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Assessment of Fugitive Particulate Emission Factors for Industrial Processes

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Assessment of Fugitive Particulate Emission Factors for Industrial Processes

by

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1.0 SUMMARY

1.1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has called for revisions of State Implementation Plans (SIP's) in areas where the total suspended particulate (TSP) standard is being exceeded. An integral part of the SIP's is the TSP emission inventory, which is necessary to identify areas requiring emission control. Deficiencies in some state inventories must be corrected before strategies can be developed. One of these deficiencies is the lack of reliable emission factor data for TSP resulting from fugitive emissions from industrial processes.

The purpose of this assessment is to develop a priority listing of fugitive industrial processes on which source sampling is needed and to provide EPA with recommendations and support documentation for the development of fugitive TSP emission factors for industrial processes.

The industries covered are those whose processes contribute to fugitive particulate emissions. This study also includes an update of data found in the manual, Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions.[1] Fugitive dust sources such as storage piles, vehicular traffic, and windblown dust are not included in this study.

1.2 PRIORITY LISTING

Two criteria were used for the priority listing of industrial categories that require source sampling of fugitive process emissions: 1) adequacy of currently available fugitive emission factor data, and 2) total potential uncontrolled fugitive particulate emissions (industrywide). The priority listing is presented in Table 1-1.

TABLE 1-1. PRIORITY LISTING OF INDUSTRIAL CATEGORIES

Industrial category	Adequacy of emission data ranking[a]	Uncontrolled fugitive particulate emissions[b] Mg/yr	(tons/yr)	rankings[c]	Percent of total plant uncontrolled particulate emissions	Total priority ranking[d]
1. Foundries	5	106,719	(117,872)	4	50.3	9
2. Portland cement	4	697,589	(768,961)	5	5.7	9
3. Minerals extraction and beneficiation	4	648,401	(714,096)	5	100.0	9
4. Iron production	4	99,450	(110,070)	4	0.9	8
5. Secondary lead	5	4,250	(4,684)	2	6.2	7
6. Primary aluminum	4	52,470	(57,890)	3	24.4	7
7. Asphaltic concrete	4	46,845	(51,638)	3	0.7	7
8. Lime manufacturing	4	44,824	(49,410)	3	1.3	7
9. Coke manufacturing	3	131,700	(145,400)	4	100.0	7
10. Secondary aluminum	5	1,808	(1,995)	1	5.6	6
11. Secondary brass/bronze	5	766	(842)	1	10.9	6
12. Secondary zinc	5	429	(472)	1	6.9	6
13. Lumber and furniture	4	8,665	(9,549)	2	52.9	6
14. Concrete batching	3	31,026	(34,200)	3	100.0	6
15. Primary copper	3	19,977	(22,024)	3	22.0	6
16. Grain elevators	1	1,238,129	(1,364,803)	5	100.0	6[e]
17. Primary zinc	4	1,806	(1,991)	1	2.1	5
18. Primary lead	3	11,742	(12,945)	2	6.1	5
19. Steel manufacturing	2	61,520	(68,250)	3	2.8	5[e]

[a] Ranking definitions: 5 - very poor; 4 - poor; 3 - fair; 2 - good; and 1 - very good.

[b] See Section 2 for detailed descriptions of potential emission sources, their respective emission factors, and emission estimates within each industry.

[c] Sources with the highest emissions receive the highest ranking.

[d] Source categories with greatest total ranking deserve highest priority for emission sampling.

[e] Since emission factor ranking is good or very good, sampling for emission factor development is not required.

1.2.1 Rating Criteria

The detailed supporting data and analysis of the rating criteria are contained in Section 2 of this report. The emission calculations represent the total uncontrolled fugitive particulate emissions from industrial processes. These calculations were used as a rating criterion since they indicate the potential fugitive emission levels of each industrial category. Actual fugitive emissions cannot readily be calculated because industrywide fugitive control levels have not been documented.

Table 1-1 also presents the adequacy of currently available fugitive emission factor data. The sources of available factors (or estimates) are given in Section 2, along with the method used to develop the factors. Thus, a factor based on an estimate of 5 percent of the uncontrolled process emission rate found in the Compilation of Air Pollutant Emission Factors (AP-42) is less adequate than a fugitive emission rate based on sampling.

1.2.2 Ranking System

The emission estimates and adequacy of the emission factor analysis are numerically ranked by industrial category. The emission estimates are ranked from one to five, with one representing the lowest fugitive emission rate and five the highest.

The adequacy of the fugitive emission factors also are ranked from one to five. The industrial categories with the least adequate data are assigned a ranking of five, whereas the categories with the best data are assigned a one. The adequacy of emission factor rankings is defined as follows:

5 Very poor. Based only on estimates or assumed values, or the development is unknown.

4 Poor. Based on engineering judgment, related factors from other industries, or material balance.

3 Fair. Based on engineering judgment and limited tests.

2 Good. Based on incomplete test data.

1 Very good. Based on complete test data.

A material balance is much less accurate for use in arriving at a fugitive particulate emission factor than it is for other applications, such as determining the sulfur emissions from a boiler based on fuel flow rate and sulfur content. Hence it is considered a "poor" rating for developing fugitive emission factors. All emission factors for each industry were considered in determining the overall adequacy ranking, which represents the status of emission factor development for that industry.

The rankings for both criteria are summed for each industrial category and listed in numerical order. The sources with the highest ranking totals have top priority in a sampling program to measure the fugitive particulate emissions from industrial processes. The industries with lower ranking totals have a corresponding lower priority of fugitive emission factor development. As can be seen from Table 1-1, the industries with equal total priority rankings are rated based on the adequacy of emission data rankings. When the adequacy rankings are equal, the industry with the highest annual fugitive emissions is given highest priority.

1.3 FUGITIVE PARTICULATE EMISSIONS BY PROCESS TYPE

Industries that produce or manufacture completely unrelated products will often have several very similar processes that have the potential to generate fugitive emissions. Approximately 39 types of processes have been identified as contributors to fugitive emissions from the industries covered in this report.[1] Table 1-2 presents the major sources of fugitive particulate emissions within each industry.

About 80 percent of the potential uncontrolled fugitive emissions result from the following five process types that, except for the grain elevator headhouse, are common to several industries:

1. Loading and unloading, 800,900 Mg/yr (882,900 tons/yr)
2. Headhouse operations, 602,400 Mg/yr (664,000 tons/yr)

TABLE 1-2. MAJOR SOURCES OF FUGITIVE PARTICULATE EMISSIONS

Industry and total uncontrolled fugitive particulate emissions, Mg/yr (tons/yr)	Major sources of fugitive particulate emissions	Uncontrolled fugitive particulate emissions by source category, Mg/yr	(tons/yr)	Percent of annual uncontrolled particulate emissions
1. Foundries 106,719 (117,872)	Hot metal and slag transfer, casting, and refining	68,856	(76,152)	65
	Metal melting operations	22,436	(24,710)	21
	Core preparation	11,425	(12,584)	11
2. Portland cement 697,589 (768,961)	Loading, unloading and storage	538,937	(594,077)	77
	Crushing, grinding, and screening	127,421	(142,078)	18
3. Minerals extraction and beneficiation 648, 401 (714,096)	Crushing, grinding and screening	359,013	(395,387)	55
	Transfer and conveying	97,206	(107,056)	15
	Drilling and blasting	76,956	(84,752)	12
	Overburden removal	56,903	(62,668)	9
4. Iron production 99,450 (110,070)	Sintering	67,100	(74,000)	67
	Hot metal and slag, transfer, casting, and refining	31,600	(35,200)	32
5. Secondary lead 4250 (4684)	Hot metal and slag, transfer, casting, and refining	3,384	(3,730)	79
	Reverberatory furnace	595	(656)	14
6. Primary aluminum	Reduction cells	24,620	(27,140)	47
	Transfer and conveying	19,000	(21,000)	36
	Crushing, grinding, and screening	5,310	(5,850)	10

(continued)

TABLE 1-2. (continued)

Industry and total uncontrolled fugitive particulate emissions, Mg/yr (tons/yr)	Major sources of fugitive particulate emissions	Uncontrolled fugitive particulate emissions by source category, Mg/yr	(tons/yr)	Percent of annual uncontrolled particulate emissions
7. Asphaltic concrete 46,845 (51,638)	Transfer and conveying	28,740	(31,680)	61
	Loading, unloading and storage	14,370	(15,840)	31
8. Limestone manufacturing 44,824 (49,410)	Crushing, grinding, and screening	36,388	(40,111)	81
	Transfer and conveying	7,653	(8,436)	17
9. Coke manufacturing 131,700 (145,400)	Charging	63,800	(70,400)	48
	Quenching	38,200	(42,200)	29
	Pushing	25,500	(28,100)	19
10. Secondary aluminum 1808 (1,995)	Fluxing (chlorination)	1,425	(1,575)	79
	Chip (rotary) dryer	223	(245)	12
11. Secondary brass/bronze 766 (842)	Metal melting	358	(393)	47
	Insulation burning	275	(303)	36
	Rotary dryer	69	(76)	9
12. Secondary zinc 429 (472)	Metal melting	290	(319)	66
	Crushing, grinding, and screening	138	(152)	32
13. Lumber and furniture 8,665 (9,549)	Sawing	7,078	(7,802)	82
	Log debarking	544	(599)	6
	Wood waste storage and and unloading	425	(468)	5

(continued)

TABLE 1-2. (continued)

Industry and total uncontrolled fugitive particulate emissions, Mg/yr (tons/yr)	Major sources of fugitive particulate emissions	Uncontrolled fugitive particulate emissions by source category, Mg/yr	(tons/yr)	Percent of annual uncontrolled particulate emissions
14. Concrete batching 31,026 (34,200)	Loading, unloading, and storage	31,026	(34,200)	100
15. Primary copper 19,977 (22,024)	Metal melting	18,153	(20,675)	94
16. Grain elevators 1,238,127 (1,364,803)	Headhouse (legs)	602,368	(663,996)	49
	Transfer and conveying,	378,868	(417,631)	31
	Loading, unloading, and and storage	177,704	(195,887)	14
17. Primary zinc 1806 (1991)	Hot metal and slag transfer, casting, and refining	1,198	(1,321)	66
	Sintering	608	(670)	34
18. Primary lead 11,742 (12,945)	Sintering	6,978	(7,689)	59
	Metal melting	2,326	(2,566)	20
	Crushing, grinding, and screening	692	(763)	6
	Silver retort building	551	(608)	5
19. Steel manufacturing 61,520 (68,250)	Metal melting	51,600	(57,300)	84
	Hot metal and slag transfer, casting, and refining	9,600	(10,600)	15

3. Crushing, grinding, and screening, 569,300 Mg/yr (627,600 tons/yr)

4. Transfer and conveying, 468,000 Mg/yr (515,900 tons/yr)

5. Metal melting operations, 246,200 Mg/yr (271,400 tons/yr)

It should be noted that these are uncontrolled emission estimates, and in cases where emissions are controlled, the rates would be reduced substantially.

Fugitive emissions from loading and unloading are generated by such operations as loading haul trucks with raw materials at the quarry or mine site, dumping these materials into a primary crusher or storage area, and loading partially processed materials into interim storage prior to loadout for further processing. The portland cement industry is a major contributor of such emissions, primarily because of the large volume of materials (both raw and partially processed) loaded and unloaded. Loading and unloading of raw materials from the quarry and clinker from clinker storage are the major potential fugitive sources within this industry. Although the lime manufacturing, coal mining, and crushed stone industries have similar processes, either the volumes handled or the number of actual loading and unloading operations are on a smaller scale, thereby lessening the total potential fugitive emissions from loading and unloading.

Headhouses at grain elevators are a potentially large source of fugitive particulate emissions. The headhouse is the distribution center of a grain elevator, where the grain is distributed, possibly weighed, and loaded in storage silos. Actual total annual emissions from this source, however, are probably much lower than indicated in this report because emission controls are often used on headhouse operations.

Crushing, grinding, and screening processes, as well as transfer and conveying, are common in industries where raw materials must undergo size reduction at some point to attain the desired product. This is particularly the case in industries involved in the extraction of limestone, dolomite, crushed stone, metallic ores, and other minerals. The mined raw materials are often in large pieces that must be reduced by crushers. Crushing can involve up to three steps, each successive step further reducing the material size, and screening usually takes place between each crushing operation. The crushing steps often occur at different locations within the facility. Primary crushing may take place at the quarry or mine site, and the product may subsequently be transferred to secondary and tertiary crushing and screening operations at another location within the plant. The transfer process can generate fugitive emissions particularly if there are numerous transfer points along the way. Most industries do not control the emissions generated by these operations. The amount of uncontrolled emissions depends somewhat on the moisture content of the raw material, which can vary greatly within an industry and from one season to another.

A smaller potential source of fugitive emissions is the metals melting industries (ferrous and nonferrous). The major potential source is the melting furnace, particularly the charging and tapping operations, although furnace leakage contributes some emissions. The principal furnace types are reverberatory, blast, electric, basic oxygen, and pot. These furnaces are used in the production of many different metals. Emissions from any one furnace type will vary, depending on the type of metal produced.

1.4 ONGOING FUGITIVE EMISSION PROJECTS

Currently several ongoing or recently completed studies are concerned with the quantification of fugitive emissions from industrial processes. These projects will supply additional information for the development of fugitive emission factors. Table 1-3 lists these projects as well as other pertinent information, such as anticipated completion dates for each project given (so that appropriate personnel can be contacted and information obtained from the particular report).

TABLE 1-3. LISTING OF ONGOING PROJECTS CONCERNED WITH THE QUANTIFICATION OF FUGITIVE EMISSIONS FROM INDUSTRIAL PROCESSES

Project title	Contractor	EPA contract no.	EPA Project Officer or contact	Scheduled completion date or report number
1. Survey of Fugitive Dust from Coal Mines	PEDCo Environmental, Inc.	68-01-4489	E.A. Rachal (Region VIII, Air Planning and Operations Section)	EPA-908/ 1-78-003
2. Coke Quench Tower Emission Testing Program	York Research	68-02-1401 68-01-4138	B. Bloom (OE, DSSE)	9/78
3. Study of Fugitive Emissions in the Iron and Steel Industry	Midwest Research Institute	68-02-2120	R. Hendriks (IERL-RTP, Metallurgical Processes Branch)	EPA-600/ 2-78-050
4. Emissions from Iron Ore Mining, Beneficiation, and Pelletizing	Midwest Research Institute	68-02-2113	N. Plaks (IERL-RTP, Metallurgical Processes Branch)	11/78
5. Dust from Western Coal Strip Mines	Mathematica, Inc.	68-03-2226	E. Bates (IERL-CI, Mining and Extraction Division)	2/79
6. Fugitive Dust from Oil Shale Extraction	TRW	68-03-2560 Task T-5002	E. Bates (IERL-CI, Mining and Extraction Division)	1/79
7. Iron and Steel Plant Open Source Fugitive Emission Evaluation	Midwest Research Institute	68-02-2609 Task 3	R. Hendriks (IERL-RTP, Metallurgical Processes Branch)	9/78
8. Coal Refuse Piles and Slurry Ponds	W. A. Wahler	68-03-2344 68-03-2431	E. Bates (IERL-CI, Mining and Extraction Division)	11/78
9. Coal Mine Transfer Points	Not Determined	Not determined	E. Bates (IERL-CI, Mining and Extraction Division)	Not determined

The numbers preceding the following brief descriptions of these projects correspond with those in Table 1-3.

1. Survey of Fugitive Dust from Coal Mines - The purpose of this study was to quantify the suspended particulate air pollution emissions from surface coal mining in the West. Five such coal mines were sampled, and fugitive emission factors for the following processes were developed:

   - Dragline
   - Haul roads
   - Shovel/truck loading
   - Blasting
     - coal
     - overburden
   - Truck dumping
   - Storage pile

2. Coke Quench Tower Emission Testing Program - This sampling and analysis program will determine the nature and amounts of organic pollutants that are emitted during wet quenching of coke and will identify individual compounds.

3. Study of Fugitive Emissions in the Iron and Steel Industry - This report identifies and quantifies fugitive emissions in the iron and steel and gray iron foundry industries and contains original test data for six open dust sources. Control technologies for fugitive sources are described, and a research program is outlined to develop and demonstrate technology for the most important sources.

4. Emissions from Iron Ore Mining, Beneficiation, and Pelletizing - This project is to accomplish the following: to determine the available data regarding atmospheric emissions from the iron ore mining, beneficiation, and pelletizing industries; to perform limited sampling to help complete the emission data picture; and to make recommendations for future projects in those industries. The pollutants to be measured are particulates, SO_x, NO_x, CO, and hydrocarbons. Particulates will be analyzed for asbestos and metallics.

5. Dust from Western Coal Strip Mines - This project is specifically designed to evaluate the surface mining methods currently employed in the mining of coals in arid and semiarid regions of the West and to evaluate their effect on the environment.

6. Fugitive Dust from Oil Shale Extraction - The objective of this study is to sample fugitive emissions from the following processes at an oil shale extraction site:

   - Crushers
   - Haul roads
   - Mine adits
   - Spent tailings shale transfer

7. Iron and Steel Plant Open Source Fugitive Emission Evaluation - This sampling and analysis project is conducting active field testing of the following open sources at three iron and steel plants:

   - Unpaved roads
   - Paved roads
   - Coal stacking
   - Ore unloading

   It is anticipated that emission factors will be generated from this study.

8. Pollution Control Guidelines for Coal Refuse Disposal Sites and Slurry Ponds - This project involves the investigation of acid and heavy metal ion concentrations in water passing through refuse piles, suspended solids in waters from refuse piles and slurry ponds, noxious gases from oxidation and fires in refuse piles, and airborne particulates from dry exposed refuse surfaces.

9. Coal Mine Transfer Points - This project, which is still in the early planning stage, involves the determination of emissions from coal mine transfer points. The contractor has not yet been selected, and the project schedule and target completion date have not been determined.

REFERENCES FOR SECTION 1

1. PEDCo Environmental, Inc. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. Prepared for Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency. Research Triangle Park, North Carolina. EPA-450/3-77-010. March 1977.

2.0 SUPPORTING ANALYSIS FOR THE PRIORITY LISTING

This section contains the supporting data and analysis used to determine the priority ranking. The emission estimates of the uncontrolled fugitive particulate emission potential of each industry and the origin or derivation of all available fugitive particulate emission estimates are presented in the appropriate subsections.

2.1 IRON AND STEEL PRODUCTION

This section reflects data available at the time this report was prepared. Forthcoming new and revised fugitive emission factors from the American Iron and Steel Institute and EPA Joint Committee on Fugitive Emissions (AISI-EPA Committee) should be available in early 1978. Therefore, emission rates and conclusions contained in this section are not final.

2.1.1 Coke Manufacturing

Emissions - Figure 2-1 depicts the general process flow in the metellurgical coke industry, and Table 2-1 lists the emission sources noted in the process flow diagram. Table 2-2 shows potential uncontrolled fugitive particulate emission totals for the metallurgical coke industry. These rates were calculated using the emission factors from AP-42.[1] As shown, potential fugitive particulate emissions are 131,700 Mg/yr (145,500 tons/yr).

Adequacy of Emission Factor Data - The uncontrolled emission factor for charging metallurgical coke ovens is reported in AP-42 as 0.75 kg/Mg (1.5 lb/ton) coal charged.[1] The early version of the emission factor document reports that this factor

Note: Refer to statement of caution under Section 2.1.

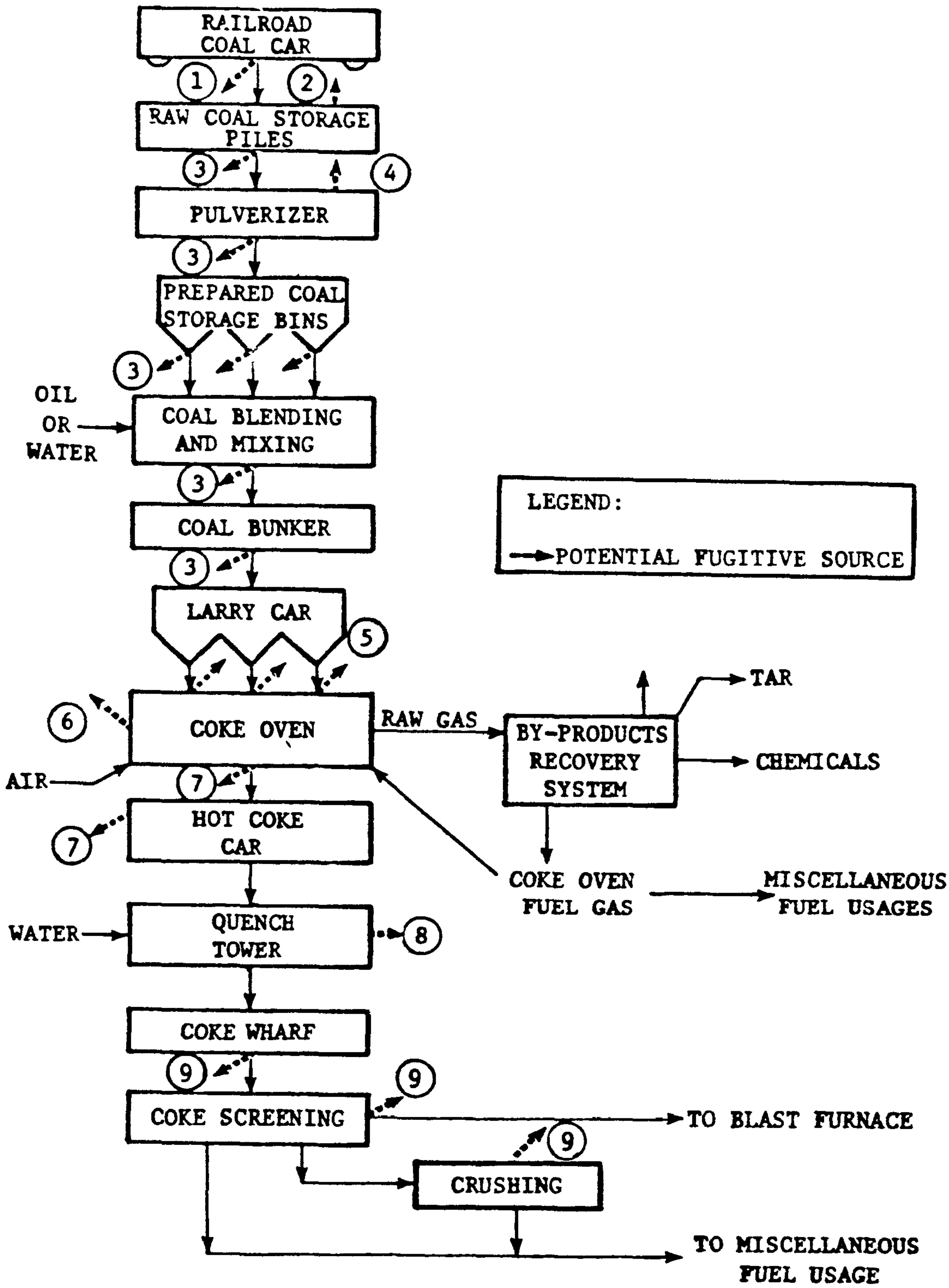

Figure 2-1. Process flow diagram for coke manufacturing showing origin of uncontrolled fugitive industrial process particulate emissions.

Table 2-1. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE COKE MANUFACTURING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Coal unloading	2. Coal storage
3. Coal conveying and transfer	4. Coal pulverizing and screening
5. Coal charging	6. Coking (door leakage)
7. Pushing	8. Quenching
9. Coke handling	

[a] Numeral and letter demotations refer to emission sources on the previous figure.

Table 2-2. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE METALLURGICAL COKE INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a,b]		Coal charged to coke ovens in 1976[c]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Charging	0.75	1.5	85,000	93,800	63,800	70,400
Coking	0.05	0.1	85,000	93,800	4,200	4,700
Pushing	0.3	0.6	85,000	93,800	25,500	28,100
Quenching	0.45	0.9	85,000	93,800	38,200	42,200
Total					131,700	145,400

[a] Emission factors expressed as units per unit weight of coal charged.

[b] Reference 1.

[c] Iron and steel industry coke production was reported as 55.2×10^6 Mg (60.9×10^6 tons) in 1976 (Reference 2). Assuming 1.54 units of coal are required to produce 1.0 unit of coke (Reference 3), 85×10^6 Mg (93.8×10^6 tons) coal were charged to c[illegible] ovens in 1976.

Note: Refer to statement of caution under Section 2.1.

was selected from a range of 0.055 to 2.15 kg/Mg (0.11 to 4.3 lb/ton) coal charged and was based on United Nations (U.N.) and unpublished data.[4] The AISI-EPA, committee is considering a charging emission factor of 0.5 kg/Mg (1.0 lb/ton) coal charged based on a range of 0.04 to 1.15 kg/Mg (0.08 to 2.3 lb/ton) coal charged (from AISI and U.N. data).[5] Two other references have reported the U.N. data lists the range as 0.045 to 1.38 kg/Mg (0.09 to 2.76 lb/ton) coal charged.[6,7] Because the U.N. report was prepared in 1968 and changes and improvements in charging techniques have occurred since then, additional test data are needed to update this factor.

Uncontrolled emissions from the coking cycle are reported in AP-42 (based on U.N. data) as 0.05 kg/Mg (0.1 lb/ton) coal charged.[1] The AISI-EPA committee is also considering this factor on the basis of a range of 0.013 to 0.15 kg/Mg (0.026 to 0.3 lb/ton) coal charged (from U.N. and AISI data confirmed by EPA).[5] Some additional data may be found in Reference 8.

Table 2-3 shows pushing emission factors based on the degree of greenness and control level. In addition, a general emission factor contained in AP-42 is 0.3 kg/Mg (0.6 lb/ton) coal charged.[1] This was based on a range of 0.07 to 0.68 kg/Mg (0.14 to 1.37 lb/ton) coal charged from the U.N. data.[4] In addition, a factor of 0.25 kg/Mg (0.5 lb/ton) is being considered by the AISI-EPA joint committee.[5] This was based on a range of 0.13 to 0.35 kg/Mg (0.26 to 0.70 lb/ton) coal charged.[17]

Quenching emissions are reported in AP-42 a 0.45 kg/Mg (0.9 lb/ton) coal charged.[1] This value is based on a range of 0.25 to 0.7 kg/Mg (0.5 to 1.4 lb/ton) coal charged reported in the U.N. data.[4] The AISI-EPA committee is considering an emission factor of 0.25 + 0.00028 TDS kg/Mg (0.5 + 0.00056 TDS lb/ton) coal charged where TDS (total dissolved solids) is in ppm.[5] Tests show that TDS range from 5 to 12,000 ppm on dirty water with 5,000 ppm typical.[5] Additional information shows that in quench towers with baffles, quenching with clean water generates 0.6

Note: Refer to statement of caution under Section 2.1.

Table 2-3. PUSHING EMISSION FACTORS

[kg/Mg (lb/ton) coal charged]

Degree of greenness	Shed[a]	Travelling hood[b]	Direct, uncaptured plume[b]
Green coke	0.32[c] - 0.5[d] (0.65 - 1.0)	1.0[d] - 1.8[e] (2.1 - 3.5)	1.5 - 2.0[f] (3 - 4)
Moderately green	0.28[c] (0.57)	1.65[e] (2.3)	1.0[f] (2.1)
Cleanly pushed coke	0.17[g,h] (0.35)	0.75[e] (1.5)	0.19[i] - 0.26[f] (0.38 - 0.52)

[a] Includes most of travel emissions.

[b] Does not include travel emissions.

[c] Reference 9 and 10. Testing and analysis by Clayton Environmental Consultants, 1975 and 1976.

[d] Reference 11. Data reported by Bethlehem Steel Corporation, 1975.

[e] Reference 12. Testing of Ford/Koppers smokeless coke pushing system by Clayton Environmental Consultants, Inc., 1976.

[f] Reference 13. Based on emission measurements as reported by Robert Jacko, 1976.

[g] Reference 14. Data reported by Great Lakes Carbon Corp., 1975.

[h] Reference 15. Test results reported by U.S. Steel Corp., 1975.

[i] Reference 16. Testing of CF&I Steel Corporation coke plant by York Research, 1976.

Note: Refer to statement of caution under Section 2.1.

kg/Mg (1.2 lb/ton) coke produced, and quenching with highly contaminated water generates 1.0 to 3.0 kg/Mg (2.0 to 6.0 lb/ton) coke produced.[18]

Note: Refer to statement of caution under Section 2.1.

REFERENCES FOR SECTION 2.1.1

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12. Emission Testing and Evaluation of Ford/Koppers Smokeless Coke Pushing System. Prepared by Clayton Environmental Consultants, Inc., for the U.S. Environmental Protection Agency, Contract No. 68-02-0630, Volume I, Table 8.0-1 (May 5, 1976).

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15. U.S. Steel Corp. Clairton Works. Emission Tests of Shed on Number 17 Coke Oven Battery. 1975.

16. Measurement of Coke Pushing Particulate Emissions at CF&I Steel Corporation Coke Plant. Prepared by York Research for CF&I Steel Corporation, Report No. 7-9167. October 4, 1976.

17. An Investigation of the Best Systems of Emission Reductions for Pushing Operation on By-product Coke Ovens. Emission Standards and Engineering Division, U.S. Environmental Protection Agency. Research Triangle Park, N.C. July 1976.

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2.1.2 Iron Production

Emissions - Figure 2-2 depicts the general process flow in the iron production industry, and Table 2-4 lists the emission sources noted in the process flow diagram. Table 2-5, which presents the estimated potential uncontrolled fugitive particulate emissions from the iron production industry, shows that the potential fugitive emissions from sintering (discharge and cooler) and blast furnace (upsets and tapping) are 99,450 Mg/yr (110,070 tons/yr).

Adequacy of Emission Factor Data - Fugitive particulate emissions from sinter strand windbox leakage were considered to be negligible by the AISI-EPA committee.[3] This appraisal was confirmed by Midwest Research Institute (MRI) estimates.[1]

The fugitive particulate emission factor for the sinter strand discharge and breaker considered by the AISI-EPA committee is 0.35 kg/Mg (0.7 lb/ton) sinter produced.[1] This is based on an assumption of 10 percent of the uncontrolled discharge and breaker emissions measured and reported by AISI.[1,4] Another estimate, 0.55 kg/Mg (1.1 lb/ton) sinter produced, made by MRI, is based on 5 percent of an uncontrolled discharge emission estimate of 11.2 kg/Mg (22.4 lb/ton) reported by Schuenemoh.[1,5]

One of the particulate emission factors for sinter cooling is reported as 1.5 kg/Mg (3.0 lb/ton) sinter produced.[1] The method by which this factor was developed is unknown. The other sinter cooler emission factor is 8.4 kg/Mg (16.8 lb/ton) sinter produced.[1] This factor was developed from measurements of uncontrolled emissions in England.[6]

The AISI-EPA committee is considering an emission factor of 0.01 kg/Mg (0.021 lb/ton) iron produced for blast furnace slips, based on a range of 0.0019 to 0.019 kg/Mg (0.0038 to 0.038 lb/ton) in a Battelle report to EPA.[3] Blast furnace tapping

Note: Refer to statement of caution under Section 2.1.

