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TECHNICAL GUIDANCE FOR CONTROL OF INDUSTRIAL PROCESS FUGITIVE PARTICULATE EMISSIONS

by

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7.6

2.3.3 Primary Lead Smelters

Process Description - Lead is usually found in nature as a sulfide ore (Galena - PbS) containing small amounts of copper, iron, zinc and other trace elements. Smelting is the process by which lead is separated from its ores and purified, and uses essentially three steps: sintering, reduction in a blast furnace, and refining.

The basic purpose of sintering is to convert the lead sulfide concentrate into an oxide or sulfate form, while simultaneously producing a hard porous clinker material suitable for the rigid requirements of the blast furnace. In order to maintain the desired level of sulfur content in the sinter, sulfide-free fluxes such as silica and limestone, plus large amounts of recycled sinter and smelter residues are added to the mix. The feed for the sinter machine is crushed and mixed, sometimes pelletized, and loaded onto the moving sinter machine pallets. The feed is then ignited, the lead sulfide converted to lead oxide, sulfur oxides are liberated, and sinter is formed. As the pallets turn over at the end of the machine, the sinter cakes go through a coarse breaker and screen.

Reduction of the lead oxide to metallic lead occurs in the blast furnace. The charge, consisting of sinter, coke, flux and slag forming materials are mixed and introduced into the blast furnace. During the melting process, the charge may separate into as many as four layers. From heaviest to lightest, the layers are: lead metal, matte, speiss and slag. The slag is removed and conveyed hot to a fuming furnace for recovery of lead and zinc. Some slag may be granulated and recycled to sintering. The matte, speiss, and lead bullion are transferred to drossing kettles where the lead dross (copper matte, speiss, and oxidized lead) copper oxides or sulfides, and some of the other impurities such as tin, indium and antimony are removed.

In the drossing kettles, the molten bullion is cooled to 370 to 480°C (700 to 900°F) at which point copper and other impurities which are soluble in hotter bullion, but not at this temperature, rise to the surface and are skimmed off.

The copper drosses are transferred to a reverberatory furnace where they are melted with pig iron and silica sand. After melting is complete, four layers are usually present. They are from top to bottom: slag, matte, speiss, and molten lead. The slag is returned to the blast furnace for resmelting, the matte and speiss are shipped to copper plants for recovery of copper and the lead bullion is returned to the drossing kettle. Arsenic is recovered at only one copper smelter in the United States.

The lead metal is heated to approximately 540°C (1000°F) and charged with zinc. The solution is agitated and allowed to cool. Silver crusts which form may be removed from the surface by skimming or by use of a vacuum press. These crusts then go to a retort furnace where the zinc is distilled off.

The remaining zinc must be removed from the molten lead. Vacuum dezincing is accomplished in a large kettle so designed that it is possible to form a vacuum over the metal surface. The zinc vaporizes in the vacuum chamber and condenses on the inner dome.

The refined lead is then pumped into casting kettles. Caustic soda and niter are agitated into the molten metal. The metal is allowed to stand and cool, which brings any contained impurities to the surface. Submerged pumps continually pump lead from the kettle bottom and it is cast into 100 lb pigs or 1 ton ingots.

A process flow diagram for lead production is shown in Figure 2-9. Each potential process fugitive particulate emission point is identified and explained in Table 2-24. Plant haul roads which are a common source at most facilities are not depicted in the Table or Figure. Proper evaluation of this emission category is explained in Section 2.1.

IPFPE Emission Rates - Table 2-24 presents a summary of uncontrolled emission factors for primary lead smelting IPFPE sources. Since these are potential uncontrolled emission rates, the site-specific level of control must be considered for application to a specific plant. Also included are reliability factors for each estimate.

The emission factors for the various smelting operations (other than storage pile) are based mostly on very limited test data and therefore receive a reliability rating of D. Consequently, actual emission rates at a given facility could differ significantly from those in Table 2-24.

Midwest Research Institute is presently conducting fugitive emission tests on lead smelters. Data should be available in several months.

Example Plant Inventory - The example plant inventory for primary lead smelting as shown in Table 2-24 presents potential fugitive particulate emission quantities from the various uncontrolled sources within the process. The inventory represents a plant which produces 200,000 Mg (220,000 tons) of lead per year. The plant inventory is not meant to display a typical plant, but merely a potential set of circumstances.

The assumed feed rate of raw materials to produce 1 Mg of lead was as follows:

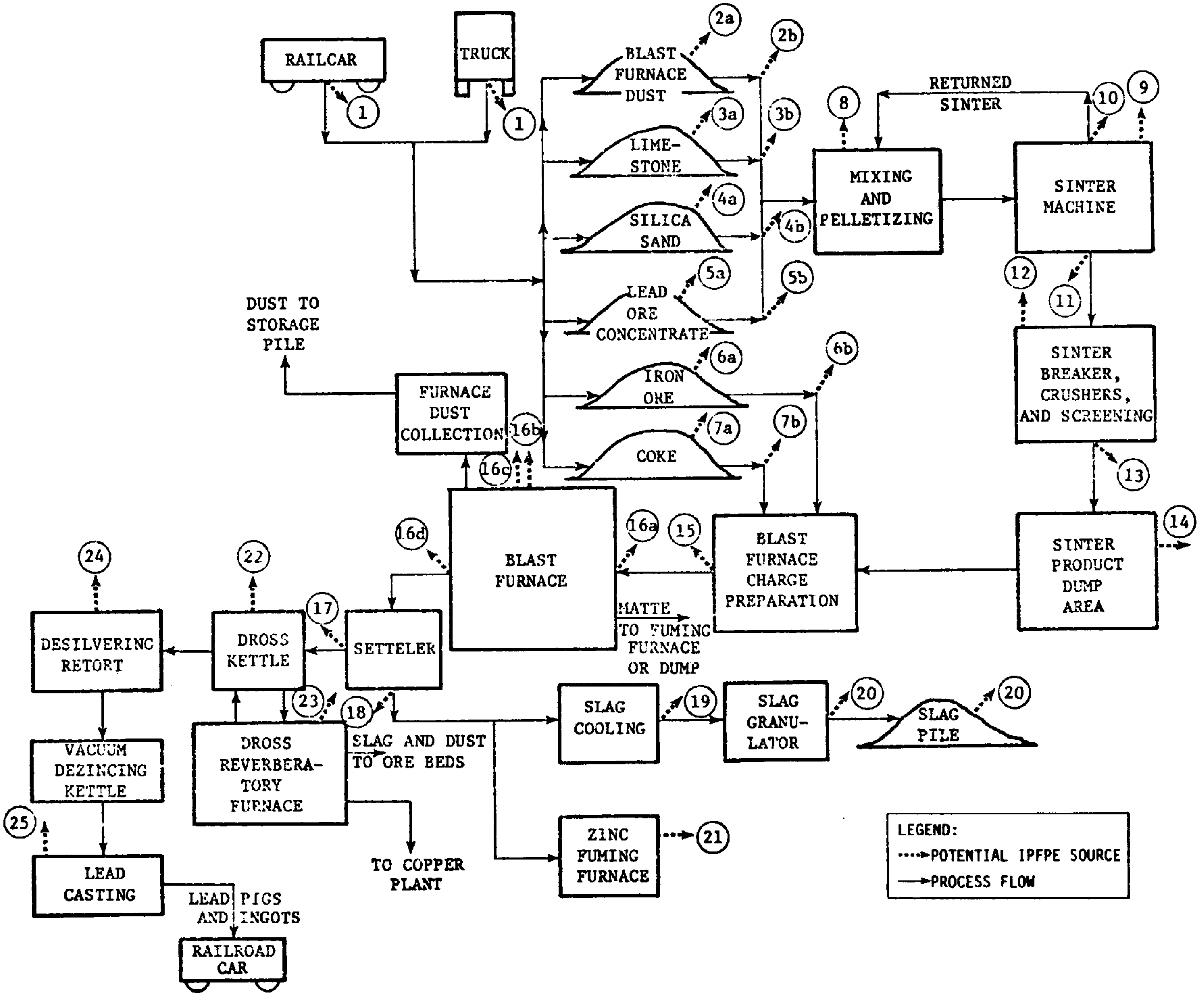

Figure 2-9. Process flow diagram for primary lead smelting showing potential industrial process fugitive particulate emission points.

