1 \text{ tons}^B$$

b. Precleaning and handling

(1) Processing rate: The amount of grain handled is assumed to be the same as the amount received (1.5×10^5 tons).

(2) Emission factor: Since the process is so similar to that in wheat milling the emission factor was assumed to be the same (5.0 lb/ton).

(3) Extent of control: The control factors are assumed to be the same as those for wheat milling (an 85% application of control and a 95% efficiency of control).

(4) Calculation of emissions: Total emissions for precleaning and handling of about 72 tons have been calculated below using Eq. (1) and the factors presented above.

$$(1.5 \times 10^5 \text{ tons})(5.0 \text{ lb/ton})(1/2,000)[1-(0.85)(0.95)] = 7.22 \times 10^1 \text{ tons}^B$$

c. Cleaning house

(1) Processing rate: The amount of grain cleaned is assumed to be the same as amount received (1.5×10^5 tons).

(2) Emission factor: Since there was a lack of sufficient data for cleaning operations for both wheat milling and rye milling, it was not possible to determine an emission factor.

(3) Extent of control: The control factors for cleaning house operations were not determined.

(4) Calculation of emissions: Emissions were not estimated because of insufficient data.

d. Mill house

(1) Processing rate: The amount of grain milled was 1.5×10^5 tons.

(2) Emission factor: Some data on certain milling operations (Table 136, Vol. I) indicate a controlled emission factor of 1.0 lb/ton. This is equivalent to an uncontrolled emission factor of 10 lb/ton assuming 90% cyclone efficiency. However, these data did not include break rolls or other operations so the factor of 70 lb/ton that was used for wheat milling was assumed applicable to rye milling.

(3) Extent of control: Due to lack of sufficient data for the rye milling process the control factors were assumed to be the same as those for wheat milling (96% application of control and 98% efficiency of control).

(4) Calculation of emissions: Mill house emissions of approximately 300 tons have been calculated below:

$$(1.5 \times 10^5 \text{ tons})(70 \text{ lb/ton})(1/2,000)[1-(0.96)(0.93)] = 3.11 \times 10^2 \text{ tons}^B$$

e. Summary of calculated emissions for rye milling: Due to the fact that data for the cleaning house were unavailable and the assumptions about the mill house emission factor have the same uncertainty as those in wheat milling, the confidence in the total emissions summarized below is low.

	Emissions (1971) (tons/year)	Confidence Rating[a]
a. Receiving	2.55×10^1	B
b. Precleaning and handling	7.22×10^1	B
c. Cleaning house	Insufficient information	C
d. Mill house	3.11 x 10	B
	Total 4.09 x 10	C

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

G. Dry Corn Milling

Corn is dry milled by two general systems, degerming and nondegerming. The degerming system used in the United States will be the basis of this report. The process includes the receiving operations, the drying and cleaning of the corn, the preparation and degerming of the corn, the milling, and finally the shipping of the products. The main sources of emissions in the process are listed below:

a. Receiving

b. Drying

c. Precleaning and handling

d. Cleaning house

e. Degerming and milling

Shipping operations are not a major source because of the efforts to minimize loss of products.

a. Receiving

(1) Processing rate: Volume I (page 59) shows that the amount of corn milled to meal and grits in 1970 was 165 x 10^6 bushels (approximately 4.6 x 10^6 tons).

(2) Emission factor: Using the same rationale as for flour mills, an average emission factor of 1.00 lb/ton has been used for the receiving operation.

(3) Extent of control: A 70% application of control was obtained from Table 210 of Vol. I. From this same table a weighted average efficiency of control of 97% was calculated.

(4) Calculation of emissions: Equation (1) and the factors delineated above have been used to determine yearly emissions of 738 tons. The calculations were performed as follows:

$$(4.6 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.70)(0.97)] = 7.38 \times 10^2 \text{ tons}^B$$

b. Drying

(1) Processing rate: Questionnaire data from Vol. I indicate that about 20% of the grain received may be dried. This amounts to 0.9×10^6 tons.

(2) Emission factor: Data are insufficient to determine the type of dryers (rack or column) used. However, about 50% use the Day-Vac system. For this reason an emission factor of 0.5 lb/ton was estimated.

(3) Extent of control: A 92% application of control was obtained from Table 210 of Vol. I. Average efficiency of control was calculated at 83% assuming 90% efficiency for Day-Vac units and 75% efficiency for other control units.

(4) Calculation of emissions: Dryer emissions in the dry corn milling industry have been calculated below to be approximately 53 tons.

$(0.9 \times 10^6 \text{ tons})(0.5 \text{ lb/ton})(1/2{,}000)[1-(0.92)(0.83)] = 5.32 \times 10^1$ tons[B]

c. Precleaning and handling

(1) Processing rate: It is assumed that the amount of grain processed is the same as the amount received (4.6×10^6 tons).

(2) Emission factor: As explained in the section on ~~flour~~ what (p 34) mills, an average emission factor of 5.0 lb/ton was used.

(3) Extent of control: Table 210 of Vol. I shows that the application of control is about the same for each operation associated with precleaning and handling. Using these data, the application of control was calculated to be 82% and the efficiency of control 97%.

(4) Calculation of emissions: Equation (1) and the factors described above have been used to calculate annual particulate emissions of 2.35×10^3 tons as follows:

$(4.6 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.82)(0.97)] = 2.35 \times 10^3$ tons[B]

d. Cleaning house

(1) Processing rate: It was assumed that all grain received passes through the cleaning house (4.6×10^6 tons).

(2) Emission factor: As explained in Vol. I (page 218) several steps are involved in grain cleaning, one of which includes air aspiration and is a source which could generate considerable dust. This type of source yielded an emission factor of 5.78 lb/ton, which was determined for grain elevator corn cleaning (Ref. 3). Also, Table 133 of Vol. I indicated an emission factor of 0.0015 lb/bushel (0.05 lb/ton) for a cleaning house controlled by fabric filter. If the fabric filter were 99% efficient the equivalent uncontrolled factor would be 5.0 lb/ton which agrees closely with the previous factor of 5.78 lb/ton. Thus an emission factor of 6.0 lb/ton was used.

(3) Extent of control: Data from Vol. I (page 429) were not sufficient to determine the percent of application of control, but did indicate that it is probably quite high with considerable utilization of fabric filters. For this reason the overall extent of control has been estimated at 97%.

(4) Calculation of emissions: Using the above estimates and Eq. (1) the calculations below indicated yearly emissions of approximately 400 tons.

$$(4.6 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(0.97)] = 4.14 \times 10^2 \text{ tons}^B$$

e. Degerming and milling

(1) Processing rate: The amount of grain through the degerming and milling operations was assumed to be the same as the amount received (4.6×10^6 tons).

(2) Emission factor: Data were insufficient to determine the emission factors for the various degerming and milling operations.

(3) Extent of control: Some data on the extent of control for these operations are available in Table 210 of Vol. I. However, since calculations are not possible as a result of lack of emissions data, the averages were not calculated.

(4) Calculation of emissions: Emissions were not estimated because of lack of data. However, because of the product value it can probably be assumed that this is not a major source compared with the previous operations discussed.

f. Summary of calculated emissions for dry corn milling: Emission quantities for those operations for which there was sufficient information to perform calculations are summarized in the table below:

	Emissions (1970) (tons/year)	Confidence Rating[a/]
a. Receiving	7.38×10^2	B
b. Drying	5.32×10^1	B
c. Precleaning and handling	2.35×10^3	B
d. Cleaning house	4.14×10^2	B
e. Degerming and milling	Insufficient information	C
	Total 3.55×10^3	B

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability

H. Oat Milling

The initial stages for the milling process for oats are much the same as those in the wheat milling process. However, the separation requirements in the oat milling process necessitate the use of aspirators, and a forced draft is used in the cooling process. Neither of these possible sources is a part of the wheat milling process. Also, the receiving and handling process is reported to be dustier for oats than for wheat.