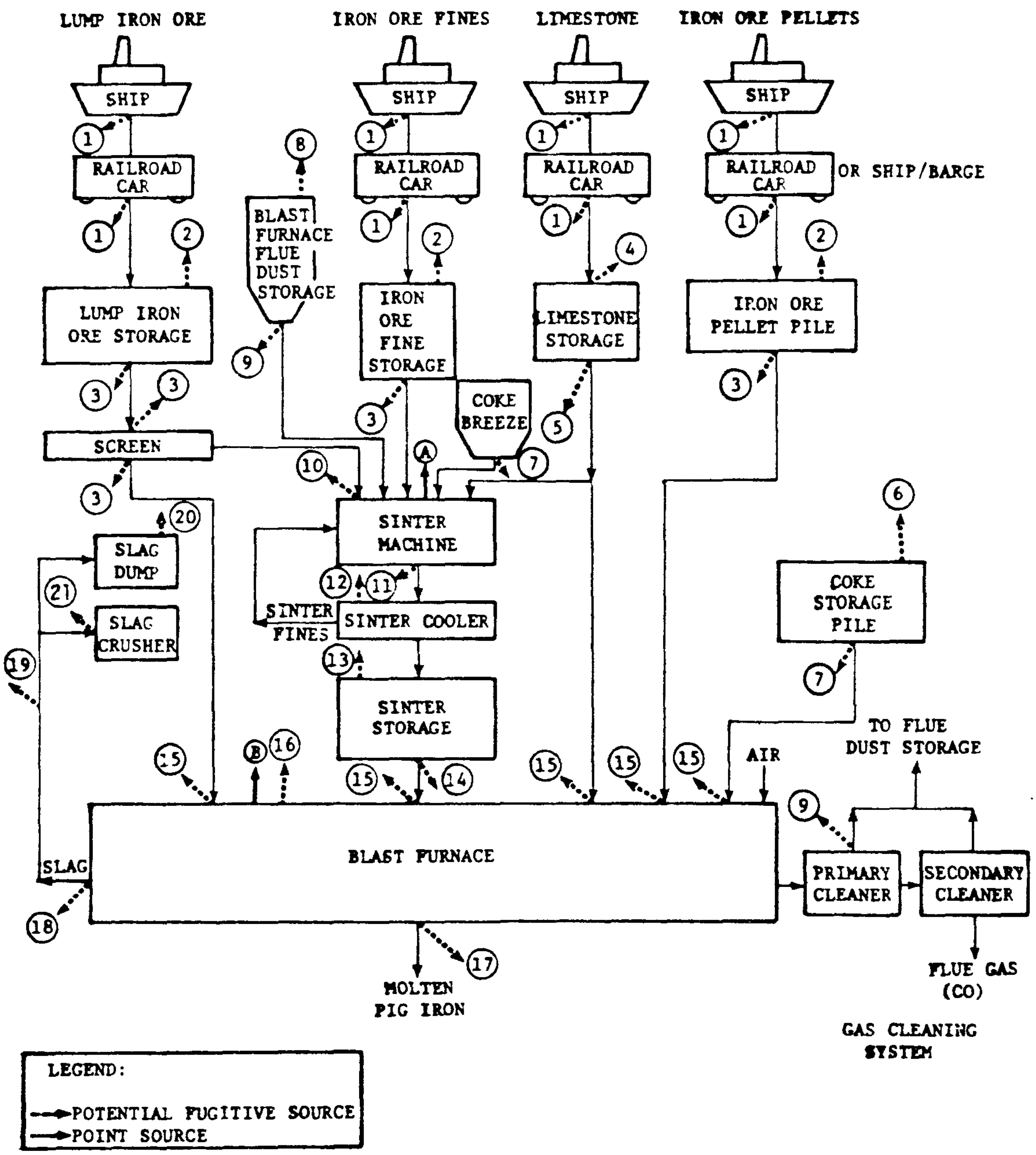

Figure 2-2. Process flow diagram for iron production showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-4. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE IRON PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Ship or railroad car unloading	2. Iron ore storage
3. Iron ore handling and transfer	4. Limestone storage
5. Limestone handling and transfer	6. Coke storage
7. Coke handling and transfer	8. Blast furnace flue dust storage
9. Blast furnace flue dust handling and transfer	10. Sinter machine windbox discharge
11. Sinter machine discharge and screens	12. Sinter cooler
13. Sinter storage	14. Sinter handling and transfer
15. Blast furnace charging	16. Blast furnace upsets (slips)
17. Blast furnace tapping - iron	18. Blast furnace tapping - slag
19. Slag handling	20. Slag storage
21. Slag crushing	
Point sources	
A. Sintering	B. Blast furnace

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-5. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE IRON PRODUCTION INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor		1976 U.S. iron production throughput		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Sintering						
Discharge	0.35[a]	0.7[a]	36,300[c]	40,000[c]	12,700	14,000
Cooler	1.5[a]	3.0[a]	36,300[c]	40,000[c]	54,400	60,000
Blast furnace						
Upsets (slips)	0.01[b]	0.021[b]	75,200[d]	82,900[d]	750	870
Tapping (cast house)	0.42[b]	0.85[b]	75,200[d]	82,900[d]	31,600	35,200
Total					99,450	110,070

[a] Recommended best available emission factor, Reference 1. Emissions per unit of sinter produced.

[b] Reference 2. Average of the range of given valves. Emissions per unit of iron produced.

[c] Amount of sinter produced. Reference 1.

[d] Amount of hot metal (iron) produced. Reference 1.

Note: Refer to statement of caution under Section 2.1.

emissions are emitted through the cast house roof monitor. A factor of 0.15 kg/Mg (0.3 lb/ton) iron produced has been reported by AISI test data and confirmed by EPA.[3] Additional test data show an emission range of 0.39 to 0.46 kg/Mg (0.78 to 0.92 lb/ton) iron produced from the blast furnace cast house.[7]

Note: Refer to statement of caution under Section 2.1.

REFERENCES FOR SECTION 2.1.2

1. A Study of Fugitive Emissions from Metallurgical Processes. Midwest Research Institute. Prepared for Industrial Environmental Research Laboratory, Environmental Protection Agency, Research Triangle Park under Contract No. 68-02-2120. Draft final report. August 25, 1977.

2. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Prepared for Office of Air Quality Planning and Standards, Environmental Protection Agency, Research Triangle Park, North Carolina. Publication No. EPA-450/3-77-010. March 1977.

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2.1.3 Steel Production

Emissions - Figure 2-3 depicts the general process flow in the steel production industry, and Table 2-6 lists the emission sources noted in the process flow diagram. Table 2-7, which presents estimated potential total uncontrolled fugitive particulate emissions from steel production, shows the total uncontrolled fugitive potential to be 61,520 Mg/yr (68,250 tons/yr).

Adequacy of Emission Factor Data - An estimate of 0.12 kg/Mg (0.25 lb/ton) hot metal has been made for the particulate emissions from hot metal (iron) reladling (i.e., transfer)[3]; however, no testing was done in the development of this factor.[1] Another estimate for emissions from hot metal transfer indicated 0.028 kg/Mg (0.056 lb/ton) steel.[1] This represents an average of eight measurements taken at one plant by AISI, and the method of sampling was not reported. Midwest Research Institute obtained an estimate of 0.08 kg/Mg (0.16 lb/ton) steel from an industrial source (sampling methodology unknown).[1,4] MRI also reports an estimate by B. Bloom (no testing involved) of 0.1 kg/Mg (0.2 lb/ton) steel.[1]

Fugitive particulate emissions from basic oxygen furnace (BOF) charging and tapping has been estimated at 0.15 to 0.2 kg/Mg (0.3 to 0.4 lb/ton) hot metal poured and 0.075 to 0.1 kg/Mg (0.15 to 0.2 lb/ton) steel produced, respectively.[3] The method by which these factors were developed is unknown. AISI has reported an average of 15 measurements at one plant (test method unspecified) for both charging and tapping to be 0.07 kg/Mg (0.14 lb/ton) steel and 0.14 kg/Mg (0.29 lb/ton) steel, respectively.[1]

The AISI-EPA committee is considering a particulate emission factor of 0.25 kg/Mg (0.5 lb/ton) steel produced for fugitive emissions from the BOF building monitor.[5] This was based on AISI data submitted to EPA. Another factor of unknown derivation is 0.6 kg/Mg (1.2 lb/ton) steel produced for emissions from the BOF building monitor.[6] An AISI average of six measurements at different plants (test methods unspecified) for total BOF fugitive

Note: Refer to statement of caution under Section 2.1.

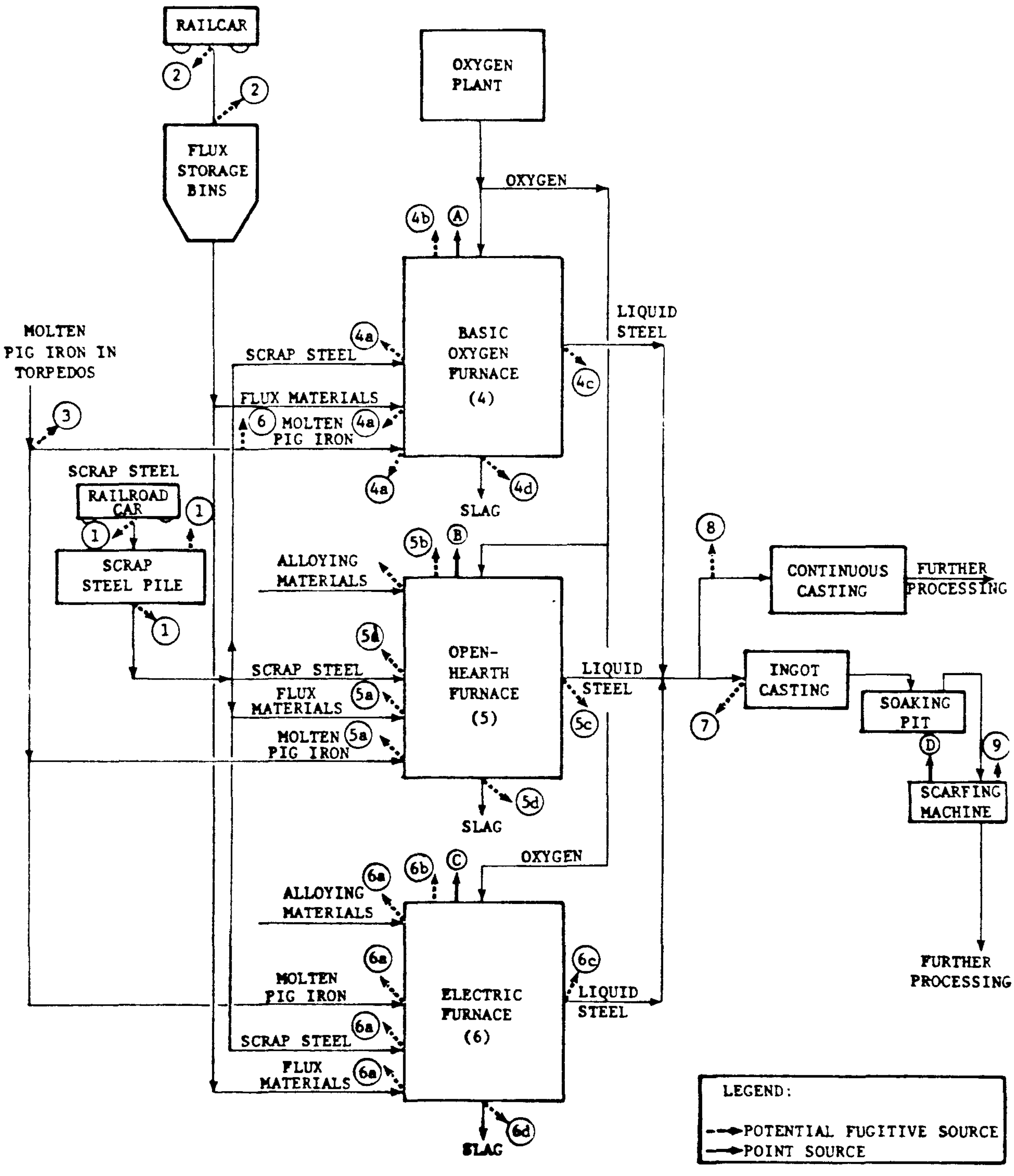

Figure 2-3. Process flow diagram for steel production showing origin of fugitive industrial process and point source particulate emissions.

Table 2-6. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE STEEL PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Scrap steel unloading, transfer and storage	2. Flux material unloading, transfer, and storage
3. Molten pig iron transfer from torpedos to charge ladles (hot metal reladling)	4. Basic oxygen furnace 4a. Charging 4b. Leakage 4c. Tapping-steel 4d. Tapping-slag
5. Open hearth furnace 5a. Charging 5b. Leakage 5c. Tapping-steel 5d. Tapping-slag	6. Electric arc furnace 6a. Charging 6b. Leakage 6c. Tapping-steel 6d. Tapping-slag
7. Ingot casting	8. Molten steel reladling
9. Scarfing	
Point sources	
A. Basic oxygen furnace	B. Open hearth furnace
C. Electric arc furnace	D. Scarfing

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-7. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE STEEL INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a]		1976 steel production[d]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Hot metal transfer	0.1[b]	0.2[b]	75,200	82,900	7,500	8,300
Basic oxygen furnace	0.24[b]	0.49[b]	72,500	79,900	17,400	19,600
Open hearth furnace	0.084[b]	0.168[b]	21,300	23,500	1.800	2,000
Electric arc furnace						
alloy	0.725[b]	1.45[b]	5,400	5,900	3,900	4,300
carbon	1.85[b]	3.7[b]	15,400	17,000	28,500	31,400
Steel reladling or casting	0.037[c]	0.074[c]	57,300[e]	63,200[e]	2,100	2,300
Scarfing	0.0055[c]	0.011[c]	57,300[e]	63,200[e]	320	350
Total					61,520	68,250

[a] Emission factors per unit weight of metal or steel processed or produced.

[b] Best uncontrolled fugitive particulate emission factor as reported by Reference 1.

[c] Reference 2. An average of any range presented in that document was used.

[d] Production data from Reference 1, except as noted.

[e] Estimated assuming 50 percent of the steel produced is reladled or cast in ingots and 50 percent undergoes scarfing.

Note: Refer to statement of caution under Section 2.1.

emissions is 0.16 kg/Mg (0.32 lb/ton) steel produced.[1] MRI reported an estimate by B. Bloom for BOF fugitive emissions of 0.5 kg/Mg (1.0 lb/ton) steel produced.[1] MRI also reported a total BOF fugitive emission range of 0.21 to 0.44 kg/Mg (0.42 to 0.88 lb/ton) steel produced based on detailed skylight (monitor) measurements in Sweden.[1,7] These BOF's have primary hoods but it is not clear if they were the open or closed type.[1] Test data for roof monitors in Sweden above the Kaldo process resulted in an emission factor of 0.5 to 0.8 kg/Mg (1.0 to 1.6 lb/ton) steel produced.[1,7] For both Swedish test series, the methodology was not reported. Another relationship representing BOF fugitive emissions has been developed based on multiple test data. This relationship is E, kg/Mg = $0.545e^{0.00915P}$, where P = BOF capacity, Mg (E, lb/ton = $1.09e^{0.0083P}$, where P = BOF capacity, tons).[8]

The AISI-EPA committee is considering an emission factor of 0.14 kg/Mg (0.29 lb/ton) steel produced for fugitive particulate emission from open hearth furnaces.[5] This is based on AISI data and confirmed by EPA. MRI reported a value of 0.084 kg/Mg (0.168 lb/ton) steel produced based on AISI measurements in the roof monitor at one plant.[1] This is an average emission factor for the entire cycle of one furnace. The device used to measure the concentration is unknown, but the flow rate was attained by velocity measurements through given areas of the roof monitor. MRI cited a value of 0.055 kg/Mg (0.11 lb/ton) steel produced, as reported by an Ontario, Canada, control agency.[1] The method by which this factor was obtained is unknown. MRI also reported a value of 0.44 kg/Mg (0.87 lb/ton) steel produced, an estimate based on 5 percent of the AP-42 uncontrolled stack (primary) emission factor, assuming oxygen lancing.[1] Measured roof monitor values in Sweden for open hearth furnaces with primary controls were reported as 0.23 to 0.3 kg/Mg (0.46 to 0.6 lb/ton) steel produced.[1] The measurement techniques were not reported.

Note: Refer to statement of caution under Section 2.1.

Total fugitive particulate emissions from an alloy steel electric arc furnace were measured by AISI as 0.725 kg/Mg (1.45 lb/ton) steel produced.[1] The measurement technique was not reported. G. McCutchen estimated that fugitive emissions equal 10 percent of the uncontrolled total emission rate reported in the electric arc furnace background document.[1,9] This resulted in an emission rate of 0.75 kg/Mg (1.5 lb/ton) steel produced for alloy steel and 1.5 kg/Mg (3.0 lb/ton) steel produced for carbon steel.[1] Measurements of the canopy hood catch resulted in uncontrolled fugitive emission estimates of 0.45 to 0.75 kg/Mg (0.9 to 1.5 lb/ton) steel produced.[1] The method used to measure and develop these factors was not presented. Measurement of a direct shell evacuation system resulted in a fugitive emission factor of 1.8 kg/Mg (3.7 lb/ton) steel produced.[1] Full explanation of the development of the emission factor was not available. In addition, several measurements of roof monitor emissions were made for electric arc furnaces in Sweden, but the measurement techniques were not explained. These measurements were 0.25 to 0.5 kg/Mg (0.5 to 1.0 lb/ton) steel produced for furnaces with direct shell evacuation and canopy hoods; 0.55 to 1.8 kg/Mg (1.1 to 3.7 lb/ton) steel produced for furnaces with direct shell evacuation only; 0.45 kg/Mg (0.9 lb/ton) steel produced for furnaces with only a canopy hood; and 14 to 16 kg/Mg (28 to 32 lb/ton) for furnaces with no primary or secondary controls.[1,7]

An emission factor for molten steel reladling or ingot casting was estimated at 0.014 to 0.06 kg/Mg (0.028 to 0.12 lb/ton) steel.[2] This factor was estimated by assuming 50 percent of the hot metal transfer emission factor range, because of the lower carbon content of steel.[2]

The AISI-EPA committee is considering an emission factor of 0.0055 kg/Mg (0.011 lb/ton) steel processed for machine scarfing.[5] This factor is based on 10 percent of the uncontrolled emissions reported by AISI.[1,5] A factor of 0.0025 kg/Mg (0.005

Note: Refer to statement of caution under Section 2.1.

lb/ton) steel processed was estimated based on 5 percent of an average of nine tests of uncontrolled emissions.[1] The tests were conducted by AISI. The measurement method is unknown in most cases.[1] An estimate of 0.025 kg/Mg (0.05 lb/ton) steel processed was made by G. McCutchen, based on 5 percent of the AP-42 stack emissions.[1] An estimate of 0.055 kg/Mg (0.11 lb/ton) steel processed for hand scarfing is based on an average of eight tests performed on uncontrolled ducted emissions from machine scarfers.[1]

Note: Refer to statement of caution under Section 2.1.

REFERENCES FOR SECTION 2.1.3

1. A Study of Fugitive Emissions from Metallurgical Processes. Midwest Research Institute. Prepared for Industrial Environmental Research Laboratory. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Under Contract No. 68-02-2120. Draft final. August 25, 1977.

2. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Prepared for Office of Air Quality Planning and Standards. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication No. EPA-450/3-77-010. March 1977.

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5. Iversen, R. Personal Communication. U.S. Environmental Protection Agency, Office of Air Programs. Research Triangle Park, North Carolina. December 3, 1976.

6. Notes prepared by G. McCutchen. U.S. Environmental Protection Agency, Office of Air Quality Planning Standards. Research Triangle Park, North Carolina. February 1976.

7. Midwest Research Institute. Particulate Pollutant System Study, Volume III: Handbook of Emission Properties, 1971. p. 163.

8. Mattis, R.P. An Evaluation of Charging and Tapping Emission for the Basic Oxygen Process. U.S. Environmental Protection Agency. (Presented at 68th Annual Meeting of the Air Pollution Control Association. Boston, Massachusetts. June 15-20, 1975. Publication No. 75-15.1).

9. Background Information of Standards of Performance: Electric Arc Furnaces in the Steel Industry. Volume 1: Proposed Standards. Emission Standards and Engineering Division. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. Publication No. EPA-450/2-74-017a. October 1974.

2.2 PRIMARY NON-FERROUS SMELTING INDUSTRY

2.2.1 Primary Aluminum Production

Emissions - Figure 2-4 depicts the general process flow in the primary aluminum production industry, and Table 2-8 lists the emission sources noted in the process flow diagram. Fugitive emission rates for bauxite grinding, material handling, and anode baking have been reported in AP-42.[1] Fugitive emission rates from prebake, horizontal-stud Soderberg (HSS), and vertical-stud Soderberg (VSS) electrolytic reduction cells have been estimated based on response to industry questionnaires.[2] Table 2-9, which presents uncontrolled fugitive emission estimates for the primary aluminum industry, shows the potential fugitive particulate emissions to be 52,470 Mg/yr (57,890 tons/yr).

Adequacy of Emission Factor Data - The uncontrolled particulate emission factors for bauxite grinding [3.0 kg/Mg bauxite processed (6.0 lb/ton)] and materials handling [5.0 kg/Mg aluminum produced (10.0 lb/ton)] are contained in AP-42.[1,3] The bauxite grinding emission factor was developed by assuming it to be equivalent to the emission factor for pulverizing phosphate rock for the manufacture of wet-process phosphoric acid.[3] The materials handling emission factor was assumed to be the same as the materials handling emission factor in the copper industry.[3] Hence, although these emission factors are included in AP-42, additional sampling would be helpful to substantiate them.

The uncontrolled anode baking furnace particulate emission factor of [1.5 kg/Mg (3.0 lb/ton) aluminum produced] is also from AP-42.[1,2] This value, however, is based on a very limited amount of testing and was supplied by a multiplant aluminum producer.[2] Again, additional testing would improve the reliability of the factor.

The uncontrolled emission factors in AP-42 for the electrolytic reduction cells (prebaked, HSS, and VSS) include both primary and fugitive emissions.[1,2] Table 2-10 presents the data used to develop the AP-42 factors. The main data source was "Air Pollution Control in the Primary Aluminum Industry."[2] The

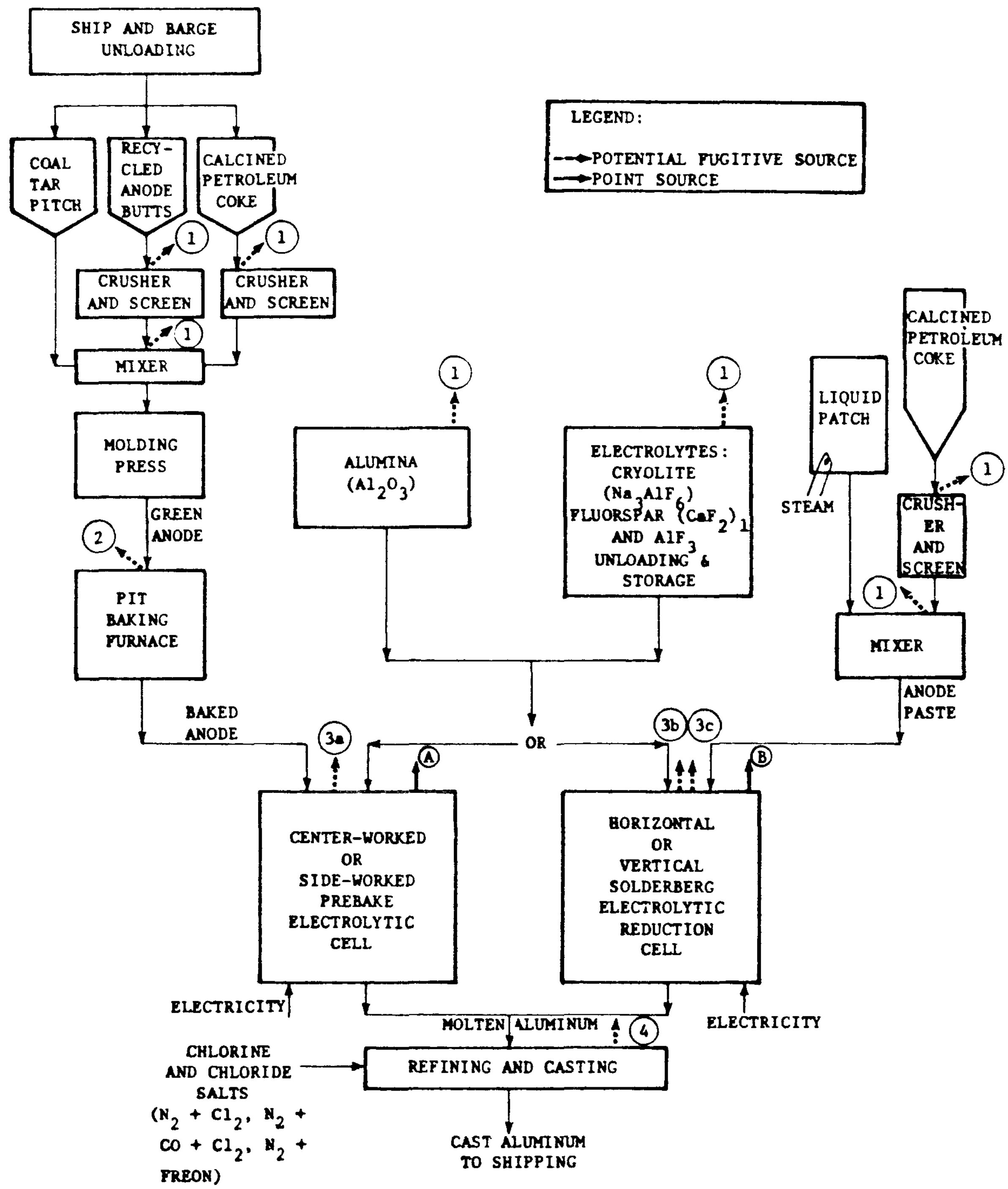

Figure 2-4. Process flow diagram for primary aluminum production showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-8. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE PRIMARY ALUMINUM PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Material handling 2. Electrolytic reduction cell 3a. Prebaked 3b. VSS Soderberg 3c. HSS Soderberg	2. Anode baking 4. Refining
Point sources	
A. Prebake electrolytic reduction cell	B. Horizontal or vertical stud Soderberg electrolytic reduction cell

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-9. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE PRIMARY ALUMINUM INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a]		U.S. primary aluminum throughput		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Bauxite grinding	3.0[b]	6.0[b]	1,770[d]	1,950[d]	5,310	5,850
Materials handling	5.0[b]	10.0[b]	3,800[e]	4,200[e]	19,000	21,000
Anode baking furnace	1.5[b]	3.0[b]	2,360[f]	2,600[f]	3,540	3,900
Reduction cells						
Prebake	4.0[c]	8.0[c]	2,360[f]	2,600[f]	9,440	10,400
HSS	10.1[c]	20.2[c]	970[g]	1,070[g]	9,800	10,800
VSS	11.2[c]	22.4[c]	480[h]	530[h]	5,380	5,940
Total					52,470	57,890

[a] Bauxite grinding expressed as kg/Mg (lb/ton) of bauxite processed. All other factors in terms of Mg (tons) of molten aluminum produced.

[b] Reference 1.

[c] Reference 2.

[d] In 1970, 11,800,000 Mg (13,000,000 tons) of bauxite were processed. Of this approximately 85 percent was ground overseas before shipment to the U.S.

[e] The remainder equals 1,770,000 Mg (1,950,000 tons). Reference 3 1976 estimated aluminum production (Reference 4).

[f] Approximately 61.9 percent of the aluminum produced is by prebake cells. Reference 1.

[g] Approximately 25.5 percent of the aluminum produced is by HSS cells. Reference 1.

[h] Approximately 12.6 percent of the aluminum produced is by VSS cells. Reference 1.

Table 2-10. UNCONTROLLED PARTICULATE EMISSIONS FROM PRIMARY ALUMINUM REDUCTION CELLS

Cell type	Emission source	Uncontrolled AP-42[a]		Particulate emission air pollution in the primary aluminum industry[b]		Factors source test[c]	
		kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Prebake	Total	40.65	81.3	47.2	94.4	5.95	11.9
	Primary			43.8	87.6		
	Fugitive			4.0	8.0		
HSS	Total	49.2	98.4	49.2	98.4		
	Primary			39.1	78.2		
	Fugitive			10.1	20.2		
VSS	Total	39.2	78.4	39.2	78.4		
	Primary			22.0	44.0		
	Fugitive			11.2	22.4		

[a] Reference 1.

[b] Reference 2.

[c] Reference 5.

emission factors in this reference were derived from responses to a questionnaire sent to the industry. It is not known how the industry determined the emission rates reported on the questionnaires.

The AP-42 uncontrolled particulate emission factor for the prebake cells is a weighted average of the factors presented in References 2 and 5. The prebake factors in Reference 2 for total, primary, and fugitive emissions represent a response from 60, 83, and 65 percent respectively, of the prebake production. Because of this difference in data bases, the primary and fugitive factors do not equal the total emission rate. Also, since it is not known if the test data from Reference 5 separate the primary and fugitive emissions, the AP-42 total uncontrolled emission factor cannot be readily separated into primary and fugitive emission rates.

The AP-42 HSS uncontrolled particulate emission factor was taken directly from Reference 2. The factors in Reference 2 are based on questionnaire responses representing 93 percent of the HSS production. For this cell type, the sum of the primary and fugitive factors equal the total emission rate; therefore the AP-42 uncontrolled particulate factor could be easily separated into primary and fugitive emission rates.

The AP-42 VSS uncontrolled particulate emission factor was also taken directly from Reference 2. The VSS factors in Reference 2 are based on less than three questionnaire responses, and it is not known what percentage of the VSS production they represent. As in the case of the data for the prebake cells, the primary and fugitive emission rates do not equal the total emission rate. Therefore, the AP-42 total uncontrolled particulate emission rate cannot be readily separated into primary and fugitive emission rates.

The controlled potline emission rates in AP-42 were calculated by applying the percent control efficiency to the total uncontrolled emission rate. Hence the controlled emission factors appear to be those emissions that result from passing the total (primary and fugitive) emissions through the control device.

REFERENCES FOR SECTION 2.2.1

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2. Air Pollution Control in the Primary Aluminum Industry, Volume I. Prepared by Singmaster & Breyer, New York, New York for U.S. Environmental Protection Agency. Publication No. EPA-450/3-73-004. July 1973.

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2.2.2 Primary Copper Smelters

Emissions - Figure 2-5 depicts the general process flow for primary copper smelting and Table 2-11 lists the emission sources noted in the process flow diagram. Table 2-12 presents the 1976 estimated fugitive particulate emissions from primary copper smelting for the four principal process operations: roasting, smelting, converting, and refining. This table also presents U.S. domestic mine production of refined copper, from which an estimated 19,977 Mg (22,024 tons) of particulates was generated.

Principal operations contributing fugitive particulates (and taken into consideration in the fugitive emission factors) include unit charging, leaking, tapping, and materials handling. All fugitive emission factors listed in Table 2-12 have been obtained from the document entitled "Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions"[2] whereby an arithmetic average was normally made of any factor presented as a range.

