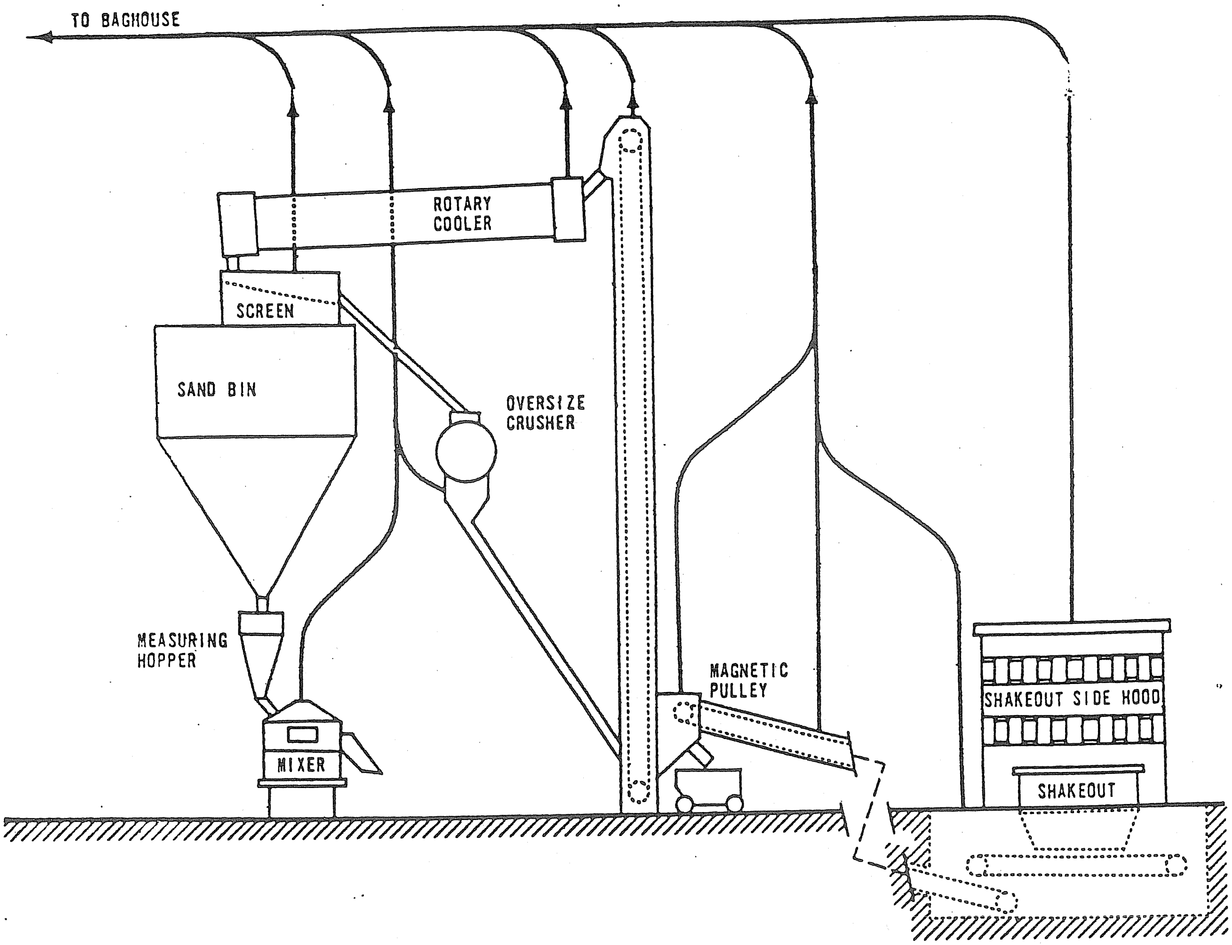

Figure 2.7-15. Capture design for a typical sand-handling system.[46]

2.7.2 Recommended Reasonably Available Control Measures (RACM)

The RACM selections for iron foundry fugitive sources are presented in Table 2.7-3.

The recommended control measure for cupola furnace charging emissions is the maintenance of sufficient draft through the charge door to effectively contain charging emissions and vent them to the existing primary control device. This is the most effective means of control that would not require a large capital outlay for cupolas having above-charge and below-charge take-offs. However, under this control measure, cupola furnace tapping emissions would be uncontrolled.