Since there are insufficient emission data on the various operations in the oat milling process and since comparisons with various operations in the wheat milling process would be highly inaccurate, it is not possible to do an operational breakdown of the oat milling process emissions. However, sufficient data are available to make an estimate of plant emissions.

1. Processing rate: Volume I (page 60) states that the amount of oats used for breakfast food in 1970 was 49 x 10^6 bushels (0.7 x 10^6 tons).

2. Emission factor: A controlled emission factor of 2.5 lb/ton (Vol. I, page 236) was calculated from the data available. It is not known if these data (for one mill) include most major dust sources or if this mill is representative of the industry; however, both are assumed to be true.

3. Extent of control: Since the emission factor is for controlled emissions, extent of control is not applicable.

4. Calculation of emissions: Oat milling industry emissions have been estimated to be 875 tons as per the calculations below:

$$(0.7 \times 10^6 \text{ tons})(2.5 \text{ lb/ton})(1/2{,}000) = 8.75 \times 10^2 \text{ tons}^c$$

I. Rice Milling

Rice mills are of two types; conventional and parboil. In the United States 85% are of the conventional type. Each type of mill has three distinct stages: (1) rough rice receiving, cleaning, drying and storages; (2) milling; and (3) milled rice and by-product bagging, packaging, and shipping (Vol. I, page 235). The first two stages are the main sources of emissions. These stages have been divided into the following processes in order to calculate emissions:

a. Receiving

b. Handling and precleaning

c. Drying

d. Cleaning and mill house

a. Receiving

(1) Processing rate: According to Vol. I (page 82) the amount of rough rice milled in 1970 was 77×10^6 cwt (3.85×10^6 tons).

(2) Emission factor: Emission factor data for all rice milling operations are meager. Volume I stated that emission sources associated with receiving, cleaning, and storage are similar to those involved with all grain processing but it is not known if rice is more or less dusty than other grains. However, estimates were made based upon emission factors for other grains. Since data in Vol. I (Table 218) indicated that most rice was received by trucks, the emission factor of 0.64 lb/ton for truck unloading was used (Ref. 3).

(3) Extent of control: A 67% application of control was indicated in Table 218 of Vol. I. Data from this same table were used to calculate a weighted average efficiency of control of 94%.

(4) Calculation of emissions: Equation (1) and the factors delineated above were used to calculate emissions of 456 tons for rice mill receiving as follows:

$$(3.85 \times 10^6 \text{ tons})(0.64 \text{ lb/ton})(1/2{,}000)[1-(0.67)(0.94)] = 4.56 \times 10^2 \text{ tons}^B$$

b. Handling and precleaning

(1) Processing rate: The amount of grain handled was assumed to be the same as the amount received (3.85×10^6 tons).

(2) Emission factor: As explained in the previous section, emission factor data for rice milling are meager. Therefore, the cumulative emission factor of 5.0 lb/ton, determined in the wheat milling section, has been assumed for similar operations in rice milling.

(3) Extent of control: Extent of control for each handling operation is not similar, as it was for wheat operations. Therefore, average values have been calculated from the data in Table 218 of Vol. I, resulting in a 63% application of control and a 96% efficiency of control.

(4) Calculation of emissions: The calculations below were used to determine the yearly emissions of 3.80×10^3 tons for handling and precleaning.

$$(3.85 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.63)(0.96)] = 3.80 \times 10^3 \text{ tons}^B$$

c. Drying

(1) Processing rate: The amount of grain dried is assumed to be 3.85×10^6 tons.

(2) Emission factor: Observation of rice dryers indicates that the emission factor may be considerably higher than for other grains but supporting data were not available. Thus, it was not possible to estimate an emission factor.

(3) Extent of control: Since emission factors could not be determined, control factors were not calculated.

(4) Calculation of emissions: Emissions were not estimated because of insufficient data.

d. Cleaning and mill house: Because of lack of emission factor data, no estimate of emissions could be made.

e. Summary of calculated emissions for rice milling: Because of a lack of emission factor data, estimates of emissions for some operations could not be made. Those operations for which estimates of emissions were made are summarized in the table below:

	Emissions (1970) (tons/year)	Confidence Rating[a]
a. Receiving	4.56×10^2	B
b. Handling and precleaning	3.80×10^3	B
c. Drying	Insufficient information	C
d. Cleaning and mill house	Insufficient information	C
	Total 4.26×10^3	C

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

J. Commercial Rice Drying

A commerical rice drying facility has four basic operations: receiving, drying, storage, and shipping. The emission of pollutants results primarily from rice handling, cleaning drying operations. The cleaning step, if accomplished by aspiration, is a major source of emissions. The grain dryer is the other major emission source (Vol. I, page 243).

It was possible to determine the amount of rice processed in 1965-1966 as 3.5 x 10^6 tons (Vol. I, page 79). However, as was the case for rice milling, emission factor data for the dryers were not available. In addition, there was no information available on extent of control for these installations. Therefore, no estimate of emissions could be made.

K. Soybean Mills

The sources of emissions in a soybean processing plant can be grouped into three broad categories: (1) soybean receiving, handling and drying operations; (2) soybean processing operations; and (3) soybean meal load-out operations. In order to determine emissions from the various sources, these categories have been divided into the following operations:

a. Receiving

b. Handling

c. Cleaning

d. Drying

e. Cracking (and dehulling)

f. Hull grinding

g. Bean conditioning

h. Flaking

i. Meal dryer

j. Meal cooler

k. Bulk loading

a. Receiving

(1) Processing rate: The amount of soybeans processed in 1970 was 760×10^6 bushels or 23×10 tons (Vol. 1, page 92).

(2) Emission factor: Data in Table 232 of Vol. I show that soybeans are received by truck, hopper cars, and boxcars. Table 142 in the same report indicated an average controlled emission factor for a truck dump pit of 0.017 lb/ton, or an uncontrolled factor of 1.7 lb/ton assuming 99% efficiency for fabric filters. This is in good agreement with data obtained in Ref. 3 for soybeans which showed 1.63 lb/ton for truck unloading and 1.5 lb/ton for car unloading. Therefore, an emission factor of 1.6 lb/ton was used for soybean receiving.

(3) Extent of control: Table 232 of Vol. I showed that extent of control for trucks and boxcars is about the same, but is considerably lower for hopper cars although it is noted that some plants are using choke unloading for hopper cars. Therefore, data from Table 232 on extent of control for trucks and boxcars have been used to determine a 50% application of control and a 98% efficiency of control.

(4) Calculation of emissions: Emissions for the receiving have been determined to be 9.38×10^3 tons as shown below:

$$(23 \times 10^6 \text{ tons})\ (1.6 \text{ lb/ton})(1/2{,}000)[1-(0.50)(0.98)] = 9.38 \times 10^3 \text{ tons}^B$$

b. Handling

(1) Processing rate: The amount of grain handled was assumed to be the same as the amount received or 23×10^6 tons.

(2) Emission factor: No specific information was available on emission factors for soybean handling operations. Even though emissions for soybeans may be higher than for other grains, the 5.0 lb/ton emission factor discussed in the wheat milling section was used.

(3) Extent of control: A 76% application of control was obtained from Vol. I, Table 232. This same table was used to calculate an average 96% efficiency.

(4) Calculation of emissions: Handling emissions for soybean mills were calculated, using the data delineated above and Eq. (1), to be approximately 1.5×10^4 tons.

$$(23 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.76)(0.96)] = 1.55 \times 10^4 \text{ tons}^B$$

c. Cleaning

(1) Processing rate: It is assumed that all of the grain is cleaned or 23×10^6 tons.