Adequacy of Emission Factor Data - The only factor available to estimate fugitive roaster emissions is 11.50 kg (23 lb) particulates per Mg (ton) of primary copper produced.[3] The factor was developed by material balance, using the same percentage (of the total dust generated) that was used in estimating sulfur dioxide fugitive emissions (13.6%). Actual fugitive particulate test data are not available. This factor should be given a low reliability rating, insufficient to be considered for AP-42 without further test support verification.

An emission range of 4.15 to 4.35 kg (8.3 to 8.7 lb) particulates per Mg (ton) of copper produced[4] was established to quantify reverberatory furnace charging, leakage, tapping, and slag tapping emissions. The lower rate represents smelters that use roasting to preheat the ore prior to smelter furnace charging; the higher rate represents smelters that do not use roasting.[16] Both are based on measurements reported by Kennecott Copper Corporation, and it is not known if they were determined by actual test or by material balance. Kennecott also reported a

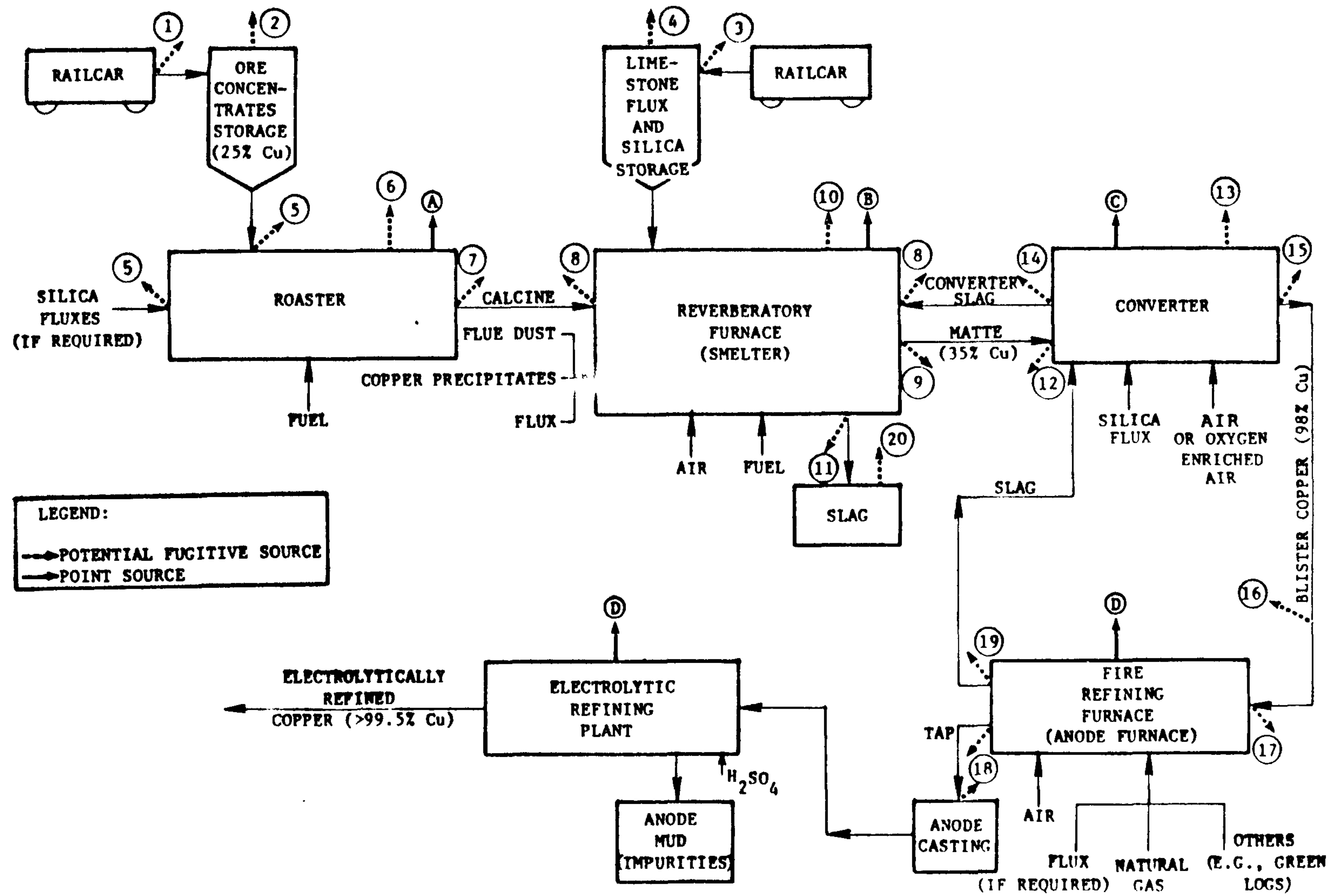

Figure 2-5. Process flow diagram for primary copper smelting showing origins of fugitive industrial process and point source emissions.

Table 2-11. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE PRIMARY COPPER SMELTING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Unloading and handling of ore concentrate	2. Ore concentrate storage
3. Limestone flux unloading and handling	4. Limestone flux storage
5. Roaster charging	6. Roaster leakage
7. Calcine transfer	8. Charging reverberatory furnace
9. Tapping of reverberatory	10. Reverberatory furnace leakage
11. Slag tapping	12. Converter charging
13. Converter leakage	14. Slag tapping from converter
15. Blister copper tapping	16. Blister copper transfer
17. Charging blister copper to fire refining furnace	18. Copper tapping and casting
19. Slag tapping and handling	
Point sources	
A. Roaster	B. Reverberatory furnace
C. Converter	D. Refining

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-12. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE PRIMARY COPPER SMELTING INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a]		1976 U.S. primary copper production[1]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Roasting	11.50	23.00	567[b]	625[b]	6,517	7,185
Reverberatory smelting furnace	4.25	8.50	1,288	1,420	5,474	6,035
Converter	5.25	10.50	1,288	1,420	6,762	7,455
Fire refining furnace (anode furnace and casting)	0.95	1.90	1,288	1,420	1,224	1,349
Total					19,977	22,024

[a] Factors were obtained from Reference 3, and are expressed in units per end product copper produced.

[b] Estimated on the assumption that 44 percent of industry uses roaster processing. Reference 2

factor of 1.26 kg/Mg (2.52 lb/ton) of copper produced for estimating fugitive emissions from fire-refining (anode) furnace tapping and anode casting.[16] Again, the measurement methodology was not revealed. These factors are not believed to be adequate for input to AP-42 at this time; however, if the test methods and extent of testing can be verified, they may be considered acceptable for AP-42 (with a low rating).

Phelps Dodge Corporation reports that baghouses installed to capture particulates generated during the anode furnace cycle collect anywhere from 0.45 to 0.68 kg/Mg (1 to 1.5 lb/ton) of copper cast.[5] Inspectors from the New York City Air Resources Department observed an emission rate (on a day basis) of about 0.57 kg/Mg (1.25 lb/ton) of copper cast during tests conducted at a specific Phelps Dodge facility in 1975.[5] These factors must be validated and clarified before being included in AP-42. Clarification is needed regarding method and extent of testing and the specific operations included in these emission factors. Additional data are also needed to substantiate these values.

The results of a 1-day test by the American Smelting and Refining Company (ASARCO) of emissions from the anode furnaces at their Tacoma copper smelter showed a particulate generation of 1.27 kg/Mg (2.8 lb/ton) of copper input.[6] Here again, extensive information regarding how this measurement was derived is lacking, and additional test results are necessary to support this value. In addition, the Tacoma copper smelter is a custom-designed facility and, for the most part, is not truly representative for emission factor characterization.

An emission range of 1.6 to 8.85 kg (3.3 to 17.7 lb) particulates per Mg (ton) of copper produced has been established to quantify particulate emissions generated by converter charging, leaking, tapping, slag tapping, and blister copper transfer.[6,7] The lower rate, based on engineering judgment, represents an estimate of the fugitive emisisons generated by converter operations at ASARCO's Tacoma copper smelter.[6] The higher rate is based upon measurements reported by Kennecott Copper Corporation, but the method of determination has not been clearly revealed.[7] Neither is felt to be adequate for incorporation into AP-42 without being justified by further testing.

REFERENCES FOR SECTION 2.2.2

1. Schroeder, H.J. Copper - 1977. In: Mineral Commodity Profiles (MCP-3). Pittsburgh, Pennsylvania. Bureau of Mines. June 1977. 19 p.

2. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task Number 33. Environmental Protection Agency. March 1977.

3. Shannon, L.J. and P.G. Gorman. Particulate Pollutant System Study, Vol. III - Emissions Characteristics. Midwest Research Institute. Prepared for U.S. Environmental Protection Agency. Contract No. 22-69-104.

4. Personal communication from R.J. Heaney (Kennecott Copper Smelters) to R.D. Rovang. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. November 22, 1974.

5. Personal Communication from Phelps Dodge Corp., New York, New York, to Don Goodwin, U.S. Environmental Protection Agency, Emission Standards and Engineering Division, Research Triangle Park, North Carolina. January 21, 1977.

6. Evaluation of Sulfur Dioxide and Arsenic Control Techniques for ASARCO - Tacoma Copper Smelter. PEDCo Environmental, Inc. Contract No. 68-02-1321, Task Order No. 35. Cincinnati, Ohio. July 1976.

7. Evaluation of the Controllability of Copper Smelters in the United States, Fugitive Emissions Section, Final Report Draft. Pacific Environmental Services, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1354, Task Order No. 8. November 1974.

2.2.3 Primary Lead Smelters

Emissions - Figure 2-6 depicts the general process flow for primary lead smelting, and Table 2-13 lists the emission sources noted in the process flow diagram. Table 2-14 presents estimated fugitive particulate emissions from the principal process operations in primary lead smelting. Based on estimated 1976 domestic primary lead production of 612,000 Mg (675,000 tons)[2] and a ratio of 2 unit weights of concentrated ore to 1 unit weight of lead metal,[6] approximately 1,225,000 Mg (1,350,000 tons) is the assumed quantity of concentrated ore (sintered material) on which sintering emissions are based. Hence, total annual particulate fugitive emissions generated are determined to be 11,742 Mg (12,945 tons).

The greatest amount of processing fugitive emissions (almost 47%) results from the return handling of large amounts of recycled sinter from the sinter machine for repelletizing and mixing with fluxes, etc. prior to refeeding. Other major particulate sources are the sinter machine discharge and sinter crushing/screening, zinc fuming furnace vents, and reverberatory furnace leakage, which contribute 8, 12, and 8 percent of total fugitive emissions, respectively.

Adequacy of Emission Factor Data - Primary lead smelting involves essentially three steps: sintering, reduction (blast furnace), and refining. Fugitive particulate emissions have been quantified by limited test measurements at several processing points within these three operations.[1] Table 2-15 lists these processes and the emission ranges, which have been determined by various sampling devices over incremental periods of time. Further support testing should be considered for verification of these values.

Fugitive emission factors determined by engineering judgment (using steel sinter machine leakage emission factors) are as follows:

Sinter machine	0.12-0.55 kg/Mg (0.25-1.1 lb/ton) of sinter[4,5]

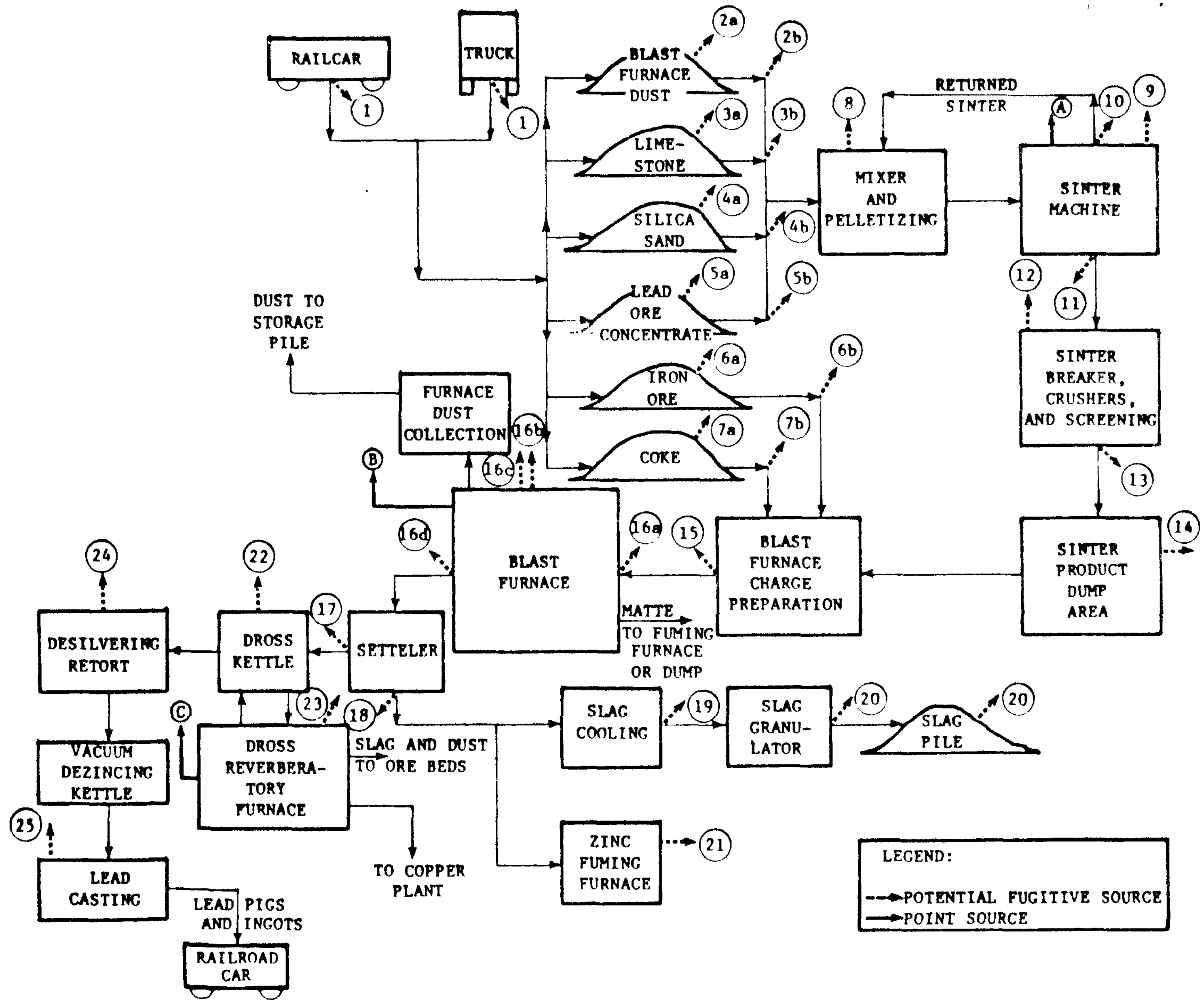

Figure 2-6. Process flow diagram for primary lead smelting showing origins of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-13. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE PRIMARY LEAD SMELTING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Railroad car and truck unloading	2. Blast furnace flue dust 2a. Storage 2b. Handling and transfer
3. Limestone 3a. Storage 3b. Handling and transfer	4. Silica sand 4a. Storage 4b. Handling and transfer
5. Lead ore concentrate 5a. Storage 5b. Handling and transfer	6. Iron ore 6a. Storage 6b. Handling and transfer
7. Coke 7a. Storage 7b. Handling and transfer	8. Mixing and pelletizing
9. Sinter machine	10. Sinter return handling
11. Sinter machine discharge and screens	12. Sinter crushing
13. Sinter transfer to dump area	14. Sinter product dump area
15. Charge car or conveyor loading and transfer of sinter	16. Blast furnace - monitor 16a. Charging 16b. Blow condition 16c. Upset 16d. Tapping
17. Lead pouring to ladle and transfer	
18. Slag pouring	19. Slag cooling
20. Slag granulator and slag piling	21. Zinc fuming furnace vents
22. Dross kettle	23. Reverberatory furnace leakage
24. Silver retort building	25. Lead casting
Point sources	
A. Sintering	B. Blast furnace
C. Dross reverberatory furnace	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-14. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE PRIMARY LEAD INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a] kg/Mg	lb/ton	Estimated 1976 U.S. primary lead production[2] 1000 Mg	1000 tons	Estimated uncontrolled emissions Mg/yr	tons/yr
Ore mixing and pelletizing (crushing)	1.13	2.26	612	675	692	763
Sinter machine leakage	0.34[b]	0.68[b]	1225[c]	1350[c]	417	459
Sinter return handling	4.50	9.00	1225[c]	1350[c]	5513	6075
Sinter machine discharge, sinter crushing & screening	0.75[b]	1.50[b]	1225[c]	1350[c]	919	1013
Sinter transfer to dump area	0.10	0.20	1225[c]	1350[c]	123	135
Sinter product dump area	0.005	0.010	1225[c]	1350[c]	6	7
Car charging (conveyor loading and transfer) of sinter	0.25	0.50	1225[c]	1350[c]	306	338
Blast furnace (charging, blow condition, tapping)	0.0775	0.1550	612	675	47	52
Lead pouring to ladle, transferring, and slag pouring emissions	0.465[d]	0.930[d]	612	675	285	314
Slag cooling	0.235[e]	0.470[e]	612	675	144	159
Zinc fuming furnace vents	2.3	4.6	612	675	1408	1553
Dross kettle	0.24	0.48	612	675	147	162
Reverberatory furnace leakage	1.5	3.0	612	675	918	1013
Silver retort building	0.9	1.8	612	675	551	608
Lead casting	0.435	0.870	612	675	266	294
Total					11,742	12,945

[a] Average of test data presented in Reference 1. All factors are expressed in units per end product lead produced, except sinter operations, which are expressed in units per sinter or sinter handled/transferred/charged.

[b] Average based on engineering judgment, using steel sinter machine leakage emission factor.[4,5]

[c] Approximately 2 unit weights of concentrated ore input. Therefore, 1,225,000 Mg (1,350,000 tons) is assumed to be the quantity of concentrated ore input. The emission factor is expressed as units per unit weight of concentrated ore processed.

[d] Reference 3.

[e] Engineering judgment; estimated to be half the magnitude of lead pouring and ladling operation emissions.[3]

Table 2-15. PRIMARY LEAD SMELTING PROCESS POINTS WHERE FUGITIVE PARTICULATE EMISSION MEASUREMENTS HAVE BEEN CONDUCTED[1]

Source	Uncontrolled fugitive emission factor
Ore mixing and pelletizing	0.57-1.70 kg/Mg (1.13-3.39 lb/ton) of lead product
Sinter return handling	2.25-6.75 kg/Mg (4.5-13.5 lb/ton) of sinter
Sinter transfer to storage dumping area	0.05-0.15 kg/Mg (0.10-0.30 lb/ton) of sinter
Sinter storage dump area	0.0025-0.0075 kg/Mg (0.005-0.015 lb/ton) of sinter
Car charging (or conveyor loading and transfer) of sinter	0.13-0.38 kg/Mg (0.25-0.75 lb/ton) of sinter
Blast furnace (charging, blow condition, tapping)	0.04-0.12 kg/Mg (0.08-0.23 lb/ton) of lead product
Zinc fuming furnace vents	1.15-3.45 kg/Mg (2.3-6.9 lb/ton) of lead product
Dross kettle	0.12-0 36 kg/Mg (0.24-0.72 lb/ton) of lead product
Reverberatory furnace leakage	0.75-2.25 kg/Mg (1.5-4.5 lb/ton) of lead product
Silver retort building	0.45-1.35 kg/Mg (0.9-2.7 (lb/ton) of lead product
Lead casting	0.22-0.66 kg/Mg (0.43-1.30 lb/ton) of lead product

Sinter machine discharge, sinter crushing and screening	0.28-1.22 kg/Mg (0.55-2.45 lb/ton) of sinter[4,5]

Midwest Research, Inc., has assessed a fugitive particulate emission rate of 0.47 kg/Mg (0.93 lb/ton) of lead product as being generated from lead pouring to ladle, transferring, and slag pouring.[3] Slag cooling fugitive particulates have been estimated as 0.24 kg/Mg (0.47 lb/ton) of lead product, based solely on the former. All of the factors reported for lead smelting/refining should be supported by initial or more extensive test data before being submitted for AP-42 documentation.

REFERENCES FOR SECTION 2.2.3

1. Silver Valley/Bunker Hill Smelter Environmental Investigation, Interim Report. PEDCo Environmental, Inc. Contract No. 68-02-1343, Task Order No. 8. Cincinnati, Ohio. February 1975.

2. Commodity Data Summaries 1977. U.S. Dept. of the Interior. Bureau of Mines. 1977.

3. Vandegrift, A.E. and L.J. Shannon. Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Sources. Midwest Research Institute. Prepared for U.S. Environmental Protection Agency. Contract No. CPA 22-69-104. November 1, 1970.

4. Iversen, R.E. Meeting with U.S. Environmental Protection Agency and AISI on Steel Facility Emission Factors. April 14 and 15, 1976. U.S. Environmental Protection Agency Memorandum. June 7, 1976.

5. Speight, G.E. Best Practicable Means in the Iron and Steel Industry. The Chemical Engineer. March 1973.

6. Compilation of Air Pollutant Emission Factors, Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. February 1972.

2.2.4 Primary Zinc Production

Emissions - Figure 2-7 depicts the general process flow for primary zinc production, and Table 2-16 lists the emission sources noted in the process flow diagram. Industrywide fugitive particulate emissions from primary zinc production (1976) have been estimated to be 1551 Mg (1710 tons). Table 2-17 presents the sources of these emissions, along with emission factors used, domestic primary zinc production (1976), and the estimated source total emissions. These emissions are generated by only 58 percent of total industry production. The remaining 42 percent, or 201,939 Mg (222,600 tons), of U.S. primary zinc is produced at electrolytic plants, where the roasted ore concentrate is leached with sulfuric acid rather than sintered, and no fugitive particulates are generated.[8]

The sources of fugitive emissions from pyrometallurgical processing are sintering, mixing of coke with pelletized clinker (before charging it into the retort furnace), charging, and casting of molten zinc. Casting produces the major portion of these emissions (nearly 34 percent of total fugitive particulates generated), however, this percentage includes emissions from both electrolytic and pyrometallurgical zinc processing.

Adequacy of Emissions Factor Data - Ore roasting, which almost always precedes the numerous processes in primary zinc production that involve ore concentrate zinc extraction, is generally not a source of fugitive particulate emissions.[1] Forty-two percent of domestic zinc production is accomplished by electrolytic recovery, which does not generate fugitive particulate emissions.[8] The pyrometallurgical method of producing zinc is the most significant in terms of fugitive losses that occur in the industry. This encompasses sintering, mixing coke with the pelletized clinker (prior to charging into a retort furnace), charging, and casting molten zinc. Fugitive particulates generated by sinter machine windbox discharging are estimated to vary from 0.12 to 0.55 kg/Mg (0.25 to 1.1 lb/ton) of sinter.[3] Collectively, sinter machine discharge, screening, and coke-sinter mixing emissions

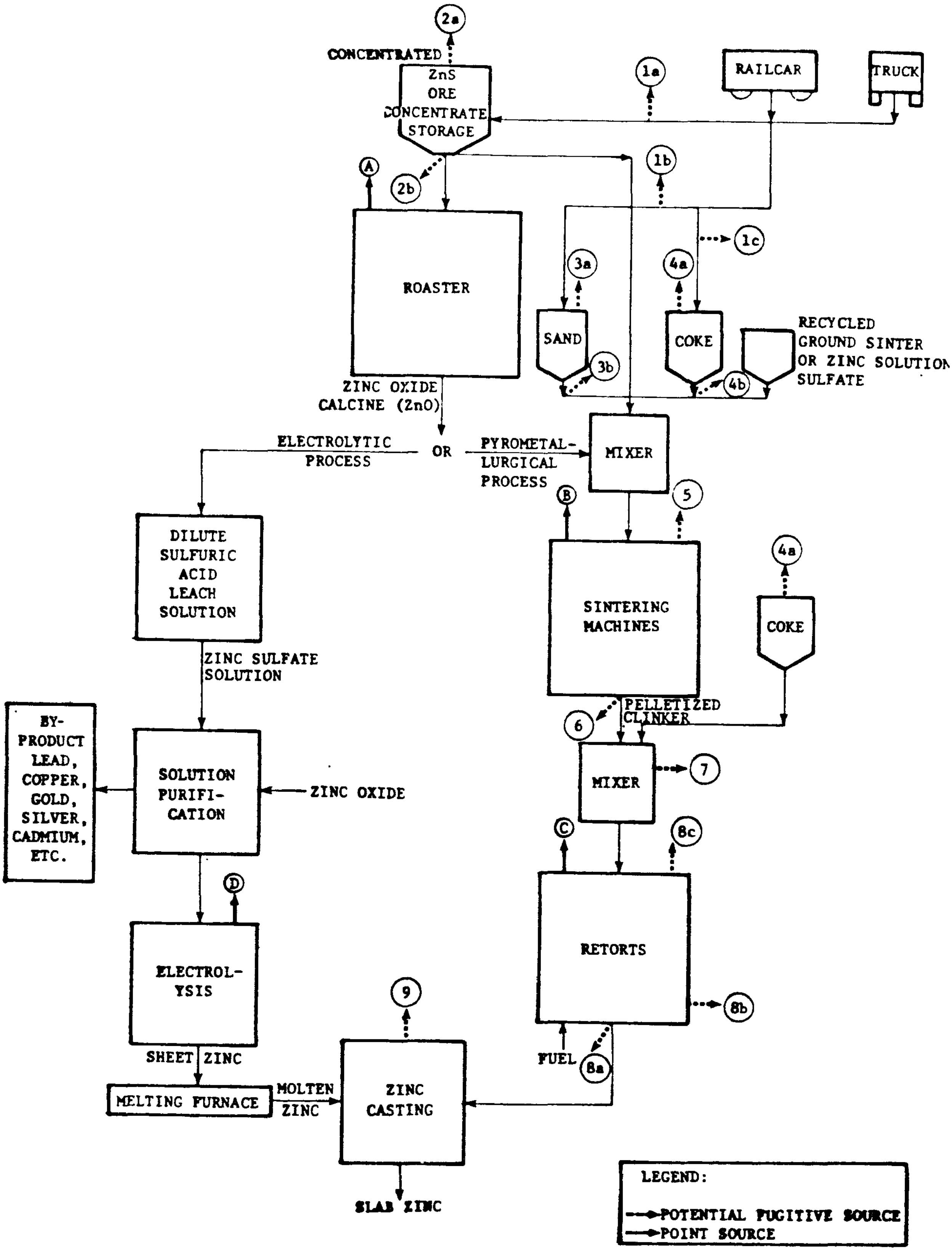

Figure 2-7. Process flow diagram for primary zinc production showing origins of uncontrolled fugitive industrial process and point source emissions.

Table 2-16. IDENTIFICATION OF EMISSIONS SOURCES SHOWN ON THE PRIMARY ZINC PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Railroad car or truck unloading	2. Zinc ore concentrate 2a. Storage 2b. Handling and transfer
3. Sand 3a. Storage 3b. Handling and transfer	4. Coke 4a. Storage 4b. Handling and transfer
5. Sinter machine windbox discharge	
6. Sinter machine discharge and screens	7. Coke-sinter mixer
8. Retort furnace building 8a. Retort furnace tapping 8b. Retort furnace residue discharge and cooling 8c. Retort furnace upset	9. Zinc casting
Point sources	
A. Roaster	B. Sinter machine
C. Retort	D. Electrolysis

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-17. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM PRIMARY ZINC PRODUCTION

Emission source	Uncontrolled fugitive particulate emission factor[a]		Estimated 1976 U.S. primary zinc production[9]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Sinter machine windbox discharge	0.34[b]	0.68[b]	557.7[c]	614.8[c]	190	209
Sinter machine discharge, screens, and coke-sinter mixer	0.75[b]	1.50[b]	557.7[c]	614.8[c]	418	461
Retort furnace building leakage and tapping	1.5[d]	3.0[d]	278.9[e]	307.4[e]	418	461
Retort furnace residue discharge and cooling	0.625[f]	1.250[f]	278.9[e]	307.4[e]	174	192
Zinc casting	1.26[g]	2.52[g]	480.8	530	606	668
Total					1806	1991

[a] Factors are expressed as units per end product zinc produced, except as noted.

[b] Engineering judgment average, assuming that fugitive emission factors given for sintering machine in iron production are similar for sintering in zinc production.[3,4,10,11] Emission factor per unit of sinter produced.

[c] Fifty-eight percent[8] of the total 1976 primary zinc production (480,808 Mg or 530,000 tons),[9] was produced by this pyrometallurgical method. This value also includes that approximately 2 unit weights of concentrated ore (sinter) are required to produce 1 unit weight of zinc metal.[10] Emission factors are expressed as units per unit weight of concentrated ore (sinter) processed. No fugitve particulates are assumed to generate from the electrolytic method of primary zinc production.

[d] Judgment made, assuming that an average of emission factors from retort building in primary lead smelting would be similar for primary zinc.[5,11]

[e] Fifty-eight percent[8] of the 1976 primary zinc production (480,808 Mg or 530,000 tons)[9] was produced pyrometallurgically.

[f] Average value based on observations made at a secondary zinc smelter, which is similar to the primary zinc production operation.[11]

[g] Assumption made that fugitive emissions from zinc casting are equal to that from copper casting.[7,11]

have been determined to range from 0.28 to 1.22 kg/Mg (0.55 to 2.45 lb/ton) of sinter.[3,4] These fugitive emission factors actually represent sintering emissions from iron production and are only assumed to be similar for zinc. Retort furnace building leakage and tapping emissions are estimated to vary from 1 to 2 kg/Mg (2 to 4 lb/ton) of zinc.[5] Here again, this estimate assumes that zinc retort building emissions are similar to the primary lead smelting emissions on which it is based. Retort furnace residue discharge and cooling emissions of 0.25 to 1 kg/Mg (0.5 to 2 lb/ton) of zinc are based on observations at a secondary zinc smelter, and therefore not entirely representative of primary production.[6] Zinc casting fugitive emissions are estimated to be 1.26 kg/Mg (2.52 lb/ton) of zinc, and again, are not based on actual test emissions from the zinc operation, but on emissions from copper casting.[7]

Because they are based on engineering judgment and similar operations, all of the emission factors reported require extensive test support data before they are incorporated into AP-42.

REFERENCES FOR SECTION 2.2.4

1. Personal communication from Mr. James C. Caraway of Texas Air Control Board to R. Amick, PEDCo Environmental, Inc., during a meeting with the Texas Air Control Board. Austin, Texas. October 6, 1976.

2. Personal communication from Mr. S. Norman Kesten, Assistant to the Vice-President, Environmental Affairs, ASARCO, to Mr. Donald R. Goodwin, Director, U.S. Environmental Protection Agency, Emission Standards and Engineering Division, Research Triangle Park, North Carolina. January 17, 1977.

3. Iversen, R.E. Meeting with U.S. Environmental Protection Agency and AISI on Steel Facility Emission Factors, April 14 and 15, 1976. U.S. Environmental Protection Agency Memorandum. June 7, 1976.