For control of electric arc and large electric induction furnaces which have primary controls, the selected RACM is maintenance of a continuous draft during the charging and tapping operations through the existing hooding for primary control. This technique could involve some modifications or extensions to the existing hoods to assure good capture. For furnaces which do not have primary controls, RACM consists of localized and canopy hooding which is vented to a fabric filter. For very small electric induction furnaces which have minimal visible emissions, no control is recommended.

No control is recommended for reverberatory furnaces since these are very low emitters of particulate matter and are not usually controlled.

The recommended RACM for ductile iron inoculation is hooding with exhaust to a fabric filter or wet scrubber. This system gives very good control and is commonly applied on existing foundries.

TABLE 2.7-8. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM SOURCES AT IRON FOUNDRIES

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan. 1980, $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
(1) Cupola furnace charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	2.60	Maintenance of continuous draft through charge door (if primary controls present); otherwise hooding, vent to fabric filter
	Building enclosure, evacuation to fabric filter	95[c]	d	d	NA	
	Maintenance of continuous draft through charge door	70[e]	150,000[f]	30,000[g]	1.22	
(2) Electric arc furnace charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	3.94[r] 1.97[s]	Maintenance of continuous draft during charging and tapping operations (if primary controls present); otherwise hooding, vent to fabric filter
	Building enclosure, evacuation to fabric filter	95[c]	d	d	NA	
	Maintenance of continuous draft during charging and tapping	70[e]	20,000[h]	4,000[g]	0.25[r] 0.12[s]	
(3) Electric induction furnace melting, charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	1.82	Maintenance of continuous draft during charging and tapping (if primary controls present); otherwise, hooding, vent to fabric filter
	Building enclosure, evacuation to fabric filter	95[c]	d	d	NA	
	Maintenance of continuous draft during charging and tapping	70[e]	20,000[h]	4,000[g]	0.11	
(4) Reverberatory furnace charging and tapping	Hooding, vent to fabric filter or ESP	90[a]	336,000[a]	82,000[b]	27.61	No control
	Building enclosure, evacuation to fabric filter or ESP	95[c]	d	d	NA	
(5) Ductile iron inoculation	Hooding, vent to fabric filter or scrubber	90[a]	153,000[a,i]	33,000[b]	0.28	Hooding, vent to fabric filter or scrubber
	Room enclosure, vent to filter or scrubber	95[c]	d	d	NA	
(6) Pouring molten metal	Hoods, vent to wet scrubber	95[c]	63,000[j]	17,000[b]	0.26	Hoods, vent to scrubber
(7) Casting shakeout	Hoods, vent to wet scrubber or fabric filter	95[c]	234,000[k]	82,000[b]	0.20	Hoods, vent to fabric filter or scrubber

(continued)

TABLE 2.7-8 (continued)

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan. 1980, $ Capital	Annualized	Cost benefit, $/lb	RACM selection
(8) Cooling and cleaning castings	Hooding, mechanical collector, fabric filter or scrubber	90[c]	l	l	0.20	m
(9) Finishing castings	Hooding, vent to mechanical collector, fabric filter or scrubber	90-99[a]	l	l	0.20	m
(10) Core and molding sand unloading and storage: mechanical handling	Hooding, vent to mechanical collector	80[c]	33,600[c]	12,000[c]	2.14	Wet suppression (chemical)
	Wet suppression (chemical)	85[c]	26,000[h]	7,000[o]	1.18	
	Enclosure	50[c]	15,000[p]	3,000[q]	0.85	
pneumatic handling	Vent storage hopper to fabric filter	99[c]	NA	NA	NA	Vent storage hopper to fabric filter
(11) Core sand and binder mixing	Hooding, vent to mechanical collector or fabric filter	90[c]	l	l	0.20	m
(12) Core making	Hooding, vent to fabric filter	90[c]	l	l	0.20	m
(13) Core baking	Afterburners	90[c]	35,000[q]	21,000[q]	2.59	No control
(14) Mold sand preparation	Hooding, vent to fabric filter or scrubber	90[c]	l	l	0.20	m
(15) Mold makeup	Hooding, vent to fabric filter or scrubber	90[c]	l	l	0.20	m

NA = Not available.

TABLE 2.7-8 (continued)

[a] Reference 47.

[b] Reference 48.

[c] Estimated.

[d] No cost data available.

[e] Based on control of 95% of charging emissions only. Reference 49.

[f] Reference 49.

[g] Includes only capital charges and maintenance estimated at 20% of capital investment.