Table 2-24. IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR PRIMARY LEAD SMELTERS

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, metric tons/year (tons/year)	Uncontrolled emissions metric tons/yr (tons/yr)
1. Railroad car and truck unloading				
Limestone	0.015-0.2 kg/Mg unloaded[a] (0.03-0.4 lb/ton unloaded)	E	Limestone unloaded 79,445 (87,390)	8 (9)
Silica sand	0.015-0.2 kg/Mg unloaded[a] (0.03-0.4 lb/ton unloaded)	E	Silica unloaded 3,500 (3,850)	0.38 (0.41)
Lead ore concentrate	0.015-0.2 kg/Mg unloaded[a] (0.03-0.4 lb/ton unloaded)	E	Lead ore unloaded 317,782 (349,560)	34 (37)
Iron ore	0.015-0.2 kg/Mg unloaded[a] (0.03-0.4 lb/ton unloaded)	E	Iron ore unloaded 45,000 (49,500)	5 (6)
Coke	0.2 kg/Mg unloaded[a] (0.4 lb/ton unloaded)	E	Coke unloaded 94,494 (103,943)	19 (21)
2. Blast furnace flue dust				
2a. Storage	Negligible[b]	E	-	b
2b. Handling and transfer	Negligible[b]	E	-	b
3. Limestone				
3a. Storage Loading onto pile	$\frac{(0.02)(K_1)(S/1.5)}{(PE/100)^2}$ kg/Mg material loaded onto pile[c] $\left(\frac{(0.04)(K_1)(S/1.5)}{(PE/100)^2}\right.$ lb/ton material loaded onto pile$\left.\right)$	D	Limestone loaded 79,445 (87,390)	2 (2)

Table 2-24 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR PRIMARY LEAD SMELTERS

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
Vehicular traffic	$\frac{(0.065)(K_2)(S/1.5)}{(PE/100)^2}$ kg/Mg material stored^c $\left(\frac{(0.04)(K_2)(S/1.5)}{(PE/100)^2}\right.$ lb/ton material stored$\left.\right)$	D	Limestone stored 79,445 (87,390)	5 (6)
Loading out	$\frac{(0.025)(K_3)(S/1.5)}{(PE/100)^2}$ kg/Mg material loaded out^c $\left(\frac{(0.05)(K_3)(S/1.5)}{(PE/100)^2}\right.$ lb/ton material loaded out$\left.\right)$	D	Limestone loaded out 79,445 (87,390)	2 (2)
Wind erosion	$\frac{(0.055)(S/1.5)}{(PE/100)^2}\ \frac{D}{90}$ kg/Mg material stored^c $\left(\frac{(0.011)(S/1.5)}{(PE/100)^2}\ \frac{D}{90}\right.$ lb/ton material stored$\left.\right)$	D	Limestone stored 79,445 (87,390)	4 (4)
3b. Handling and transfer	0.1 kg/Mg limestone handled^d (0.2 lb/ton limestone handled)	E	Limestone handled 79,445 (87,390)	8 (9)
4. Silica sand				
4a. Storage	c	D	Silica stored 3,500 (3,850)	1 (1)
4b. Handling and transfer	0.15 kg/Mg silica sand handled^e (0.3 lb/ton silica sand handled)	E	Silica handled 3,500 (3,850)	1 (1)

Table 2-24 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR PRIMARY LEAD SMELTERS

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
5. Lead ore concentrate				
5a. Storage	c	D	Concentrate stored 317,782 (349,560)	52 (57)
5b. Handling and transfer	0.82-2.5 kg/Mg handled^{f} (1.64-5.0 lb/ton handled)	E	Concentrate handled 317,782 (349,560)	528 (580)
6. Iron ore				
6a. Storage	c	D	Ore stored 45,000 (49,500)	29 (32)
6b. Handling and transfer	1.0 kg/Mg iron ore handled^{g} (2.0 lb/ton iron ore handled)	E	Ore handled 45,000 (49,000)	45 (49)
7. Coke				
7a. Storage	c	D	Coke stored 94,494 (103,943)	7 (8)
7b. Handling and transfer	0.06-0.1 kg/Mg coke handled^{h,i} (0.13-3.39 lb/ton coke handled)	E	Coke handled 94,494 (103,943)	8 (9)

Table 2-24 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR PRIMARY LEAD SMELTERS

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
8. Mixing and pelletizing	0.57-1.70 kg/Mg lead product^{j} (1.13-3.39 lb/ton lead product)	D	Lead produced 200,000 (220,000)	227 (247)
9. Sinter machine	0.12-0.55 kg/Mg sinter^{k} (0.25-1.1 lb/ton sinter)	E	Sinter produced 349,979 (384,977)	117 (130)
10. Sinter return handling	2.25-6.75 kg/Mg sinter^{j} (4.5-13.5 lb/ton sinter)	D	Sinter produced 349,979 (384,977)	1,575 (1,732)
11. Sinter machine discharge and screens	0.28-1.22 kg/Mg sinter^{k} (0.55-2.45 lb/ton sinter)	E	Sinter produced 349,979 (384,977)	262 (289)
12. Sinter crushing	1			1
13. Sinter transfer to dump area	0.05-0.15 kg/Mg sinter transfered^{j} (0.10-0.30 lb/ton sinter transfered)	D	Sinter transfered 349,979 (384,977)	35 (38)
14. Sinter product dump area	0.0025-0.0075 kg/Mg sinter dumped^{j} (0.005-0.015 lb/ton sinter dumped)	D	Sinter dumped 349,979 (384,977)	2 (2)

Table 2-24 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR PRIMARY LEAD SMELTERS

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
15. Charge car or conveyor loading and transfer of sinter	0.13-0.38 kg/Mg charged[j] (0.25-0.75 lb/ton charged)	D	Blast furnace charge 477,226 (524,949)	122 (131)
16. Blast furnace - monitor (total)	0.04-0.12 kg/Mg lead produced[j,m] (0.08-0.23 lb/ton)	D	Lead produced 200,000 (220,000)	16 (17)
16a. Charging	m			m
16b. Blow condition	m			m
16c. Upset[n]	3.5-11.5 kg/Mg lead produced[j,m] (7.0-23.0 lb/ton)	D		o
16d. Tapping	m			m
17. Lead pouring to ladle and transfer	0.47 kg/Mg lead produced[f] (0.93 lb/ton lead produced)	E	Lead produced 200,000 (220,000)	94 (102)
18. Slag pouring	p			p
19. Slag cooling	0.24 kg/Mg lead produced[q] (0.47 lb/ton lead produced)	E	Lead produced 200,000 (220,000)	48 (52)
20. Slag granulator and slag piling	Negligible[r]	E	Slag crushed 200,000 (220,000)	200 (220)
21. Zinc fuming furnace vents	1.15-3.45 kg/Mg lead[j] (2.3-6.9 lbs/ton lead)	D	Lead produced 200,000 (220,000)	460 (506)
22. Dross kettle	0.12-0.36 kg/Mg lead[j] (0.24-0.72 lb/ton lead)	D	Lead produced 200,000 (220,000)	48 (53)