4. Scheuneman, J.J., M.D. High, and W.E. Bye. Air Pollution Aspects of the Iron and Steel Industry. U.S. Department of Health, Education, and Welfare, Division of Air Pollution. June 1963.

5. Silver Valley/Bunker Hill Smelter Environmental Investigation, Interim Report. PEDCo Environmental, Inc. Prepared for U.S. Environmental Protection Agency, Region X. Contract No. 68-02-1343. Seattle, Washington. February 1975.

6. Plant visit to the W.J. Bullock secondary zinc facilities, Birmingham, Alabama. September 29, 1976.

7. Personal communication from R.J. Kearney (Kennecott Copper Smelters) to R.D. Rovany, U.S. Environmental Protection Agency. November 22, 1974.

8. Environmental Assessment of the Domestic Primary Copper, Lead, and Zinc Industries. Executive Summary. PEDCo Environmental, Inc. Prepared for the U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory. Contract No. 68-02-1321. Cincinnati, Ohio. November 1976.

9. Comodity Data Summaries 1977. U.S. Dept. of the Interior. Bureau of Mines. 1977.

10. Compilation of Air Pollutant Emission Factors, Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning and Standards, Publication No. AP-42. Research Triangle Park, North Carolina. February 1972.

11. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.3 SECONDARY NONFERROUS INDUSTRIES

2.3.1 Secondary Aluminum Smelters

Emissions - Secondary aluminum production involves scrap pretreatment, smelting, fluxing, alloying, degassing, and demagging (removal of magnesium). Chip (rotary) drying may be done to pretreat scrap containing large amounts of paint, oil, grease, and other contaminants prior to loading into the smelting furnace. Scrap rich in iron content is processed in a sweating furnace before it is smelted. Fluxing, alloying, degassing, and demagging can all take place within the reverberatory smelting furnace, but this does not necessarily occur. Figure 2-8 depicts the general process flow in secondary aluminum smelting, and Table 2-18 lists the emission sources noted in the process flow diagram. In 1973 fugitive particulate emissions from the industry were estimated to be approximately 1808 Mg (1995 tons), based on total domestic scrap consumed (Table 2-19). This table also presents the fugitive particulate factors used and the estimated annual emissions per process source.

Production sources of significant fugitive emissions are chlorine (most commonly used) fluxing and chip (rotary) drying. The latter processes the bulk of the throughput of industry scrap. Fluxing generates nearly 80 percent of the total fugitive particulates in the industry, and chip drying generates about 12 percent.

Adequacy of Emission Factor Data - The available fugitive particulate emission factors are not based on actual test data, but are assumed, for the most part, to be 5 percent of the total uncontrolled primary emissions.[2] This is true for fugitive emission factors shown for the following processes:

Sweating	0.36 kg/Mg of metal processed (0.72 lb/ton of metal processed)
Smelting (reverberatory)	0.11 kg/Mg of metal processed (0.22 lb/ton of metal processed)

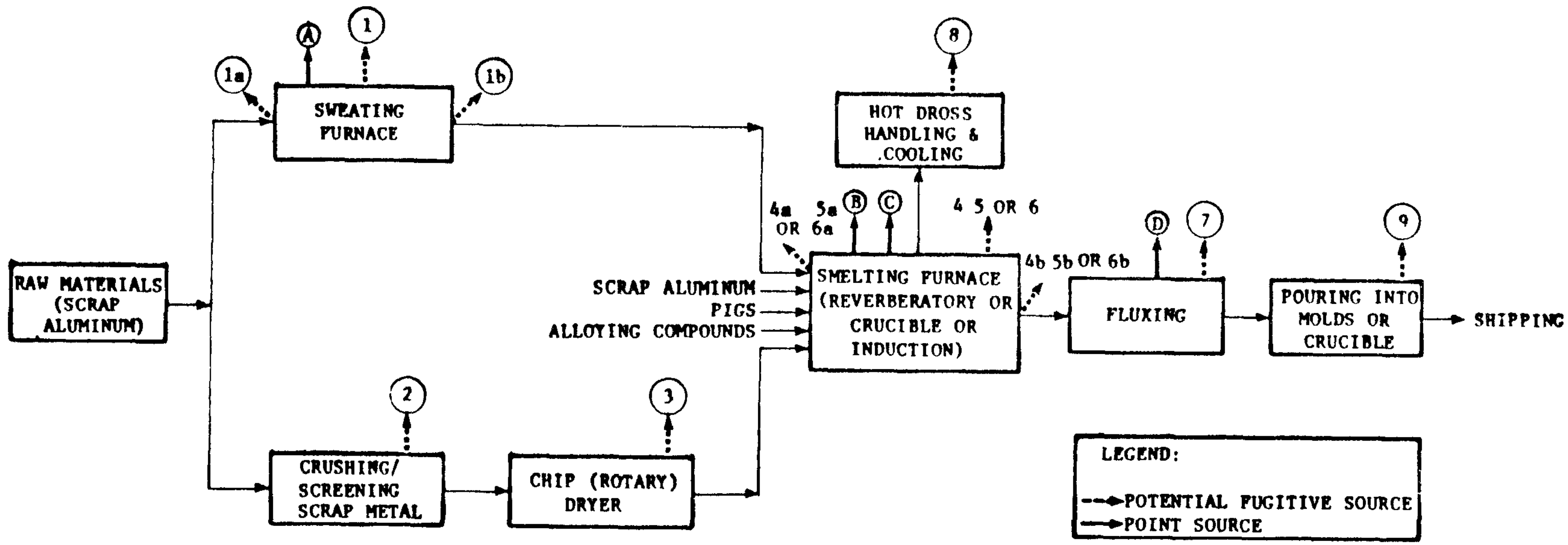

Figure 2-8. Process flow diagram for secondary aluminum production showing origins of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-18. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE SECONDARY ALUMINUM PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Sweating furnace 1a. Charging 1b. Tapping	2. Crushing and screening scrap metal
	3. Chip (rotary) dryer
4. Smelting (reverberatory) furnace	5. Smelting (crucible) furnace 5a. Charging 5b. Tapping
6. Smelting (induction) furnace 6a. Charging 6b. Tapping	7. Fluxing (chlorination)
8. Hot dross handling and cooling	9. Pouring hot metal into crucible
Point source	
A. Sweating furnace	B. Reverberatory smelting furnace
C. Crucible smelting furnace	D. Chlorination (fluxing)

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-19. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE SECONDARY ALUMINUM SMELTING INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a]		1973 U.S. total scrap consumed[1]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Sweating furnace	0.36[j]	0.72[j]	51[b]	56[b]	18	20
Chip (rotary) dryer	0.36[c]	0.72[c]	619[d]	682[d]	223	245
Reverberatory furnace	0.11[j]	0.22[j]	569[e]	626[e]	63	69
Crucible smelting furnace	0.045[j]	0.090[j]	67[e]	74[e]	3	3
Electric induction furnace	0.045[f,j]	0.090[f,j]	34[e]	37[e]	2	2
Hot dross handling and cooling	0.11[g]	0.22[g]	669	737	74	81
Fluxing (chlorination)	25.0[h]	50.0[h]	57[i]	63[i]	1425	1575
Total					1808	1995

[a] Reference 4. All factors are expressed as units per unit of metal scrap processed.

[b] 1973 U.S. sweated pig consumption for secondary aluminum smelting.[1]

[c] Assumed to be the same as fugitive emission rate from sweating furnace.[1]

[d] 1973 total U.S. new and old scrap consumed, excluding sweated pig.[1]

[e] Percentage of 1973 U.S. total scrap consumed by reverberatory, crucible, and electric induction smelting furnaces was assumed to be 85, 10, and 5 percent, respectively.

[f] Assumed to be the same as fugitive emission rate from crucible furnace.

[g] Assumed to be the same as fugitive emission loss from reverberatory furnace.

[h] Factors are expressed as units per volume of chlorine used.

[i] Since fluxing emission factor is based upon quantity of chlorine used, this volume is assumed at 10 percent of the weight of metal processed in the reverberatory furnace.[3]

[j] Included are charging and tapping emissions.

Smelting (crucible)	0.55 kg/Mg of metal processed (0.09 lb/ton of metal processed)
Fluxing (chlorination)	25 kg/Mg of chlorine used (50 lb/ton of chlorine used)

Emissions from chip (rotary) drying are assumed to be equal to the uncontrolled emissions from a sweating furnace [i.e., 0.36 kg/Mg (0.72 lb/ton) of metal processed]. Fugitive particulates from a smelting (induction) furnace are assumed to be equal to those from crucible furnaces [i.e., 0.05 kg/Mg (0.09 lb/ton) of metal processed]. Fugitive emissions from hot dross handling and cooling are assumed to be equal to those from a reverberatory furnace [i.e., 0.11 kg/Mg (0.22 lb/ton) of metal processed]. None of these factors is believed to be significant or accurate enough to justify incorporation into AP-42.

REFERENCES FOR SECTION 2.3.1

1. Stamper, J.W. Aluminum. Preprint. 1973 Mineral Yearbook. U.S. Bureau of Mines. 1975.

2. Compilation of Air Pollutant Emission Factors. Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Management, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. April 1977.

3. Danielson, J.A. Air Pollution Engineering Manual, Second Edition. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. AP-40. May 1973.

4. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.3.2 Secondary Lead Smelting

Emissions - Figure 2-9 depicts the general process flow for secondary lead smelting, and Table 2-20 lists the emission sources noted in the process flow diagram. In 1973, 593,558 Mg (654,286 tons) of lead were recovered from scrap processed in the United States. Uncontrolled fugitive particulates were estimated to be 4,250 Mg (4,684 tons) (Table 2-21). Table 2-21 also presents the uncontrolled fugitive emission factors used, total domestic scrap consumed in 1973, and estimated annual uncontrolled fugitive emissions by specific process source.

Approximately 75 percent of the fugitive emissions emanate from blast furnace smelting and holding pot tapping because they have the largest processed lead throughput. About 15 percent of the total fugitive emissions result from reverberatory furnace smelting of battery plates, drosses, and the like.

Adequacy of Emission Factor Data - Three types of furnaces are commonly used in secondary lead smelting: the reverberatory furnace, blast furnace or cupola, and pot furnace. Two-thirds of the output of secondary lead is processed in blast furnaces or cupolas,[5] and the balance is processed in reverberatory and pot furnaces. Pretreatment of scrap before it is charged into the reverberatory furnace involves burning (of wood, rubber, paper, and plastics) and sweating (within a rotary or the reverberatory furnace). A fugitive particulate emission factor of 0.8 kg/Mg (1.6 lb/ton) of scrap burned can be estimated for lead and iron scrap burning, based on secondary zinc residual scrap processing[1] and 5 percent of the uncontrolled particulate emissions. An emission factor range of 0.8 to 1.75 kg/Mg (1.6 to 3.5 lb/ton) of scrap charged has been determined for sweating (rotary or reverberatory) furnace fugitive particulates,[3] also based on 5 percent of the uncontrolled primary emissions from similar processes. Reverberatory smelting furnace fugitive emissions may vary between 1.4 to 7.85 kg/Mg (2.8 to 15.7 lb/ ton) of scrap charged as estimated from values reported by Radian Corporation.[3] The

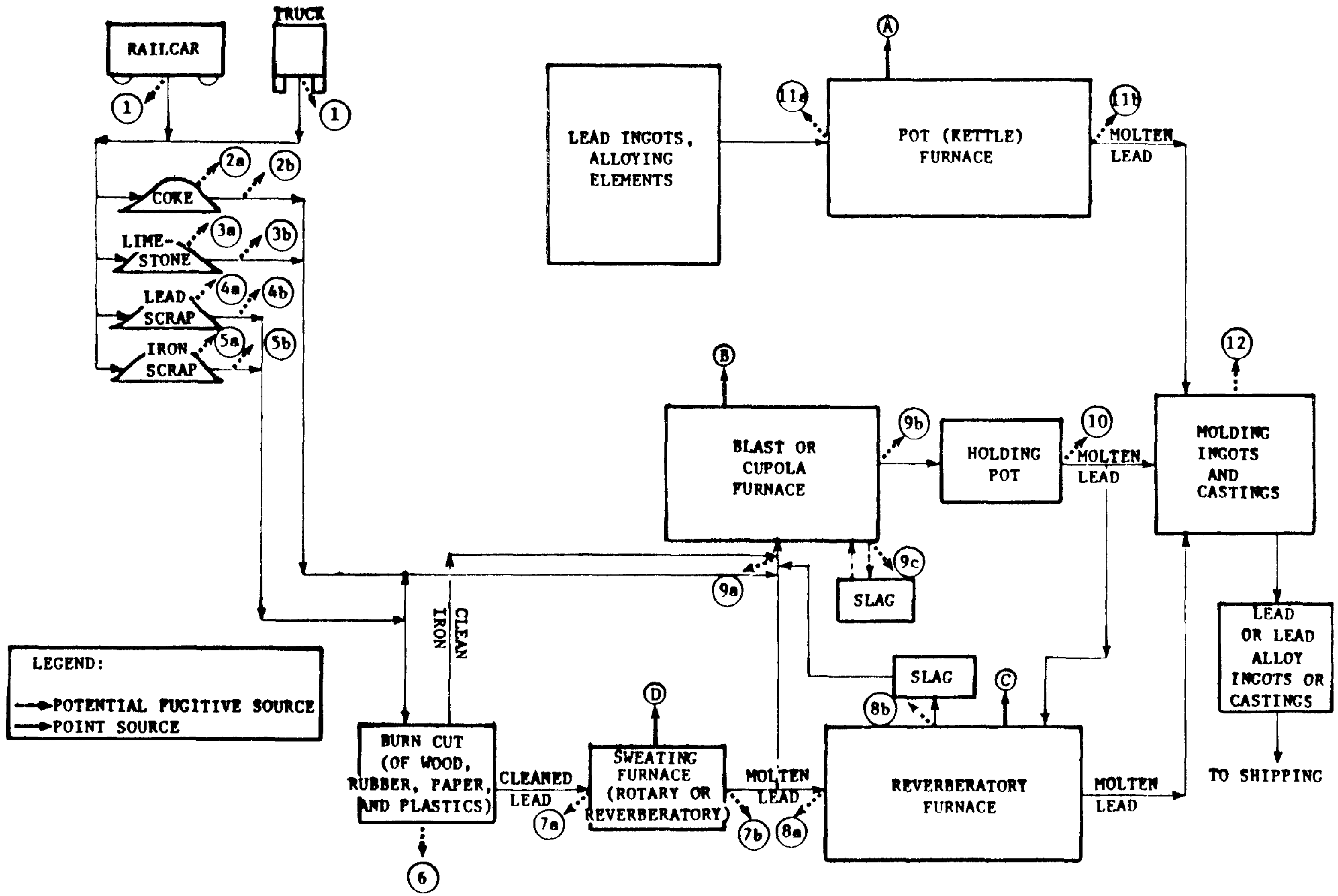

Figure 2-9. Process flow diagram for secondary lead smelting showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-20. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE SECONDARY LEAD SMELTING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Railroad car and truck unloading	2. Coke
	2a. Storage 2b. Handling and transfer
3. Limestone	4. Lead scrap
3a. Storage 3b. Handling and transfer	4a. Storage 4b. Handling and transfer
5. Iron scrap	6. Lead and iron scrap burning
5a. Storage 5b. Handling and transfer	
7. Sweating furnace	8. Reverberatory furnace
7a. Charging 7b. Tapping	8a. Charging 8b. Tapping
9. Blast or cupola furnace	10. Tapping of holding pot
9a. Charging 9b. Lead tapping to holding pot 9c. Slag tapping	11. Pot (kettle) furnace 11a. Charging 11b. Tapping
12. Casting	

Point sources	
A. Pot (kettle) furnace	B. Blast or cupola furnace
C. Reverberatory furnace	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-21. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE SECONDARY LEAD SMELTING INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a]		1973 total U.S. scrap consumption[2]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Lead and iron scrap burning	0.8	1.6	129[b]	142[b]	103	114
Sweating furnace	1.275[c]	2.550[c]	129[b]	142[b]	165	181
Reverberatory furnace	4.615[d]	9.230[d]	129[b]	142[b]	595	656
Blast (cupola) furnace and tapping of holding pot	6.0[e]	12.0[e]	521[f]	574[f]	3126	3445
Pot (kettle) furnace	0.02[g]	0.04[g]	129[b]	142[b]	3	3
Casting	0.435[h]	0.870[h]	594[i]	654[i]	258	285
Total					4250	4684

[a] Reference 5. Factors are expressed as units per volume of scrap processed.

[b] Processed is an assumed 16.5 percent of the total (1973) domestic scrap consumed.

[c] Average based on 5 percent of the uncontrolled emission factors determined. Included are emissions from charging and tapping.

[d] Average based on 5 percent of the uncontrolled emission factors determined. Included are emissions from charging and tapping.

[e] Included are emissions from charging, lead tapping to holding pot, slag tapping, and tapping of holding pot.

[f] Processed is an assumed 67 percent of the total (1973) domestic scrap consumed.

[g] Included are emissions from charging and tapping.

[h] Factors are expressed as units per end product lead cast.

[i] Domestic secondary lead supply (1973) recovered from scrap.

factors, 6 kg/Mg (12 lb/ton) and 0.02 kg/Mg (0.04 lb/ton) of metal charged are respectively attributed to blast (or cupola) smelting furnace and pot (kettle) furnace fugitive emissions.[4,3] Here again, these values are based on 5 percent of the total uncontrolled primary particulate emission. Secondary lead casting losses are assumed to be equal to primary lead casting emissions at 0.435 kg/Mg (0.87 lb/ton) of lead cast.[6] Without supportive fugitive emission testing, these reported factors are insufficiently reliable for inclusion in AP-42.

REFERENCES FOR SECTION 2.3.2

1. Compilation of Air Pollutant Emission Factors. Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Management, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. February, 1976.

2. Ryan, J.P. Lead. 1973 Minerals Yearbook. U.S. Bureau of Mines. 1973.

3. Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Volume II: Industry Profile. Radian Corporation. Contract No. 68-02-1319, Task No. 49. Austin, Texas. June 21, 1976.

4. Control Techniques for Lead Air Emissions, Draft Final Report - PEDCo Environmental, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02- 1375, Task Order No. 32. Research Triangle Park, North Carolina. October 1976.

5. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. U.S. Environmental Protection Agency. Contract No. 68-02-1375, Task No. 33. Research Triangle Park, North Carolina. March 1977.

6. Silver Valley/Bunker Hill Smelter Environmental Investigation, Interim Report. PEDCo Environmental, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1343, Task Order No. 8. Region X, Seattle, Washington. February 1975.

2.3.3 Secondary Zinc Production

Emissions - Figure 2-10 depicts the general process flow in secondary zinc production, and Table 2-22 lists the emission sources noted in the process flow diagram. Uncontrolled fugitive particulate emissions generated from secondary zinc industry production are estimated to have been potentially 429 Mg (472 tons) in 1973. Because information is not available as to what proportion of scrap was consumed throughout the various process schemes in zinc production, these values represent the maximum uncontrolled emissions possible so as to present a "worst case" condition.

Table 2-23 lists process sources, emission factors, 1973 domestic secondary zinc production, and estimated annual uncontrolled fugitive particulates generated. As indicated in the table, the major source of fugitive emissions is distillation processing, which accounts for approximately 47 percent of total industry emissions.

Adequacy of Emission Factor Data - The three distinct processes in the secondary zinc industry are pretreatment (i.e., sweating), melting, and distillation. Zinc-bearing scrap may be sweat-processed in reverberatory, kettle (pot), rotary, muffle, or electric resistance furnaces, or not at all, depending upon the degree of zinc purity. Clean scrap (high zinc content) and residue skimmings (substances that form on the molten metal bath surface) have been estimated to constitute approximately 25 and 35 percent, respectively, of the total zinc-based scrap consumed in 1973.[2] It has been estimated that emissions from skimmings, which range between 0.5 and 3.75 kg/Mg (1.0 and 7.5 lb/ton) of residue processed, are generated during the pulverizing and screening process stages.[1] At small plants, zinc recovery from clean scrap only is commonly done by electric resistence furnace sweating. A particulate fugitive emission factor of 0.25 kg/ Mg (0.50 lb/ton) of scrap charged to the electric furnace has been determined, based on estimated primary emission data[1] and calculated as 5 percent of the total particulate generated. Table 2-24

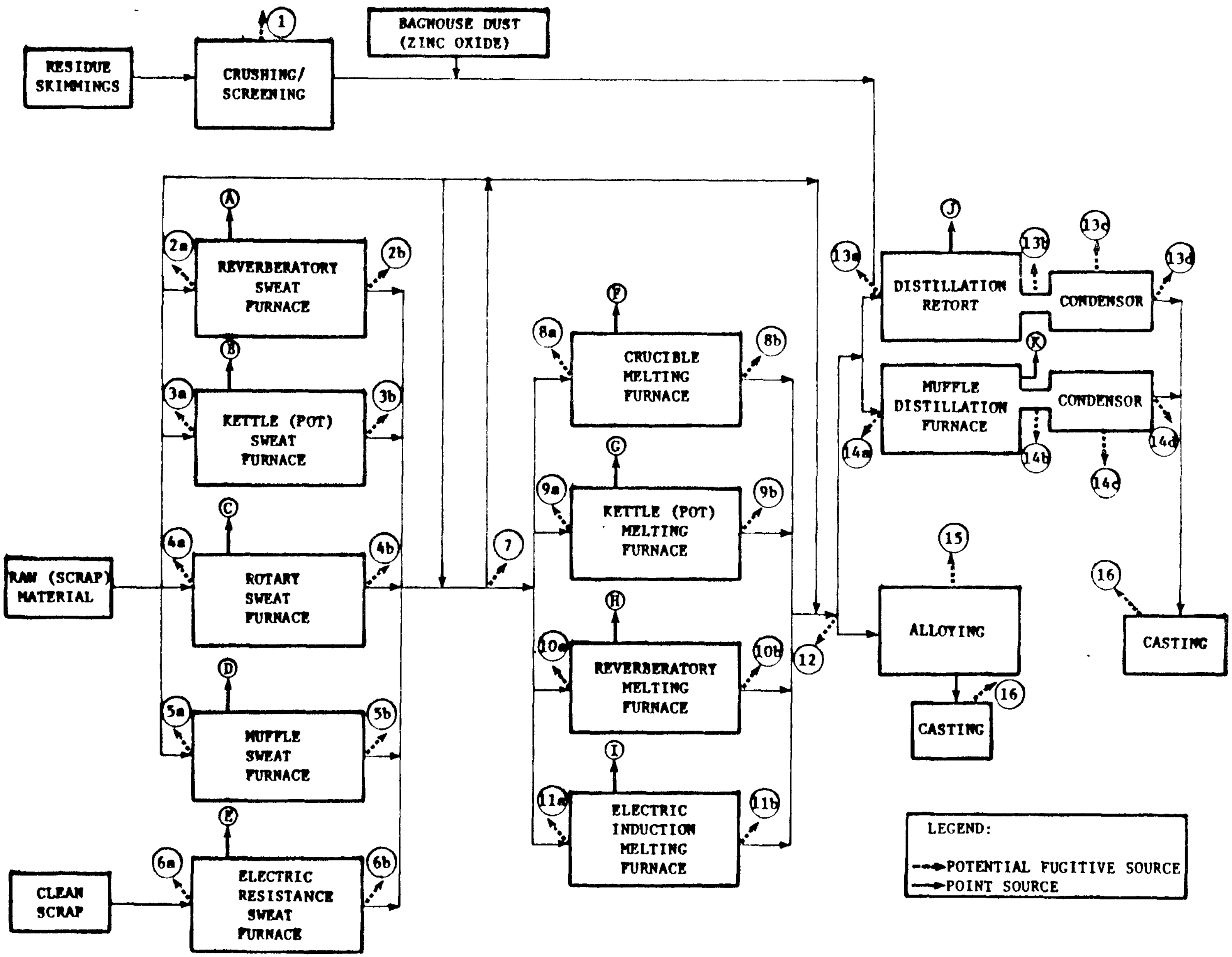

Figure 2-10. Process flow diagram for secondary zinc production showing origins of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-22. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE SECONDARY ZINC PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources

1. Crushing/screening of residue skimmings	2. Reverberatory sweat furnace
3. Kettle (Pot) sweat furnace	2a. Charging 2b. Tapping
3a. Charging 3b. Tapping	4. Rotary sweat furnace
5. Muffle sweat furnace	4a. Charging 4b. Tapping
5a. Charging 5b. Tapping	6. Electric resistance sweat furnace
7. Hot metal transfer to melting furnaces	6a. Charging 6b. Tapping
8. Crucible metling furnace	9. Kettle (pot) melting furnace
8a. Charging 8b. Tapping	9a. Charging 9b. Tapping
10. Reverberatory melting furnace	11. Electric induction melting
10a. Charging 10b. Tapping	11a. Charging 11b. Tapping
12. Hot metal transfer to retort or alloying	13. Distillation retort and condenser
14. Muffle distillation furnace and condenser	13a. Charging distillation retort 13b. Leakage between retort and condenser 13c. Upset in condenser 13d. Tapping
14a. Charging muffle distillation furnace 14b. Leakage between furnace and condenser 14c. Upset in condenser 14d. Tapping	15. Alloying
	16. Casting

Point sources

A. Reverberatory sweat furnace	B. Kettle (pot) sweat furnace
C. Rotary sweat furnace	D. Muffle sweat furnace
E. Electric resistance sweat furnace	F. Crucible melting furnace
G. Kettle (pot) melting furnace	H. Reverberatory melting furnace
I. Electric induction melting furnace	J. Distillation retort
K. Muffle distillction furnace	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-23. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM SECONDARY ZINC PRODUCTION

Emission source	Uncontrolled fugitive partic- factor[a]		1973 U.S. secondary zinc production[2]		Estimated controlled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Crushing/screening of residue skimmings	2.125[b]	4.250[b]	65[c]	71[c]	138	152
Rotary sweat furnace	0.45[b,d]	0.90[b,d]	171	188	77	85
Electric resistence sweat furnace	0.25[d]	0.50[d]	46[e]	51[e]	12	13
Reverberatory melting furnace	0.0025[d]	0.0050[d]	171	188	<1	<1
Distillation retort and condenser	1.18[f]	2.36[f]	171	188	201	221
Casting	0.0075[g]	0.0150[g]	171	188	1	1
Total					429	472

[a] Reference 4. Factors are expressed as units per end product zinc except factors for crushing/screening of residue skimmings and electric resistence sweat furnace which are expressed as units per volume of scrap processed.

[b] Average of reported emission factors.

[c] Approximately 35 percent of the 185,040 Mg (203,972 tons) of total zinc scrap consumed domestically (1973) consisted of residue skimmings.

[d] Includes emission from charging and tapping.

[e] Approximately 25 percent of the 185,040 Mg (203,972 tons) of total U.S. zinc scrap consumed (1973) was clean scrap, which is processed commonly by electric resistence sweating.

[f] Reference 3. Factor includes emissions generated via charging, leakage between retort condenser, and tapping.

[g] Factors are expressed as units per quality of zinc cast.

Table 2-24. SECONDARY ZINC PRODUCTION FUGITIVE PARTICULATE SOURCES AND ESTIMATED EMISSION FACTORS

Source	Uncontrolled fugitive emission factor
Sweating	
Reverberatory furnace[1,3]	Neg. - 0.63 kg/Mg of zinc product (Neg. - 1.3 lb/ton of zinc product)
Kettle (pot) furnace[1,3]	0.28 kg/Mg of zinc product (0.56 lb/ton of zinc product)
Rotary furnace[1]	0.28 - 0.63 kg/Mg of zinc product (0.56 - 1.26 lb/ton of zinc product)
Muffle furnace[1]	0.27 - 0.80 kg/Mg of zinc scrap charged (0.54 - 1.6 lb/ton of zinc scrap charged)
Melting	
Crucible furnace[1,3]	0.0025 kg/Mg of zinc product (0.005 lb/ton of zinc product)
Kettle (pot) furnace[1,3]	0.0025 kg/Mg of zinc product (0.005 lb/ton of zinc product)
Reverberatory furnace[1]	0.0025 kg/Mg of zinc product (0.005 lb/ton of zinc product)
Electric induction furnace[1]	0.0025 kg/Mg of zinc product (0.005 lb/ton of zinc product)
Distillation	
Distillation retort and and condenser[3]	1.18 kg/Mg of zinc product (2.36 lb/ton of zinc product)
Muffle distillation furnace and condenser[3]	1.18 kg/Mg of zinc product (2.36 lb/ton of zinc product)
Casting[1]	0.005 - 0.01 kg/Mg of zinc cast (0.01 - 0.02 lb/ton of zinc cast)

lists pretreatment, melting, and distillation process fugitive emission factors and ranges, all of which are estimated as 5 percent of the total primary particulate emission. In the determination of total industry fugitive emissions, only those factors for selected processes (Table 2-23) were considered so as to present a maximum uncontrolled emission as a worst case situation. Actual particulate fugitive emission test data have not been reported for secondary zinc processing operations.

REFERENCES FOR SECTION 2.3.3

1. Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Volume II: Industry Profile. Radian Corporation. Contract No. 68-02-1319, Task Order No. 49. Austin, Texas. June 21, 1976.

2. Minerals Yearbook 1973, Volume I. Metal, Minerals, and Fuels. U.S. Department of the Interior. Bureau of Mines. 1973.

3. Compilation of Air Pollutant Emission Factors, Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning Standards. Publication No. AP-42. Research Triangle Park, North Carolina. April 1977.

4. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.3.4 Secondary Brass/Bronze (Copper Alloy) Production

Emissions - Figure 2-11 depicts the general process flow in secondary brass/bronze production, and Table 2-25 lists the emission sources noted in the process flow diagram. Fugitive particulate emissions from secondary brass/bronze ingot production have been determined for the pretreatment, smelting, and refining of copper-based scrap. Table 2-26 presents these estimated 1976 emissions. Total domestic fugitive particulate generation in 1976 is estimated to have been approximately 766 Mg (842 tons).

Production operations that contribute the greatest volume of fugitive particulates are burning of insulation off copper wire and reverberatory or rotary furnace smelting/refining. Of the total scrap used for brass/bronze ingot production, 50 percent is assumed to be pretreated. Of that 50 percent, insulation burning is assumed to constitute about 20 percent. Reverberatory smelting furnaces are assumed to process 40 percent of the total scrap, and rotary smelting furnaces, 30 percent. Annual fugitive particulates from the operations are estimated to be 275, 213, and 134 Mg (303, 235, and 148 tons) respectively.