(2) Emission factor: Although no information was available on the cleaning of soybeans, it was assumed to be at least as much as the 6.00 lb/ton used for corn milling.

(3) Extent of control: Data were not available on extent of control for soybean cleaning. However, it was assumed to be about the same as handling operations, or about 75%.

(4) Calculation of emissions: Emissions were calculated as shown below:

$(23 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-0.75] = 1.73 \times 10^4 \text{ tons}^B$

d. Drying

(1) Processing rate: The amount of grain dried was assumed to be 23×10^6 tons.

(2) Emission factor: Observations have indicated that the emission factors for the drying of soybeans may be higher than the average factors of 0.3 and 3.0 lb/ton discussed in the section on dryers at grain elevators. The only data available on soybean dryers (Vol. I, Table 146) were 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 figure, the average factor is 7.2 lb/ton. This appears to be a more reasonable number in comparison with other dryer factors, so a value of 7.2 lb/ ton was used.

(3) Extent of control: A 42% application of control was determined from Table 232 of Vol. I. Data from this same table were also used to calculate an efficiency of control of 80%.

(4) Calculation of emissions: Dryer emissions of 5.5×10^4 tons for the year 1970 have been calculated below:

$(23 \times 10^6 \text{ tons})(7.2 \text{ lb/ton})(1/2{,}000)[1-(0.42)(0.80)] = 5.50 \times 10^4 \text{ tons}^C$

e. Cracking (and dehulling)

(1) Processing rate: The amount of grain cracked is assumed to be 23×10^6 tons.

(2) Emission factor: Volume I (Table 147) indicated that the controlled emission factor for the cracking and dehulling operations is on the order of 0.01 lb/bushel or 0.33 lb/ton. Assuming 90% efficiency for cyclone control devices, the uncontrolled emission factor is 3.3 lb/ton.

(3) Extent of control: A 96% application of control was obtained from Table 232 of Vol I. This same table was used to calculate a 93% efficiency of control.

(4) Calculation of emissions: Emissions from the cracking process have been determined to be 4.07×10^3 tons as shown below:

$(23 \times 10^6 \text{ tons})(3.3 \text{ lb/ton})(1/2,000)[1-(0.96)(0.93)] = 4.07 \times 10^3 \text{ tons}^C$

f. Hull grinding

(1) Processing rate: The amount ground is again assumed to be 23×10^6 tons because the emission factor is based on the amount of grain rather than just the hulls.

(2) Emission factor: Controlled emission factors for hull grinding (Vol. I, Table 174) show an average, for three reported values, of 0.0055 lb/bushel or 0.18 lb/ton. Again, assuming 90% efficiency for cyclone control devices, the uncontrolled emission factor would be approximately 2.0 lb/ton.

(3) Extent of control: Information from questionnaires (Table 232 of Vol. I) showed 98% application of control and the average efficiency of controls was computed to be 93%.

(4) Calculation of emissions: Grinding emissions of about 2,000 tons have been calculated using Eq. (1) as shown below:

$(23 \times 10^6 \text{ tons})(2.0 \text{ lb/ton})(1/2,000)[1-(0.98)(0.93)] = 2.04 \times 10^3 \text{ tons}^B$

g. Bean conditioning

(1) Processing rate: The processing rate is again assumed to be 23×10^6 tons.

(2) Emission factor: Table 147 of Vol. I shows a cyclone controlled emission factor of 0.003 lb/bushel or 0.01 lb/ton. Assuming 90% cyclone efficiency, the uncontrolled emission factor would be 0.1 lb/ton.

(3) Extent of control: A 79% application of control was obtained from Table 232 of Vol. I. Data from this same table were used to calculate a 91% efficiency of control.

(4) Calculation of emissions: Bean conditioning emissions have been determined to be 3.23×10^2 tons. The calculations are shown below:

$(23 \times 10^6 \text{ tons})(0.1 \text{ lb/ton})(1/2,000)[1-(0.79)(0.91)] = 3.23 \times 10^2 \text{ tons}^B$

h. Flaking

(1) Processing rate: The amount of grain flaked is assumed to be 23 x 10^6 tons.

(2) Emission factor: A total of four controlled emission factors presented in Tables 144 and 147 Vol. I shows an average of 0.0017 lb/bushel or 0.057 lb/ton. These were each cyclone controlled systems, so assuming an efficiency of 90%, the uncontrolled emission factor is 0.57 lb/ton.

(3) Extent of control: A 96% application of control was obtained from Vol. I (Table 232). Data from this same source were used to calculate an efficiency of control of 91%.

(4) Calculation of emissions: The following calculations resulting in an emission figure of 8.29 x 10^2 tons for flaking were made using Eq. (1) and the data presented above.

$$(23 \times 10^6 \text{ tons})(0.57 \text{ lb/ton})(1/2{,}000)[1-(0.96)(0.91)] = 8.29 \times 10^2 \text{ tons}^B$$

i. Meal dryer

(1) Processing rate: The amount of meal dried is assumed to be 23 x 10^6 tons.

(2) Emission factor: Cyclone controlled emission factors for meal dryers were presented in Tables 144 and 147 of Vol. I and showed a range of 0.0003-0.0128 lb/bushel with an average of 0.0045 lb/bushel or 0.15 lb/ton. Again, assuming a 90% cyclone efficiency, the uncontrolled emission factor is estimated to be 1.5 lb/ton.

(3) Extent of control: A 62% application of control was determined from Table 232 of Vol. I. Data from the same table were used to calculate a 90% efficiency of control.

(4) Calculation of emissions: Meal dryer emissions are shown in the calculations below to be about 7.6 x 10^3 tons.

$$(23 \times 10^6 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.62)(0.90)] = 7.62 \times 10^3 \text{ tons}^B$$

j. Meal cooler

(1) Processing rate: The amount of meal cooled was assumed to be the same as the amount of soybeans received, 23 x 10^6 tons.

(2) Emission factor: Only one cyclone controlled emission factor was available (Table 144 of Vol. I); 0.0056 lb/bushel or 0.18 lb/ton. Assuming a 90% efficiency for the cyclone, the uncontrolled emission factor would be 1.8 lb/ton.

(3) Extent of control: A 94% application of control was obtained from Table 232 of Vol. I. The same table was used to calculate an efficiency of control of 91%.

(4) Calculation of emissions: Using the limited data presented above, the cooler emissions were calculated in the following manner to be about 3,000 tons.

$(23 \times 10^6 \text{ tons})(1.8 \text{ lb/ton})(1/2{,}000)[1-(0.94)(0.91)] = 2.99 \times 10^3 \text{ tons}^B$

k. Bulk loading

(1) Processing rate: The amount loaded was assumed to be about 23×10^6 tons.

(2) Emission factor: No emission factor data were available for meal loading. However, observation of these operations indicated that it may be about the same as the loading of grain at elevators, or about 0.27 lb/ton. Although this is only an estimate it has been used to calculate emissions.

(3) Extent of control: Data in Table 232 of Vol. I indicated an application of control of 37%. This same table was used to calculate a 97% efficiency of control.

(4) Calculation of emissions: The emissions for bulk loading were determined to be 1.99 x 10 tons as shown below:

$(23 \times 10^6 \text{ tons})(0.27 \text{ lb/ton})(1/2{,}000)[1-(0.37)(0.97)] = 1.99 \times 10^3 \text{ tons}^B$

l. Summary of calculated emissions for soybean mills: The calculated emissions for the soybean milling industry are summarized in the table below.