Table 2-24 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR PRIMARY LEAD SMELTERS

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
23. Reverberatory furnace leakage	0.75-2.25 kg/Mg lead[j] (1.5-4.5 lb/ton lead)	D	Lead produced 200,000 (220,000)	300 (330)
24. Silver retort building	0.45-1.35 kg/Mg lead[j] (0.9-2.7 lb/ton lead)	D	Lead produced 200,000 (220,000)	180 (198)
25. Lead casting	0.22-0.66 kg/Mg lead[j] 0.43-1.30 lb/ton lead)	D	Lead produced 200,000 (200,000)	88 (96)

[a] Engineering judgement based on data presented in Section 2.1.2; emission range derived using emission factors for unloading of Taconite pellets and coal/hopper car; emission factor for coke derived from coal unloading emission factor only.

[b] Engineering judgement, assumed enclosed handling and storage or direct recycle to system.

[c] For complete development of this emission factor, refer to Section 2.1.4. The emission factor for sources 4a, 5a, 6a, and 7a are the same as source 3a. For sources 3a, 4a, and 5a it was assumed that S = 1.5, D = 90, PE = 100, and K_1, K_2, and K_3 = 1. Values for sources 6 and 7 can be found in Section 2.1.4. Reference 1.

[d] Engineering judgment, assumed 50 percent of coal handling emissions as reported in Reference 2.

[e] Engineering judgment based on aggregate storage pile emission factors in Reference 2.

[f] Reference 3.

[g] Reference 4.

[h] Engineering judgment; calculated from emission factor (0.055 kg/Mg of iron) given in Reference 5.

[i] Reference 6.

[j] Reference 7.

[k] Engineering judgment using steel sinter machine leakage emission factor given in Reference 8 and 9.

[l] Emissions for sinter crushing included in emissions from sinter machine discharge and screens.

[m] Emissions for charging, blow condition, and tapping included in total.

[n] Emission factor for upset not considered part of normal operating conditions and is not included in emission factor for the blast furnace roof monitor.

[o] Emissions for blast furnace upset are not included in model plant inventory.

[p] Emissions for slag pouring included in lead pouring to ladle and transfer emission.

[q] Engineering judgment; estimated to be one half the magnitude of pouring and ladling operations (source number 17).

[r] Granulated slag is wet and therefore most likely not a source of fugitive emissions. Reference 10.

° Sinter Machine Feed

1.5 Mg (1.65 tons) of ore concentrate
0.4 Mg (0.44 tons) of flux (limestone)
0.2 Mg (0.22 tons) of coke

° Blast Furnace Feed

1.7 Mg (1.8 tons) of sinter
0.3 Mg (0.33 tons) of coke
0.1 Mg (0.11 tons) of slag (dross)
0.02 Mg (0.022 tons) of silica
0.02 Mg (0.022 tons) of limestone
0.02 Mg (0.022 tons) of baghouse dust
0.2 Mg (0.22 tons) of iron ore

Not included in the inventory are fugitive emissions from plant haul roads. These sources may be calculated using procedures outlined in Section 2.1. Total model plant uncontrolled process fugitive particulate emissions are 4532 Mg (4985 tons) per year. Fugitive emissions from upset conditions are not included in this total since it cannot be predicted how often upset conditions will occur during a year's operation. Major sources of fugitive particulate emissions are sintering operations, lead ore concentrate handling and transfer, and zinc fuming furnace vents.

Characteristics of Fugitive Emissions - Fugitive particulate emissions from primary lead smelting consist basically of dust from the various stockpiles as well as metal oxides from the various smelter process operations. Ninety-six percent of fugitive coke dust from stockpiling, handling, and transfer has a mean particulate diameter of less than 47 µm. Seven percent of silica dust from stockpiling, handling, and transfer of sand is less than 75 µm and 80 percent is greater than 5 µm. Limestone dust from stockpiling, handling, and transfer has a mean particulate diameter of 3-6 µm of which 45-70 percent is less than 5 µm.[3]

Little information is available concerning fugitive particulate emissions from the sintering operation except that exit temperatures from leakage and fumes are 120-315°C (250°-600°F).[3] Table 2-25 lists the percent of lead, cadmium, and zinc contained in fugitive particulate emissions from various sintering operations.[7] The following is a listing of size distributions of flue dust from an updraft sintering machine effluent.[11] 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.[3] Effluents from the flues consist of oxides as well as sulfates, sulfide, chloride, fluoride, and coke dust all of which may well be contained in the fugitive emissions.[11] Table 2-25 lists the percentage of lead, cadmium and zinc contained in fugitive particulate emissions from blast furnace roof vents and from blast furnace upset conditions.[7]

Information concerning fugitive particulate emission from lead dross reverberatory is unavailable; however, the following data on uncontrolled exhaust gas is presented since it may closely parallel fugitive emission characteristics. Particulates are largely less than 1 μm with a lead content of 13-35 percent by weight. Exit temperatures are 760-980°C (1400-1800°F).[12]

Table 2-25. CONCENTRATIONS OF LEAD, CADMIUM, AND ZINC IN FUGITIVE PARTICULATE EMISSIONS OF VARIOUS PRIMARY LEAD SMELTING OPERATIONS

Process	Percent by weight		
	Lead	Cadmium	Zinc
Ore concentrate storage	37	0.8	8
Return sinter transfer	19	0.6	2
Sinter sizes and storage	58	0.7	5
Sinter product dump area	31	0.6	6
Sinter transfer to blast furnace	39	0.7	6
Blast furnace roof vents	47	0.4	8
Blast furnace upset	27	4.0	7
Lead refinery roof vents	37	0.3	19
Lead casting roof ducts	38	0.1	18
Zinc fuming furnace area	3	-	62

Source: Reference 7.

Note: In the near future Midwest Research Institute will complete a lead control techniques document with further information on lead concentrations.

Control Technology - Control technology options for the primary lead production IPFPE sources (except those covered in Section 2.1) are presented in Table 2-26 and are explained in further detail below.

Storage, handling, and transfer of the raw materials used in primary lead production as well as process transfer operations can be effectively controlled by either wet suppression (water and/or chemical) or confinement by enclosure. Wet suppression is the least desirable method since the resultant higher moisture content of the raw materials may necessitate increased energy requirements in further process steps which require low moisture content materials. Confinement by enclosure can be accomplished in several ways. Complete enclosure of a storage area may not be necessary, rather a three-sided structure (with or without roof) which protects against the predominate wind direction may adequately control fugitive emissions. Handling and transfer equipment such as conveyor belts can be covered or enclosed to prevent fugitive emissions during such operations. Since blast furnace flue dust is normally collected in a closed system, fugitive emissions are normally negligible.

Fugitive emissions from mixing and pelletizing can be controlled if these operations are enclosed to prevent particulate escape. However, if this is not practicable because of limited space, building evacuation to a baghouse can be used to control fugitive emissions.