Adequacy of Emission Factor Data - Preparation of copper-based scrap iron before it is smelted and refined for brass/bronze ingot production may involve any of the following: sweating, insulation (wire) burning, rotary drying, and cupola furnace melting. The alternative is no preparation at all. Fugitive particulate emission factors are unavailable for these processes, but factors are based upon 5 percent of the factor for uncontrolled stack emissions. The factor, 7.5 kg/Mg (15 lb/ton) of scrap sweated, was established by Midwest Research, Inc., for controlled sweating furnace stack emissions based on particulate generated from aluminum and zinc sweating furnace operations.[3] Midwest Research, Inc., also estimated that 138 kg/Mg (275 lb/ton) of wire burned can be assumed as an uncontrolled particulate emission resulting from the burning of insulation of copper

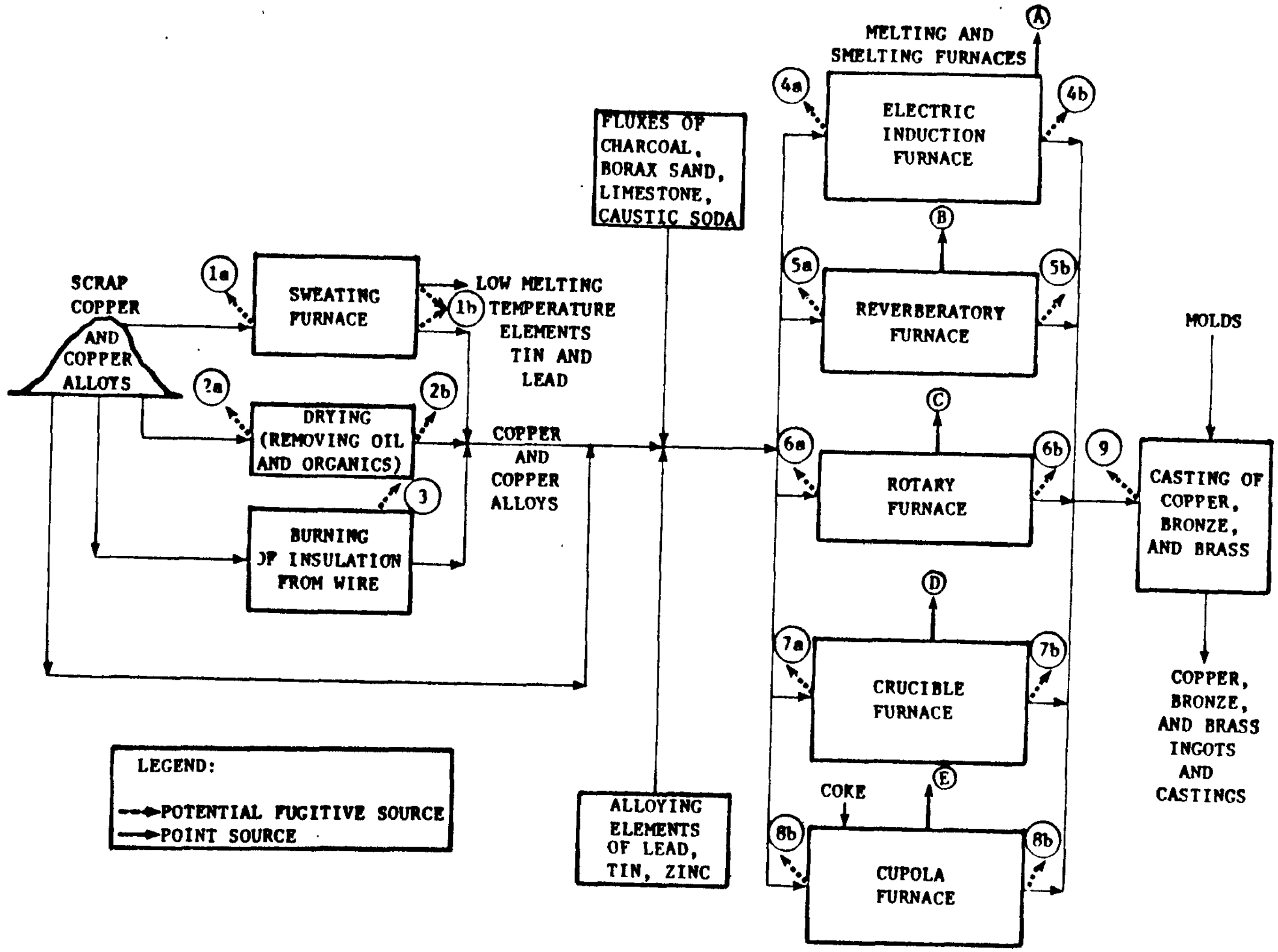

Figure 2-11. Process flow diagram for secondary brass/bronze (copper alloy) production showing origins of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-25. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE SECONDARY BRASS/BRONZE PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Sweating furnace	2. Drying
1a. Charging	2a. Charging
1b. Tapping	2b. Discharging
3. Insulation burning	4. Electric induction furnace
5. Reverberatory furnace	4a. Charging
	4b. Tapping
5a. Charging	
5b. Tapping	6. Rotary furnace
7. Crucible furnace	6a. Charging
	6b. Tapping
7a. Charging	
7b. Tapping	8. Cupola (blast) furnace
9. Casting	8a. Charging
	8b. Tapping

Point sources	
A. Electric induction furnace	B. Reverberatory furnace
C. Rotary furnace	D. Crucible furnace
E. Cupola furnace	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-26. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM 1976 BRASS AND BRONZE INGOT PRODUCTION

Emissions source	Uncontrolled fugitive partic- factor[a]		1976 Brass/bronze ingot scrap consumption[2]			Estimated controlled emissions	
	kg/Mg	lb/ton	percent[b]	1000 Mg	1000 tons	Mg/yr	tons/yr
Raw material preparation							
Sweating furnace	0.38[c,h]	0.75[c,h]	10	20	22	7	8
Rotary dryer	6.88[c,h]	13.75[c,h]	5	10	11	69	76
Insulation burning	6.88[d]	13.75[d]	20	40	44	275	303
Cupola furnace	1.83[e,h]	3.66[e,h]	15	30	33	55	60
Smelting & Refining							
Reverberatory furnace	2.64[f,h]	5.27[f,h]	40	81	89	214	235
Rotary furnace	2.22[f,h]	4.43[f,h]	30	61	67	135	148
Crucible furnace	0.25[f,h]	0.49[f,h]	15	30	33	7	8
Electric induction furnace	0.07[e,h]	0.14[e,h]	15	30	33	2	2
Casting	0.008[c]	0.015[c]	100	193[g]	213[g]	2	2
Total						766	842

[a] Factors are expressed as units per volume of scrap processed, except casting which is expressed as units per volume cast.

[b] Assumed percentage of copper-containing scrap fed through various processing. The pyrometallurgical processes for scrap preparation being; sweating, drying, burning, or cupola furnace melting are assumed to pretreat approximately 50 percent of the total industry scrap. The mechanical and hydrometallurgical methods are assumed to pretreatment the balance of the total industry scrap. These methods are not considered since they involve little or no air pollution.

[c] Assumption was made that fugitive particulate emission factor is equal to 5 percent of uncontrolled primary emission factor given in Reference 1.

[d] Assumption was made that fugitive particulate emission factor is equal to 5 percent of uncontrolled primary emission factor given in Reference 3.

[e] Average made assuming that the fugitive particulate emission factor is equal to 5 percent of uncontrolled primary emission factor given in Reference 4.

[f] Average of two sets of test data, assuming fugitive emissions being equal to 5 percent of primary emission factor average given in Reference 4.

[g] 1976 actual quantity of brass/bronze ingot production.[2]

[h] Includes emission from charging and tapping.

wire.[3] No emission test data are presented to substantiate the latter value, nor are there any data to establish an uncontrolled particulate emission factor from the rotary drying of scrap. Some tests were conducted towards the quantification of particulate emissions from cupola furnace operations, and an uncontrolled primary emission factor of 36.6 kg/Mg (73.2 lb/ ton) of scrap charged was determined.[4]

Melting, smelting, refining, and alloying of the processed scrap material take place in reverberatory, rotary, crucible, and electric induction furnaces. Here again, fugitive particulate emission factors are unavailable, but factors can be estimated at 5 percent of the uncontrolled stack emission factor. Two sets of 1968 test data are available for measurement of primary particulate emissions from reverberatory furnaces.[4] Test 1 revealed a controlled (97.7% collection efficiency) furnace emission of 0.62 kg/Mg (1.24 lb/ton) of material charged, whereas Test 2 indicated a controlled (99.6% collection efficiency) emission of 0.32 kg/Mg (0.63 lb/ton) of material charged. Two sets of 1968 test data have also been reported for rotary furnace particulate emissions.[4] Results of these tests show a controlled (94.8% collection efficiency) furnace emission of 0.78 kg/Mg (1.56 lb/ton) of material charged and an uncontrolled emission of 73.5 kg/Mg (147 lb/ton) of material charged. Test data for controlled gas crucible furnace emissions have established factors of 0.12 kg/Mg (0.24 lb/ton) of material charged and 0.42 kg/Mg (0.83 lb/ton) of material charged.[4] These data are not directly applicable to ingot production; rather, they refer to the brass and bronze foundry industry, as does the controlled emission (test) factor of 0.055 kg/Mg (0.11 lb/ton) of material charged for an electric induction furnace.[4] The only particulate emission factor found for casting [0.0075 kg/Mg (0.015 lb/ton) of material cast] was for zinc, and is not entirely representative of brass and bronze ingot casting.[1]

REFERENCES FOR SECTION 2.3.4

1. Multimedia Environmental Assessment of the Secondary Nonferreous Metal Industry, Volume II/III. Radian Corporation. Contract No. 68-02-1319, Task Order No. 49. Austin, Texas. June 21, 1976.

2. Personal Communication between W. Maudlin and J.Thomas Bertke, PEDCo Environmental, Inc. September 1977. Information obtained from Copper, 1976 Annual Statistical Supplement. July 1977. Copper Quarterly. Department of Commerce.

3. Particulate Pollutant System Study, Volume III - Handbook of Emission Properties. Midwest Research Institute. Contract No. CPA 22-69-104. Kansas City, Missouri. May 1, 1971.

4. Air Pollution Aspects of Brass and Bronze Smelting and Refining Industry. U.S. Department of Health, Education, and Welfare, Public Health Service. Raleigh, North Carolina. November 1969.

2.4 FOUNDRIES

2.4.1 Emissions

The foundry industry encompasses various metal industries. Figure 2-12 depicts the general process flow in the foundry industries, and Table 2-27 lists the emission sources noted in the process flow diagram. Fugitive particulate emissions from most furnace operations have been estimated as a percentage of uncontrolled primary emissions as listed in AP-42.[1] Fugitive particulate emissions from subsequent operations have been reported in various individual reports (as noted in Section 2.4.2). Table 2-28 presents estimated uncontrolled fugitive particulate emission from the gray iron foundry industry. Emissions are calculated for the gray iron foundry industry only, because this industry accounts for approximately 85 percent of the foundry production. The potential uncontrolled fugitive particulate emissions are estimated to be 106,719 Mg/yr (117,872 tons/yr).

2.4.2 Adequacy of Emission Factor Data

Data concerning uncontrolled particulate fugitive emission factors for the gray iron foundry industry will be forthcoming from Midwest Research Institute under EPA Contract No. 68-02-2120. This report will also include the sources and methods from which the factors were derived.

Currently, the methods by which many of the factors were obtained are unknown. Emission factors for the cupola, crucible, open hearth, electric induction, pot, and reverberatory furnaces (shown in Table 2-29) were derived mostly from a percentage of the uncontrolled primary emissions as listed in Reference 3. Most of these factors were derived as 5 percent of the uncontrolled primary emission rate. Though this is a common practice, extensive testing will be necessary before these fugitive emission factors can be considered adequate for incorporation into AP-42. Several of the other factors listed in Table 2-29 were derived from other sources (References 5,6,7, and 8), and the methods by which they were obtained is unknown. Hence, these factors also are not considered adequate for input into AP-42.

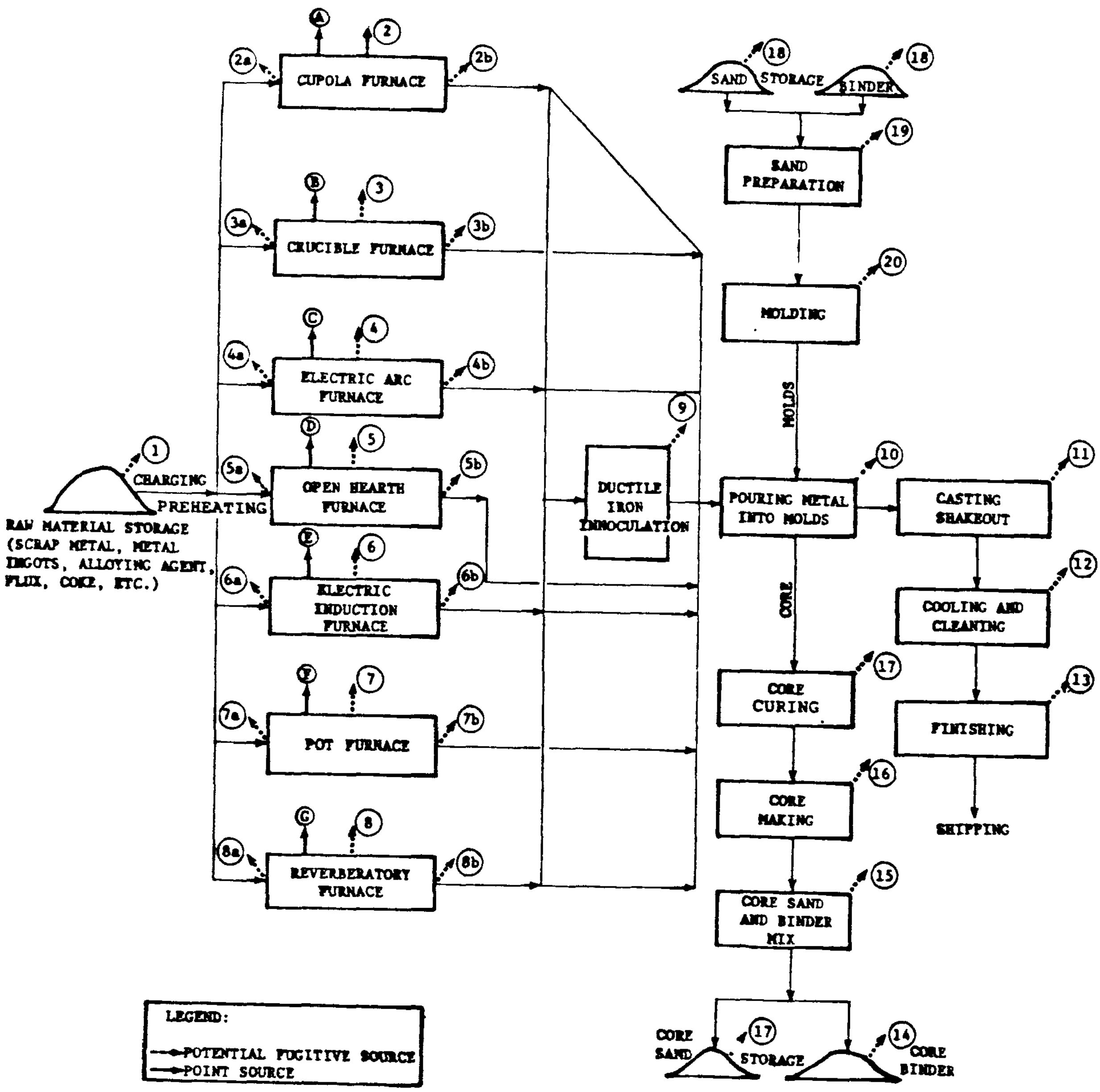

Figure 2-12. Process flow diagram for foundries showing origins of uncontrolled fugitive industrial process and point-source particulate emissions.

Table 2-27. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE FOUNDRIES PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Raw material receiving and storage 1a. Unloading 1b. Storage	2. Cupola furnace operation (charging, tapping, etc.) 3. Crucible furnace operation (charging, tapping, etc.)
4. Electric arc furnace operation	5. Open hearth furnace operation
6. Electric induction furnace operational	7. Pot furnace operation
8. Reverberatory furnace operation	9. Ductible iron innoculation
10. Pouring molten metal into molds	11. Casting shakeout
12. Cooling and cleaning castings	13. Finishing castings
14. Core sand and core binder receiving and storage	15. Core sand and binder mixing
16. Core making	17. Core baking
18. Mold sand and binder receiving and storage	19. Sand preparation
20. Mold makeup	
Point sources	
A. Cupola furnace	B. Crucible furnace
C. Electric arc furnace	D. Open hearth furnace
E. Electric induction furnace	F. Pot furnace
G. Reverberatory furnace	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-28. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FOR FOUNDRIES

Emission source	Uncontrolled fugitive particulate emission factor[a]		1976 U.S. iron production		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Cupola furnace operation	0.525	1.05	10,540[b]	11,645[b]	5,534	6,114
Electric arc furnace operation	3.75	7.5	2,982[c]	3,280[c]	11,183	12,300
Electric induction furnace operation	1.0	2.0	1,086[c]	1,196[c]	1,086	1,196
Reverberatory furnace operation	4.25	8.5	1,090[b]	1,200[b]	4,633	5,100
Pouring molten metal into molds	1.06	2.12	15,100[b]	16,700[b]	16,006	17,702
Casting shakeout	3.5	7.0	15,100[b]	16,700[b]	52,850	58,450
Cooling and cleaning castings	0.24	0.48	15,100[b]	16,700[b]	3,624	4,008
Finishing castings	0.005	0.01	15,100[b]	16,700[b]	76	84
Core sand and binder mixing	0.15	0.30	6,760[d]	7,446[d]	1,014	1,117
Core making	0.18	0.35	6,760[d]	7,446[d]	1,217	1,340
Core baking	1.36	2.71	6,760[d]	7,446[d]	9,194	10,127
Mold makeup	0.02	0.04	15,100[b]	16,700[b]	302	334
Total					106,719	117,872

[a] Reference 1. Mean value for any range given.

[b] Tons of metal produced in 1976. Reference 2.

[c] Tons of metal charged in 1976. Reference 2.

[d] Tons of sand used for molding in 1973. Reference 3.

Table 2-29. FUGITIVE PARTICULATE EMISSION FACTORS

DERIVED FROM AP-42

Type of furnace	Emission factor
Cupola furnace	0.05-1 kg/Mg iron[a] (0.1-2 lb/ton iron)
Crucible furnace	0.05-0.3 kg/Mg of metal processed[a] (0.1-0.6 lb/ton of metal processed)
Electric arc furnace	2.5-5 kg/Mg of metal charged[b] (5.0-10.0 lb/ton of metal charged) 0.53-1.74 kg/Mg of steel[c,d] (1.05-3.48 lb/ton of steel)
Open hearth furnace	0.05-0.45 kg/Mg of metal charged[a,e] (0.1-0.9 lb/ton of metal charged)
Electric induction furnace	1.0 kg/Mg of metal charged[a] (2.0 lb/ton of metal charged) 0.75 kg/Mg of iron[b] (1.5 lb/ton of iron)
Pot furnace	0.2 kg/Mg[f] (0.4 lb/ton)
Reverberatory furnace	4.15-4.35 kg/Mg of copper[a] (8.3-8.7 lb/ton of copper)

[a] Engineering judgment, assumed 5% of uncontrolled primary emissions as reported in Reference 4.

[b] Reference 5.

[c] Reference 6.

[d] Reference 7.

[e] Reference 8.

[f] Engineering judgment, assumed 50% of uncontrolled primary emissions as reported in Reference 4.

Table 2-30 contains emission factors that were obtained from sources other than AP-42, but as the footnotes indicate, in most cases their derivation is unknown. The source of these factors must be verified before they can be considered for input into AP-42. Emission factors based on limited testing and engineering judgment must also undergo more extensive testing before being considered adequate for inclusion in AP-42.

Table 2-30. FUGITIVE PARTICULATE EMISSION FACTORS DERIVED FROM SOURCES OTHER THAN AP-42

Source of emission	Emission factor
Ductile iron innoculation	1.65-2.3 kg/Mg of iron[a,b,c] (3.3-4.5 lb/ton of iron)
Pouring molten metal into molds	0.05-2.07 kg/Mg of gray iron[a,c,d] (0.1-4.13 lb/ton of gray iron) 1.26 kg/Mg of copper[e] (2.52 lb/ton of copper) 0.47 kg/Mg of lead[e] (0.93 lb/ton of lead)
Casting shakeout	0.6-6.4 kg/Mg of iron[a,f] (1.2-12.8 lb/ton of iron)
Cooling and cleaning castings	0.08-0.4 kg/Mg of iron castings[a,f] (0.16-0.8 lb/ton of iron castings)
Finishing castings	0.005 kg/Mg iron castings[f] (0.01 lb/ton iron castings)
Core sand and binder mixing	0.15 kg/Mg of sand[g] (0.3 lb/ton of sand) 0.38-4.12 kg/Mg of iron[a,f] (0.75-8.24 lb/ton of iron)
Core making	0.18 kg/Mg of cores[g] (0.35 lb/ton of cores)
Core baking	0.015-2.7 kg/Mg of cores[f,h] (0.03-5.4 lb/ton of cores)
Mold makeup	0.02 kg/Mg iron castings[f] 0.04 lb/ton iron castings)

[a] Reference 6. Derivation of emission factor is unknown.

[b] Reference 7. Derivation of emission factor is unknown.

[c] Reference 9. Limited testing including melting, pouring, and innoculation.

[d] Reference 10. Derivation of emission factor is unknown.

[e] Reference 11. Derivation of emission factor is unknown.

[f] Reference 12. Derivation of emission factor is unknown.

[g] Reference 5. Derivation of emission factor is unknown.

[h] Engineering judgment, assumed all uncontrolled emissions as reported in Reference 13, as fugitive.

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2.5 MINERALS EXTRACTION AND BENEFICIATION

2.5.1 Emissions

Figure 2-13 depicts the general process flow in the minerals extraction industry, and Table 2-31 lists the emission sources noted in the process flow diagram. The minerals extraction industry encompasses a multitude of different mining operations. In this report, however, emissions are calculated for surface coal mining and crushed stone extraction only, and Tables 2-32 and 2-33 present estimates of uncontrolled fugitive emissions from the surface coal and crushed stone industries. Potential fugitive particulate emissions generated by the surface mining of 251,194,000 Mg (276,645 tons) of coal in 1973 are estimated to be 119,381 Mg (131,475 tons). Potential uncontrolled fugitive particulate emissions generated by the extraction of 961,155,000 Mg (1,058,541 tons) of stone in 1973 are estimated to be 529,020 Mg (582,621 tons).

2.5.2 Adequacy of Emission Factor Data

The emission factor for overburden removal of 0.0004 and 0.225 kg/Mg (0.0008 and 0.45 lb/ton) of ore are derived from separate sources. The lower emission rate is an estimate for an open pit copper mine,[5] whereas the higher rate is derived from a comparison with tests conducted around construction sites and aggregate handling systems.[2] Neither factor is now acceptable for inclusion in AP-42. Comparison with construction site or aggregate handling is not acceptable as a source, the emission factor for open pit copper mining will have to be substantiated further as to the extent and type of testing performed.

The emission factor of 0.0005 kg/Mg (0.001 lb/ton) for drilling and blasting is based on a personnel observation[5] and is therefore not adequate to be included in AP-42. The drilling and blasting emission factor of 0.08 kg/Mg (0.16 lb/ton) is derived from limited testing at a granite quarry.[6] With more extensive testing this factor may be substantiated as a factor for AP-42, in reference to granite quarries.

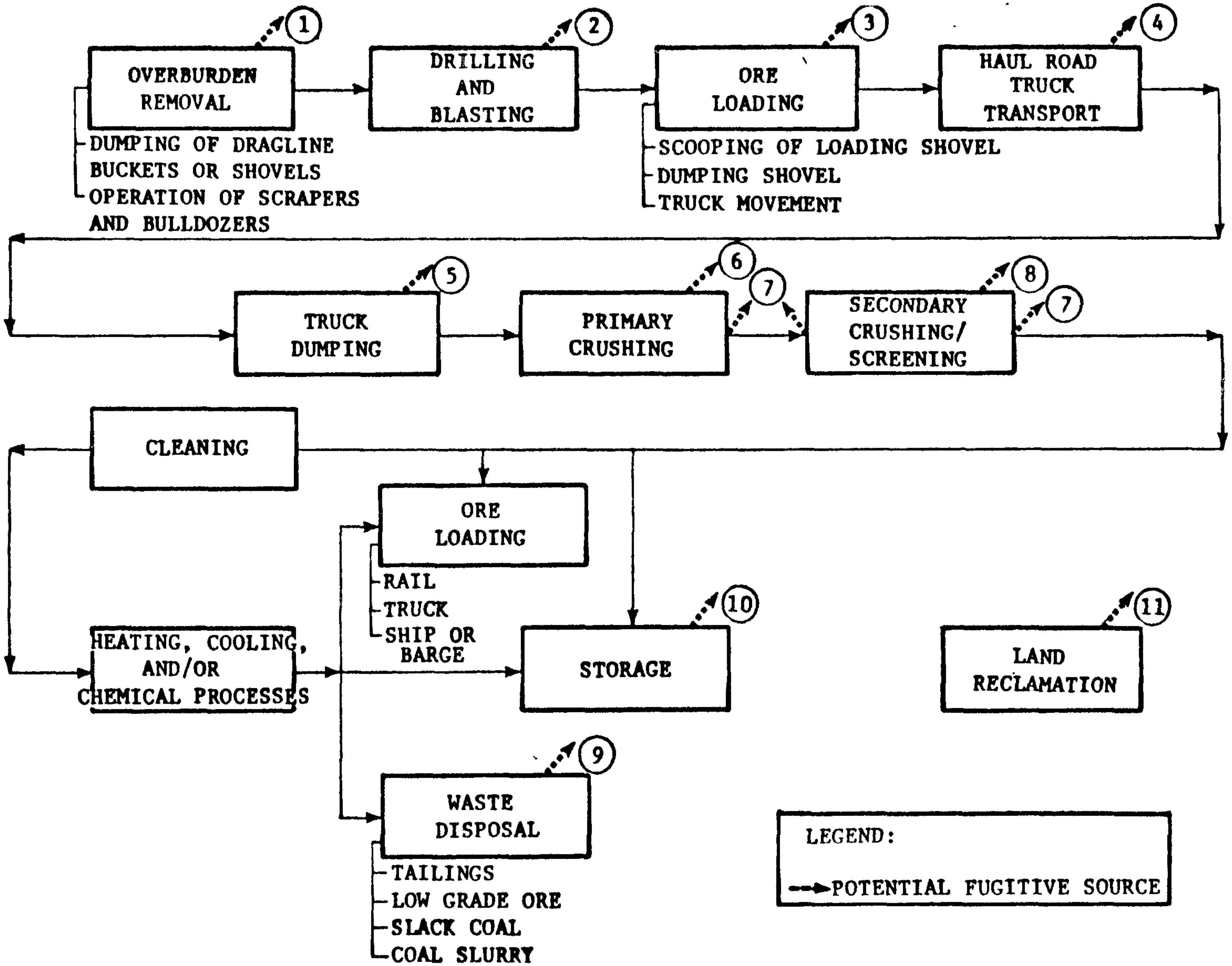

Figure 2-13. Process flow diagram for material extraction and beneficiation showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-31. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE MATERIAL EXTRACTION AND BENEFICIATION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Overburden removal	2. Drilling and blasting
3. Ore loading	4. Haul road truck transport
5. Truck dumping	6. Primary crushing
7. Transfer and conveying	8. Secondary crushing/ screening
9. Waste disposal	10. Storage
11. Land reclamation	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-32. ESTIMATED UNCONTROLLED PARTICULATE FUGITIVE EMISSIONS FOR THE SURFACE COAL MINING INDUSTRY

Emission source	Uncontrolled fugitive particulate emission[a]		1973 Bituminous and lignite coal production[b]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Overburden removal	0.225[c]	0.45[c]	251,194	276,645	56,519	62,245
Drilling and blasting	0.0005[d]	0.001[d]	125,597[e]	138,323[e]	63	69
Coal loading	0.05[c]	0.10[c]	251,194	276,645	12,560	13,832
Coal unloading	0.01[f]	0.02[f]	251,194	276,645	2,512	2,766
Primary crushing	0.01[g]	0.02[g]	251,194	276,645	2,512	2,766
Transfer and conveying	0.1[h]	0.2[h]	251,194	276,645	25,119	27,665
Secondary crushing/ screening	0.08[g]	0.16[g]	251,194	276,645	20,096	22,132
Waste disposal	i	i				
Total					119,381	131,475

[a] Reference 11.

[b] Strip mined coal only, Reference 1.

[c] Emission factor is on a per ton of coal mined basis, Reference 2.

[d] Reference 5. Estimate based on visual observation at open pit copper mine.

[e] Assume only 50% of coal is blasted.

[f] Reference 2. Estimated by reducing the EPA published emission factor for unloading crushed rock to account for the larger size of coal and its higher moisture content.

[g] Reference 3. Estimate based on total loss of 0.02 percent for rock crushing operation.

[h] Reference 4. Proportioned from a total fugitive emission factor of 0.22 kg/Mg (0.44 lb/ton) for western surface coal mines.

[i] Site specific problem, emissions cannot be quantified for the industry as a whole.

Table 2-33. ESTIMATED UNCONTROLLED PARTICULATE FUGITIVE EMISSIONS IN THE CRUSHED STONE INDUSTRY

Emission source	Uncontrolled fugitive particulate emission[a]		1973 total crushed stone production[b]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Overburden removal	0.0004[c]	0.0008[c]	961,155	1,058,541	384	423
Drilling and blasting	0.08[d]	0.16[d]	961,155	1,058,541	76,892	84,683
Rock loading	0.025[e]	0.05[e]	961,155	1,058,541	24,029	26,464
Truck unloading	0.02[f]	0.04[f]	961,155	1,058,541	19,223	21,171
Primary crushing	0.25[g]	0.5[g]	961,155	1,058,541	48,058[h]	52,927[h]
Transfer and conveying	0.075[i]	0.15[i]	961,155	1,058,541	72,087	79,391
Secondary crushing/ screening	0.75[j]	1.5[j]	961,155	1,058,541	288,347[k]	317,562[k]
Waste disposal	1	1	-	-	-	-
Total					529,020	582,621

[a] Reference 11.
[b] Reference 1.
[c] Reference 5. Estimate from comparison with emission rate for an active construction area.
[d] Reference 6. Estimate for granite drilling of 0.0004 kg/Mg (0.0008 lb/ton) and 0.08 kg/Mg (0.16 lb/ton) for granite blasting.
[e] Reference 7. Estimate from sampling of crushed rock by plant end loader.
[f] Reference 8. Estimate for dumping crushed rock onto storage piles.
[g] Reference 9. Includes both stack and fugitive emissions, 80% of which falls out on plant property.
[h] Represents a 80% fall out on plant property.
[i] References 2 and 10. Based on reported industry estimates of 0.075 kg/Mg (0.15 lb/ton) with 90% control.
[j] Reference 9. Includes stack and fugitive emissions, 60% of which falls out on plant property.
[k] Represents a 60% fall out on plant property.
[l] Site specific, cannot be estimated for the industry as a whole.

Both emission factors for ore loading, negligible to 0.05 kg/Mg (0.1 lb/ton), were obtained from limited testing at a granite quarry[6] and a coal mine.[2] Only with more extensive testing can these factors be considered adequate for inclusion in AP-42. The emission factor listed for loading of rock, 0.025 kg/Mg (0.05 lb/ton) is derived from limited source testing. More extensive testing is needed to substantiate this factor before it is incorporated into AP-42.