[h] Estimated costs of movable ducting required.

[i] Assumed equivalent to control tapping emissions.

[j] Reference 50.

[k] Reference 50. Based on 50,000 acfm and control of sand handling, cooling, cleaning, mixing, core and mold mixing operations.

[l] Control costs included under the casting shakeout system.

[m] RACM is an integrated system ducting the casting shakeout, sand handling, cooling, cleaning, mixing, core and mold making operations to a single fabric filter or wet scrubber.

[n] Reference 51.

[o] Reference 52.

[p] Reference 53. Based on 20' x 20' x 30' enclosure.

[q] Reference 54.

r With no alloying in the ladle.

s With alloying in the ladle.

The RACM selected for hot metal pouring operations is hooding and local exhaust to a wet scrubber. This type of system provides very good control (95%).

The selected RACM for control of the casting shakeout fugitive emissions is a system of hoods ducted to a common fabric filter or wet scrubber. This system would be designed to handle exhaust gases from the cleaning and cooling of castings, finishing operations, sand and binder mixing, core and mold makeup, and sand preparation and handling operations. This system is very effective and is used in existing foundries.

The sand unloading operations (truck or railcar dumping into receiving hopper) can be effectively controlled by use of wet suppression. Other options offer inferior control at costs on the same order of magnitude. For the pneumatic unloading and storage of sand, the general industry practice is the use of a fabric filter to control emissions from the storage hopper vent.

No control was selected for the core baking operation since with proper operation this is a relatively minor source of particulate emissions.

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Assume furnace capacity = 11 tph or 33,000 tpy

(1) Cupola furnace charging and tapping
Emissions = (1.05 lb/ton)(33,000 tpy) = 35,000 lbs/yr

<u>Hooding, vent to fabric filter</u>

Capital cost = $336,000
Annual cost = 82,000

$$C/B = \frac{\$82{,}000/yr}{.9\ (35{,}000)} = \$2.60/lb$$

<u>Building enclosure evacuation to fabric filter</u>
No data

<u>Maintenance of continuous draft through charge door</u>

Capital cost = $150,000
Annual cost = 30,000

$$C/B = \frac{\$30{,}000/yr}{.70\ (35{,}000)} = \$1.22/lb$$

(2) Electric arc furnace charging and tapping
Emissions = (0.7 lb/ton)(33,000 tpy) = 23,100 lbs/yr (no alloying in ladle); (1.4 lbs/ton)(33,000 tpy) = 46,200 lbs/yr (with alloying in ladle)

<u>Hooding, vent to fabric filter</u>

Capital cost = $336,000
Annual cost = 82,000

$$C/B = \frac{\$82{,}000/yr}{.9\ (23{,}100)} = \$3.94/lb$$

$$C/B = \frac{\$82{,}000/yr}{.9\ (46{,}200)} = \$1.97/lb$$

<u>Building enclosure, evacuation to fabric filter</u>
No data

<u>Maintenance of continuous draft during charging and tapping</u>

Capital cost = $20,000
Annual cost = 4,000

$$C/B = \frac{\$4{,}000/yr}{.7\ (23{,}100)} = \$0.25/lb$$

$$C/B = \frac{\$4{,}000/yr}{.7\ (46{,}200)} = \$0.12/lb$$

(3) Electric induction furnace melting, charging and tapping
Emissions = (1.5 lb/ton)(33,000 tpy) = 50,000 lbs/yr

Hooding, vent to fabric filter

Capital cost = \$336,000
Annual cost = 82,000

$$C/B = \frac{\$82,000/yr}{.9\ (50,000)} = \$1.82/lb$$

Building enclosure, evacuation to fabric filter
No data

Maintenance of continuous draft during charging and tapping

Capital cost = \$20,000
Annual cost = 4,000

$$C/B = \frac{\$4,000/yr}{.7\ (50,000)} = \$0.11/lb$$

(4) Reverberatory furnace charging and tapping
Emissions = (0.1 lb/ton)(33,000 tpy) = 3,300 lbs/yr

Hooding, vent to fabric filter or ESP

Capital cost = \$336,00
Annual cost = 82,000

$$C/B = \frac{\$82,000/yr}{.9\ (3,000)} = \$27.61$$

Building enclosure, evacuation to fabric or ESP
No data

(5) Ductile iron inoculation
Emissions = (3.9 lbs/ton)(33,000 tpy) = 129,000 lbs/yr

