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Project Summary

Ferroalloy Industry Particulate Emissions: Source Category Report

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A review was made of all available data characterizing particulate emissions from ferroalloy producing electric arc furnaces. The data were summarized and rated in terms of reliability. Total and size specific emission factors were developed for the ferroalloy industry. The ferroalloy industry and furnace operation were described in detail with emphasis on factors affecting emissions. A replacement for Section 7.4 (Ferroalloy Production) of EPA report AP-42, A Compilation of Air Pollutant Emission Factors, was prepared, containing the size specific emission factors developed during this program.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information on back).

Introduction

The purpose of this program was to summarize the best available information on inhalable particulate matter emissions in the ferroalloy industry. The main objective of the program was to develop reliable total and size-specific emission factors for each ferroalloy product group. Both uncontrolled and controlled emission factors are presented in this report. The uncontrolled emission factors represent emissions that would result from a particulate control system if the control device (baghouse, scrubber, etc.) were bypassed. The controlled emission factors represent emissions emanating from a particulate control system. Size specific emission factors are generally based on the results of cascade impactor sampling conducted simultaneously with total particulate sampling at the inlet or outlet to a control device.

A second objective of this program was to present current information on the ferroalloy industry. A third objective was to prepare a replacement for Section 7.4, Ferroalloy Production, in AP-42, "A Compilation of Air Pollutant Emission Factors."

The above objectives were met by an intensive 10 week search for data. Data were collected from the following sources:

- New England Research Application Center (NERAC) computerized literature searches
- Telephone conversations with state and federal EPA personnel
- Industry personnel
- Environmental consultants
- GCA/Technology Division files
- AP-42 ferroalloy background file at EPA's Office of Air Quality Planning and Standards
- Fine Particle Emission Information System (FPEIS)

The particulate emissions data contained in the referenced documents were reviewed, analyzed, summarized, and ranked according to the criteria provided in the report, "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections," April 1980. After ranking the data, emission factors were calculated using the highest quality data available. The quality of the data used to develop each

emission factor is indicated by the emission factor rating.

Process control system operating data as well as general industry information were also obtained and summarized as general background information. It was not the objective of this program to provide detailed engineering analyses, product specifications, or detailed evaluations of trends in the industry.

Summary of Project Results

Emissions are generated from several activities at a ferroalloy facility including raw material handling, smelting, and product handling. The emission factors presented in Tables 1 and 2 represent controlled and uncontrolled emissions from a ferroalloy smelting furnace. Emissions from raw material handling, pretreatment operations, and product handling are not included due to insufficient data. The smelting furnaces are by far the largest particulate emission source in a ferroalloy plant. Fugitive emissions from open sources are treated in a different report.

Furnace emissions are captured by hoods (for open furnaces) or aspirated directly from the furnace (for closed furnaces). Baghouses are used to control emissions generated from 85 percent of open furnaces in the U.S., while scrubbers are used on 13 percent of furnaces and electrostatic precipitators on 2 percent. Scrubbers are used almost exclusively to control high temperature exhaust gases from closed (sealed) furnaces. Scrubbers do not remove much CO and H_2.

Control efficiencies for well designed and operated control systems (i.e., baghouses with air-to-cloth ratios of 1 - 2 ft^3/ft^2 (18-38 m^3/m^2), and srubbers with pressure drops of 55 - 96 in. H_2O (19 - 24 kPa) have been reported to be in excess of 99 percent. It must be stressed that conscientious maintenance of the control system is necessary if such high efficiencies are to be consistently achieved.

Emissions from tapping can often be significant. Some plants capture these

Table 1. *Emission Factors for Particulate from Submerged Arc Ferroalloy Furnaces*[a]

Product[b]	Furnace type	Particulate emission factors (uncontrolled)[c] kg/Mg (lb/ton) alloy		kg (lb)/MW-hr		Size data	Notes	Emission factor rating	Control device[d]	Particulate emission factors (controlled)[c] kg/Mg (lb/ton) alloy		kg (lb)/MW-hr		Size data	Notes	Emission factor rating
FeSi (50%)	Open	35	(70)	7.4	(16.3)	Yes	e,f	B	Baghouse	0.9	(1.8)	0.2	(0.4)	Yes	e	B
	Covered	46	(92)	9.3	(20.5)			E	Scrubber							
									High energy	0.24	(0.48)	0.05	(0.1)		g	E
									Low energy	4.5	(9.0)	0.77	(1.7)		g	E
FeSi (75%)	Open	158	(316)	16	(35)			E								
	Covered	103	(206)	13	(29)		g	E	Scrubber							
									Low energy	4.0	(8.0)	0.5	(1.1)		g	E
FeSi (90%)	Open	282	(564)	24	(53)	Yes		E								
Si metal (98%)	Open	436	(872)	33	(73)	Yes	h	B	Baghouse	16	(32)	1.2	(2.6)	Yes	h	B
FeMn (80%)	Open	14	(28)	4.8	(11)	Yes	i	B	Baghouse	0.24	(0.48)	0.078	(0.2)	Yes	i	B
									Scrubber							
									High energy	0.8	(1.6)	0.34	(0.7)		j	E
FeMn (1% Si)	Covered	6	(12)	2.4	(5.3)		k	E	High energy	0.25	(0.5)	0.10	(0.2)		j,m	C
	Sealed	37	(74)	17	(37)		l	E								
FeCr (high carbon)	Open	78	(157)	15	(33)	Yes	n	C	ESP	1.2	(2.3)	0.23	(0.5)	Yes	n	C
SiMn	Open	96	(192)	20	(44)	Yes	o	C	Scrubber	2.1	(4.2)	0.44	(1.0)	Yes	p	C
	Sealed	–	(–)	–	(–)		q		Scrubber							
									High energy	0.15	(0.30)	0.016	(0.04)		m	E