Fugitive emissions resulting from leakage of sinter machine updraft exhaust and reverberatory furnaces may be effectively controlled by better control of operating parameters and procedures. For instance, if proper feed rates and operational checks are adhered to properly, often times

Table 2-26. CONTROL TECHNIQUES FOR PRIMARY LEAD SMELTING IPFPE SOURCES

			FUGITIVE EMISSIONS CAPTURE AND CONTROL METHODS														
				Preventative procedures and operating changes							Capture methods				Removal equipment		
Industry: Primary Lead Smelting	Negligible emissions	IPFPE source typically uncontrolled	Control technologies identified in Section 2.1	Wet suppression (water and/or chemical)	Confinement by enclosure	Better control of raw material quality	Better control of operating parameters and procedures	Improved maintenance and/or construction program	Increase exhaust rate of primary control system		Fixed hoods, curtains, partitions, covers, etc.	Movable hoods with flexible ducts	Closed buildings with evacuation		Fabric filter	Scrubber	ESP
1. Railroad car and truck unloading																	
1a. Limestone			✓														
1b. Silica sand			✓														
1c. Lead ore concentrate			✓														
1d. Iron ore			✓														
1e. Coke			✓														
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		✓	✓														

x Typical control technique.

o In use (but not typical) control technique.

\+ Technically feasible control technique.

Table 2-26 (continued). CONTROL TECHNIQUES FOR PRIMARY LEAD SMELTING IPFPE SOURCES

			FUGITIVE EMISSIONS CAPTURE AND CONTROL METHODS														
				Preventative procedures and operating changes							Capture methods				Removal equipment		
Industry: Primary Lead Smelting	Negligible emissions	IPFPE source typically uncontrolled	Control technologies identified in Section 2.1	Wet suppression (water and/or chemical)	Confinement by enclosure	Better control of raw material quality	Better control of operating parameters and procedures	Improved maintenance and/or construction program	Increase exhaust rate of primary control system		Fixed hoods, curtains, partitions, covers, etc.	Movable hoods with flexible ducts	Closed buildings with evacuation		Fabric filter	Scrubber	ESP
8. Mixing and pelletizing					o								o		o		
9. Sinter machine updraft exhaust leakage							o	o	o				+		+		
10. Sinter return handling					o										+		
11. Sinter machine discharge and screens					x		x	x			o		o		o		
12. Sinter crushing					x		x	x			o		o		o		
13. Sinter transfer to dump area					o		o										
14. Sinter product dump area					+								+		+		
15. Charge car or conveyor loading and transfer of sinter					+		x										
16. Blast furnace - monitor (total)																	
16a. Charging											o	o			o		
16b. Blow condition						x	x	x									
16c. Upset						x	x										
16d. Tapping											o	o			o		
17. Lead pouring to ladle and transfer											o	o			o		
18. Slag pouring											o	o			o		
19. Slag cooling		✓			+						+		+		+		
20. Slag granulator and slag piling		✓		+	+												
21. Zinc fuming furnace vents		✓								+			+		+		
22. Dross kettle											o	o			o		
23. Reverberatory furnace leakage							x	o									
24. Silver retort building		✓											+		+		
25. Lead casting											o	o			o		

x Typical control technique.

o In use (but not typical) control technique.

+ Technically feasible control technique.

this will prevent the initial generation of fugitive emissions. However, if fugitive emissions are a result of poorly maintained equipment, faulty seals, worn equipment, etc. replacement of necessary parts and/or improved maintenance schedules will be necessary to eliminate fugitive emissions. Increased exhaust rate of the primary collection system may reduce leakage, however this may not be a desirable method of control if ambient air is drawn into the furnace or sinter machine.

Fugitive emissions from sinter machine discharge and screening as well as sinter crushing can be effectively controlled in several ways. The simplest way is to control operating parameters and procedures such as not overloading the process to the point where excessive fugitive emissions may be generated. Because of the nature of such operations, however, it may be necessary to completely enclose the operations, evacuate the building, or install fixed hoods which can be vented to fabric filters. In the same manner, fugitive emissions from the silver retort building may also be controlled by means of building evacuation to a fabric filter. Confinement and evacuation of the sinter dump area may also be integrated into this control system.

Fugitive emission from blast furnace charging and tapping, lead and slag pouring, and lead casting are most effectively controlled by the use of movable or fixed hoods, depending upon space limitations, with subsequent venting to a fabric filter system. Fugitive emission from the blast furnace blow condition can normally be controlled through sinter quality control and proper sinter/coke ratios to maintain a smoothly running blast furnace operation. Upsets in the blast furnace can be minimized by use of quality materials and/or improvement of operating procedures to prevent upset and thus fugitive emissions. Enclosure of the blast furnace with subsequent ventilation to control equipment will effectively control fugitive emissions but space may be a limiting factor.[13]

Confinement by enclosure will effectively control fugitive emissions from slag while cooling. However, if the volume of slag is small enough so as to allow use of a hood, this may be more desirable if it can be vented to an existing fabric filter system. It may also be possible to apply such a system to buildings housing zinc fuming furnaces. Since a fabric filter is the product collector for zinc fuming furnace it may therefore be more desirable to employ a good hooding system rather than enclosure.[14]

Wet suppression will effectively control fugitive emissions from slag granulation and piling after it has cooled. If, however, the slag is still hot during this operation confinement by enclosure is more desirable since wet suppression may only generate more fugitive emissions.

Fugitive emissions from dross kettles can be controlled by use of fixed or movable hoods (depending on space limitation) with subsequent venting to a fabric filter.

REFERENCES FOR SECTION 2.3.3

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7.8

EPA-450/3-77-010

TECHNICAL GUIDANCE FOR CONTROL OF INDUSTRIAL PROCESS FUGITIVE PARTICULATE EMISSIONS

by

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Contract No. 68-02-1375
Task No. 33
Project No. 3155-GG

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7.8

2.4 SECONDARY NON-FERROUS INDUSTRIES

2.4.1 Secondary Aluminum Smelters

Process Description - The raw materials for secondary aluminum smelting may be (1) aluminum pigs (to meet standard alloy specifications), (2) foundry returns (gates, risers, rejected castings, etc.), and (3) scrap (painted sidings, turnings, cans, etc.). If the scrap contains large amounts of paint, oil, grease and other contaminants, it may be dried in a chip dryer prior to loading into the reverberatory furnace. Scrap, rich in iron content is processed in a sweating furnace prior to charging into a reverberatory furnace.[2,3]

In the United States, the reverberatory furnace is used for 80 to 90 percent of all secondary aluminum smelting. All types of scrap aluminum are charged into the furnace, which operates at a temperature of 677°C to 760°C (1250°F to 1400°F). Fluxing, alloying, degassing and demagging all take place in the furnace; however, fluxing, degassing and demagging can also be done in a separate chamber. Because molten aluminum oxidizes rapidly when exposed to air, it must always be covered with a molten flux to retard oxidation.

Demagging (removal of magnesium) is accomplished by introducing elemental chlorine gas into the molten aluminum. The chlorine reacts and is driven off in the form of magnesium chloride.

While the charge is melting, alloying may be done. Specified amounts of other metals are added to the melt to obtain the desired percentage of each metal. If solvent fluxes are added to the melt, impurities in the form of oxides float to the top of the melt and are skimmed off and allowed to cool. After it is cooled, it is either discarded as waste or remelted in the sweating furnace.