Hooding, vent to fabric filter or scrubber

Capital cost = \$153,000
Annual cost = 33,000

$$C/B = \frac{\$33,000/yr}{0.9\ (129,000)} = \$0.28/lb$$

Room enclosure, vent to filter or scrubber
No data

(6) Pouring molten metal

Emissions = (2.115 lb/ton)(33,000 tpy) = 70,000 lbs/yr

Hoods, vent to wet scrubber

Capital cost = $63,000
Annual cost = 17,000

$$C/B = \frac{\$17,000/yr}{.95\ (70,000)} = \$0.26/lb$$

(7) Casting shakeout

Emissions = (7.0 lb/ton)(33,000) = 231,000 lbs/yr

Hoods, vent to wet scrubber or fabric filter

Capital cost = $234,000
Annual cost = 82,000

$$C/B = \frac{\$82,000/yr}{.95\ (231,000) + .9\ (16,000) + .95\ (330) + .9\ (148,500) + .9\ (1,000) + .9\ (43,000) + .9\ (1,300)}$$

$$= \$\ 0.20/lb$$

(8) Cooling and cleaning castings

Emissions = (0.48 lb/ton)(33,000 tpy) = 16,000 lbs/yr

Hooding, mechanical collector, fabric filter or scrubber

See (7)
C/B = $0.20/lb

(9) Finishing casting

Emissions = (0.01 lb/ton)(33,000 tpy) = 330 lbs/yr

Hooding, vent to mechanical collector, fabric filter or scrubber

See (7)
C/B = $0.20/lb

(10) Core and molding sand unloading and storage

<u>Mechanical handling</u>

Emissions = (.03 lb/ton)(33,000 tpy)(15)(.5) = 7,000 lbs/yr

<u>Hooding, vent to mechanical collector</u>

Capital cost = \$33,600
Annual cost = 12,000

$$C/B = \frac{\$12,000/yr}{.8\ (7,000)} = \$2.14/lb$$

<u>Wet suppression (chemical)</u>

Capital cost = \$26,000
Annual cost = 7,000

$$C/B = \frac{\$7,000/yr}{.85\ (7,000)} = \$1.18/lb$$

<u>Enclosure</u>

Capital cost = \$15,000
Annual cost = 3,000

$$C/B = \frac{\$3,000/yr}{.5\ (7,000)} = \$0.85/lb$$

<u>Pneumatic handling</u>

Emissions = NA

<u>Vent Storage hopper to fabric filter</u>
No data

(11) Core sand and binder mixing
Emissions = (4.5 lb/ton)(33,000 tpy) = 148,500 lbs/yr

<u>Hooding, vent to mechanical collector or fabric filter</u>

See (7)
C/B = \$0.20/lb

(12) Core making
Emissions = (0.35 lb/ton cores)(3,300 tpy) = ∿1,000 lbs/yr

<u>Hooding, vent to fabric filter</u>

See (7)
C/B = \$0.20/lb

(13) Core baking
Emissions = (2.7 lb/ton core) (3,300 tpy) = 9,000 lbs/yr

Afterburners

Capital cost = $35,000
Annual cost = 21,000

$$C/B = \frac{\$21,000/yr}{.9\ (9,000)} = \$2.59/lb$$

(14) Mold sand preparation
Emissions = (1.3 lb/ton) (33,000 tpy) = 43,000 lbs/yr

Hooding, vent to fabric filter or scrubber

See (7)
C/B = $0.20/lb

(15) Mold makeup
Emissions = (0.04 lb/ton) (33,000 tpy) = 1,300 lbs/yr

Hooding, vent to fabric filter or scrubber

See (7)
C/B = $0.20/lb

2.8 STEEL FOUNDRIES

2.8.1 Process Description

Most steel foundries are operated independently from any integrated iron and steel mill. They produce low carbon content (1 percent or less) steel castings for use within the foundry to produce another product or by manufacturers of heavy equipment.

Several types of furnaces are used to melt the raw materials used to produce these steel castings: direct electric arc, electric induction, open hearth and crucible. The crucible furnace is not in widespread use. (See Sections 2.2.3 and 2.7 for illustrations of some of those types of furnaces.)