		Emissions (1970) (tons/year)	Confidence Rating[a/]
a.	Receiving	9.38×10^3	B
b.	Handling	1.55×10^4	B
c.	Cleaning	1.73×10^4	B
d.	Drying	5.50×10^4	C
e.	Cracking (and dehulling)	4.07×10^3	B
f.	Hull grinding	2.04×10^3	B
g.	Bean conditioning	3.23×10^2	B
h.	Flaking	8.29×10^2	B
i.	Meal dryer	7.62×10^3	B
j.	Meal cooler	2.99×10^3	B
k.	Bulk loading	1.99×10^3	B
		Total 11.70×10^4	B

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

L. Corn Wet Milling

The corn refining or wet milling industry has grown into one of the most diversified grain processing industries. As a result of this diversity, there are numerous and varied potential sources of emissions. Volume I divided these sources into three basic categories: (1) grain receiving, cleaning and storage; (2) separation process; and (3) conversion process. The various sources within each category are delineated in Table 148 of Vol. I. As noted in Vol. I the main sources of emissions in the separation and conversion processes are the various dryers. For the calculations in these reports the various dryers have been grouped and will be considered as one source. It should be noted that detailed emissions data for these two processes are lacking. The assumptions that have been made in order to calculate emissions are explained in the following sections concerning these emission sources:

a. Receiving

b. Handling

c. Cleaning

d. Dryers

a. Receiving

(1) Processing rate: The amount of corn processed by the corn wet milling industry in 1970 was 225 x 10^6 bushels or 6.3 x 10^6 tons (Vol. I, page 100).

(2) Emission factor: Corn is received by both cars and trucks and the emission factor was assumed to be approximately the same as that for similar operations in grain elevators, or about 1.0 lb/ton.

(3) Extent of control: Data from Table 240 of Vol. I was used to determine weighted averages for extent of control. A 67% application of control and a 92% efficiency of control were determined.

(4) Calculation of emissions: Emissions from the receiving process of 1.21 x 10^3 tons are calculated below.

$$(6.3 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.67)(0.92)] = 1.21 \times 10^3 \text{ tons}^3$$

b. Handling

(1) Processing rate: The amount of grain handled is assumed to be the same as that received (6.3×10^6 tons).

(2) Emission factor: Emission factors specifically applicable to the handling of corn are not available. However, as was done in the section on dry corn mills, an average cumulative emission factor of 5.0 lb/ton was used.

(3) Extent of control: Extent of control for each handling operation is different, but the largest contributor to the cumulative emission is the legs. Therefore, the extent of control for the legs was used. Table 240 of Vol. I indicated a 77% application of control and a 96% efficiency of control.

(4) Calculation of emissions: Equation (1) and the data determined above were used in the following calculation of emissions for corn handling:

$$(6.3 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2,000)[1-(0.77)(0.96)] = 4.11 \times 10^3 \text{ tons}^B$$

c. Cleaning

(1) Processing rate: The amount of corn cleaned was assumed to be 6.3×10^6 tons.

(2) Emission factor: An emission factor of 6.0 lb/ton, as developed in the section on dry corn mills, was used to estimate emissions.

(3) Extent of control: Data from Table 240 of Vol. I were used to determine a 100% application of control and a 95% efficiency of control.

(4) Calculation of emissions: Emissions of 945 tons for cleaning are calculated below:

$$(6.3 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2,000)[1-(1.0)(0.95)] = 9.45 \times 10^2 \text{ tons}^B$$

d. Dryers

(1) Processing rate: All data on emission rates for dryers in wet corn mills are in units of pound per hour. Therefore, the plant operating time has been estimated at 8,000 hr/year.

(2) Emission factor: Feed, gluten, and germ dryers are a major source of emissions from wet corn mills, but emission factor data are lacking. Table 149 of Vol. I contains emission rate data (lb/hr) for dryers at five plants. The capacity of these dryers in relation to those in the 17 plants in the industry is unknown. Neither is it known if it included all the dryers at each plant nor their load at time of testing. However, the only method of estimating emission rates for the industry was to add the emission rates for these five plants (365 lb/hr) and multiply by the ratio of the number of plants--17/5. This gives a controlled emission rate of (17/5) x (365 lb/hr) or 1,240 lb/hr.

(3) Extent of control: Since the above emission factors were controlled emission factors, this information was unnecessary.

(4) Calculation of emissions: Even though the above data were somewhat uncertain, calculations were made for the emissions from the dryers. Emissions were determined to be about 5,000 tons as shown below:

$$(8{,}000\ \text{hr/year})(1{,}240\ \text{lb/hr})(1/2{,}000) = 4.96 \times 10^3\ \text{tons}^{c}$$

e. Summary of calculated emissions for corn wet milling: The emissions from the corn wet milling industry have been calculated using the best data available. However, the lack of specific data for the various emission sources within the separation and conversion processes, especially the various drying processes, lowers the confidence level of the calculated emissions of those processes. Below is a table summarizing the calculated emissions:

	Emissions (1970) (tons/year)	Confidence Rating[a]
a. Receiving	1.21×10^3	B
b. Handling	4.11×10^3	B
c. Cleaning	9.45×10^2	B
d. Dryers	4.96×10^3	C
Total	1.12×10^4	C

a/ A = Good reliability.
B = Fair reliability.
C = Poor reliability.

IV. PROJECTED EMISSIONS

Projected yearly emissions for various facets of the feed and grain industry for the years 1975 and 1980 are delineated in this section of the report. The projections are based on the general assumptions discussed in the paragraphs below, and calculations were made using Eq. (1). Specific assumptions for each industry and projections of emissions from individual sources within the industry are presented in the appropriate sections of this report. Finally, specific estimated processing rates, emissions factors, and extents of control for each process are contained in the calculations, presented in Appendix A.

The general methods that follow were used to obtain the data that were inserted into Eq. (1) to project emissions for 1975 and 1980.

Changes in processing rates have been estimated using production trends in the industry. These trends have been determined through an analysis of the production figures for each industry over the last 10 years, and projections that have been made by the U.S. Department of Agriculture.

It has been assumed that the uncontrolled emission factors for all processes will remain the same over the projection period. A change in extent of control for any process can be based on a change in either or both of two factors: the efficiency of control or the application of control. Projections for changes in control have been based on the assumption that most changes will occur as a result of pressure from governmental control agencies. Therefore, the factors most likely to effect changes are plant size and plant location. Those industries that are larger operations and that are located in large urban areas (e.g., export elevators) were assumed to be under the most pressure, and therefore it was assumed that application of control would reach 100% by 1985. Other smaller industries located in urban areas or large rural communities were assumed to be under somewhat less pressure, and it was assumed that the application of control would reach 100% by 1990 or 1995. Finally, smaller operations in rural areas were assumed to be receiving the least pressure, so each of these industries was assigned a certain percent increase in application of control per year (i.e., feed mill application of control will increase increase 3% per year).

Estimates of increases in efficiency of control were based on the assumption that all processes would be equipped with "best control" devices by the time they reached 100% application of control. This means that fabric filters with 99% efficiency would be used wherever possible. The "best" type cyclone with an efficiency of 95% would be used on all other sources.

The following pages contain the specific assumptions used for each industry and summaries of projected emissions for 1975 and 1980 for the major sources of emission within each industry.

A. Elevators

1. Country elevators: Since country elevators tend to be smaller operations, it was assumed that controls would not be applied as quickly nor would those controls be as efficient as those in terminal and export elevators. It was also felt that since many of the operations were in smaller communities, there would not be as much public and agency pressure to control emissions. For these reasons it was estimated that the application of control would increase by 2% per year for every operation except drying, which would increase to 35% application of control by 1980. Efficiency of control for all operations but dryers was assumed to reach 95% by 1980.