[a] *Factors are for main furnace dust collection system before and after control device. Where other emissions, such as leaks or tapping, are included or quantified separately, such is noted. Particulate sources not included: raw material handling, storage, preparation; and product crushing, screening, handling, packaging.*

[b] *Percentages are of the main alloying element in product.*

[c] *In most source testing, fugitive emissions not measured or collected. Where tapping emissions are controlled by primary system, their contribution to total emissions could not be determined. Fugitive emissions may vary greatly among sources, with furnace and collection system design and operating practices.*

[d] *Low energy scrubbers are those with $\Delta P < 20$ in. H_2O; high energy, with $\Delta P > 20$ in. H_2O.*

[e] *Includes fumes captured by tapping hood (efficiency estimated near 100%).*

[f] *Factor is average of three sources, fugitive emissions not included. Fugitive emissions at one source measured an additional 10.5 kg/Mg alloy, or 2.7 kg/MW-hr*

[g] *Does not include emissions from tapping or mix seal leaks.*

[h] *Estimated 60% of tapping emissions captured by control system (escaped fugitive emissions not included in factor).*

[i] *Estimated 50% of tapping emissions captured by control system (escaped fugitive emissions not included in factor).*

[j] *Includes fume only from primary control system.*

[k] *Includes tapping fumes and mix seal leak fugitive emissions. Fugitive emissions measured at 33% of total uncontrolled emissions.*

[l] *Assumes tapping fumes not included in emission factor.*

[m] *Does not include tapping or fugitive emissions.*

[n] *Tapping emissions included. Factor developed from two test series performed on the same furnace 7 years apart. Measured emissions in latter test were 36% les than in former.*

[o] *Factor is average of two test series. Tests at one source included fugitive emissions (3.4% of total uncontrolled emissions). Second test insufficient to determin if fugitive emissions were included in total.*

[p] *Factors developed from two scrubber controlled sources: one operated at ΔP = 47-57 in. H_2O; the other at unspecified ΔP. Uncontrolled tapping operation emissions are 2.1 kg/Mg alloy.*