The final step prior to pouring is degassing. The metal is degassed by bubbling dry nitrogen, chlorine or a mixture of the two gases through the molten metal bath. Chlorine forms hydrogen chloride while nitrogen mechanically sweeps the gas out of the molten metal.

After degassing, the metal is poured either into ingot molds or sometimes into preheated crucibles for direct delivery to the customer.

A process flow diagram for secondary aluminum processing is shown in Figure 2-11. Each potential process fugitive emission point is identified and explained in Table 2-29.

IPFPE Emission Rates - Table 2-29 presents a summary of uncontrolled emission factors for secondary aluminum smelting. Since these are potential uncontrolled emission rates, the site-specific level of control must be considered for application to a specific plant. Also included are reliability factors for each estimate. Note that the emission factors with an "E" rating are at best order of magnitude estimates; consequently, actual emission rates at a given facility could differ significantly from those in Table 2-29.

Example Plant Inventory - The example plant inventory for secondary aluminum, as shown in Table 2-29 presents potential fugitive particulate emission quantities from the various uncontrolled sources within the process. The inventory represents a plant which processes 4,546 Mg (5,000 tons) of metal per year. The plant inventory is not meant to display a typical plant, but merely a potential set of circumstances.

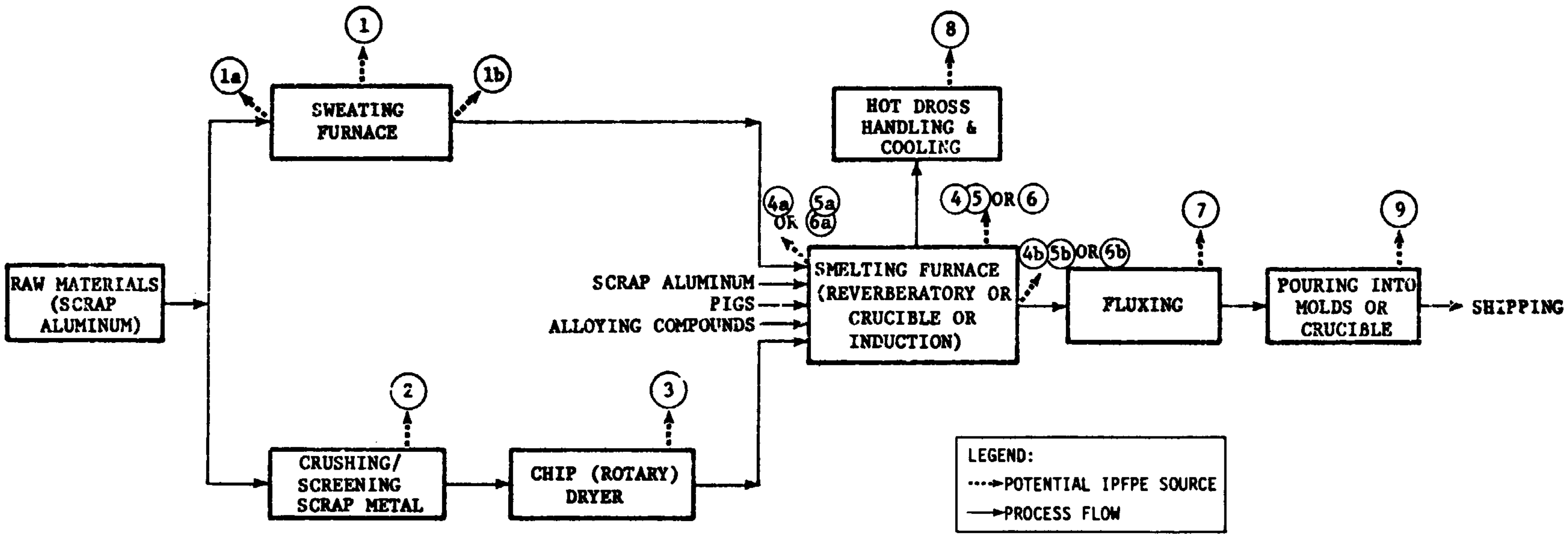

Figure 2-11. Process flow diagram for secondary aluminum production showing potential industrial process fugitive particulate emission points.

Table 2-29. IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR SECONDARY ALUMINUM PRODUCTION

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
1. Sweating furnace	0.36 kg/Mg metal processed[a] (0.72 lb/ton metal processed)	E	Scrap processed 2,727 (3,000)	1 (1)
1a. Charging	b			
1b. Tapping	b			
2. Crushing and screening scrap metal	Negligible[c]	E		Negligible
3. Chip (rotary) dryer	0.36 kg/Mg metal dried[d] (0.72 lb/ton metal dried)	E	Metal dried 1,136 (1,250)	5 (6)
4. Smelting (reverberatory) furnace	0.11 kg/Mg metal processed[a] (0.22 lb/ton metal processed)	E	Metal processed 4,546 (5,000)	1 (1)
4a. Charging	e			
4b. Tapping	e			
5. Smelting (crucible) furnace	0.05 kg/Mg metal processed[a] (0.09 lb/ton metal processed)	E	-	-
5a. Charging	f			
5b. Tapping	f			
6. Smelting (induction) furnace	0.05 kg/Mg metal processed[g] (0.09 lb/ton metal processed)	E	-	-
6a. Charging	h			
6b. Tapping	h			

Table 2-29 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR SECONDARY ALUMINUM PRODUCTION

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
7. Fluxing (chlorination)	25 kg/Mg chlorine used[a] (50 lb/ton chlorine used)	E	Chlorine used[i] 455 (500)	12 (13)
8. Hot dross handling and cooling	0.11 kg/Mg metal processed[j] (0.22 lb/ton metal processed)	E	Metal processed 4,546 (5,000)	1 (1)
9. Pouring hot metal into molds or crucible	Negligible[k]	E	-	Negligible

[a] Engineering judgement, assume 5% of uncontrolled stack emissions as reported in Reference 4, p. 7.8-1.

[b] Emissions included with total sweating furnace emission factor.

[c] Based on engineering judgement.

[d] Assume uncontrolled fugitive emissions are equal to the emissions from the sweating furnace.

[e] Emissions included with total reverberatory furnace emission factor.

[f] Emissions included with total crucible furnace emission factor.

[g] Assume uncontrolled fugitive emissions are equal to the emissions from the crucible furnace.

[h] Emissions included with total induction furnace emission factor.

[i] Assume that the amount of fluxing agent used is 10% of the weight of the metal processed in the reverberatory furnace (Reference 1, p. 286).

[j] Assume that the emissions are equal to the emissions from the reverberatory furnace.

[k] Emissions are negligible as reported in Reference 1, p. 285.

In drawing the plant inventory, the following assumptions were made:

- 2,727 Mg (3,000 tons) of scrap aluminum containing high temperature elements (such as iron) are processed in the sweating furnace.
- 1,126 Mg (1,250 tons) of scrap such as sheet, cashings, borings and turnings are received, and processed in a rotary dryer.
- 4,546 Mg (5,000 tons) of metal are processed and refined in the reverberatory furnace.
- 455 Mg (500 tons) of chlorine are used for fluxing.

Not included in the inventory are plant haul roads since this source should be negligible. Total model plant uncontrolled process fugitive particulate emissions are 20 Mg (22 tons) per year.

<u>Characteristics of Fugitive Emissions</u> - Particulates from secondary aluminum production are less than 2 μm in size. The particulates may be toxic because of the fluorides and chlorides that are emitted. Table 2-30 shows the effluent characteristics from secondary aluminum production.