Previously described calculations for dryer emissions considered rack and column dryers separately but assumed that half the dryers were of each type. However, in making emission projections it is difficult to estimate how the distribution of dryer types may change and where new control devices will be applied in the future. Therefore, in calculating projected emissions only one calculation was made, covering both types of dryers, using an average emission factor of 1.65 lb/ton [(3.0 + 0.3)/2] with increases in the overall application of control as described above. Dryer control efficiency was based on an average efficiency of 80% for 1971 and the assumption that all new devices will be 95% efficient.

Current and projected emissions for each source are presented in the table below:

Source	Emissions (tons/year) 1971	1975	1980
a. Unloading	4.1×10^4	4.4×10^4	4.3×10^4
b. Turning	6.65×10^4	7.27×10^4	7.15×10^4
c. Loading	1.9×10^4	2.1×10^4	2.1×10^4
d. Drying	2.36×10^4	3.49×10^4	3.81×10^4
e. Cleaning	1.38×10^4	1.17×10^4	0.81×10^4
f. Headhouse	1.92×10^5	1.92×10^5	1.58×10^5
Total	3.57×10^5	3.76×10^5	3.39×10^5

2. Terminal elevators: Because terminal elevators tend to be larger operations in more highly populated areas, it was felt that there would be a greater pressure for controls than for country elevators. It was assumed that application of control would reach 100% by 1995. It was also assumed that all sources would be equipped with the best devices by 1995. This indicates a 99% efficiency for all operations except drying which would be 95% efficient. Projected emissions for dryers were calculated using the same methodology as for country elevators. Present and projected emissions for the various sources in terminal elevators are listed in the table below:

Source	Emissions (tons/year) 1971	1975	1980
a. Unloading	1.22×10^4	1.31×10^4	1.20×10^4
b. Turning	3.78×10^3	4.32×10^3	3.96×10^3
c. Loading	5.25×10^3	5.68×10^3	5.12×10^3
d. Drying	2.78×10^3	3.76×10^3	3.54×10^3
e. Cleaning	2.18×10^4	2.28×10^4	2.12×10^4
f. Headhouse	3.44×10^4	3.72×10^4	3.38×10^4
g. Tripper	3.67×10^4	3.94×10^4	3.55×10^4
Total	1.17×10^5	1.26×10^5	1.15×10^5

3. Export elevators: Export elevators are large operations and are located in urban areas. Therefore, they will receive the most pressure to control emissions. This leads to the assumption that export elevators will have 100% application of control with highest possible efficiency of control by 1985. This also means a 99% efficiency of control on all operations except drying which will have 95% efficiency. Projected emissions for dryers were calculated using the same methodology as for country elevators. The projected emissions for 1975 and 1980 for individual processes are included in the table below:

Source	Emissions (tons/year) 1971	1975	1980
a. Unloading	1.13×10^4	1.07×10^4	0.68×10^4
b. Turning	8.95×10^2	8.38×10^2	5.12×10^2
c. Loading	3.12×10^4	2.96×10^4	1.82×10^4
d. Drying	4.20×10^2	3.90×10^2	2.60×10^2
e. Cleaning	2.30×10^4	2.19×10^4	1.34×10^4
f. Headhouse	5.34×10^4	4.94×10^4	3.10×10^4
g. Tripper	2.02×10^4	1.93×10^4	1.18×10^4
Total	1.40×10^5	1.32×10^5	0.82×10^5

B. Feed Mills

Feed mills, like country elevators, are smaller operations in predominantly rural areas. Therefore, there is expected to be less pressure for controls. Thus it has been assumed that the application of control will increase by 3% per year. It has also been assumed that the efficiency of control will reach 97% by 1980. The emissions from those operations for which a controlled emissions factor has previously been used will be calculated using the same controlled emission factor. Current emissions and emissions projected for 1975 and 1980 are listed in the table below:

Source	Emissions (tons/year)		
	1969	1975	1980
a. Receiving	4.66×10^4	4.15×10^4	3.36×10^4
b. Shipping	1.95×10^4	1.89×10^4	1.72×10^4
c. Handling operations	10.5×10^4	9.14×10^4	7.15×10^4
d. Grinding	2.44×10^3	2.92×10^3	3.29×10^3
e. Pellet coolers	0.90×10^3	1.05×10^3	1.19×10^3
Total	1.74×10^5	1.56×10^5	1.27×10^5

C. Alfalfa Dehydrating

Alfalfa dehydration plants are also small operations in rural areas. However, several states are beginning to set standards and it has been assumed that there will be increasing pressure for control on alfalfa dehydrating plants. Therefore, it is estimated that there will be a 5% per year increase in application of controls. It is also assumed that the efficiency will be 95% on all installed controls.

Emissions data for alfalfa dehydration plants are for the total plant. Therefore, estimated plant emissions for 1975 and 1980 and present plant emissions are presented below:

Emissions (tons/year)		
1971	1975	1980
1.6×10^4	1.30×10^4	0.92×10^4

D. Wheat Mills

It has been assumed for these calculations that all operations for which emission factors are available will reach 100% application of control with the controls being 99% efficient, by 1990. Current and projected emissions are contained in the table below:

Source	Emissions (tons/year)		
	1971	1975	1980
a. Receiving	2.78×10^3	2.24×10^3	1.54×10^3
b. Precleaning and handling	7.89×10^3	6.44×10^3	4.47×10^3
c. Cleaning house		Insufficient information	
d. Mill house	3.49×10^4	2.87×10^4	2.30×10^4
Total	4.56×10^4	3.74×10^4	2.90×10^4

E. Durum Mills

Data on emission factors for some operations in durum mills are not sufficient to calculate emissions. On those operations for which sufficient emission factor data are available, it has been assumed that 100% application of control will have been attained by 1990. It is also assumed that all controls will be 99% efficient by this time. Projected emissions for each source within the durum milling industry are listed in the table below:

Source	Emissions (tons/year) 1971	1975	1980
a. Receiving	1.68×10^2	1.62×10^2	1.30×10^2
b. Precleaning and handling	4.81×10^2	4.66×10^2	3.77×10^2
c. Cleaning house		Insufficient information	
d. Mill house		Insufficient information	
Total	6.49×10^2	6.28×10^2	5.07×10^2

F. Rye Milling

For those rye milling operations for which sufficient data were available to calculate emissions, it has been assumed that the application of control will reach 100% with a 99% efficiency of control by 1990. Below is a table containing present emissions and projected emissions for 1975 and 1980.

Source	Emissions (tons/year) 1971	1975	1980
a. Receiving	2.55×10^1	2.03×10^1	1.39×10^1
b. Precleaning and handling	7.22×10^1	5.82×10^1	4.04×10^1
c. Cleaning house		Insufficient information	
d. Mill house	3.11×10^2	2.59×10^2	2.08×10^2
Total	4.08×10^2	3.38×10^2	2.62×10^2

G. Dry Corn Milling

Those operations in the dry corn milling process for which sufficient data were available to enable calculation of emissions were assumed to have reached 100% application of control by 1990. All operations but drying were assumed to have reached 99% efficiency by 1990. Drying was assumed to have reached an efficiency of control of 95% by that date. Listed below are the present calculated emissions and projected emissions for 1975 and 1980.

Source	Emissions (tons/year) 1970	1975	1980
a. Receiving	7.38×10^2	5.72×10^2	3.93×10^2
b. Drying	5.32×10^1	4.50×10^1	3.42×10^1
c. Precleaning and handling	2.35×10^3	1.83×10^3	1.27×10^3
d. Cleaning house	4.14×10^2	4.23×10^2	2.82×10^2
e. Degerming and milling		Insufficient information	
Total	3.55×10^3	2.87×10^3	1.98×10^3

H. Oat Milling

The only emission factor available for oat milling is a controlled emission factor of 2.5 lb/ton. For these calculations it is assumed that this figure remains constant and only the production rate will increase. Below are projections of estimated emissions for oat mills in 1975 and 1980.