Neither of the emission factors given for truck dumping is acceptable for AP-42. The lower factor, 0.00017 kg/Mg (0.00034 lb/ton) of ore dumped, is derived from limited testing at a granite quarry.[6] The higher factor, 0.02 kg/Mg (0.04 lb/ton) of ore dumped, represents a percentage (12%) of the estimated total emissions given in Reference 4. Only further testing can substantiate these factors. The lower emission factors for coal and copper also require detailed testing before their value can be determined. The emission factor listed for truck dumping of copper ore and coal is estimated from limited testing at a rock quarry.[2] This emission factor is therefore not considered adequate for AP-42 for either copper or a coal dumping.

Fugitive emission rates for primary crushing were obtained from two sources. The factor of 0.25 kg/Mg (0.5 lb/ton) is now listed under stone crushing in AP-42[9] and has a rating of C. Further testing is needed to improve this rating. The factor listed for coal crushing[3] is not adequate for AP-42 inclusion because the type and extent of testing used to derive this factor are unknown.

All emission factors listed for transfer and conveying were derived from limited testing at a granite quarry[6] and coal mine.[4] It is now believed that these sources were not sufficiently tested for the emission factors to be included in AP-42. More extensive testing is suggested to substantiate these factors.

The emission factor of 0.75 kg/Mg (1.5 lb/ton) of rock crushed now contained in AP-42 has a rating of C.[9] Limited testing at a granite quarry indicated emissions to be 0.022 kg/Mg (0.044 lb/ton).[6] More extensive testing could improve the previous rating of the AP-42 factor and further substantiate the factor for secondary granite crushing and screening. The emission factor for secondary crushing and screening of coal [0.08 kg/Mg (0.16 lb/ton) of coal crushed] is derived from a material balance.[3] Extensive testing would be required before its incorporation into AP-42.

The emission factor of negligible to 3.23 Mg/1000 m^2 per year (14.4 ton/acre per year) for waste disposal is derived from a factor listed in AP-42 for a heavy construction site.[9] This is not considered adequate for waste disposal emissions. Extensive testing will be required to develop a specific emission factor for each type of waste disposal.

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2.6 GRAIN ELEVATORS

2.6.1 Emissions

Figure 2-14 depicts the general process flow in the grain elevator industry, and Table 2-34 lists the emission sources noted in the process flow diagram. Uncontrolled particulate emission rates reported for country, terminal, and export grain elevators in AP-42[3] were used to estimate the 1973 total uncontrolled fugitive industry emission [1,238,127 Mg (1,364,803 tons)] shown in Table 2-35. Presented within this table are the emission factors, the total domestic grain production (1973), and the estimated particulate generated by specific process (e.g., unloading, loading, drying) operations. Headhouse emissions contribute the bulk of the grain industry elevator uncontrolled emissions (nearly 50 percent), followed by those (nearly 25 percent) generated by grain removal from the bins by tunnel belt.

2.6.2 Adequacy of Emission Factor Data

Grain elevators are classified as country, terminal, and export, according to their purpose and location. Country elevators operate principally during harvest season and hold grain only till a market is found to sell to terminals, exporters, and/or processors. Terminal elevators are large elevators that operate the year round. Export elevators are similar to terminals except that their main function is to load grain onto ships for export. Grain elevator particulate emissions (considered wholly fugitive) can occur from many different operations within any of the three elevator types described, including unloading (receiving), loading (shipping), drying, cleaning, headhouse (bags), tunnel belt, gallery belt, and belt trippers. Emission factors[3] determined for these operations are presented in Table 2-36, along with the incorporated multipliers that were used to represent a typical ratio of throughput to the amount of grain

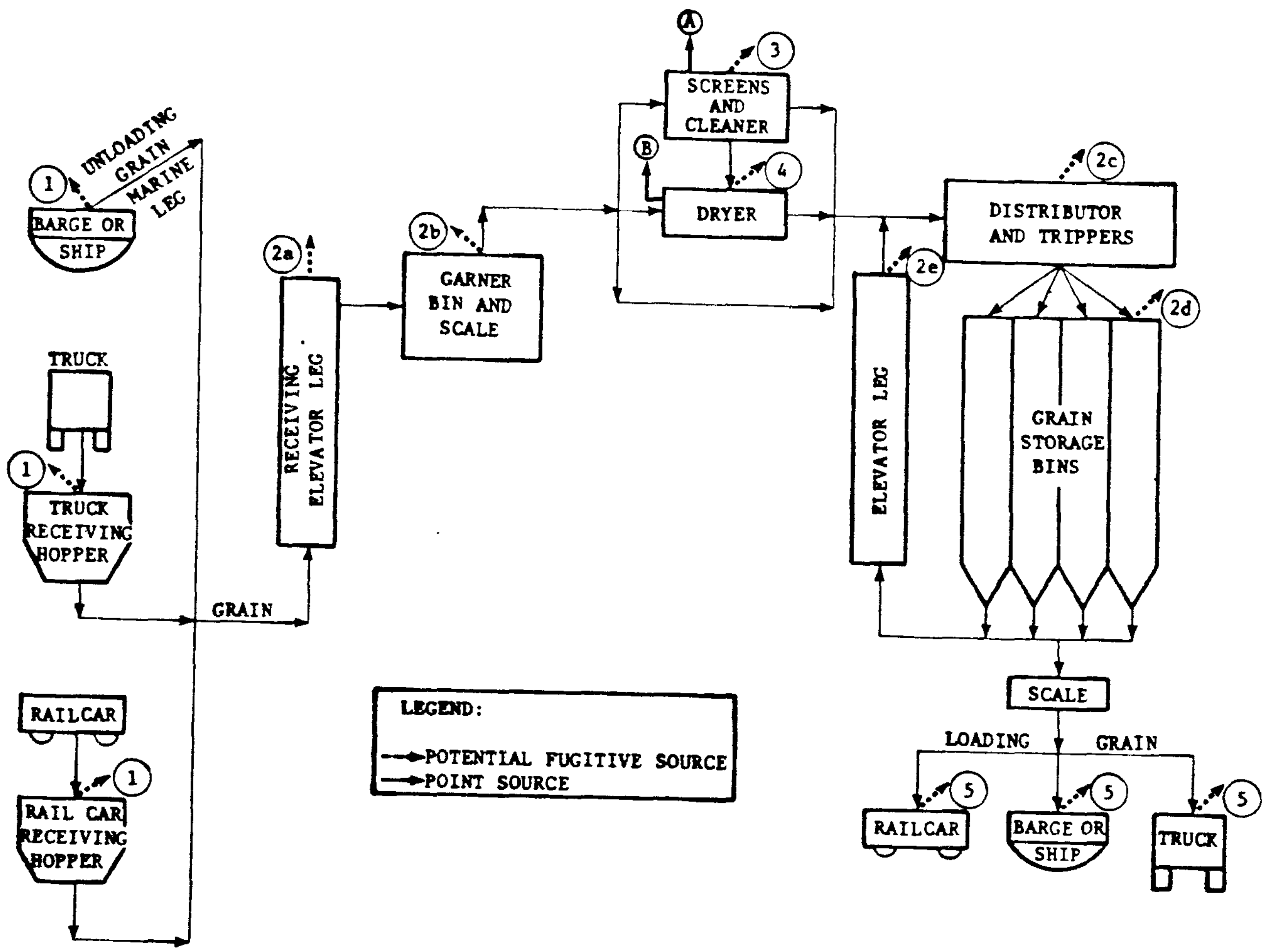

Figure 2-14. Process flow diagram for country and terminal grain elevators, showing origins of fugitive industrial process and point source particulate emissions.

Table 2-34. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE GRAIN ELEVATOR INDUSTRY PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
I. Terminal Elevators	
1. Receiving Truck unloading Railcar unloading Barge unloading 3. Screening and cleaning 4. Drying 5. Shipping	2. Transferring and conveying 2a. Receiving elevator leg and elevator head 2b. Garner and scale vents 2c. Distributor, trippers 2d. Storage bin vents 2e. Turning
II. Country Elevators	
1. Receiving Truck unloading Railcar unloading Barge unloading 3. Screening and cleaning 4. Drying 5. Shipping Truck loading Railcar loading Barge loading	2. Transferring and conveying which includes following: 2a. Receiving elevator leg and head 2b. Garner and scale vents 2c. Distributor, trippers and spouting 2d. Storage bin vents 2e. Turning
Point sources	
A. Screens and cleaners	B. Dryers

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-35. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM DOMESTIC FEED AND GRAIN ELEVATORS

Emission source	Uncontrolled fugitive particulate emission factor[a]		1973 U.S. grain production[b]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Terminal elevators						
Unloading (receiving)	0.5	1.0	47,762	52,649	23,881	26,325
Loading (shipping)	0.15	0.30	47,762	52,649	7,164	7,897
Removal from bins (tunnel belt)	1.4	2.8	47,762	52,649	66,867	73,709
Drying	0.05	0.10	47,762	52,649	2,388	2,632
Cleaning	0.3	0.6	47,762	52,649	14,329	15,795
Headhouse (legs)	2.25	4.50	47,762	52,649	107,465	118,460
Tripper (gallery belt)	0.85	1.70	47,762	52,649	40,598	44,752
Country elevators						
Unloading (receiving)	0.3	0.6	157,335	173,432	47,201	52,030
Loading (shipping)	0.15	0.30	157,335	173,432	23,600	26,015
Removal from bins	1.05	2.10	157,335	173,432	165,202	182,104
Drying	0.1	0.2	157,335	173,432	15,734	17,343
Cleaning	0.15	0.30	157,335	173,432	23,600	26,015
Headhouse (legs)	2.35	4.70	157,335	173,432	369,737	407,565
Export elevators						
Unloading (receiving)	0.5	1.0	75,858	83,619	37,929	41,810
Loading (shipping)	0.5	1.0	75,858	83,619	37,929	41,810
Removal from bins (tunnel belt)	0.85	1.70	75,858	83,619	64,479	71,076
Drying	0.005	0.010	75,858	83,619	379	418
Cleaning	0.3	0.6	75,858	83,619	22,757	25,086
Headhouse (legs)	1.65	3.30	75,858	83,619	125,166	137,971
Tripper (gallery belt)	0.55	1.10	75,858	83,619	41,722	45,990
Total					1,238,127	1,364,803

[a]Reference 3. Factors are expressed as units per weight of grain received or shipped.

[b]Of the 280,955,114 Mg (309,700,000 tons) total domestic grain produced (1973), 56, 17, and 27 percent was handled by country elevators, inland terminals, and port (or export) terminals, respectively.[1,2]

Table 2-36. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS BASED ON AMOUNT OF GRAIN RECEIVED OR SHIPPED[a]

Type of source	Emission factor, lb/ton processed	x	Typical ratio of tons processed to tons received or shipped[d]	x	Emission factor, lb/ton received or shipped
Terminal elevators					
Unloading (receiving	1.0		1.0		1.0
Loading (shipping)	0.3		1.0		0.3
Removal from bins (tunnel belt)	1.4		2.0		2.8
Drying[b]	1.1		0.1		0.1
Cleaning[c]	3.0		0.2		0.6
Headhouse (legs)	1.5		3.0		4.5
Tripper (gallery belt)	1.0		1.7		1.7
Country elevators					
Unloading (receiving)	0.6		1.0		0.6
Loading (shipping)	0.3		1.0		0.3
Removal from bins	1.0		2.1		2.1
Drying[b]	0.7		0.3		0.2
Cleaning[c]	3.0		0.1		0.3
Headhouse (bags)	1.5		3.1		4.7
Export elevators					
Unloading (receiving)	1.0		1.0		1.0
Loading (shipping)	1.0		1.0		1.0
Removal from bins (tunnel belt)	1.4		1.2		1.7
Drying[b]	1.1		0.01		0.01
Cleaning[c]	3.0		0.2		0.6
Headhouse (legs)	1.5		2.2		3.3
Tripper (gallery belt)	1.0		1.1		1.1

[a] Assume that over a long term the amount received is approximately equal to amount shipped.[3]

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

[c] Emission factor of 3.0 for cleaning is an average value which may range from <0.5 for wheat up to 6.0 for corn.

[d] Ratios shown are average values taken from a survey of many elevators across the U.S. These ratios can be considerably different for any individual elevator or group of elevators in the same locale.

shipped or received at each operation. These factors (extensively developed through source test evaluation by Midwest Research Institute) are quite reliable for each of the individual operations, and no further emissions investigation should be necessary for revision to AP-42.

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2.7 PORTLAND CEMENT MANUFACTURING

2.7.1 Emissions

Figure 2-15 depicts the general process flow for portland cement manufacturing, and Table 2-37 lists the emission sources noted in the process flow diagram. Sources of fugitive dust in portland cement processing are (1) raw material handling and storage, (2) crushing and screening, (3) grinding and blending (dry process only), (4) clinker/gypsum finish grinding, and (5) loading and packaging. Table 2-38 shows that estimated uncontrolled total fugitive particulate emissions from these processes in 1973 was 697,589 Mg (768,961 tons). Also shown are emission factors, total U.S. raw material consumption in 1973, and the estimated uncontrolled emissions determined for specific process operations. Table 2-39 provides a breakdown of the raw materials used in the 1973 domestic production of portland cement.[3] The principal process sources of fugitive emissions are (1) loading, storage, and load-out of clinker/gypsum; (2) raw material loading, storage, and transferring to conveyer (via clam shell); and (3) vibrating screen and secondary crushing. These operations generate 40, 35, and 15 percent, respectively, of the total estimated uncontrolled fugitive emissions from the industry.

2.7.2 Adequacy of Emission Factor Data

The fugitive emission factor range for initial unloading of limestone, gypsum, iron ore, clay, and sand was based on an emission range of 0.015 to 0.2 kg/Mg (0.03 to 0.4 lb/ton) of raw material, which was established for taconite and coal railcar/barge unloading. These factors were derived from data presented in References 1 and 2. Factors for raw material charging (via truck dumping) to primary crusher were obtained from Reference 4 and are based on limited test data and engineering judgment. As reported in that reference:

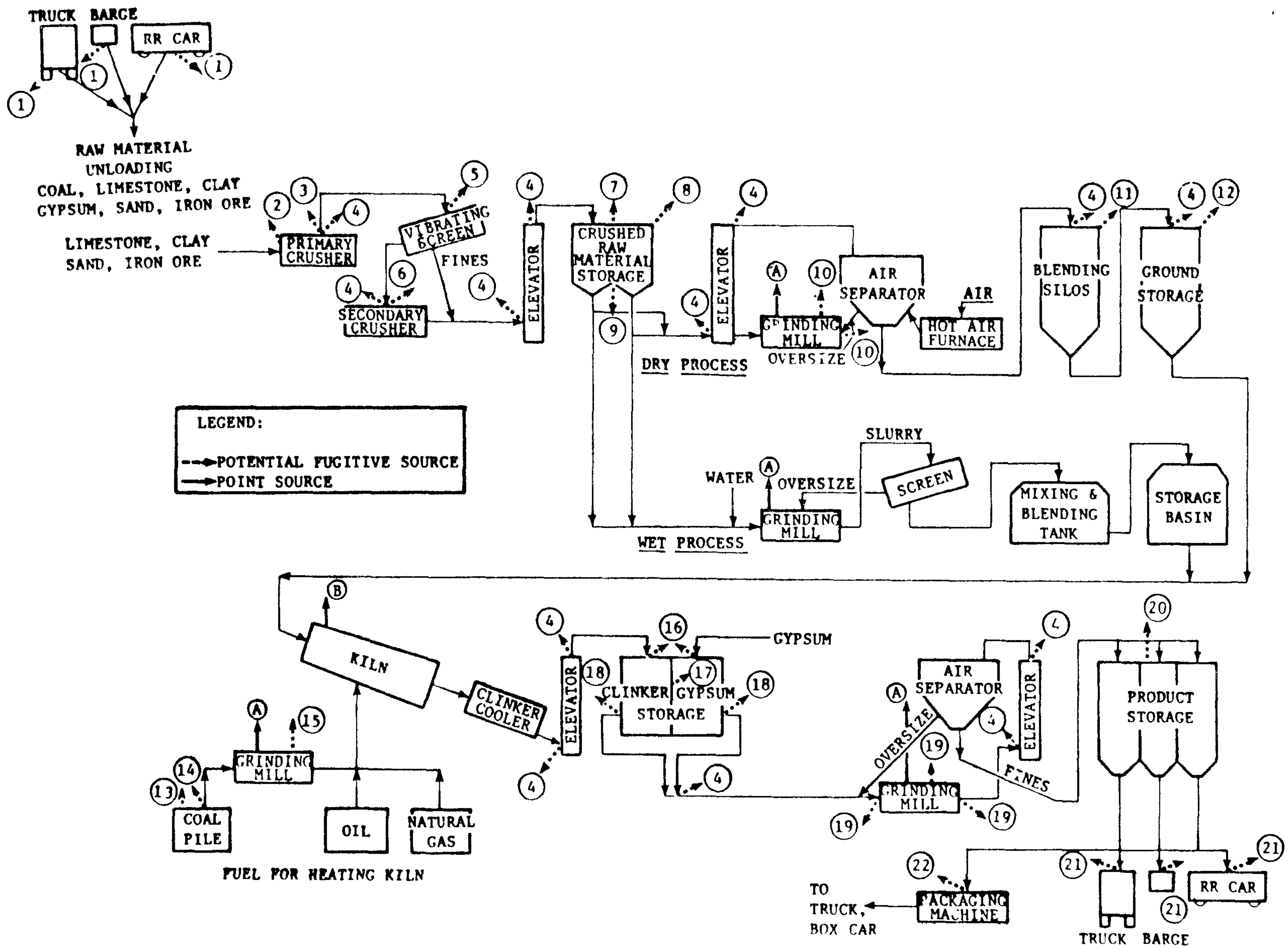

Figure 2-15. Process flow diagram for portland cement manufacturing showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-37. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE PORTLAND CEMENT PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Raw material unloading (rail, barge, truck) gypsum, iron ore, clay, limestone, sand, coal	2. Raw material charging to primary crusher
3. Primary crusher	4. Transfer points and associated conveying
5. Vibrating screen	6. Secondary crusher
7. Unloading outfall to storage	8. Raw material storage
9. Transfer to conveyor via clamshell	10. Raw grinding mill and feed/ discharge exhaust systems
11. Raw blending	12. Blended material storage
13. Coal storage	14. Transfer of coal to grinding mills
15. Leakage from coal grinding mills	16. Unloading-clinker/gypsum outfall to storage
17. Clinker/gypsum storage	18. Clinker/gypsum load-out
19. Finish grinding with leaks from mill and from feed/ discharge exhaust systems	20. Cement silo vents
21. Cement loading	22. Cement packaging
Point sources	
A. Grinders	B. Cement kilns

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-38. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM PORTLAND CEMENT MANUFACTURING

Emission source	Uncontrolled fugitive particulate emission factor[a]		1973 domestic raw material consumption[3]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	ton/yr
Raw material unloading (gypsum, iron ore, clay, limestone, sand)	0.1075	0.2150	126,269	139,188	13,574	14,963
Raw material charging to primary crusher	0.01	0.02	122,411[b]	134,935[b]	1,224	1,349
Primary crusher	0.25	0.50	122,411[b]	134,935[b]	30,603	33,734
Transfer points and associated conveying	0.15	0.30	126,269	139,188	18,940	20,878
Vibrating screen and secondary crushing	0.75	1.50	122,411[b]	134,935[b]	91,808	101,201
Raw material loading, storage, and transferring to conveyor (via clam shell)	2.0	4.0	122,411[b]	134,935[b]	244,822	269,870
Raw grinding mill and feed/discharge exhaust systems	0.05	0.10	53,861[c]	59,371[c]	2,693	2,969
Raw blending and blended material storage	0.025	0.050	53,861[c]	59,371[c]	1,347	1,484
Loading, storage, and loading out of clinker/ gypsum	3.75	7.50	74,811[d]	82,465[d]	280,541	309,244
Finish grinding with leaks from mill and feed/discharge exhaust system	0.05[e]	0.10[e]	75,728[f]	83,476[f]	3,786	4,174
Cement loading	0.118[e]	0.236[e]	69,670[g]	76,798[g]	8,221	9,062
Cement packaging	0.005[e]	0.010[e]	6,058[g]	6,678[g]	30	33
Total					697,589	768,961

[a]Reference 8. Some factors consist as arithmetic averages of emission factor ranges presented. Emission rates are expressed as units per unit weight of raw material processed.

[b]Excludes the weight of gypsum (and anhydrite) from the annual tonnage of raw materials consumed.

[c]Considers 44 percent of the industry's raw material is processed by these dry methods (grinding, air separation, etc.) prior to calcination.[3]

[d]Reference 3. Considers both the 70,952,733 Mg (78,212,000 tons) weight of clinker and 3,858,257 Mg (4,253,000 tons) of gypsum.

[e]Factors are expressed as units per unit weight of end product Portland cement produced.

[f]1973 production of finished cement (Portland).[3]

[g]Considers that bulk cement shipments consisted of 92 percent of the total 1973 production, whereas bag cement shipment/packaging was 8 percent.[3]

Table 2-39. RAW MATERIALS USED IN PRODUCING PORTLAND CEMENT IN THE UNITED STATES[a,b]

Raw materials	1973 raw materials usage, 1000 Mg	1000 tons
Calcareous:		
Limestone (include aragonite)	78,652	86,699
Cement rock (includes marl)	23,647	26,067
Oystershell	4,667	5,144
Argillaceous:		
Clay	7,195	7,931
Shale	3,719	4,099
Other (includes staurolite, bauxite, aluminum dross, pumice, and volcanic material)	218	240
Siliceous:		
Sand	1,862	2,053
Sandstone and quartz	679	748
Ferrous:		
Iron ore, pyrites, millscale, and other iron-bearing material	878	968
Other:		
Gypsum and anhydrite	3,858	4,253
Blast furnace slag	619	682
Fly ash	271	299
Other	4	5
Total	126,269	139,188

[a] Includes Puerto Rico.

[b] Reference 3.

"Midwest Research Institute, in a sampling study of aggregate handling operations, estimated that dumping of crushed rock or gravel onto storage piles accounted for about 12 percent of the total emissions of 0.16 kg/Mg (0.33 lb/ton) from handling, or 0.02 kg/Mg (0.04 lb/ton). The truck dumping operation was not sampled in isolation from the other handling operations and the estimate of 12 percent was partially subjective. This emission factor for dumping of aggregate onto storage piles was recently published in Supplement 5 of EPA's Compilation of Air Pollution Emission Factors.[5]

Monsanto Research determined an emission rate of 0.00017 kg/Mg (0.00034 lb/ton) for truck unloading at the hopper of a primary crusher.[7] The material being handled was quarried granite with very little fine material present."

The factors of 0.1 to 0.2 kg/Mg (0.2 to 0.4 lb/ton) of material handled for transfer points and associated conveying were also obtained from Reference 4. These factors represent total transfer and conveying operations at coal mines and are assumed to be the same for portland cement manufacture. None of the factors presented are founded on emission testing at cement production facilities.

Emission factors for the primary crusher [0.25 kg/Mg (0.5 lb/ton) of rock crushed] and the vibrating screen and secondary crusher [0.75 kg/Mg (1.5 lb/ton) screened] were taken from AP-42.[5] These factors represent uncontrolled fugitive emissions for stone crushing facilities and are not specific to portland cement. The particulate emission factor for cement loading [0.118 kg/Mg (0.236 lb/ton) of cement loaded] was obtained from Reference 6. This was based on tests of mechanical unloading of cement to a hopper and subsequent transport of cement by enclosed bucket elevator to elevated bins with a fabric sock over the bin vent. This emission rate was estimated to approximate truck, rail, or barge loadout, and is not regarded as reliable for inclusion in AP-42.

Emission rates for the remaining sources listed in Table 2-40 were determined by engineering judgment and based on observations made during specific plant visits. These emission factors also should not be regarded as reliable for documentation in AP-42.

Table 2-40. FUGITIVE PARTICULATE SOURCES AND EMISSION RATES DETERMINED FROM OBSERVATIONS[9]

Source	Uncontrolled fugitive emission factor
Raw material loading, storage, and transfer to conveyor (via clamshell)	1.5-2.5 kg/Mg (3.0-5.0 lb/ton) of raw material handled
Raw material grinding mill and feed/discharge exhaust system	0.05 kg/Mg (0.1 lb/ton) of raw material milled
Raw blending and blended of raw material storage	0.02 kg/Mg (0.05 lb/ton) material blended
Loading, storage, and load-out of clinker/gypsum	2.5-5.0 kg/Mg (5.0-10.0 lb/ton) of clinker and gypsum handled
Finish grinding with leakage from mill and feed/discharge exhaust systems	0.05 kg/Mg (0.1 lb/ton) of cement produced
Cement packaging	Negligible - 0.005 kg/Mg (negligible - 0.01 lb/ton) of cement packaged

REFERENCES FOR SECTION 2.7

1. Cross, F.L. Jr. and Forehand, G.D. Air Pollution Emissions from Bulk Loading Facilities, Volume 6, Environmental Nomograph Series. Technomic Publishing Co., Inc., Westport, Connecticut, 1975. pp. 3-4.

2. Environmental Assessment of Coal Transportation. PEDCo Environmental Specialists, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1321, Task 40, October 15, 1976. pp. 4-28 and 4-51.

3. Ela, R.E. Cement. Mineral Yearbook, 1973. Volume I Metals, Minerals, and Fuels. U.S. Department of the Interior. Bureau of Mines. Washington, D.C. 1975.

4. Evaluation of Fugitive Dust from Mining, Task 1 Report. PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. Prepared for Industrial Environmental Research Laboratory/REHD, U.S. Environmental Protection Agency, Cincinnati, Ohio. Contract No. 68-02-1321, Task No. 36, June 1976.

5. Compilation of Air Pollution Emission Factors, AP-42. U.S. Environmental Protection Agency, Office of Air and Waste Management, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

6. Personal communication to John M. Zoller, PEDCo Environmental, Inc., from T.R. Blackwood, Monsanto Research Corporation, Dayton Laboratory, 1515 Nicholas Road, Dayton, Ohio. October 18, 1976.

7. Chalekode, P.K. and J.A. Peters, Assessment of Open Sources. Monsanto Research Corporation, Dayton, Ohio. (Presented at Third National Conference on Energy and the Environment. College Corner, Ohio. October 1, 1975.) 9 p.

8. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.8 LIME MANUFACTURING

2.8.1 Emissions

Figure 2-16 depicts the general process flow in lime manufacturing, and Table 2-41 lists the emission sources noted in the process flow diagram. An assessment has been made of uncontrolled fugitive particulate emissions from the principal lime manufacturing sources listed in Table 2-42. This table also presents uncontrolled fugitive emission factors, total domestic lime produced in 1973, and the estimated uncontrolled emissions per processing source. The total potential fugitive emissions from the industry was determined to be 44,824 Mg (49,410 tons), approximately 60 percent of which occur from secondary crushing and screening. Primary crushing/screening and associated conveying/transferring points contribute 19 and 17 percent, respectively.

2.8.2 Adequacy of Emission Factor Data

Lime manufacture entails the calcination of limestone to cause the release of carbon dioxide and formation of calcium oxide (or quicklime). Major fugitive particulate emission sources are the primary and secondary crushing/screening of ore and various conveying/transferring points. An emission factor range of 0.00017 kg/Mg (0.00034 lb/ton) (Monsanto Research Corporation) to 0.02 kg/Mg (0.04 lb/ton) (Midwest Research Institute) of rock charged was determined for limestone (dolomite) charging to primary crushers.[1] This was based on the truck dumping of quarried granite (with very little fines present) and crushed rock (gravel), rather than on actual limestone handling at a lime manufacturing facility. Uncontrolled particulate emissions from primary and secondary crushing/screening [0.25 and 0.75 kg/Mg (0.5 and 1.5 lb/ton) of limestone entering the primary crusher] are listed in AP-42 under overall rock-handling processes.[4] It is unknown what type of stone quarrying operation this refers to or what (if any) emission testing was conducted. An emission

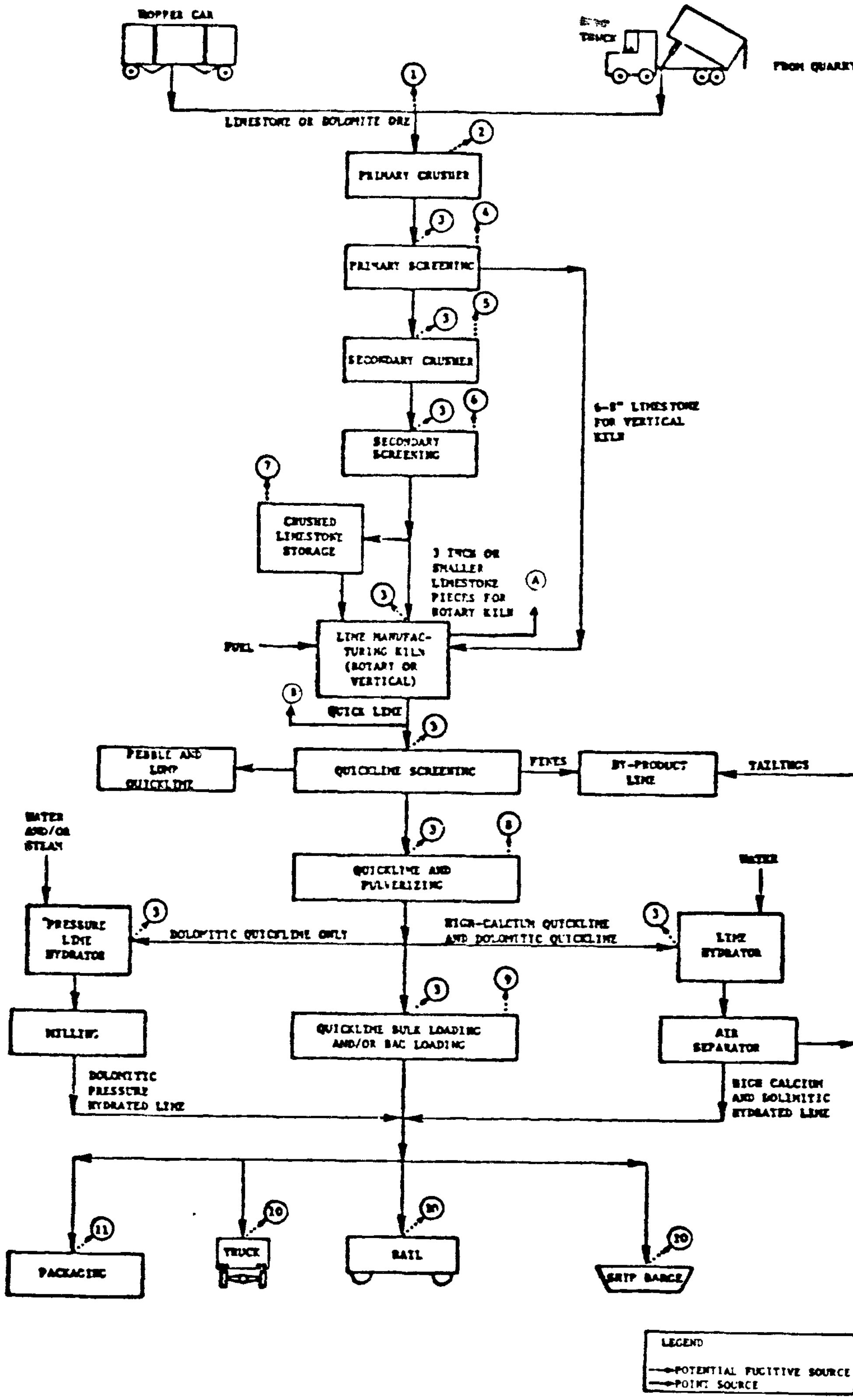

Figure 2-16. Process flow diagram for lime manufacturing showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-41. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE LIME MANUFACTURING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Limestone/dolomite charging to primary crusher	2. Primary crushing
3. Transfer points and associated conveying	4. Primary screening
5. Secondary crushing	6. Secondary screening
7. Crushed limestone storage	8. Quicklime screening
9. Quicklime and hydrated lime crushing and pulverizing with leaks from mill and feed/discharge exhaust systems	10. Lime product silo vents
11. Truck,rail, ship/barge loading of quicklime and hydrated lime	12. Packaging quicklime and hydrated lime
Point sources	
A. Lime kiln	B. Cooler

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-42. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE MANUFACTURE OF LIME

Emission source	Uncontrolled fugitive particulate emission factor[a]		1973 total U.S. lime manufactured[3]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Limestone/dolomite charging to primary crusher	0.02[b]	0.01[b]	35,431[c]	39,056[c]	355	390
Primary crushing and screening	0.25[b]	0.50[b]	35,431[c]	39,056[c]	8,858	9,764
Transfer points and associated conveying	0.4	0.8	19,133	21,090	7,653	8,436
Secondary crushing and screening	0.75[b]	1.50[b]	35,431[c]	39,056[c]	26,573	29,292
Quicklime and hydrated lime crushing/pulverizing/screening with leaks from mill and from feed/discharge exhaust systems	0.05	0.10	19,133	21,090	957	1,055
Truck, rail, ship/barge loading of quicklime and hydrated lime (including lime product silo vents)	0.118	0.236	6,314[d]	6,960[d]	745	821
Packaged quicklime and hydrated lime	0.005	0.010	6,314[d]	6,960[d]	32	35
Total					44,824	49,410

[a] Reference 7. Factors are expressed as units per unit weight of lime (quicklime, hydrated lime, dead-burned dolomite) produced.