Table 2-30. EFFLUENT CHARACTERISTICS FROM SECONDARY ALUMINUM PRODUCTION[2]

Source	Maximum particle size, μm	Chemical composition	Toxicity
Fluxing	2.0	Highly variable, may contain Al_2O_3, $AlCl_3$, NaCl fluorides, oxides of alkali metals	Toxic due to fluorides and chlorides
Chlorinating	1.0		

One study found that the major constituent in the fume from salt-cryolite fluxing in a furnace was sodium chloride with considerable smaller quantities of compounds of aluminum and magnesium. The particles were all under 2 μm. The fumes were somewhat corrosive when dry, and when wet, formed a highly corrosive sludge that tended to set up and harden if allowed to stand for any appreciable time.[1]

Another study made of the fumes from degassing of aluminum revealed that 100 percent of the fumes were smaller than 2 μm and 90 to 95 percent smaller than 1 μm. Mean particle size appeared under a microscope to be about 0.7 μm.[1]

Particle size data from an aluminum sweating furnace with a capacity of 345 kg/hr (760 lb/hr) indicate that 95 percent of the particles are less than 39 μm.[5]

Control Technology - Control technology options for the secondary aluminum production IPFPE sources (except those covered in Section 2.1) are presented in Table 2-31 and explained in further detail below.

Raw materials in the form of sheet castings, clippings, and borings are normally received and stored inside the building, therefore the fugitive dust, if any, is confined.

In the dry milling process, dust generated at the crusher, shaker screens and at points of transfer can be controlled by hooding these operations.[1]

Emissions from the rotary dryer are usually vented to a scrubber system. Fugitive dusts could result from process leaks, and may be controlled by improved maintenance and/or increasing the exhaust rate.

Emissions from sweating and smelting furnaces may be controlled by installing a canopy hood and ducting it to a fabric filter. Another system that may be used is enclosing

Table 2-31. CONTROL TECHNIQUES FOR SECONDARY ALUMINUM SMELTERS IPFPE SOURCES

			FUGITIVE EMISSIONS CAPTURE AND CONTROL METHODS													
				Preventative procedures and operating changes							Capture methods				Removal equipment		
Industry: Secondary Aluminum Processing	Negligible emissions	IPFPE source typically uncontrolled	Control technologies identified in Section 2.1	Wet suppression (water and/or chemical)	Confinement by enclosure	Better control of raw material quality	Better control of operating parameters and procedures	Improved maintenance and/or construction program	Increase exhaust rate of primary control system		Fixed hoods, curtains, partitions, covers, etc.	Movable hoods with flexible ducts	Closed buildings with evacuation		Fabric filter	Scrubber	Afterburner
1. Sweating furnace						+					x				x		x
2. Crushing and screening scrap metal											+	+	+				
3. Chip (rotary) dryer								o	+								
4. Smelting (reverberatory) furnace											x		+		x		
5. Smelting (crucible) furnace						+					x		o		x		
6. Smelting (induction) furnace											x		+		x		
7. Fluxing (chlorination)											+				x	x	
8. Hot dross handling and cooling											+	+			+		
9. Pouring hot metal into molds or crucible	✓																

x Typical control technique.

o In use (but not typical) control technique.

\+ Technically feasible control technique.

the building with subsequent evacuation and venting it to a control device; this would also control emissions from other operations within the building.

For control of emissions from fluxing, the emissions can be captured by installing a hood above the fluxing operation and venting it to a baghouse or a scrubber.[1,2]

Hot dross handling and cooling emissions can also be captured by hooding and venting it to a fabric filter.[1] If the slag is cooled indoors, building evacuation can also control the emissions.

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12.7, #9

TECHNICAL GUIDANCE FOR CONTROL OF INDUSTRIAL PROCESS FUGITIVE PARTICULATE EMISSIONS

by

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Contract No. 68-02-1375
Task No. 33
Project No. 3155-GG

EPA Project Officer: Gilbert H. Wood

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2.4.3 Secondary Zinc Production

Process Description - Raw materials used in secondary zinc processing are zinc scrap materials, fluxes, and fuels for furnaces. Zinc scrap materials include such items as: plated and unplated zinc castings, zinc fabrication scrap, contaminated zinc die-cast scrap, skimmings, and dross. There are three distinct processes used in the secondary zinc industry: pretreatment, melting, and distillation.

The pretreatment processes in use are based on mechanical, pyrometallurgical, and hydrometallurgical methods. Mechanical pretreatment involves physical reduction of the scrap and some means of separating the zinc from contaminating components. The primary hydrometallurgical pretreatment method is sodium carbonate leaching which is used to process skimmings and residues. Neither of these two pretreatment methods are considered sources of fugitive emissions. Sweating is the term applied to the pyrometallurgical pretreatment method used to separate zinc from higher melting metals and inorganic impurities. Reverberatory, kettle (pot), rotary, muffle, and electric furnaces are utilized to sweat zinc-bearing scrap.

Sweat processing is accomplished by charging the scrap into the furnace. The charge may be worked, by agitation or stirring during melting; and chloride flux may be present either as residual flux, in charged residual scrap, or as flux added to the charge. Working and fluxing of the charge are done to help effect the desired metal separation. A molten-metal bath is formed from the metallic zinc (with dissolved alloy metals). Non-metallic residues, along with some platings, form on the molten-metal bath surface and are skimmed off. Unmeltable attachments settle to the bottom and are removed. The molten zinc metal may then be (1) fed directly to furnaces for further processing, (2) fed directly to a distillation furnace, or (3) it may be sampled and analyzed, and then alloyed by adding metals to obtain the specified composition, and then cast as ingots.

In some cases, the scrap received can be fed directly to melting furnaces or distillation furnaces, thereby bypassing pretreatment and/or melting furnaces. In the melting operation, melt from sweat furnaces and/or scrap zinc is melted and usually fluxed to remove impurities. Crucible, kettle (pot), reverberatory, or electric induction furnaces are used in this operation. After the melting operation, the melt may be fed directly to distillation or cast into ingots.

Distillation may be done in either of two systems: a retort furnace or a muffle furnace. Material fed into either furnace may consist of zinc scrap, or molten or cast metal obtained from the sweating and/or melting furnaces.

In retort distillation, the charge is fed into retort on a batch scale. Once the metal is molten, it begins vaporizing. The vapor passes from the retort through a refractory pipe to a condenser where it is condensed into molten zinc. At the end of the distillation process the condenser is tapped and the zinc poured into ingots.

In the muffle furnace system the bed is charged into the melting unit. As the zinc melts, the molten metal flows into the vaporizing unit. From the vaporizing unit, the vaporized zinc is channeled to the condenser where it is condensed to liquid metal. Periodically, the molten zinc is tapped from the condenser and cast into ingots.

A process flow diagram for secondary zinc production is shown in Figure 2-13. Each potential process fugitive emission is identified and explained in Table 2-34.