Emissions (tons/year)		
1970	1975	1980
8.75×10^2	10.0×10^2	10.0×10^2

I. Rice Milling

The only two operations in the rice milling process for which calculations were possible were receiving and precleaning and handling. It was assumed that application of control on these operations would reach 100%, with 99% efficiency, by 1990. Projected emissions for some of the rice milling operations are listed below:

Source	Emissions (tons/year) 1970	1975	1980
a. Receiving	4.56×10^2	4.05×10^2	2.61×10^2
b. Precleaning and handling	3.80×10^3	3.32×10^3	2.16×10^3
c. Drying		Insufficient information	
d. Cleaning and mill house		Insufficient information	
Total	4.26×10^3	3.73×10^3	2.42×10^3

J. Commercial Rice Drying

Data are insufficient to estimate emissions for commercial rice drying.

K. Soybean Mills

It has been assumed that all operations in soybean mills will have 100% application of controls with the most efficient type of control device by 1985. This means a 99% efficiency of control for all operations except drying, bean conditioning, flaking, meal drying, and meal cooling which will be 95% efficient. Projected emissions for the various sources in the soybean milling operation are presented in the table below:

Source	Emissions (tons/year) 1970	1975	1980
a. Receiving	9.38×10^3	7.09×10^3	4.36×10^3
b. Handling	1.55×10^4	1.19×10^4	0.75×10^4
c. Cleaning	1.73×10^4	1.32×10^4	0.82×10^4
d. Drying	5.50×10^4	4.47×10^4	2.99×10^4
e. Cracking (and dehulling)	4.07×10^3	3.34×10^3	2.00×10^3
f. Hull grinding	2.04×10^3	1.54×10^3	1.21×10^3
g. Bean conditioning	3.23×10^2	2.69×10^2	1.93×10^2
h. Flaking	8.29×10^2	7.91×10^2	6.05×10^2
i. Meal dryer	7.62×10^3	6.00×10^3	4.38×10^3
j. Meal cooler	2.99×10^3	2.71×10^3	2.17×10^3
k. Bulk loading	1.99×10^3	1.49×10^3	0.93×10^3
Total	11.7×10^4	9.30×10^4	6.14×10^4

L. Corn Wet Mills

It has been assumed that all operations except drying on corn wet mills will have reached 100% application of control with 99% efficiency of control by 1985. Estimated dryer emissions have been calculated using a controlled emission factor of 1,241 lb/hr and multiplying by the ratio of increased production. Current process emissions and projected emissions for 1975 and 1980 are contained in the table below:

Source	Emissions (tons/year)		
	1970	1975	1980
a. Receiving	1.21×10^3	0.97×10^3	0.55×10^3
b. Handling	4.11×10^3	3.20×10^3	1.97×10^3
c. Cleaning	9.45×10^2	8.76×10^2	4.80×10^2
d. Drying	4.96×10^3	5.75×10^3	6.30×10^3
Total	1.12×10^4	1.08×10^4	0.93×10^4

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APPENDIX A

CALCULATION OF PROJECTED EMISSIONS

A. Elevators

1. Country elevators

a. Unloading

(1) 1975 -

$(216 \times 10^6 \text{ tons})(0.64 \text{ lb/ton})(1/2{,}000)[1-(0.39)(0.92)] = 4.4 \times 10^4 \text{ tons}$

(2) 1980 -

$(255 \times 10^6 \text{ tons})(0.64 \text{ lb/ton})(1/2{,}000)[1-(0.49)(0.95)] = 4.3 \times 10^4 \text{ tons}$

b. Turning

(1) 1975 -

$(16.2 \times 10^7 \text{ tons})(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.39)(0.92)] = 7.27 \times 10^4 \text{ tons}$

(2) 1980 -

$(19.1 \times 10^7 \text{ tons})(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.49)(0.95)] = 7.15 \times 10^4 \text{ tons}$

c. Loading

(1) 1975 -

$(21.6 \times 10^7 \text{ tons})(0.27 \text{ lb/ton})(1/2{,}000)[1-(0.30)(0.92)] = 0.21 \times 10^5 \text{ tons}$

(2) 1980 -

$(25.5 \times 10^7 \text{ tons})(0.27 \text{ lb/ton})(1/2{,}000)[1-(0.40)(0.95)] = 0.21 \times 10^5 \text{ tons}$

d. Drying*

(1) 1975 -

$(5.5 \times 10^7 \text{ tons})(1.65 \text{ lb/ton})(1/2{,}000)[1-(0.28)(0.82)] = 3.49 \times 10^4 \text{ tons}$

(2) 1980 -

$(6.5 \times 10^7 \text{ tons})(1.65 \text{ lb/ton})(1/2{,}000)[1-(0.35)(0.84)] = 3.81 \times 10^4 \text{ tons}$

* Original data obtained on the application of control for dryers were given a low level of confidence. Therefore, these predictions based on that data may be inaccurate.

e. Cleaning

(1) 1975 -

$(1.7 \times 10^7 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(0.81)(0.95)] = 1.17 \times 10^4$ tons

(2) 1980 -

$(2.0 \times 10^7 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(0.91)(0.95)] = 0.81 \times 10^4$ tons

f. Headhouse

(1) 1975 -

$(66.6 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.67)(0.92)] = 1.92 \times 10^5$ tons

(2) 1980 -

$(78.6 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.77)(0.95)] = 1.58 \times 10^5$ tons

2. Terminal elevators

a. Unloading

(1) 1975 -

$(6.9 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.66)(0.94)] = 1.31 \times 10^4$ tons

(2) 1980 -

$(8.1 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.74)(0.95)] = 1.20 \times 10^4$ tons

b. Turning

(1) 1975 -

$(4.9 \times 10^7 \text{ tons})(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.93)(0.94)] = 4.32 \times 10^3$ tons

(2) 1980 -

$(5.3 \times 10^7 \text{ tons})(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.95)(0.95)] = 3.96 \times 10^3$ tons

c. Loading

(1) 1975 -

$$(6.9 \times 10^7 \text{ tons})(0.27 \text{ lb/ton})(1/2{,}000)[1-(0.42)(0.93)] = 5.68 \times 10^3 \text{ tons}$$

(2) 1980 -

$$(8.1 \times 10^7 \text{ tons})(0.27 \text{ lb/ton})(1/2{,}000)[1-(0.56)(0.95)] = 5.12 \times 10^3 \text{ tons}$$

d. Drying

(1) 1975 -

$$(0.66 \times 10^7 \text{ tons})(1.65 \text{ lb/ton})(1/2{,}000)[1-(0.37)(0.83)] = 3.76 \times 10^3 \text{ tons}$$

(2) 1980 -

$$(0.78 \times 10^7 \text{ tons})(1.65 \text{ lb/ton})(1/2{,}000)[1-(0.52)(0.86)] = 3.54 \times 10^3 \text{ tons}$$

e. Cleaning

(1) 1975 -

$$(1.5 \times 10^7 \text{ tons})(6.00 \text{ lb/ton})(1/2{,}000)[1-(0.53)(0.93)] = 2.28 \times 10^4 \text{ tons}$$

(2) 1980 -

$$(1.8 \times 10^7 \text{ tons})(6.00 \text{ lb/ton})(1/2{,}000)[1-(0.64)(0.95)] = 2.12 \times 10^4 \text{ tons}$$

f. Headhouse

(1) 1975 -

$$(20.9 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.82)(0.93)] = 3.72 \times 10^4 \text{ tons}$$