Figure 2.8-1 illustrates the process flow for a typical steel foundry operation. The melting furnace is charged through a door or opening with raw materials such as steel scrap, pig iron, ferroalloys and limestone. These materials melt as the furnace temperature is increased. When the temperature reaches about 3000°F, the furnace is tapped and molten metal flows to a holding ladle. The molten metal is transferred from the holding ladle to a pouring ladle and is then poured into prepared molds. The molten steel sets to form castings which are then shaken out of the mold and allowed to cool further. The castings are usually cleaned by shot blasting, and excess metal and surface defects are removed by localized melting and grinding. Finishing operations may include heat treatment in a soaking pit or furnace and surface painting.

Production of molds and cores is an integral part of the steel foundry operation. A mold is usually made of silica sand (although zircon and olivine sand are also used) mixed with water and binders such as clay, pitch or cereal. The mixture is transferred to a molding area, where it is either mechanically or hand packed into a flask.

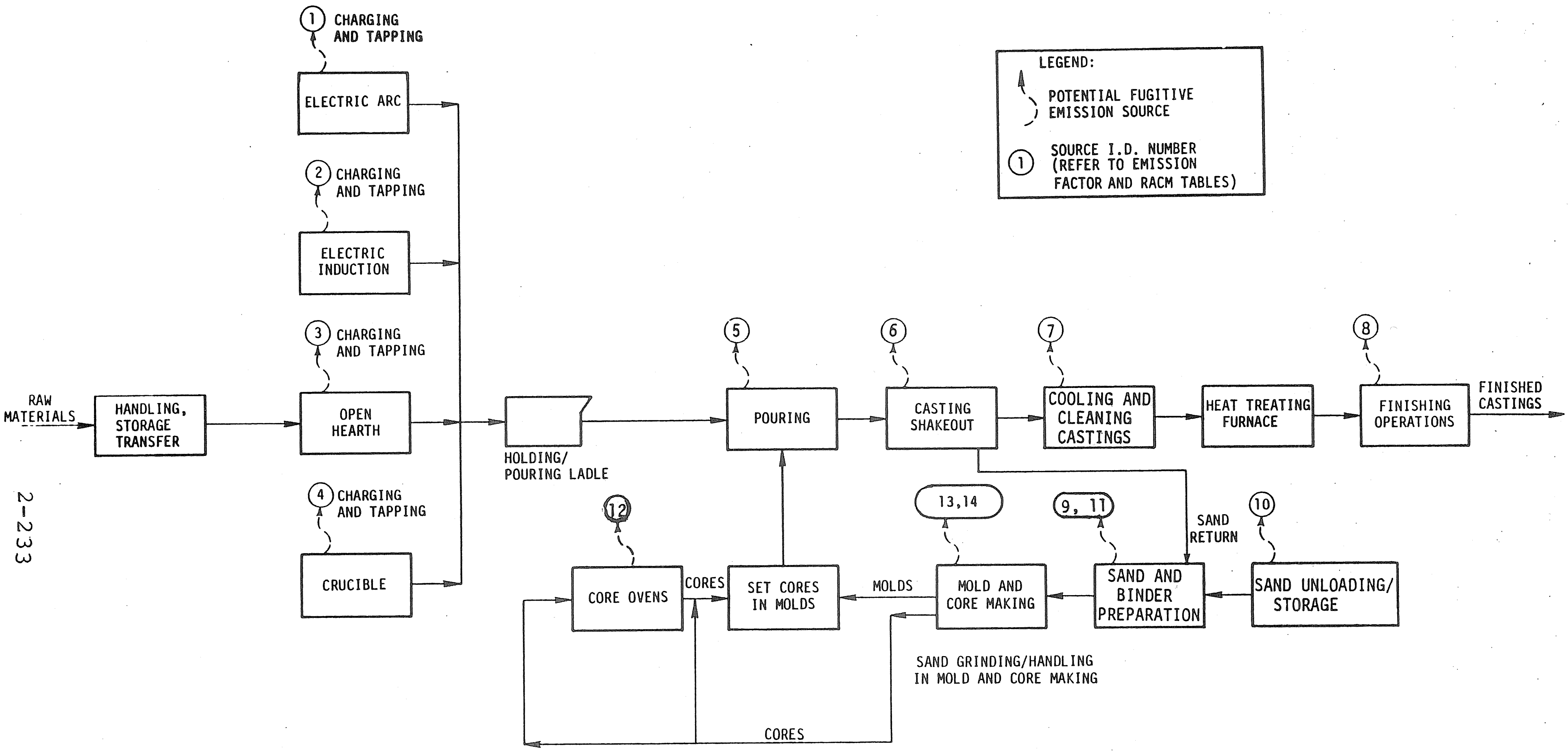

Figure 2.8-1. Simplified process flow diagram for steel foundries and associated fugitive particulate emission sources.