Table 2-34 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR SECONDARY ZINC PRODUCTION

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
6. Electric resistance sweat furnace (total)	0.25 kg/Mg zinc scrap charged[e] (0.5 lb/ton zinc scrap charged)	E	v	v
6a. Charging	h		v	v
6b. Tapping	h		v	v
7. Hot metal transfer to melting furnaces	i			i
8. Crucible melting furnace (total)	0.0025 kg/Mg zinc produced[j] (0.005 lb/ton zinc produced)	E	Zinc produced 5,230 (5,753)	0.01 (0.01)
8a. Charging	k			k
8b. Tapping	k			k
9. Kettle (pot) melting furnace (total)	0.0025 kg/Mg zinc product[b] (0.005 lb/ton zinc produced)	E	v	v
9a. Charging	l		v	v
9b. Tapping	l		v	v
10. Reverberatory melting furnace (total)	0.0025 Kq/Mg zinc produced[e] (0.005 lb/ton zinc produced)	E	Zinc produced 5,230 (5,753)	0.01 (0.01)
10a. Charging	m			m
10b. Tapping	m			m

Table 2-34 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR SECONDARY ZINC PRODUCTION

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
11. Electric induction melting (total)	0.0025 kg/Mg zinc produced[e] (0.005 lb/ton zinc produced)	E	v	v
11a. Charging	n		v	v
11b. Tapping	n		v	v
12. Hot metal transfer to retort or alloying	i			i
13. Distillation retort and condenser (total)	1.18 kg/Mg zinc produced[o] (2.36 lb/ton zinc produced)	E	Zinc produced 5,475 (6,023)	6 (7)
13a. Charging distillation retort	p			p
13b. Leakage between retort condenser	Negligible	E	-	-
13c. Upset in condenser	2.5-5.0 kg/Mg zinc produced[q] (5.0-10 lb/ton zinc produced)	E	-	w
13d. Tapping	0.01-0.02 kg/Mg tapped[e,p] (0.02-0.04 lb/ton tapped)	E	p	p
14. Muffle distillation furnace and condenser	1.18 kg/Mg zinc produced[o] (2.36 lb/ton zinc produced)	E	Zinc produced 5,475 (6,023)	(6) (7)
14a. Charging muffle distillation furnace	r			r
14b. Leakage between furnace and condenser	Negligible	E	-	-

Table 2-34 (continued). IDENTIFICATION AND QUANTIFICATION OF POTENTIAL FUGITIVE PARTICULATE EMISSION POINTS FOR SECONDARY ZINC PRODUCTION

Source of IPFPE	Uncontrolled fugitive emission factor	Emission factor reliability rating	Model plant fugitive emission inventory	
			Operating parameter, Mg/yr (tons/year)	Uncontrolled emissions Mg/yr (tons/yr)
14c. Upset in condenser	2.5-5.0 kg/Mg zinc produced[s] (5.0-10.0 lb/ton zinc produced)	E	-	w
14d. Tapping	0.01-0.02 kg/Mg zinc tapped[t,r] (0.02-0.04 lb/ton tapped)	E		r
15. Alloying	u			u
16. Casting	0.005-0.01 kg/Mg zinc cast[e] (0.01-0.02 lb/ton zinc cast)	E	Zinc cast 10,950 (12,045)	0.08 (0.09)

[a] Reference /1.

[b] Engineering judgment based on emission factors given in references 1 and 2 assuming fugitive emissions to be equal to 5 percent of stack emissions. Ranges, when they appear, were derived from factors for clean and residual scrap.

[c] Emission included in total for Source 2.

[d] Emission included in total for Source 3.

[e] Engineering judgment based on stack emission factor given in Reference 1 assuming fugitive emissions to be equal to 5 percent of stack emissions.

[f] Emissions included in total for Source 4.

[g] Emissions included in total for Source 5.

[h] Emissions included in total for Source 6.

[i] Emissions included in emissions for individual furnace operations.

[j] Engineering judgment assuming fugitive emissions from crucible melting furnace to be equal to fugitive emissions from kettle (pot) melting furnace (Source 9).

[k] Emissions included in total for Source 8.

[l] Emissions included in total for Source 9.

[m] Emissions included in total for Source 10.

[n] Emissions included in total for Source 11.

[o] Engineering judgment based on emission factor given in Reference 2, assuming fugitive emissions to be equal to 5 percent of stack emissions.

[p] Emissions included in total for Source 13.

[q] Personal communication from J. P. Barnhart of W. J. Bullock, Inc. to Thomas Janszen. Personal estimation by J. P. Barnhart. This is not considered part of normal operating conditions.

[r] Emissions included in total for Source 14.

[s] Engineering judgment assuming upset conditions for Source 13c to be equal to that for Source 14c.

[t] Engineering judgment assuming tapping emissions for Source 13d equal to those for Source 14d.

[u] Alloying often takes place with the sweating or melting operations (Reference 1), however, if performed separately, it is an engineering judgment that fugitive emissions could range from negligible to as high as the emission factor given for iron innoculation in Section 2.5 of this report.

[v] Not included in emission inventory.

[w] Upset conditions are not considered part of normal operating conditions and therefore are not included in the emission inventory.

IPFPE Emission Rates - Very little data concerning process fugitive particulate emission factors for the secondary zinc smelting industry has been found in the literature. Therefore, emission rates as presented in Table 2-34 resulted for the most part from engineering judgements utilizing point source emission factors for the various operations identified. Most engineering judgments assumed that fugitive emissions equal 5 percent of an operation's stack emission. These values, therefore, received a reliability rating of "E" which indicates at best an order of magnitude estimate. Consequently, actual emission rates at a given facility could differ significantly from those in Table 2-34.

Example Plant Inventory - The example plant inventory for secondary zinc smelting, as shown in Table 2-27, presents potential fugitive particulate emission quantities from the various uncontrolled sources within the process. The inventory represents a plant which produces 10,950 Mg (12,045 tons) of zinc per year. Because of the many varied types of furnaces that can be utilized in secondary zinc production, the model plant configuration assumed for the inventory includes four kettle (pot) and rotary sweat furnaces, and four crucible and reverberatory melting furnaces. Also included is one crushing and screening operation. The plant inventory is not meant to display a typical plant, but merely a potential set of circumstances.

The assumed annual rate of scrap feed into the various furnaces was as follows:

Kettle (pot) sweat furnaces	7,531 Mg (8,284 tons) scrap zinc
Rotary sweat furnaces	7,531 Mg (8,284 tons) scrap zinc
Crushing and screening	2,877 Mg (3,165 tons) scrap zinc

Reverberatory melting furnaces	6,276 Mg (6,904 tons) metal charged
Crucible melting furnaces	6,276 Mg (6,904 tons) metal charged

Not included in the inventory are fugitive emissions from plant haul roads, but the amount of roads is expected to be minimal at secondary zinc facilities. Total model plant uncontrolled process fugitive particulate emissions are 21 Mg (23 tons) per year. Major sources of fugitive emissions are crushing and screening, and sweat furnaces.

Characteristics of Fugitive Emissions - Information concerning characteristics of fugitive emissions from secondary zinc smelting was not found in the literature. Therefore, the following information concerning stack emission characteristics is presented since they may approximate those of fugitive emissions.