(2) 1980 -

$$(24.6 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.86)(0.95)] = 3.38 \times 10^4 \text{ tons}$$

g. Tripper

(1) 1975 -

$$(11.8 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.35)(0.95)] = 3.94 \times 10^4 \text{ tons}$$

(2) 1980 -

$(13.9 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.51)(0.96)] = 3.55 \times 10^4 \text{ tons}$

3. Export elevators

a. Unloading

(1) 1975 -

$(10.5 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.83)(0.96)] = 1.07 \times 10^4 \text{ tons}$

(2) 1980 -

$(12.6 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.91)(0.98)] = 0.68 \times 10^4 \text{ tons}$

b. Turning

(1) 1975 -

$(6.9 \times 10^6 \text{ tons})(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.87)(0.95)] = 8.38 \times 10^2 \text{ tons}$

(2) 1980 -

$(8.3 \times 10^6 \text{ tons})(1.40 \text{ lb/ton})(1/2{,}000)[1-(0.94)(0.97)] = 5.12 \times 10^2 \text{ tons}$

c. Loading

(1) 1975 -

$(10.5 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.47)(0.93)] = 2.96 \times 10^4 \text{ tons}$

(2) 1980 -

$(12.6 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.74)(0.96)] = 1.82 \times 10^4 \text{ tons}$

d. Drying

(1) 1975 -

$(1.05 \times 10^6 \text{ tons})(1.65 \text{ lb/ton})(1/2{,}000)[1-(0.66)(0.84)] = 3.90 \times 10^2 \text{ tons}$

(2) 1980 -

$(1.26 \times 10^6 \text{ tons})(1.65 \text{ lb/ton})(1/2{,}000)[1-(0.83)(0.90)] = 2.60 \times 10^2 \text{ tons}$

e. Cleaning

(1) 1975 -

$(1.53 \times 10^7 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(0.55)(0.95)] = 2.19 \times 10^4 \text{ tons}$

(2) 1980 -

$(1.84 \times 10^7 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(0.78)(0.97)] = 1.34 \times 10^4 \text{ tons}$

f. Headhouse

(1) 1975 -

$(23.3 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.74)(0.97)] = 4.94 \times 10^4 \text{ tons}$

(2) 1980 -

$(28.0 \times 10^7 \text{ tons})(1.5 \text{ lb/ton})(1/2{,}000)[1-(0.87)(0.98)] = 3.10 \times 10^4 \text{ tons}$

g. Tripper

(1) 1975 -

$(11.2 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.69)(0.95)] = 1.93 \times 10^4 \text{ tons}$

(2) 1980 -

$(13.4 \times 10^7 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.85)(0.97)] = 1.18 \times 10^4 \text{ tons}$

B. Feed Mills

a. Receiving

(1) 1975 -

$(12.4 \times 10^7 \text{ tons})(1.30 \text{ lb/ton})(1/2{,}000)[1-(0.50)(0.97)] = 4.15 \times 10^4$ tons

(2) 1980 -

$(14.0 \times 10^7 \text{ tons})(1.30 \text{ lb/ton})(1/2{,}000)[1-(0.65)(0.97)] = 3.36 \times 10^4$ tons

b. Shipping

(1) 1975 -

$(9.68 \times 10^7 \text{ tons})(0.5 \text{ lb/ton})(1/2{,}000)[1-(0.23)(0.94)] = 1.89 \times 10^4$ tons

(2) 1980 -

$(10.9 \times 10^7 \text{ tons})(0.5 \text{ lb/ton})(1/2{,}000)[1-(0.38)(0.97)] = 1.72 \times 10^4$ tons

c. Handling operations

(1) 1975 -

$(12.4 \times 10^7 \text{ tons})(3.0 \text{ lb/ton})(1/2{,}000)[1-(0.53)(0.96)] = 9.14 \times 10^4$ tons

(2) 1980 -

$(14.0 \times 10^7 \text{ tons})(3.0 \text{ lb/ton})(1/2{,}000)[1-(0.68)(0.97)] = 7.15 \times 10^4$ tons

d. Grinding*

(1) 1975 -

$(5.82 \times 10^7 \text{ tons})(0.1 \text{ lb/ton})(1/2{,}000) = 2.92 \times 10^3$ tons

(2) 1980 -

$(6.57 \times 10^7 \text{ tons})(0.1 \text{ lb/ton})(1/2{,}000) = 3.29 \times 10^3$ tons

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* A controlled emission factor was used to calculate emissions.

e. Pellet coolers*

(1) 1975 -

$(2.10 \times 10^7 \text{ tons})(0.1 \text{ lb/ton})(1/2,000) = 1.05 \times 10^3$ tons

(2) 1980 -

$(2.38 \times 10^7 \text{ tons})(0.1 \text{ lb/ton})(1/2,000) = 1.19 \times 10^3$ tons

C. Alfalfa Dehydrating

(1) 1975 -

$(1.6 \times 10^6 \text{ tons})(20 \text{ lb/ton})(1/2,000)[1-(0.20)(0.95)] = 1.30 \times 10^4$ tons

(2) 1980 -

$(1.6 \times 10^6 \text{ tons})(20 \text{ lb/ton})(1/2,000)[1-(0.45)(0.95)] = 9.16 \times 10^3$ tons

D. Wheat Mills

a. Receiving

(1) 1975 -

$(16.6 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2,000)[1-(0.76)(0.96)] = 2.24 \times 10^3$ tons

(2) 1980 -

$(16.6 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2,000)[1-(0.84)(0.97)] = 1.54 \times 10^3$ tons

b. Precleaning and handling

(1) 1975 -

$(16.6 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2,000)[1-(0.88)(0.96)] = 6.44 \times 10^3$ tons

(2) 1980 -

$(16.6 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2,000)[1-(0.92)(0.97)] = 4.47 \times 10^3$ tons

c. Cleaning house

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

d. Mill house

(1) 1975 -

$(16.6 \times 10^6 \text{ tons})(70 \text{ lb/ton})(1/2{,}000)[1-(0.97)(0.98)] = 2.87 \times 10^4 \text{ tons}$

(2) 1980 -

$(16.6 \times 10^6 \text{ tons})(70 \text{ lb/ton})(1/2{,}000)[1-(0.98)(0.98)] = 2.30 \times 10^4 \text{ tons}$

E. Durum Mills

a. Receiving

(1) 1975 -

$(1.2 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.76)(0.96)] = 1.62 \times 10^2 \text{ tons}$

(2) 1980 -

$(1.4 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.84)(0.97)] = 1.30 \times 10^2 \text{ tons}$

b. Precleaning and handling

(1) 1975 -

$(1.2 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.88)(0.96)] = 4.66 \times 10^2 \text{ tons}$

(2) 1980 -

$(1.4 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.92)(0.97)] = 3.77 \times 10^2 \text{ tons}$

c. Cleaning house

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

d. Mill house

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

F. Rye Milling

a. Receiving

(1) 1975 -

$(0.15 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.76)(0.96)] = 2.03 \times 10^1 \text{ tons}$

(2) 1980 -

$(0.15 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.84)(0.97)] = 1.39 \times 10^1 \text{ tons}$

b. Precleaning and handling

(1) 1975 -

$(0.15 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.88)(0.96)] = 5.82 \times 10^1 \text{ tons}$

(2) 1980 -

$(0.15 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.92)(0.97)] = 4.04 \times 10^1 \text{ tons}$

c. Cleaning house

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

d. Mill house

(1) 1975 -

$(0.15 \times 10^6 \text{ tons})(70 \text{ lb/ton})(1/2{,}000)[1-(0.97)(0.98)] = 2.59 \times 10^2 \text{ tons}$

(2) 1980 -

$(0.15 \times 10^6 \text{ tons})(70 \text{ lb/ton})(1/2{,}000)[1-(0.98)(0.98)] = 2.08 \times 10^2 \text{ tons}$