A core is a separate part of the mold that provides a cavity in the castings. Cores are usually made of sand and binders and are usually, but not always, bound to the mold with core paste. The core must be strong enough to withstand the temperature and pressure of the molten metal within the mold. Silicate, resin, oil and cereal binders are used to provide this strength. After the cores are formed, they may be baked in ovens or cured by carbon dioxide, air, a tertiary amine catalyst (Isocure process) or by using heated core boxes (shell and hotbox processes).

The potential fugitive emission sources associated with steel foundries are raw material handling, storage, and transfer operations, charging and tapping of the melting furnaces, pouring into molds, casting shakeout, cleaning operations, finishing operations, sand preparation, and mold and core making.

Large steel foundries operate continuously, 24 hours a day, 7 days a week, while smaller foundries operate only 8 hours a day. The capacity of a foundry depends upon the number and size of furnaces, but typically ranges from 25 to 240 tons of steel produced per day.

2.8.2 Fugitive Dust Emission Factors

The estimated emission factors for steel foundry fugitive particulate sources are summarized in Table 2.8-1. There is practically no data availabl on fugitive emission rates from steel foundries; and, therefore, it is suggested that emission factors for iron foundries (Section 2.7) be used for steel foundries. These are also included in Table 2.8-1 for informational purposes.

It should be noted that use of the iron foundry emission factors for mold sand preparation, core sand and binder mixing and mold making may not be directly applicable to such operations at steel foundries due to differenc in yields and possibly in sand to metal ratios between steel and iron casting production. Such differences should be evaluated and, if necessary, adjustme made to such emission factors to reflect any differences.

TABLE 2.8-1. FUGITIVE DUST EMISSION FACTORS FOR STEEL FOUNDRIES[a]

Source	Emission factor	Reliability rating	References
(1) Electric arc furnace charging and tapping	1.05 to 3.48 lb/ton steel	E	1,2
(2) Electric induction furnace melting, charging and tapping	0.1 lb/ton metal charged	E	3
(3) Open hearth furnace charging and tapping	0.1 to 0.9 lb/ton metal charged	E	4,5
(4) Crucible furnace charging and tapping	0.1 to 0.6 lb/ton metal	E	6
(5) Hot metal pouring	0.55 to 4.13 lb/ton metal	D	7,8
(6) Shakeout of castings[b]	1.2 to 12.8 lb/ton steel	E	1,9
(7) Cooling and cleaning castings[b]	0.16 to 0.8 lb/ton castings	E	9
(8) Finishing castings[b]	0.01 lb/ton castings	E	9
(9) Mold sand preparation[b]	1.3 lb/ton castings	E	1
(10) Core and mold sand unloading and storage:			
mechanical handling	0.03 lb/ton sand unloaded[c]	E	6
pneumatic handling	NA		
(11) Mixing of core sand and binder[b]	0.3 lb/ton sand, or 0.75 to 8.24 lb/ton	E E	10 1,9
(12) Core baking	0.03 to 5.4 lb/ton cores baked	E	6,9,10
(13) Core making[b]	0.35 lb/ton cores	E	10
(14) Mold making[b]	0.04 lb/ton castings	E	9

NA = Not available.

[a] Where ranges are given, use average unless more accurate data is available.

[b] Emission factor given is for iron foundries.

[c] Sand unloading emission factor is assumed to be equivalent to the taconite pellets unloading emission factor as presented in Section 2.1.3. Fugitive dust emissions from storage are estimated to be negligible since sand is normally stored indoors.

2.8.3 Particle Characterization

Data on particle characteristics specific for steel foundries were not found in the literature. Data were available for iron foundries. The available data are presented similar for steel foundries. The available data are presented in Section 2.7.3.

2.8.4 Control Methods

Control techniques available for steel foundries are essentially the same as those for iron foundries. Section 2.7.4 presents a discussion of available control options.

Available control techniques, their effectiveness, estimated costs and RACM selections are listed in Table 2.8-2. Where data were unavailable, it was assumed that control characteristics would be the same as those for control of iron foundries (See Section 2.7.4).