[b] Factors are expressed as units per unit weight of raw material handled.

[c] Reference 2. Annual end product lime is theoretically 54 percent of the input rock weight.

[d] Reference 2. Approximately 33 percent of the total domestic lime production (1973) is bulk loaded while 33 percent is packaged and the remaining 34 percent is contained for captive usage.

factor of 0.4 kg/Mg (0.8 lb/ton) of lime produced is available to quantify associated conveying and transfer point losses, but it is substaniated solely by emissions generated in the handling of dry phosphate rock.[5] Fugitive emissions occurring as leaks from the mill and feed/discharge exhaust systems and those from quicklime (and hydrated lime) crushing/pulverizing and screening have been determined to be 0.05 kg/Mg (0.1 lb/ton) of quicklime (and hydrated lime) produced. This value is based on engineering judgment regarding their similarities to controlled emissions from cement milling. Similarly, the determined emission factor of 0.118 kg/Mg (0.236 lb/ton) of lime products loaded encompasses truck, rail, and ship/barge loading of quicklime (and hydrated lime), as well as lime product silo vents, and are based on hydraulic cement loading.[6] The estimated emission factor for quicklime (and hydrated lime) [negligible to 0.005 kg/Mg (0.01 lb/ton) of lime products packaged] is based on field observation at particular lime facilities and various emission tests made of similar controlled sources. None of these factors are believed to be reliable enough for documentation in AP-42. Only actual source testing will produce such reliable factors.

REFERENCES FOR SECTION 2.8

1. Evaluation of Fugitive Dust from Mining, Task 1 Report. PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. Prepared for Industrial Environmental Research Laboratory/REDH, U.S.S Environmental Protection Agency, Cincinnati, Ohio. Contract No. 68-02-1321, Task No. 36, June 1976.

2. Personal Communication Between J.W. Pressler, Bureau of Mines, and J. Thomas Bertke, PEDCo Environmental, Inc. October 1977.

3. Minerals Yearbook 1973, Volume I, Metals, Minerals, and Fuels. U.S. Department of the Interior. Bureau of Mines. Washington, D.C. 1975.

4. Compilation of Air Pollutant Emission Factors. Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Management, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. February 1976.

5. Fugitive Dust from Mining Operations - Appendix Final Report, Task No. 10. Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. May 1975.

6. Personal Communication to John M. Zoller, PEDCo Environmental, Inc. from T.R. Blackwood of Monsanto Research Corporation. Dayton Laboratory. 1515 Nicholas Road, Dayton, Ohio. October 18, 1976.

7. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.9 CONCRETE BATCHING

2.9.1 Emissions

Uncontrolled fugitive particulate emissions from concrete production are most significant during the handling of cement and sand and gravel. Potential sources of dust emissions are the unloading/conveying of end product concrete (and aggregates) and the loading of dry-batched concrete mix. Figure 2-17 depicts the general process flow for concrete batching, and Table 2-43 lists the emission sources noted in the process flow diagram. The total uncontrolled fugitive particulate emissions from the industry were determined to be approximately 31,026 Mg (34,200) tons) in 1973. This estimation was based on a 1973 poured concrete volume of 261,000,000 m^3 (342,000,000 yd^3).[1] The emission factor used in this calculation was 0.12 kg/m^3 (0.2 lb/yd^3) from AP-42.[2,3]

2.9.2 Adequacy of Emission Factor Data

Batching operations involve the storing, conveying, and blending of cement and sand and gravel into concrete. Materials processing is conducted via elevators and weigh hoppers, then discharged into transport equipment (mixer trucks). Generated particulates consist principally of cement dust. A limited quantity of dust also occurs from sand and aggregate handling. An uncontrolled particulate emission factor of 0.12 kg/m^3 (0.2 lb per/yd^3) of concrete is available from AP-42, and although it carries an average reliability ranking of C, it is based on 1952 or earlier data.[2] Therefore, a current and more extensive testing should be performed to arrive at an uncontrolled (fugitive) particulate emissions figure that accurately represents concrete batching operations.

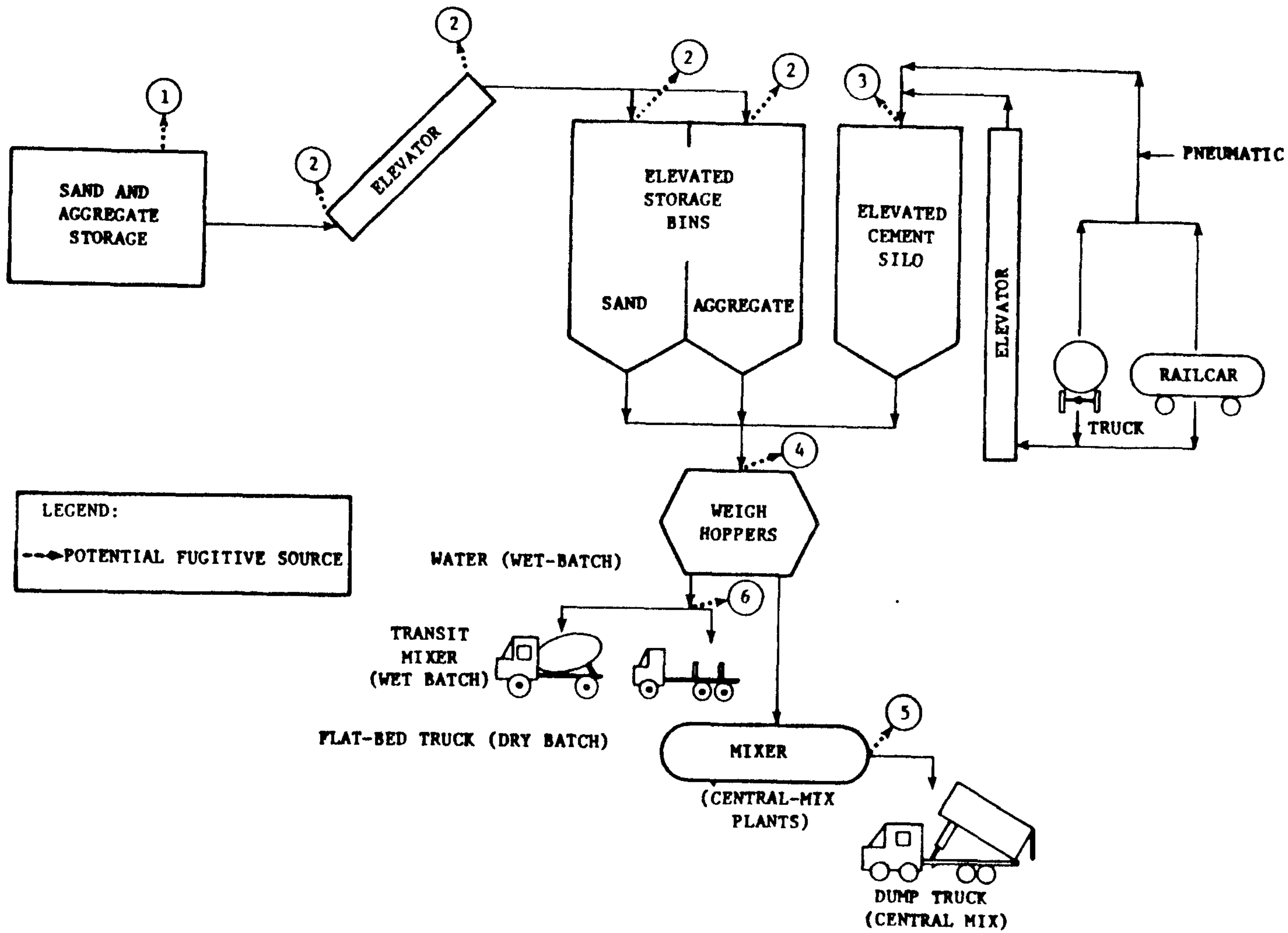

Figure 2-17. Process flow diagram for concrete batching showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-43. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE CONCRETE BATCHING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Sand aggregate storage	2. Transfer of sand and aggregate to elevated bins
3. Cement unloading to elevated storage silos	4. Weigh hopper loading of cement, sand, and aggregate
5. Mixer loading of cement, sand and aggregate (central mix plant)	6. Loading of transit mix (wet-batching) truck
7. Loading of dry-batch truck	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

REFERENCES FOR SECTION 2.9

1. Brown, B.C. Cement. Chapter from Mineral Facts and Problems, 1975 Edition. U.S. Department of the Interior. Bureau of Mines. 1975. 12 p.

2. Compilation of Air Pollutant Emission Factors. Second Edition. U.S. Environmental Protection Agency, Office of Air and Water Management, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. April, 1977.

3. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.10 ASPHALTIC CONCRETE PRODUCTION

2.10.1 Emissions

Figure 2-18 depicts the general process flow in asphaltic concrete production, and Table 2-44 lists the emission sources noted in the process flow diagram. Table 2-45 shows that potential uncontrolled fugitive particulate emissions from the asphaltic concrete industry were quantified to be 46,845 Mg (51,638 tons) in 1974. This table also presents uncontrolled fugitive emission factors, 1974 total domestic aggregate consumed by asphaltic concrete production, and estimated uncontrolled emissions per specific process source. The principal particulate emission sources concern aggregate-conveying elevators and the transfer of aggregate into cold storage bins. These separately comprise 60 and 30 percent of the total industry emissions.

2.10.2 Adequacy of Emission Factor Data

Asphaltic concrete production involves the transfer/conveying of fine (sand) and coarse (e.g., gravel, crushed stone, crushed steel mill slag, or glass) aggregates to be heated and dried before uniform mixing/coating with hot asphalt and discharging to transport trucks. An uncontrolled fugitive particulate factor of negligible to 0.05 kg/Mg (0.1 lb/ton) of aggregate handled has been determined (Monsanto Research and Environmental Research Technology) for losses from unloading coarse/fine aggregate to storage bins and a factor of negligible to 0.1 kg/Mg (0.2 lb/ton) for elevator conveying of cold and dried (hot) aggregate. These determinations are based on similar processing at granite quarries and coal mining operations.[1] An uncontrolled fugitive emission rate ranging from negligible to 0.013 kg/Mg (0.026 lb/ton) of aggregate handled has been determined for the screening of hot aggregate, based on Monsanto Research Corporation test values for crushed granite processing.[3] Extensive particulate fugitive emission test sampling data from asphalt concrete batching plants are needed to obtain representative data for documentation in AP-42.

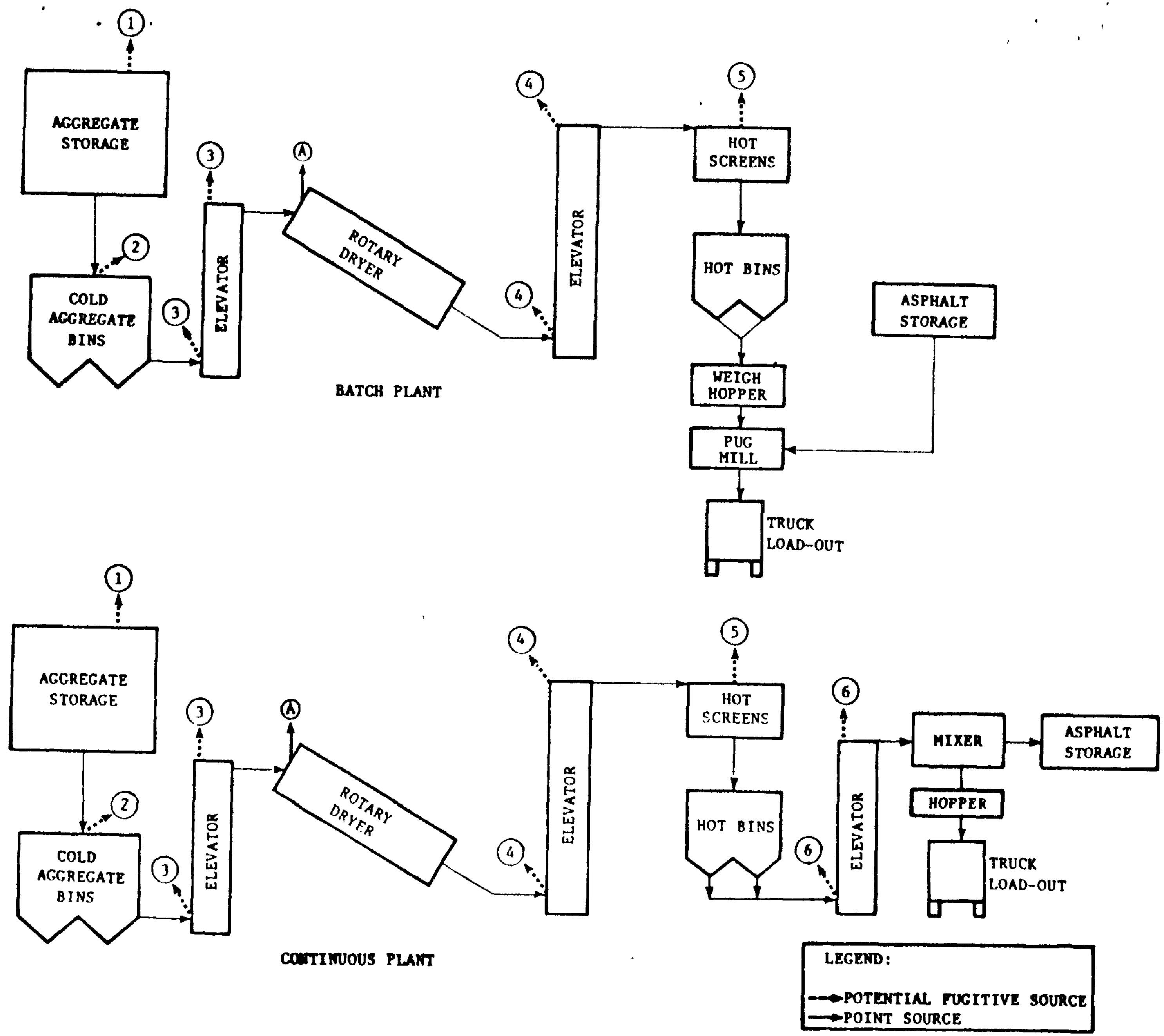

Figure 2-18. Process flow diagram for asphaltic concrete manufacturing showing uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-44. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE ASPHALTIC CONCRETE MANUFACTURING PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Storage of coarse and fine aggregate	2. Unloading coarse and fine aggregate to storage bins
3. Cold aggregate elevator	4. Dried aggregate elevator
5. Screening hot aggregate	6. Hot aggregate elevator (continuous mix plant)
Point sources	
A. Rotary dryer	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-45. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM ASPHALTIC CONCRETE PRODUCTION

Emission source	Uncontrolled fugitive particulate emission factor[a]		1974 U.S. aggregate consumption for asphaltic concrete production[b]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	Mg/yr	tons/yr
Unloading coarse and fine aggregate to cold storage bins	0.05	0.10	287,396	316,800	14,370	15,840
Cold and dried (hot) aggregate elevators	0.10	0.20	287,396	316,800	28,740	31,680
Screening hot aggregate	0.013	0.026	287,396	316,800	3,736	4,118
Total					46,845	51,638

[a] Reference 4. Factors are expressed as units per unit weight of aggregate processed.

[b] Reference 2. In 1974, asphalt paving hot mix plants produced 319,329,029 Mg (352,000,000 tons) of hot mix. Aggregate constitutes approximately 90 percent of this hot mix or 287,396,000 Mg (316,800,000 tons).

REFERENCES FOR SECTION 2.10

1. Evaluation of Fugitive Dust from Mining, Task 1 Report. PEDCo Environmental, Inc. Cincinnati, Ohio. Prepared for Industrial Environmental Research Laboratory/REHD, U.S. Environmental Protection Agency, Cincinnati, Ohio. Contract No. 68-02-1321, Task No. 36. June, 1976.

2. Khan, Z.S. and T.W. Hughes. Source Assessment: Asphalt Paving Hot Mix. Monsanto Research Corporation, Dayton, Ohio. Industrial Environmental Research Laboratory. U.S. Environmental Protection Agency. Contract No. 68-02-1874. March 1976.

3. Chalekode, P.K., and J.A. Peters, Assessment of Open Sources, Monsanto Research Corporation, Dayton, Ohio. Presented at Third National Conference on Energy and the Environment, College Corner, Ohio. October 1, 1975). 9 p.

4. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Cincinnati, Ohio. Contract No. 68-02-1375, Task No. 33. Environmental Protection Agency. March 1977.

2.11 LUMBER AND FURNITURE INDUSTRY

2.11.1 Emissions

Specific fugitive particulate emission sources at the sawmill are debarking, sawing, and sawdust handling operations. Log handling and bucking (log length shortening) are normally negligible sources of fugitive emissions. Emissions from furniture manufacturing occur principally from wood waste handling and storage. Figure 2-19 depicts the general process flow for the lumber and furniture industry, and Table 2-46 lists the emission sources noted in the process flow diagram. Table 2-47 indicates that potential uncontrolled emissions from these sources are 8,665 Mg (9,549 tons). This table also presents process source fugitive emission factors, 1976 domestic consumption of logs for lumber and lumber for furniture, and estimated total uncontrolled fugitive particulate emissions. The largest single source appears to be the sawing of logs for lumber, which accounts for nearly 80 percent of the total.

2.11.2 Adequacy of Emission Factor Data

Processing of logs for lumber and subsequent further processing for furniture manufacture begins at the sawmill. Principal operations to be considered as sources of fugitive emissions are log debarking; sawing; and sawdust pile loading, unloading, and storage. The respective emission factors are estimated to be 0.012 kg/Mg (0.024 lb/ton) of logs debarked, 0.175 kg/Mg (0.35 lb/ton) of logs sawed, and 0.5 kg/Mg (1.0 lb/ton) of sawdust handled.[2] Furniture manufacture fugitive emissions are assessed as emanating principally from the wood waste storage bin via venting and loadout. Fugitive particulate emission factors have been estimated at 0.5 kg/Mg (1.0 lb/ton) of wood waste stored and 1.0 kg/Mg (2.0 lb/ton) of wood waste loaded out.[2] All values noted are based either on material balance of waste produced

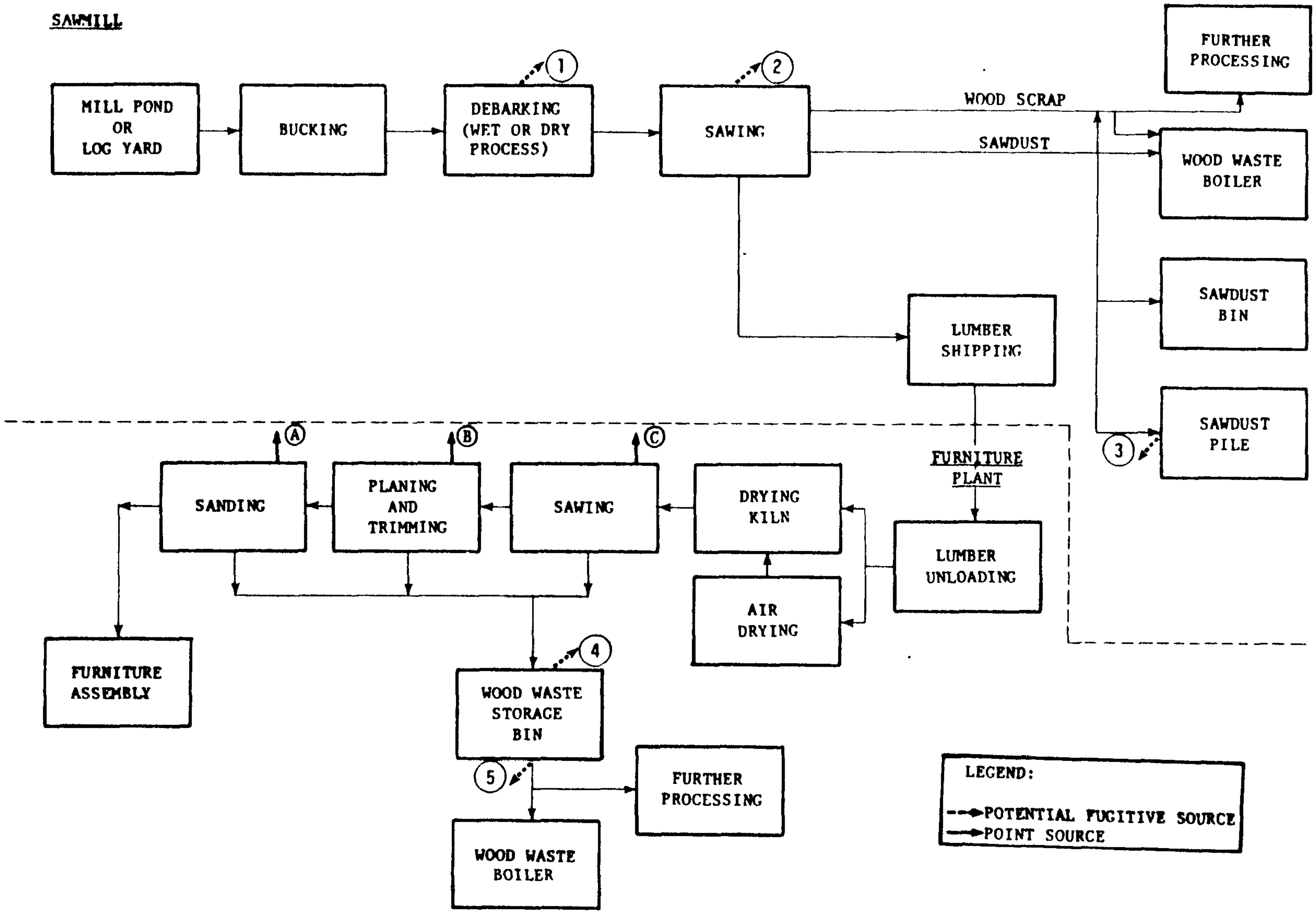

Figure 2-19. Process flow diagram for lumber and furniture production showing origin of uncontrolled fugitive industrial process and point source particulate emissions.

Table 2-46. IDENTIFICATION OF EMISSION SOURCES SHOWN ON THE LUMBER AND FURNITURE PRODUCTION PROCESS FLOW DIAGRAM[a]

Fugitive emission sources	
1. Debarking	2. Sawing
3. Sawdust pile	4. Wood waste storage bin vent
5. Wood waste storage bin loadout	
Point sources	
A. Sawing (cyclone exhaust)	B. Planing and trimming (cyclone exhaust)
C. Sander (cyclone exhaust)	

[a] Numeral and letter denotations refer to emission sources on the previous figure.

Table 2-47. ESTIMATED UNCONTROLLED FUGITIVE PARTICULATE EMISSIONS FROM THE LUMBER AND FURNITURE INDUSTRY

Emission source	Uncontrolled fugitive particulate emission factor[a]		1976 U.S. consumption of logs for lumber[b]		1976 U.S. lumber consumption for furniture[b]		Estimated uncontrolled emissions	
	kg/Mg	lb/ton	1000 Mg	1000 tons	1000 Mg	1000 tons	Mg/yr	tons/yr
Sawmill								
Log debarking	0.012	0.024	45,299[c]	49,933[c]	-	-	544	599
Sawing	0.175	0.350	40,444	44,582	-	-	7,078	7,802
Sawdust pile loading, unloading and storage	0.5[d]	1.0[d]	809[e]	892[e]	-	-	405	446
Furniture manufacturing								
Wood waste storage bin vent	0.5	1.0	-	-	425[f]	468[f]	213	234
Wood waste storage bin loadout	1.0	2.0	-	-	425[f]	468[f]	425	468
Total							8,665	9,549

[a] Reference 2. Sawmill emission factors are expressed as units per unit weight of logs processed. Furniture manufacture emission factors are expressed as units per unit weight of wood waste handled.

[b] Reference 1. Estimations.

[c] Considers an additional (assumed) weight of 12 percent for bark.[2]

[d] Factors are expressed as units per unit weight of sawdust handled.

[e] Assuming sawdust to constitute 8 percent in which 25 percent of that generated is stockpiled.

[f] Assuming wood waste to approximate 30 percent of the total 1,415,208 Mg (1,560,000 tons) of lumber consumed in furniture manufacture.

followed by judgment as to the airborne particulates or on observations made of specific plant operations during industry visits. None are based on actual test information and therefore do not qualify as having sufficient support for incorporation into AP-42.

REFERENCES FOR SECTION 2.11

1. Personal communication made between Dr. Muench, National Forest Products Association and J. Thomas Bertke, PEDCo Environmental, Inc. October 1977.

2. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. U.S. Environmental Protection Agency. Contract No. 68-02-1375 Task No 33. March 1977.

APPENDIX A

SUMMARY OF FUGITIVE PARTICULATE EMISSION FACTORS FOR POSSIBLE INCLUSION INTO AP-42

This appendix contains fugitive emission factors and particle characteristics in formats suitable for inclusion into AP-42. These are for the same industries as presented in this document with the exception of the following:

Coke manufacturing

Iron production

Steel production

Minerals extraction and beneficiation

Grain elevators

The U.S. Environmental Protection Agency in cooperation with the American Iron and Steel Institute (AISI) are presently performing studies to determine fugitive emission factors for coke manufacturing and iron and steel production. Since the factors resulting from their studies will be more reliable than those presently available, the presently available factors are not included in this appendix. The minerals extraction and beneficiation industry fugitive emission factors have not been entered into the appendix since AP-42 does not presently contain sections for these industries.

Since recently developed fugitive emission factors for grain elevators have already been entered into AP-42, they are not placed in this appendix.

For each revised AP-42 section, there is a listing of sources of potential uncontrolled fugitive emissions and the corresponding emission factor for each source. Included also is a short description of emission size characteristics when such information is available.

It is imperative to understand the limitations and applicability of the emission factors. Most of the emission factors were derived from one or a combination of the following methods:

1. Engineering judgement, assuming fugitive emissions to be equal to 5 percent of the stack emissions.

2. Comparison of fugitive emission source to an emission factor from a similar operation (who's derivation could be one of the described methods).

3. Engineering judgement based on observation of the process or similar processes.

4. Literature containing emission factors derived from very limited test data.

Therefore, the accuracy of most emission factors is considered extremely low and at best are order of magnitude estimates. It is therefore believed that these factors should not be entered into AP-42 because of the wide misuse they may receive. Additional fugitive particulate emission factors development is needed before entries can be made to AP-42.

7.1 PRIMARY ALUMINUM PRODUCTION

Potential sources of fugitive particulate emissions in the primary aluminum industry are bauxite grinding, materials handling, anode baking (see Table 7.1-3), and the prebake, horizontal soderberg, and vertical soderberg reduction cells (see Table 7.1-4). Size distribution of fugitive particulate emissions from reduction cells are assumed to be the same as presented in Table 7.1-2.

Table 7.1-4. POTENTIAL FUGITIVE EMISSION FACTORS FOR PRIMARY ALUMINUM PRODUCTION PROCESSES[a]

EMISSION FACTOR RATING: E

Type of operation	Total uncontrolled fugitive particulates[b]	
	lb/ton	kg/MT
Reduction cells		
Prebake	8.0	4.0
Horizontal Soderberg	20.2	10.1
Vertical Soderberg	22.4	11.2

[a] Emission factors represent that portion of the emission factor in Table 7.1-3 which is fugitive. Total inventories should therefore be based only on factors shown in Table 7.1-3.

[b] Reference 2.

ADDITIONAL REFERENCES FOR SECTION 7.1

No additional references.

7.3 COPPER SMELTERS

Potential sources of fugitive particulate emissions in the copper industry are roasting, smelting, converting, and fire refining. Table 7.3-2 shows the potential uncontrolled fugitive emission factors from these sources.

Fifteen percent of the particulate emissions from roasting are less than 10 µm and 50 percent of reverberatory furnace emissions are less than 37 µm.[5,6] The mean particulate diameter of converter emissions is 44 µm. Sixteen percent of pouring and casting emissions are less than 10 µm and 46 percent are less than 74 µm.[6]

Table 7.3-2. POTENTIAL FUGITIVE EMISSION FACTORS FOR PRIMARY COPPER SMELTERS WITHOUT CONTROLS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Roasting	23.00[b]	11.5
Reverberatory smelting furnace	8.50[c]	4.25
Converter	10.50[b,d]	5.25
Fire refining furnace (anode furnace and casting)	1.90[d,e]	0.95

[a] Factors are expressed in units per units of end product copper produced.

[b] Based on material balance using same percentage as estimated for SO_2 from reference 7.

[c] Reference 8.

[d] Reference 9.

[e] Reference 10.

ADDITIONAL REFERENCES FOR SECTION 7.3

5. Control Techniques for Lead Air Emissions. PEDCo Environmental, Inc. Contract No. 68-02-1375. Final Report. Cincinnati, Ohio. Publication No. 450/2-77-012. January 1978.