[q] *Dash = No data.*

Table 2. *Size Specific Emission Factors for Submerged Arc Ferroalloy Furnaces*

Product	Control device	Particle size[a] (μm)	Cumulative mass % ≤ stated size	Cumulative mass emission factor kg/Mg (lb/ton) alloy		Emission factor rating
50% FeSi						
Open furnace	*None*[b]	*0.63*	*45*	*16*	*(32)*	*B*
		1.00	*50*	*18*	*(35)*	
		1.25	*53*	*19*	*(37)*	
		2.50	*57*	*20*	*(40)*	
		6.00	*61*	*21*	*(43)*	
		10.00	*63*	*22*	*(44)*	
		15.00	*66*	*23*	*(46)*	
		20.00	*69*	*24*	*(48)*	
		[c]	*100*	*35*	*(70)*	
	Baghouse	*0.63*	*31*	*0.28*	*(0.56)*	*B*
		1.00	*39*	*0.35*	*(0.70)*	
		1.25	*44*	*0.40*	*(0.80)*	
		2.50	*54*	*0.49*	*(1.0)*	
		6.00	*63*	*0.57*	*(1.1)*	
		10.00	*72*	*0.65*	*(1.3)*	
		15.00	*80*	*0.72*	*(1.4)*	
		20.00	*85*	*0.77*	*(1.5)*	
			100	*0.90*	*(1.8)*	
80% FeMn						
Open furnace	*None*[d]	*0.63*	*30*	*4*	*(8)*	*B*
		1.00	*46*	*7*	*(13)*	
		1.25	*52*	*8*	*(15)*	
		2.50	*62*	*9*	*(17)*	
		6.00	*72*	*10*	*(20)*	
		10.00	*86*	*12*	*(24)*	
		15.00	*96*	*13*	*(26)*	
		20.00	*97*	*14*	*(27)*	
		[c]	*100*	*14*	*(28)*	
80% FeMn						
Open furnace	*Baghouse*[d]	*0.63*	*20*	*0.048*	*(0.10)*	*B*
		1.00	*30*	*0.070*	*(0.14)*	
		1.25	*35*	*0.085*	*(0.17)*	
		2.50	*49*	*0.120*	*(0.24)*	
		6.00	*67*	*0.160*	*(0.32)*	
		10.00	*83*	*0.200*	*(0.40)*	
		15.00	*92*	*0.220*	*(0.44)*	
		20.00	*97*	*0.235*	*(0.47)*	
		[c]	*100*	*0.240*	*(0.48)*	
Si Metal						
Open furnace	*None*[e]	*0.63*	*57*	*249*	*(497)*	*B*
		1.00	*67*	*292*	*(584)*	
		1.25	*70*	*305*	*(610)*	
		2.50	*75*	*327*	*(654)*	
		6.00	*80*	*349*	*(698)*	
		10.00	*86*	*375*	*(750)*	
		15.00	*91*	*397*	*(794)*	
		20.00	*95*	*414*	*(828)*	
		[c]	*100*	*436*	*(872)*	
	Baghouse	*1.00*	*49*	*7.8*	*(15.7)*	*B*
		1.25	*53*	*8.5*	*(17.0)*	
		2.50	*64*	*10.2*	*(20.5)*	
		6.00	*76*	*12.2*	*(24.3)*	
		10.00	*87*	*13.9*	*(28.0)*	
		15.00	*96*	*15.4*	*(31.0)*	
		20.00	*99*	*15.8*	*(31.7)*	
			100	*16.0*	*(32.0)*	

Table 2. *Size Specific Emission Factors for Submerged Arc Ferroalloy Furnaces—Continued*

Product	Control device	Particle size[a] (μm)	Cumulative mass % ≤ stated size	Cumulative mass emission factor kg/Mg (lb/ton) alloy		Emission factor rating
FeCr (HC)						
Open furnace	*None[b]*	*0.5*	*19*	*15*	*(30)*	*C*
		1.0	*36*	*28*	*(57)*	
		2.0	*60*	*47*	*(94)*	
		2.5	*63[f]*	*49*	*(99)*	
		4.0	*76*	*59*	*(119)*	
		6.0	*88[f]*	*67*	*(138)*	
		10.0	*91*	*71*	*(143)*	
		[c]	*100*	*78*	*(157)*	
	ESP	*0.5*	*33*	*0.40*	*(0.76)*	*C*
		1.0	*47*	*0.56*	*(1.08)*	
		2.5	*67*	*0.80*	*(1.54)*	
		5.0	*80*	*0.96*	*(1.84)*	
		6.0	*86*	*1.03*	*(1.98)*	
		10.0	*90*	*1.08*	*(2.07)*	
		[c]	*100*	*1.2*	*(2.3)*	
SiMn						
Open furnace	*None[b]*	*0.5*	*28*	*27*	*(54)*	*C*
		1.0	*44*	*42*	*(84)*	
		2.0	*60*	*58*	*(115)*	
		2.5	*65*	*62*	*(125)*	
		4.0	*76*	*73*	*(146)*	
		6.0	*85*	*82*	*(163)*	
		10.0	*96[f]*	*92[f]*	*(177)[f]*	
		[c]	*100*	*96*	*(192)*	
	Scrubber[g]	*0.5*	*56*	*1.18*	*(2.36)*	*C*
		1.0	*80*	*1.68*	*(3.44)*	
		2.5	*96*	*2.02*	*(4.13)*	
		5.0	*99*	*2.08*	*(4.26)*	
		6.0	*99.5*	*2.09*	*(4.28)*	
		10.0	*99.9[f]*	*2.10[f]*	*(4.30)[f]*	
			100	*2.1*	*(4.3)*	

[a]Aerodynamic diameter, based on Task Group on Lung Dynamics definition. Particle density = 1 g/cm^3.
[b]Includes tapping emissions.
[c]Total particulate, based on Method 5 total catch (see Table 1).
[d]Includes tapping fume (capture efficiency 50%).
[e]Includes tapping fume (estimated capture efficiency 60%).
[f]Interpolated data.
[g]Primary emission control system only, without tapping emissions.

emissions in varying degrees using the main canopy hood, and others employ separate tapping hoods ducted to either the furnace control device or a separate control device. Emission factors for tapping operations are unavailable due to the lack of data.

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The complete report, entitled "Ferroalloy Industry Particulate Emissions: Source Category Report," (Order No. PB 87-129 268/AS; Cost: $18.95, subject to change) will be available only from:
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