2.8.5 Recommended Reasonably Available Control Measures (RACM)

The RACM selections for steel foundry fugitive sources are presented in Table 2.8-2. It is noted that the reduction of emission from melting operations is enhanced when clean scrap is used in the raw charge. Clean materials that are essentially devoid of dirt, oil or grease carry no extraneous burden into and through the furnace. Use of clean scrap, or the pre-cleaning of dirty scrap before use, are useful and appropriate measures worthy of consideration as adjunctive to and supportive of other control measures.

TABLE 2.8-2. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM SOURCES AT STEEL FOUNDRIES

Fugitive dust sources	Control alternatives	Control efficiency, %	Control cost, Jan. 1980, $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
(1) Electric arc furnace charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	1.09	Maintenance of continuous draft during charging and tapping operations (if primary controls present); otherwise hooding, vent to fabric filter
	Building enclosure, evacuation to fabric filter	95[c]	d	d	d	
	Maintenance of continuous draft during charging and tapping	70[e]	20,000[h]	4,000[g]	0.07	
(2) Electric induction furnace, charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	23.11	Maintenance of continuous draft during charging and tapping (if primary controls present); otherwise, no control
	Building enclosure, evacuation to fabric filter	95[c]	d	d	d	
	Maintenance of continuous draft during charging and tapping	70[e]	20,000[f]	4,000[g]	1.45	
(3) Open hearth furnace charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	4.62	Maintenance of continuous draft during charging and tapping operations (if primary controls present); otherwise hooding, vent to fabric filter
	Building enclosure, evacuation to fabric filter	95[c]	d	d	d	
	Maintenance of continuous draft during charging and tapping	70[e]	20,000[f]	4,000[g]	0.29	
(4) Crucible furnace charging and tapping	Hooding, vent to fabric filter	90[a]	336,000[a]	82,000[b]	8.32	No control
	Building enclosure, evacuation to fabric filter	95[c]	d	d	d	
	Maintenance of continuous draft during charging and tapping	70[e]	20,000[f]	4,000[g]	0.52	

(continued)

TABLE 2.8-2 (continued)

Fugitive dust sources	Control alternatives	Control efficiency, %	Control cost, Jan. 1980, $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
(5) Hot metal pouring	Hoods, vent to wet scrubber or fabric filter	95[c]	63,000[h]	18,000[b]	0.22	Hoods, vent to fabric filter
(6) Casting shakeout	Hoods, vent to wet scrubber or fabric filter	95[c]	234,000[i]	82,000[b]	0.18	Hoods, vent to fabric filter
(7) Cooling and cleaning castings	Hooding, mechanical collector, fabric filter or scrubber	90[c]	j	j	j	k
(8) Finishing castings	Hooding, vent to mechanical collector, fabric filter or scrubber	90-99[a]	j	j	j	k
(9) Mold sand preparation	Hooding, vent to fabric filter or scrubber	90[c]	j	j	j	k
(10) Core and mold sand unloading and storage:						
mechanical handling	Wet suppression (chemical)	85[c]	26,000	7,000	1.00	Wet suppression (chemical)
	Enclosure	50[c]	15,000	3,000	0.73	
	Hooding, vent to mechanical collectors	80[c]	33,600	12,000	1.83	
pneumatic handling	Vent to storage hopper to fabric filter	99[c]	NA	NA	NA	Vent to storage hopper to fabric filter
(11) Core sand and binder mixing	Hooding, vent to mechanical collector or fabric filter	90[c]	j	j	j	k
(12) Core baking	Afterburners	90[c]	35,000	21,000	2.37	No control
(13) Core making	Hooding, vent to fabric filter	90[c]	j	j	j	k
(14) Mold makeup	Hooding, vent to fabric filter or scrubber	90[c]	j	j	j	k

[a] Reference 11.
[b] Reference 12.
[c] Estimated.
[d] No cost data available.
[e] Based on control of 95% of charging emissions only. Reference 13.
[f] Estimated costs of movable ducting required.
[g] Includes only capital charges and maintenance estimated as 20% of capital investment.
[h] Reference 14.
[i] Reference 14. Based on 50,000 acfm and control of sand handling, cooling, cleaning, mixing, screening, core and mold making operations.
[j] Control costs included under casting shakeout system.
[k] RACM is an integrated system ducting the casting shakeout, sand handling, cooling, cleaning, mixing, screening, core and mold making operations to a single fabric filter.