Particulate emissions from sweating operations commonly contain zinc, aluminum, copper, iron, lead, cadmium, manganese, and chromium, in addition to carbonaceous materials and flux materials.[1] The following are the results of samples taken from a zinc sweat furnace which were analyzed for particulate composition.[3]

	Sweat furnace particulate emission	
	Composition percent by weight	
Constituents	Sample 1	Sample 2
NH_4^+	0.47	0.36
Cl^-	8.93	8.32
Zn	47.50	44.50
Al	1.43	0.54
Cu	0.04	0.05
Fe	0.40	0.21
Pb	0.14	0.16
Cd	0.02	0.03
Mn	0.03	0.01
Cr	0.01	0.004

Another analysis of particulate emissions from zinc sweat processing resulted in the following results.[4]

Component	Sweat furnace particulate emission Composition, percent by weight
$ZnCl_2$	14.5 - 15.3
ZnO	46.9 - 50.0
NH_4Cl	1.1 - 1.4
Al_2O_3	1.0 - 2.7
Fe_2O_3	0.3 - 0.6
PbO	0.2
H_2O (in $ZnCl_2 \cdot 4H_2O$)	7.7 - 8.1
Oxides of Mg, Sn, Ni, Si, Ca, Na	2.0
Carbonaceous material	10.0
Moisture (deliquescent)	5.2 - 10.2

In addition to the major components shown above, the particulates would be expected to contain trace amounts of copper, manganese, and chromium.[4]

Another analysis of particulate data for sweating of metallic scrap has shown 4 percent zinc chloride, 77 percent zinc oxide, 4 percent water, 4 percent other metal chlorides and oxides, and 10 percent carbonaceous materials. Sizes of particulates range from less than 1 μm to greater than 20 μm, but typically they are less than 2 μm.[1]

Particulate emissions from crushing/screening operations contain metallic zinc and other metals such as aluminum, copper, iron, lead, cadmium, chromium, and tin. Emissions from melting furnaces consist mostly of smoke from incomplete combustion of organic scrap, contaminants, and zinc fumes. Retort emissions consist mostly of zinc oxide fumes containing aluminum, copper, and other metals. Particle size range is from 0.05 - 1.0 μm.[1]

Control Technology - Control technology options for secondary zinc production IPFPE sources are presented in Table 2-35 and are explained in more detail below.

Better control of operating parameters and procedures such as proper feed rates, operating machinery only when required, and following proper maintenance schedules will help alleviate fugitive emissions from crushing/screening operations. Fixed hoods which enclose or cover screening operations with subsequent venting to a baghouse will effectively control fugitive emissions. Closed building evacuation to a baghouse will also serve as a means to control fugitive emissions.

The various sweating and melting furnaces can all be controlled in basically the same way. If primary control systems already are installed, the increasing of exhaust flow rates will oftentimes help reduce the volume of fugitive emissions released. Depending on furnace design, as well as space limitations and operating practices, fixed or movable hoods are very effective in the control of fugitive emissions. These hoods are usually most effective if placed over charging and particularly tapping areas since these are the major sources of fugitive emissions. A capture velocity of 0.5-1.0 meters/second (100-200 ft/min) is usually adequate for control of the fugitive emissions.[5] If limited space or operating procedures disallow the use of hoods, building evacuation to a fabric filter will effectively control fugitive emissions.

Fugitive emissions from distillation and condensation operations can be controlled in the same manner as described above. In addition, improved maintenance and/or construction materials will help prevent fugitive emissions which can escape from the connection between the distillation unit

Table 2-35. CONTROL TECHNIQUES FOR SECONDARY ZINC PRODUCTION IPFPE SOURCES

			FUGITIVE EMISSIONS CAPTURE AND CONTROL METHODS														
				Preventative procedures and operating changes							Capture methods				Removal equipment		
Industry: Secondary Zinc Production	Negligible emissions	IPFPE source typically uncontrolled	Control technologies identified in Section 2.1	Wet suppression (water and/or chemical)	Confinement by enclosure	Better control of raw material quality	Better control of operating parameters and procedures	Improved maintenance and/or construction program	Increase exhaust rate of primary control system		Fixed hoods, curtains, partitions, covers, etc.	Movable hoods with flexible ducts	Closed buildings with evacuation		Fabric filter	Scrubber	ESP
1. Crushing/screening of residue skimmings							o	o			o		+		o		
2. Reverberatory sweat furnace																	
2a. Charging									o		o	o	+		o		
2b. Tapping									o		o	o	+		o		
3. Kettle (pot) sweat furnace																	
3a. Charging									o		o	o	+		o		
3b. Tapping									o		o	o	+		o		
4. Rotary sweat furnace																	
4a. Charging									o		o	o	+		o		
4b. Tapping									o		o	o	+		o		
5. Muffle sweat furnace																	
5a. Charging									o		o	o	+		o		
5b. Tapping									o		o	o	+		o		
6. Electric resistance sweat furnace																	
6a. Charging									o		o	o	+		o		
6b. Tapping									o		o	o	+		o		
7. Hot metal transfer to melting furnace		✓											+		+		
8. Crucible melting furnace																	
8a. Charging									o		o	o	+		o		
8b. Tapping									o		o	o	+		o		
9. Kettle (pot) melting furnace																	
9a. Charging									o		o	o	+		o		
9b. Tapping									o		o	o	+		o		

x Typical control technique.

o In use (but not typical) control technique.

\+ Technically feasible control technique.

Table 2-35 (continued). CONTROL TECHNIQUES FOR SECONDARY ZINC PRODUCTION IPFPE SOURCES

			FUGITIVE EMISSIONS CAPTURE AND CONTROL METHODS														
				Preventative procedures and operating changes							Capture methods				Removal equipment		
Industry: Secondary Zinc Production	Negligible emissions	IPFPE source typically uncontrolled	Control technologies identified in Section 2.1	Wet suppression (water and/or chemical)	Confinement by enclosure	Better control of raw material quality	Better control of operating parameters and procedures	Improved maintenance and/or construction program	Increase exhaust rate of primary control system		Fixed hoods, curtains, partitions, covers, etc.	Movable hoods with flexible ducts	Closed buildings with evacuation		Fabric filter	Scrubber	ESP
10. Reverberatory melting furnace																	
10a. Charging									o		o	o	+		o		
10b. Tapping									o		o	o	+		o		
11. Electric induction melting furnace																	
11a. Charging									o		o	o	+		o		
11b. Tapping									o		o	o	+		o		
12. Hot metal transfer to retort or alloying		✓											+		+		
13. Distillation retort and condenser																	
13a Charging distillation retort											o	o	+		o		
13b. Leakage between retort and condenser								o			o	o	+		o		
13c. Upset in condenser							o				o	o	+		o		
13d. Tapping											o	o	+		o		
14. Muffle distillation furnace and condenser																	
14a. Charging muffle distillation furnace											o	o	+		o		
14b. Leakage between furnace and condenser								o			o	o	+		o		
14c. Upset in condenser							o				o	o	+		o		
14d. Tapping											o	o	+		o		
15. Alloying											+	+	+		+		
16. Casting							o				+	+	+		+		

x Typical control technique.

o In use (but not typical) control technique.

+ Technically feasible control technique.

to the condenser. If a good fit is maintained, fugitive emissions will be prevented.

Fugitive emissions from upset conditions can be controlled in several manners. Upset usually occurs when the pressure relief hole on the condenser becomes plugged resulting in pressure and heat build up with subsequent combustion of the zinc metal. If the pressure relief hole is cleaned regularly (once every 1/2 hr), the hole will not become plugged, upsets will be avoided, and fugitive emission eliminated. When upsets do occur, however, movable hoods can be placed over the pressure relief hole to capture fugitive emissions. Building evacuation to a baghouse will also effectively control the fugitive emissions.

Alloying and casting operations can be controlled by the use of fixed or movable hoods over the areas involved. Curtains which can help direct emissions into hoods are also quite useful. Building evacuation to a baghouse will also effectively control fugitive emissions. During casting operations, several steps can be taken to prevent the generation of fugitive emissions. As long as the temperature of the molten zinc is kept below 590°C (1100°F) and mold release compounds do not contain oils or other volatiles, very little fugitive emissions will be generated.[5]

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