G. Dry Corn Milling

a. Receiving

(1) 1975 -

$(4.7 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.78)(0.97)] = 5.72 \times 10^2$ tons

(2) 1980 -

$(4.7 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.85)(0.98)] = 3.93 \times 10^2$ tons

b. Drying

(1) 1975 -

$(0.94 \times 10^6 \text{ tons})(0.5 \text{ lb/ton})(1/2{,}000)[1-(0.94)(0.86)] = 4.50 \times 10^1$ tons

(2) 1980 -

$(0.94 \times 10^6 \text{ tons})(0.5 \text{ lb/ton})(1/2{,}000)[1-(0.96)(0.89)] = 3.42 \times 10^1$ tons

c. Precleaning and handling

(1) 1975 -

$(4.7 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.87)(0.97)] = 1.83 \times 10^3$ tons

(2) 1980 -

$(4.7 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.91)(0.98)] = 1.27 \times 10^3$ tons

d. Cleaning house

(1) 1975 -

$(4.7 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-0.97] = 4.23 \times 10^2$ tons

(2) 1980 -

$(4.7 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-0.98] = 2.82 \times 10^2$ tons

e. <u>Degerming and milling</u>

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

H. <u>Oat Mills</u>

(1) 1975 -

$(0.8 \times 10^6 \text{ tons})(2.5 \text{ lb/ton})(1/2{,}000) = 1 \times 10^3 \text{ tons}$

(2) 1980 -

$(0.6 \times 10^6 \text{ tons})(2.5 \text{ lb/ton})(1/2{,}000) = 1 \times 10^3 \text{ tons}$

I. <u>Rice Milling</u>

a. <u>Receiving</u>

(1) 1975 -

$(4.4 \times 10^6 \text{ tons})(0.64 \text{ lb/ton})(1/2{,}000)[1-(0.75)(0.95)] = 4.05 \times 10^2 \text{ tons}$

(2) 1980 -

$(4.4 \times 10^5 \text{ tons})(0.64 \text{ lb/ton})(1/2{,}000)[1-(0.84)(0.97)] = 2.61 \times 10^2 \text{ tons}$

b. <u>Precleaning and handling</u>

(1) 1975 -

$(4.4 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.72)(0.97)] = 3.32 \times 10^3 \text{ tons}$

(2) 1980 -

$(4.4 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.82)(0.98)] = 2.16 \times 10^3 \text{ tons}$

c. <u>Drying</u>

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

c. Cleaning and mill house

(1) 1975 - E = Insufficient information

(2) 1980 - E = Insufficient information

J. Commercial Rice Drying

Due to insufficient data, calculations are not possible.

K. Soybean Mills

a. Receiving

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(1.6 \text{ lb/ton})(1/2{,}000)[1-(0.67)(0.98)] = 7.09 \times 10^3 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(1.6 \text{ lb/ton})(1/2{,}000)[1-(0.83)(0.99)] = 4.36 \times 10^3 \text{ tons}$

b. Handling

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.84)(0.97)] = 1.19 \times 10^4 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.92)(0.98)] = 0.75 \times 10^4 \text{ tons}$

c. Cleaning

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-0.83] = 1.32 \times 10^4 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-0.91] = 0.82 \times 10^4 \text{ tons}$

d. Drying

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(7.2 \text{ lb/ton})(1/2{,}000)[1-(0.61)(0.85)] = 4.47 \times 10^4 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(7.2 \text{ lb/ton})(1/2{,}000)[1-(0.81)(0.90)] = 2.99 \times 10^4 \text{ tons}$

e. Cracking and dehulling

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(3.3 \text{ lb/ton})(1/2{,}000)[1-(0.97)(0.95)] = 3.34 \times 10^3 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(3.3 \text{ lb/ton})(1/2{,}000)[1-(0.99)(0.97)] = 2.00 \times 10^3 \text{ tons}$

f. Hull grinding

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(2.0 \text{ lb/ton})(1/2{,}000)[1-(0.99)(0.95)] = 1.54 \times 10^3 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(2.0 \text{ lb/ton})(1/2{,}000)[1-(0.99)(0.97)] = 1.21 \times 10^3 \text{ tons}$

g. Bean conditioning

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(0.1 \text{ lb/ton})(1/2{,}000)[1-(0.86)(0.92)] = 2.69 \times 10^2 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6 \text{ tons})(0.1 \text{ lb/ton})(1/2{,}000)[1-(0.93)(0.94)] = 1.93 \times 10^2 \text{ tons}$

h. Flaking

(1) 1975 -

$(25.8 \times 10^6 \text{ tons})(0.57 \text{ lb/ton})(1/2{,}000)[1-(0.97)(0.92)] = 7.91 \times 10^2 \text{ tons}$

(2) 1980 -

$(30.6 \times 10^6$ tons$)(0.57$ lb/ton$)(1/2{,}000)[1-(0.99)(0.94)] = 6.05 \times 10^2$ tons

i. <u>Meal dryer</u>

(1) 1975 -

$(25.8 \times 10^6$ tons$)(1.5$ lb/ton$)(1/2{,}000)[1-(0.75)(0.92)] = 6.00 \times 10^3$ tons

(2) 1980 -

$(30.6 \times 10^6$ tons$)(1.5$ lb/ton$)(1/2{,}000)[1-(0.87)(0.93)] = 4.38 \times 10^3$ tons

j. <u>Meal cooler</u>

(1) 1975 -

$(25.8 \times 10^6$ tons$)(1.8$ lb/ton$)(1/2{,}000)[1-(0.96)(0.92)] = 2.71 \times 10^3$ tons

(2) 1980 -

$(30.6 \times 10^6$ tons$)(1.8$ lb/ton$)(1/2{,}000)[1-(0.98)(0.94)] = 2.17 \times 10^3$ tons

k. <u>Bulk loading</u>

(1) 1975 -

$(25.8 \times 10^6$ tons$)(0.27$ lb/ton$)(1/2{,}000)[1-(0.58)(0.98)] = 1.49 \times 10^3$ tons

(2) 1980 -

$(30.6 \times 10^6$ tons$)(0.27$ lb/ton$)(1/2{,}000)[1-(0.79)(0.98)] = 0.93 \times 10^3$ tons

L. Corn Wet Mills

a. Receiving

(1) 1975 -

$(7.3 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.78)(0.94)] = 9.74 \times 10^2$ tons

(2) 1980 -

$(8.0 \times 10^6 \text{ tons})(1.0 \text{ lb/ton})(1/2{,}000)[1-(0.89)(0.97)] = 5.47 \times 10^2$ tons

b. Handling

(1) 1975 -

$(7.3 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.85)(0.97)] = 3.20 \times 10^3$ tons

(2) 1980 -

$(8.0 \times 10^6 \text{ tons})(5.0 \text{ lb/ton})(1/2{,}000)[1-(0.92)(0.98)] = 1.97 \times 10^3$ tons

c. Cleaning

(1) 1975 -

$(7.3 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(1)(0.96)] = 8.76 \times 10^2$ tons

(2) 1980 -

$(8.0 \times 10^6 \text{ tons})(6.0 \text{ lb/ton})(1/2{,}000)[1-(1)(0.98)] = 4.80 \times 10^2$ tons

d. Drying

(1) 1975 -

$(1{,}240 \text{ lb/hr})(7.3/6.3)(8{,}000 \text{ hr})(1/2{,}000) = 5.75 \times 10^3$ tons

(2) 1980 -

$(1{,}240 \text{ lb/hr})(8.0/6.3)(8{,}000 \text{ hr})(1/2{,}000) = 6.30 \times 10^3$ tons