6. Shannon, L.J. and P.G. Gorman. Particulate Pollutant System Study, Vol. III - Emissions Characteristics. Midwest Research Institute. Prepared for U.S. Environmental Protection Agency. Contract No. 22-69-104. 1971.

7. Evaluation of the Controllability of Copper Smelter in the United States, Fugitive Emissions Section, Final Report Draft. Pacific Environmental Services, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1354, Task Order No. 8. November 1974.

8. A Study of Fugitive Emissions from Metallurgical Processes. Midwest Research Institute. Contract No. 68-02-2120. Monthly Progress Report No. 4. Kansas City, Missouri. November 20, 1975.

9. Evaluation of Sulfur Dioxide and Arsenic Control Techniques for ASARCO - Tacoma Copper Smelter. PEDCo Environmental, Inc. Prepared under Contract No. 68-02-1321, Task Order No. 35. Cincinnati, Ohio. September, 1976.

10. Personal communication from Phelps Dodge Corporation, New York, New York to Don Goodwin, U.S. Environmental Protection Agency, Emission Standards and Engineering Division. Research Triangle Park, North Carolina. January 21, 1977.

7.6 LEAD SMELTING

Potential sources of fugitive particulate emissions in the primary copper smelting processes are listed in Table 7.6-2 along with the emission factors for each source.

The following is a listing of size distributions of flue dust from updraft sintering machine effluent.[2] Though these are not fugitive emissions, the size distributions may closely resemble those of the fugitive emissions.

Size (μm)	Percent by weight
20-40	15-45
10-20	9-30
5-10	4-19
<5	1-10

Particulate fugitive emissions from the blast furnace consist basically of lead oxides, 92 percent of which are less than 4 μm in size.[2] Uncontrolled emissions from a lead dross reverberatory are mostly less than 1 μm and this may also be the case for the fugitive emission."

Table 7.6-2. POTENTIAL FUGITIVE EMISSION FACTORS FOR PRIMARY LEAD SMELTING PROCESSES WITHOUT CONTROLS

EMISSION FACTOR RATING: E

Process	Particulates[a,b] kg/MT	Particulates[a,b] lb/ton
Ore mixing and pelletizing (crushing)	1.13	2.26
Sinter machine leakage	0.34[c]	0.68
Sinter return handling	4.50	9.00
Sinter machine discharge, sinter crushing and screening	0.75[c]	1.50
Sinter transfer to dump area	0.10	0.20
Sinter product dump area	0.005	0.01
Car charging (conveyor loading and transfer) of sinter	0.25	0.50
Blast furnace (charging, blow condition, tapping)	0.0775	0.1550
Lead pouring to ladle, transferring, and slag pouring	0.465[d]	0.930
Slag cooling	0.235[e]	0.470
Zinc fuming furnace vents	2.3	4.6
Dross kettle	0.24	0.48
Reverberatory furnace leakage	1.5	3.0
Silver retort building	0.9	1.8
Lead Casting	0.435	0.870

[a] All factors are expressed in units per end product lead produced, except sinter operations which are expressed in units per sinter or sinter handled/transferred/charged.

[b] All emission factors are derived from Reference 8 except where noted.

[c] Engineering judgement using steel sinter machine leakage emission factor, References 9 and 10.

[d] Reference 2.

[e] Engineering judgement, estimated to be half the magnitude of lead pouring and ladling operations, Reference 2.

REFERENCES FOR SECTION 7.6

8. Silver Valley/Bunker Hill Smelter Environmental Investigation, Interim Report. PEDCo Environmental, Inc. Contract No. 68-02-1343, Task Order No. 8. Cincinnati, Ohio. February 1975.

9. Iverson, R.E. Meeting with U.S. Environmental Protection Agency and AISI on Steel Facility Emission Factors. April 14 and 15, 1976. U.S. Environmental Protection Agency Memorandum. June 7, 1976.

10. Spreight, G.E. Best Practicable Means in the Iron and Steel Industry. The Chemical Engineer. March 1973.

11. Control Techniques for Lead Air Emissions. PEDCo-Environmental Specialists, Inc. Prepared for U.S. Environmental Protection Agency, Emission Standards and Engineering Division. Contract No. 68-02-1375, Task Order No. 32. Research Triangle Park, North Carolina. Publication No. EPA 450/2-77-012. January 1978.

7.7 ZINC SMELTING

Potential sources of fugitive particulate emissions in the primary zinc smelting process are sintering, retort furnaces, and zinc casting. Table 7.7-2 shows a breakdown of these processes and the potential uncontrolled fugitive emission factors.

Particulate size data for fugitive emissions is unavailable. However, flue gas emission from sinter machines are mostly less than 10 μm in size and this may be similar to the size of fugitive emissions.[9]

Table 7.7-2. POTENTIAL FUGITIVE PARTICULATE EMISSION FACTORS FOR PRIMARY ZINC SMELTING WITHOUT CONTROLS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Sinter machine windbox discharge	0.68[b]	0.34
Sinter machine discharge, screens, and coke-sinter mixer	1.50[c]	0.75
Retort furnace building leakage and tapping	3.00[d]	1.50
Retort furnace residue discharge and cooling	1.25[e]	0.625
Zinc casting	2.52[f]	1.26

[a] Factors are expressed as units per end product zinc produced, except as noted.

[b] Engineering judgement average assuming 5 percent of stack emissions for sintering machine in iron production (Section 7.5), and Reference 5.

[c] Engineering judgement assuming that fugitive emission factor given for sintering machine in iron production (Reference 5) is similar for sintering in zinc production and Reference 6.

[d] Engineering judgement made assuming that emissions from retort building in primary lead smelting would be similar for primary zinc (Reference 7).

[e] Value based on observations made at a secondary zinc smelter which is similar to the primary zinc production operation.

[f] Engineering judgement assuming fugitive emissions from zinc casting equal to fugitive emissions from copper casting given in Reference 8.

ADDITIONAL REFERENCES FOR SECTION 7.7

5. Iversen, R.E. Meeting with U.S. Environmental Protection Agency and AISI on Steel Facility Emission Factors. April 14 and 15, 1976. U.S. Environmental Protection Agency Memorandum. June 7, 1976.

6. Scheuneman, J.J., M.D. High, and W.E. Bye. Air Pollution Aspects of the Iron and Steel Industry. U.S. Department of Health, Education, and Welfare, Division of Air Pollution. June 1963.

7. Silver Valley/Bunker Hill Smelter Environmental Investigation, Interim Report. PEDCo-Environmental Specialists, Inc. Prepared for U.S. Environmental Protection Agency, Region X. Contract No. 68-02-1343. Seattle, Washington. February 1975.

8. A Study of Fugitive Emissions from Metallurgical Processes. Midwest Research Institute, Contract No. 68-02-2120. Monthly Progress Report No. 4. Kansas City, Missouri. November 20, 1975.

9. Jones, H.R. Pollution Control in the Nonferrous Metals Industry. Noyes Data Corporation. Park Ridge, New Jersey. 1972.

7.8 SECONDARY ALUMINUM OPERATIONS

Potential sources of fugitive particulate emissions in secondary aluminum operations are the sweating furnace, chip dryer, reverberatory, crucible, and electric induction furnaces, hot dross handling and cooling, and fluxing. Table 7.8-2 shows the potential uncontrolled emission factors for these sources.

Ninety-five percent of particulates from sweating furnaces are less than 39 μm.[6] The maximum particulate size from fluxing and chlorinating is 2 μm.[7]

Table 7.8-2. POTENTIAL UNCONTROLLED FUGITIVE PARTICULATE EMISSION FACTORS FOR SECONDARY ALUMINUM OPERATIONS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Sweating furnace	0.72[b]	0.36
Chip (rotary) dryer	0.72[c]	0.36
Reverberatory furnace	0.22[b]	0.11
Crucible smelting furnace	0.09[b]	0.045
Electric induction furnace	0.09[d]	0.045
Hot dross handling and cooling	0.22[e]	0.11
Fluxing (chlorination)	50.0[b,f]	25.0

[a] All factors are expressed as units per unit of metal scrap processed.

[b] Engineering judgement assuming 5 percent of uncontrolled stack emissions from Table 7.8-1.

[c] Engineering judgement, assumed equal to sweat furnace.

[d] Engineering judgement, assumed equal to crucible furnace.

[e] Engineering judgement, assumed equal to reverberatory furnace.

[f] Factor expressed as units per units of chlorine used.

ADDITIONAL REFERENCES FOR SECTION 7.8

6. Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Vol. II. Final Draft. Radian Corporation. Austin, Texas. June 1976.

7. Particle Pollutant System Study. Vol. III. Handbook of Emissions Properties. Midwest Research Institute. Prepared for U.S. Environmental Protection Agency. Contract No. CPA 22-69-104. Durham, North Carolina.

7.9 BRASS AND BRONZE INGOTS (COPPER ALLOYS)

Potential sources of fugitive particulate emissions from brass/bronze operations are sweating, drying, insulation burning, smelting furnaces, and casting. Table 7.9-2 shows these sources and their corresponding emission factors.

No data is presently available concerning size characteristics of the fugitive emissions.

Table 7.9-2. POTENTIAL FUGITIVE PARTICULATE EMISSION FACTORS FOR BRASS AND BRONZE PROCESSES WITHOUT CONTROLS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Sweating furnace	0.75[b]	0.38
Rotary dryer	13.75[b]	6.88
Insulation burning	13.75[c]	6.88
Electric induction furnace	0.14[d]	0.07
Reverberatory furnace	5.27[e]	2.64
Rotary furnace	4.43[d]	2.22
Crucible furnace	0.49[e]	0.25
Cupola (blast) furnace	3.66[e]	1.83
Casting	0.015[b]	0.008

[a] Factors are expressed as units per volume of scrap processed, except casting which is expressed as units per volume cast.

[b] Engineering judgement assuming that fugitive emissions are equal to 5 percent of stack emissions shown in Reference 2.

[c] Engineering judgement assuming that fugitive emissions are equal to 5 percent of stack emission factor shown in Reference 3.

[d] Engineering judgement assuming that fugitive emissions are equal to 5 percent of stack emission factor shown in Reference 1.

[e] Engineering judgement, average of two sets of data, assuming that fugitive emissions are equal to 5 percent of stack emission factors shown in References 1 and 3.

ADDITIONAL REFERENCES FOR SECTION 7.9

2. Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Volume II: Industry Profile. Radian Corporation. Contract No. 68-02-1319, Task Order No. 49. Austin, Texas. June 21, 1976.

3. Particulate Pollutant System Study, Volume III - Handbook of Emission Properties. Midwest Research Institute. Contract No. CPA 22-69-104. Kansas City, Missouri. May 1, 1971.

7.10 GRAY IRON FOUNDRY

Potential sources of fugitive particulate emissions from the foundry processes are shown in Table 7.10-2 along with corresponding emission factors.

The particulate size of dust from various foundry operations will vary considerably. Table 7.10-3 lists various foundry operations and corresponding particulate size ranges.

Table 7.10-2. POTENTIAL UNCONTROLLED FUGITIVE EMISSION FACTORS FOR GRAY IRON FOUNDRIES

EMISSION FACTOR RATING: E

Type of operation	Particulates	
	lb/ton	kg/MT
Cupola furnace operation	0.85[a,b]	1.7
Crucible furnace operation	0.35[a,c]	0.18
Electric arc furnace operation	7.5[a,d]	3.75
Open hearth furnace operation	0.5[e,f]	0.25
Electric induction furnace operation	2.0[a,d]	1.0
Pot furnace operation	0.4[a,g]	0.2
Reverberatory furnace operation	0.1[a,b]	0.05
Ductile iron innoculation	3.9[e,h]	1.98
Pouring molten metal into molds	2.12[e,i]	1.06
Casting shakeout	7.0[e,j]	3.5
Cooling and cleaning castings	0.48[e,j]	0.24
Finishing castings	0.01[e,h]	0.005
Core sand and binder mixing	0.3[d,l]	0.15
Core making	0.35[d,l]	0.18
Core baking	2.71[d,m]	1.36
Mold makeup	0.04[d,k]	0.02

[a] Factor expressed in units per unit of metal charged.
[b] Engineering judgement, assuming fugitive emissions to be equal to 5 percent of uncontrolled stack emission as shown in Table 7.10-1.
[c] Engineering judgement, averaging 5 percent of the uncontrolled stack emissions from Tables 7.8-1 and 7.9-1.
[d] Reference 7.
[e] Factor expressed in units per unit of metal produced.
[f] Average of 5 percent of stack emission factor shown in Table 7.5-1 and factor shown in Reference 8.
[g] Engineering judgement, assuming 50 percent of uncontrolled emission factor as shown in Table 7.11-1.
[h] References 6 and 9.
[i] References 9 and 10.
[j] References 9 and 11.
[k] Reference 11.
[l] Factor expressed in units per unit of sand used.
[m] References 1 and 11.

Table 7.10-3. EMISSION CHARACTERISTICS FOR VARIOUS FOUNDRY OPERATIONS[12]

Foundry operation	Type	Particle size (μm)
Raw material storage and charge makeup	Coke dust	Fine to coarse
	Limestone and sand dust	30 to 1,000
Melting		
Cupola furnace	Fly ash	8 to 20
	Coke breeze	Fine to coarse
	Metallic oxides	up to 0.7
Electric furnace	Metallic oxides	up to 0.7
Reverberatory furnace	Metallic oxides	up to 0.7
	Fly ash	8 to 20
Inoculation	Metal oxides	up to 0.7
Molding	Sand	Coarse
Pouring	Metallic oxides	Fine to medium
Shakeout	Sand fines, dust	50% - 2 to 15
Cleaning	Dust	50% - 2 to 15
Grinding	Metal dust	above 7
	Sand fines	Fine to medium
	Abrasives	50% - 2 to 7
Sand storage	Fines	50% - 2 to 15
Sand handling	Fines	50% - 2 to 15
Screening, mixing	Fines	50% - 2 to 15
Sand drying and reclamation	Dust	50% - 2 to 15
Core sand storage	Sand fines	Fine
Core making	Sand fines, dust	Fine to medium

ADDITIONAL REFERENCES FOR SECTION 7.10

7. Particulate Pollutant System Study, Vol. III. Handbook of Emission Properties. Midwest Research Institute. Prepared for the U.S. Environmental Protection Agency, Air Pollution Control Office. Contract No. CPA 22-69-104. Durham, North Carolina. May 1971.

8. Iversen, R.E. Meeting with U.S. Environmental Protection Agency with AISI on Steel Facility Emission Factors, April 14 and 15, 1976. U.S. Environmental Protection Agency Memorandum. June 7, 1976.

9. Gutow, B.S. An Inventory of Iron Foundry Emission. Modern Casting. January 1972.

10. Kalika, P.W. Development of Procedures for Measurement of Fugitive Emissions. The Research Corporation of New England. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1815. July 1975.

11. Scott, William D. and Charles E. Bates. Measurement or Iron Foundry Fugitive Emissions. Presented at Symposium on Fugitive Emissions: Measurement and Control. Hartford, Connecticut. May 18, 1976.

12. Greenberg, J.M. and R.E. Conover. Report on Systems Analysis of Emissions and Emission Control in the Iron Foundry Industry in the U.S.A. A.T. Kearney & Co., Inc. Chicago. December 1970.

7.11 SECONDARY LEAD SMELTING

Potential sources of fugitive particulate emissions from secondary lead smelting are scrap burning, sweating, melting furnaces, and casting. Table 7.11-4 shows these potential sources and the corresponding emission factors.

Data concerning size characteristics of fugitive emissions is unavailable. However emissions from point sources may be similar to the fugitive emissions. Emissions from sweating furnaces have a mean particulate diameter of 0.3 μm with a size range of 0.07 to 0.4 μm.[10] Table 7.11-3 list the size distribution of emissions from a blast (cupola) furnace.

Table 7.11-4. POTENTIAL FUGITIVE PARTICULATE EMISSION FACTORS FOR SECONDARY LEAD SMELTING WITHOUT CONTROLS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	kg/MT	lb/ton
Lead and iron scrap buring	0.8[b]	1.6
Sweating furnace	1.275[c]	2.550
Reverberatory furnace	4.615[c]	9.230
Blast (cupola) furnace and tapping of holding pot	6.0[c]	12.0
Pot (kettle) furnace	0.02[c]	0.04
Casting	0.435[d]	0.870

[a] Factors are expressed as units per volume of scrap processed.
[b] Engineering judgement assuming 5 percent residual zinc scrap processing, Table 7.14-1.
[c] Based on any average of 5 percent of the lead smelting emission factors in References 10 and 11.
[d] Reference 12; fugitive emissions for primary lead casting assumed equal to fugitive emissions for secondary lead casting.

ADDITIONAL REFERENCES FOR SECTION 7.11

10. Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Volume II: Industry Profile. Radian Corporation. Contract No. 68-02-1319, Task No. 49. Austin, Texas. June 21, 1976.

11. Control Techniques for Lead Air Emissions. PEDCo-Environmental Specialists, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1375, Task Order No. 32. Research Triangle Park, North Carolina. Publication No. EPA 450/2-77-012. January 1978.

12. Silver Valley/Bunker Hill Smelter Environmental Investigation, Interim Report. PEDCo Environmental, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1343, Task Order No. 8. Region X, Seattle, Washington. February 1975.

7.14 SECONDARY ZINC PROCESSING

Potential sources of fugitive particulate emissions from secondary zinc processes are shown in Table 7.14-2 along with corresponding emission factors.

Data concerning size distribution of fugitive emissions is not presently available. However, the limited data concerning stack emissions may be quite similar to fugitive emissions. Particulates from sweating furnaces range from 1 μm to greater than 20 μm, but typically they are less than 2 μm.[6] Particulates from retorts range from 0.05 to 1.0 μm.[6]

Table 7.14-2. POTENTIAL FUGITIVE PARTICULATE UNCONTROLLED EMISSION FACTORS FOR SECONDARY ZINC SMELTING

EMISSION FACTOR RATING: E

Type of operation	Particulate[a]	
	lb/ton	kg/MT
Crushing/screening of residue skimmings	4.250[b]	2.125
Reverberatory sweat furnace	1.30[c]	0.63
Kettle (pot) sweat furnace	0.56[c]	0.28
Rotary sweat furnace	0.90[d]	0.45
Muffle sweat furnace	1.07[d]	0.535
Electric resistance sweat furnace	0.50[d]	0.25
Crucible melting furnace	0.005[e]	0.0025
Kettle (pot) melting furnace	0.005[c]	0.0025
Reverberatory melting furnace	0.005[d]	0.0025
Electric induction melting	0.005[d]	0.0025
Distillation retort and condenser	2.36[f]	1.18
Muffle distillation furnace and condenser	2.36[f]	1.18
Casting	0.015[d]	0.0075

[a] Factors are expressed as units per end product zinc except factors for crushing/screening of residue skimmings and electric resistence furnaces which are expressed as units per volume of scrap processed.

[b] Reference 6. Average of reported emission factors.

[c] Reference 6 and Table 7.14-1, average of factors appearing in stated references assuming 5 percent of the stack emissions.

[d] Engineering judgement based on stack emission factor given in Reference 6, assuming fugitive emissions to be equal to 5 percent of stack emissions.

[e] Engineering judgement assuming fugitive emissions from crucible melting furnace to be equal to fugitive emissions from kettle (pot) melting furnace.

[f] Engineering judgement based on emission factor shown in Table 7.14-1, assuming fugitive emissions to be equal to 5 percent of stack emissions.

ADDITIONAL REFERENCES FOR SECTION 7.14

6. Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Volume II: Industry Profile. Radian Corporation. Contract No. 68-02-1319, Task Order No. 49. Austin, Texas. June 21, 1976.

8.1 ASPHALTIC CONCRETE PLANTS

Potential fugitive particulate emission sources from asphaltic concrete plants are unloading of aggregate, elevators, and screening operations. Table 8.1-2 shows these emission sources as well as the corresponding emission factors.

Fugitive particulate emissions from hot mix asphalt plants consist basically of dust from aggregate storage, handling, and transfer. Stone dust may range from 0.1 μm to more than 300 μm. On the average, 5 percent of cold aggregate feed is <4 μm (minus 200 mesh). Dust which may escape before reaching primary dust collection generally is 50-70 percent <4 μm (minus 200 mesh).[12]

Table 8.1-2. POTENTIAL UNCONTROLLED FUGITIVE PARTICULATE EMISSION FACTORS FOR ASPHALTIC CONCRETE PLANTS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Unloading coarse and fine aggregate to storage bins	0.10[b]	0.05
Cold and dried (and hot) aggregate elevator	0.20[b]	0.10
Screening hot aggregate	0.026[c]	0.013

[a] Factors are expressed as units per unit weight of aggregate processed.

[b] Reference 11, assumed equal to similar sources.

[c] Reference 12, assumed equal to similar crushed granite process.

ADDITIONAL REFERENCES FOR SECTION 8.1

11. Evaluation of Fugitive Dust from Mining, Task 1 Report. PEDCo-Environmental Specialists, Inc. Cincinnati, Ohio. Prepared for Industrial Environmental Research Laboratory/REHD, U.S. Environmental Protection Agency, Cincinnati, Ohio. Contract No. 68-02-1321, Task No. 36. June 1976.

12. Chalekode, P.K., and J.A. Peters, Assessment of Open Sources. Monsanto Research Corporation, Dayton, Ohio. Presented at Third National Conference on Energy and the Environment, College Corner, Ohio. October 1, 1975. 9 p.

8.6 PORTLANT CEMENT MANUFACTURING

Potential sources of fugitive emissions from portland cement manufacturing process are shown in Table 8.6-3 along with corresponding uncontrolled fugitive emission factors.

Information concerning particulate size distribution is presently unavailable.

Table 8.6-3. POTENTIAL FUGITIVE EMISSION FACTORS FOR CEMENT MANUFACTURING WITHOUT CONTROLS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Raw material unloading	0.2150[b]	0.1075
Raw material charging to primary crusher	0.02[c]	0.01
Primary crushing	0.5[d]	0.25
Transfer points and associated conveying	0.3[e]	0.15
Vibrating screen and secondary crusher	1.5[d]	0.75
Raw material unloading to storage, storage, and transfer (via clamshell)	4.0[f]	2.0
Raw grinding mill and feed/discharge exhaust systems	0.1[f]	0.05
Raw blending and blended material storage	0.05[f]	0.025
Loading, storage, and loadout of clinker and gypsum	7.5[f,g]	3.75
Finish grinding with leaks from mill and from feed discharge exhaust systems	0.1[f,h]	0.05
Cement loading	0.236[h,i]	0.118
Cement packaging	0.01[f,i]	0.005

a Factors expressed as units per unit weight of raw material except as noted.

b Estimate based on average of emission factors for coal unloading in Reference 7 and taconite unloading in Reference 8.

c Reference 9.

d Table 8.20-1.

e Engineering judgement assuming emissions equal to that of transferring sand, Reference 10.

f Engineering judgement based on visual observation at various plant visits.

g Based on partially enclosed structure; open at both ends with roof. Factor expressed in units per unit of clinker and gypsum.

h Factor expressed in units per unit of cement.

i Reference 11. Based on tests of mechanical unloading of cement to hopper and subsequent transport of cement by enclosed bucket elevator to elevated bins with a fabric sock over the bin vent.

ADDITIONAL REFERENCES FOR SECTION 8.6

7. Cross, F.L., Jr. and G.D. Forehand. Air Pollution Emissions from Bulk Loading Facilities, Volume 6, Environmental Nomograph Series. Technomic Publishing Co., Inc. Westgate, Connecticut. 1975. pp 3-4.

8. Environmental Assessment of Coal Transportation. PEDCo-Environmental Specialists, Inc. Prepared for U.S. Environmental Protection Agency. Contract No. 68-02-1321, Task 40. Publication No. EPA 600/7-78-081. May 1978. pp 4-38 and 4-51.

9. Evaluation of Fugitive Dust from Mining, Task 1 Report. PEDCo-Environmental Specialists, Inc., Prepared for Industrial Environmental Research Laboratory/REHD, U.S. Environmental Protection Agency, Cincinnati, Ohio. Contract No. 68-02-1321, Task No. 36. June 1976.

10. A Study of Fugitive Emissions from Metallurgical Processes. Midwest Research Institute. Prepared for U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory. Contract No. 68-02-2120. Monthly Progress Report No. 11. Research Triangle Park, North Carolina. June 17, 1976.

11. Personal communication from T.R. Blackwood, Monsanto Research Corporation, Dayton Laboratory. Dayton, Ohio. October 18, 1976.

8.10 CONCRETE BATCHING

Potential sources of fugitive particulate emissions from concrete batching are shown in Table 8.10-2 along with the corresponding emission factors.

Particle size characteristics of the dust vary according to the grade of cement. A range of 10 to 20 percent by weight <5 μm is typical for the various grades of cement. The dust generated from dry concrete batching plants has characteristics similar to those of the cement dust discussed for wet concrete batching plants.

Table 8.10-2. POTENTIAL UNCONTROLLED FUGITIVE EMISSION FACTORS FROM CONCRETE BATCHING PROCESSES

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Transfer of sand and aggregate to elevated bins	0.04[b]	0.02
Cement unloading to elevated storage silos	0.236[c]	0.118
Weight hopper loading of cement, sand, and aggregate	0.02[b]	0.01
Mixer loading of cement, sand, and aggregate (central mix plant)	0.04[b]	0.02
Loading of transit mix (wet-batching) truck	0.02[b]	0.01
Loading of dry-batch truck	0.04[b]	0.02

[a] Factors expressed in units per unit of material handled.

[b] Engineering judgement based on observations and emission tests on controlled similar sources.

[c] Reference 5. From testing of mechanical unloading to hopper and subsequent transport of cement by enclosed bucket elevator to elevator bins with a fabric sock over the bin vent.

ADDITIONAL REFERENCES FOR SECTION 8.10

5. Personal communication from T.R. Blackwood of Monsanto Research Corporation, Dayton Laboratory. Dayton, Ohio. October 18, 1976.

8.15 LIME MANUFACTURING

Potential sources of fugitive particulate emissions from lime manufacturing operations are crushing and screening, transfer and conveying, loading, and packaging operations. Table 8.15-2 shows these potential sources and their corresponding emission factors.

Fugitive particulate emissions from limestone storage, handling, and transfer typically have a mean particulate diameter of 3-6 μm, 45-70 percent of which are less than 5 μm.[10] The following information pertaining to stack emission characteristics is presented since they most likely closely parallel those of fugitive emissions.[11,12]

Operation	Particle size distribution
Hammer mill (crusher)	30% < 3 μm, 47% < 5 μm, 60% < 10 μm 74% < 20 μm, 86% < 40 μm
Screening	46% < 3 μm, 72% < 5 μm, 85% < 10 μm 95.5% < 20 μm, 98.8% < 40 μm
Bagging house	71% < 5 μm, 87.3% < 10 μm 96% < 20 μm, 98.8% < 40 μm

Table 8.15-2. POTENTIAL UNCONTROLLED FUGITIVE PARTICULATE EMISSION FACTORS FOR LIME MANUFACTURING

EMISSION FACTOR RATING: E

Type of operation	Particulates	
	lb/ton	kg/MT
Limestone/dolomite charing to primary crusher	0.02[a,b]	0.01
Primary crushing and screening	0.5[a,c]	0.25
Transfer points and associated conveying	0.8[a,d]	0.4
Secondary crushing and screening	1.5[a,c]	0.75
Quicklime and hydrated lime crushing/ pulverizing/screening with leaks from mill and from feed/discharge exhaust	0.1[e,f]	0.05
Truck, rail, ship/barge loading of quicklime and hydrated lime (including lime product silo vents)	0.236[e,g]	0.118
Packaged quikclime and hydrated lime	0.01[e,h]	0.005

[a] Factor expressed in units per unit weight of raw material handled.

[b] Reference 7.

[c] Table 8.20-1.

[d] Engineering judgement, assumed approximately same as emission factor for dry phosphate rock, Reference 8.

[e] Factor expressed as units per unit weight of lime.

[f] Engineering judgement based on controlled cement milling emissions reported by a cement manufacturing company.

[g] Engineering judgement, assumed the same as for loading of hydraulic cement obtained from Reference 9.

[h] Engineering judgement, assumed equal to packaging of cement, Table 7.10-2.

ADDITIONAL REFERENCES FOR SECTION 8.15

7. Evaluation of Fugitive Dust from Mining, Task 1 Report. PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. Prepared for Industrial Environmental Research Laboratory/ REDH, U.S. Environmental Protection Agency, Cincinnati, Ohio. Contract No. 68-02-1321, Task No. 36. June 1976.

8. Fugitive Dust from Mining Operations -- Appendix Final Report, Task No. 10. Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. May 1975.

9. Personal communication from T.R. Blackwood of Monsanto Research Corporation, Dayton Laboratory. Dayton, Ohio. October 18, 1976.

10. A Study of Fugitive Emissions from Metallurgical Processes. Midwest Research Institute. Contract No. 68-02-2120. Monthly Progress Report No. 8. Kansas City, Missouri. March 8, 1976.

11. Particulate Pollutant System Study. Volume III- Handbook of Emissions Properties. Midwest Research Institute. Contract No. CPA 22-69-104. Kansas City, Missouri. May 1, 1971.

12. Shannon, L.J., P.G. Gorman, and M. Reichel. Particulate Pollutant System Study, Volume II - Fine Particulate Emissions. Midwest Research Institute. Prepared for U.S. Environmental Protection Agency, Air Pollution Control Office. Contract No. 22-69-104. Chapel Hill, North Carolina. August 1, 1971.

10.4 WOODWORKING OPERATIONS

Since most woodworking operations control emissions out of necessity, fugitive emissions are seldom a problem. However, the wood waste storage bins are a common source of fugitive emissions. Table 10.4-2 shows these emission sources and their corresponding emission factors.

Information concerning size characteristics is very limited. Data collected in a western red cedar furniture factory equipped with exhaust ventilation on most wood working equipment showed most suspended particulates in the working environment to be less than 2 μm in diameter.[7]

Table 10.4-2. POTENTIAL UNCONTROLLED FUGITIVE PARTICULATE EMISSION FACTOR FROM WOODWORKING OPERATIONS

EMISSION FACTOR RATING: E

Type of operation	Particulates[a]	
	lb/ton	kg/MT
Wood waste storage bin vent	1.0[b]	0.5
Wood waste storage bin loadout	2.0[b]	1.0

[a] Factors expressed as units per unit weight of wood waste handled.

[b] Engineering judgement based on observations on plant visits.

ADDITIONAL REFERENCES FOR SECTION 10.4

7. Industrial Environmental Health, The Worker and the Community. Academic Press. New York and London. 1972.

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16. ABSTRACT

This document provides a priority listing of industrial processes emitting fugitive particulates and which are in need of source sampling. Criteria for priority listing are total potential uncontrolled fugitive particulate emissions (industry-wide), and adequacy of currently available fugitive emission factor data.

Each emission factor was evaluated for its adequacy for inclusion into AP-42. Adequacy of factors ranged from very poor (based on estimates, assumed values, or unknown development) to very good (based on complete test data). An appendix contains the fugitive particulate emission factors in a format suitable for input into AP-42. Also included in the appendix is particle size information.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Control	Emission Factors, State Implementation Plans	13B
Dust	Fugitive Dust, Particle Size	11G
Industrial Processes	Airborne Wastes	13H

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