The selected RACM for control of electric arc, electric induction and open hearth furnaces is predicated upon utilization of an existing capture and control system to effect emission control at charging and tapping operations. The RACM technique may necessitate modification of the existing hood(s) and duct system(s) and may require the addition of control device capacity. For electric arc and open hearth furnaces with no primary controls, RACM consists of localized and canopy hooding vented to a fabric filter. For electric induction furnaces with no primary controls, RACM is no control.

No control is recommended for crucible furnaces since these are fairly low emitters of particulate matter, are not usually controlled, and are being phased out of the industry.

The RACM selected for hot metal pouring operations is hooding and local exhaust to a fabric filter. This type of system gives an estimated 95 percent control and has typically been employed at foundries.

The selected RACM for control of the casting shakeout fugitive emission is a local exhaust system comprised of hood(s), ductwork and a fabric filter. Combination systems can be designed to handle exhaust gases from the cleaning and cooling castings, finishing operations, sand and binder mixing, core and mold make up, sand preparation and handling operations. Such systems are very effective and are used in existing foundries.

For illustrations of some of the above control methods, see Section 2.7.

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APPENDIX FOR SECTION 2.8

Assume 100 tpd steel production, 93% yield and 108 tpd input

(1) Electric arc furnace

Emissions = (2.3 lb/ton)(100 tpd)(365 d/y)
= 83,950 lbs/yr

Hooding, vent to fabric filter

$$\text{Capital cost} = \$275{,}000\ \frac{(249.6)}{(204.1)} = \$336{,}000$$

$$\text{Annual cost} = \$67{,}100\ \frac{(249.6)}{(204.1)} = \$82{,}000$$

$$C/B = \frac{\$82{,}000/yr}{.9\ (83{,}950)} = \$1.09/lb$$

Building enclosure, evacuation to fabric filter

No data

Maintenance of continuous draft during charging and tapping

$$\text{Capital cost} = \$16{,}800\ \frac{(249.6)}{(204.1)} = \$20{,}000$$

Annual cost = \$4,000

$$C/B = \frac{\$4{,}000/yr}{.7\ (83{,}950)} = \$0.07/lb$$

(2) Electric induction furnace, charging and tapping

Emissions = (0.1 lb/ton)(108)(365) = 3,942 lbs/yr

Hooding, vent to fabric filter

See (1)

$$C/B = \frac{\$82{,}000/yr}{.9\ (3{,}942)}\ \$23.11/lb$$

Building enclosure, evacuation to fabric filter

No data

Maintenance of continuous draft during charging and tapping

See (1)

$$C/B = \frac{\$4{,}000/yr}{.7\ (3{,}942)} = \$1.45/lb$$

(3) Open hearth furnace charging and tapping

Emissions = (0.5 lb/ton)(108)(365) = 19,719 lbs/yr

Hooding, vent to fabric filter

See (1)

$$C/B = \frac{\$82,000/yr}{.9\ (19,710)} = \$4.62/lb$$

Building enclosure, evacuation to fabric filter

No data

Maintenance of continuous draft during charging and tapping

See (1)

$$C/B = \frac{\$4,000/yr}{.7\ (19,710)} = \$0.29/lb$$

(4) Crucible furnace charging and tapping

Emissions = (0.3 lb/ton)(100)(365) = 10,950 lbs/yr

Hooding, vent to fabric filter

See (1)

$$C/B = \frac{\$82,000/yr}{.9\ (10,950)} = \$8.32/lb$$

Building enclosure, evacuation to fabric filter

No data

Maintenance of continuous draft during charging and tapping

See (1)

$$C/B = \frac{\$4,000/yr}{.7\ (10,950)} = \$0.52/lb$$

(5) Hot metal pouring

Emissions = (2.34 lbs/ton)(36,500 tpy) = 85,410 lbs/yr

Hoods, vent to wet scrubber or fabric filter

$$\text{Capital cost} = 51,500\ \frac{(249.6)}{(204.1)} = \$63,000$$

$$\text{Annual cost} = 15,000\ \frac{(249.6)}{(204.1)} = \$18,000$$

$$C/B = \frac{\$18,000/yr}{.95\ (85,410)} = \$0.22/lb$$

(6) Casting shakeout

Emissions = (7.0 lbs/ton) x (100)(365) = 255,500 lbs/yr

<u>Hoods, vent to wet scrubber or fabric filter</u> (Includes control of source #'s 7, 8, 9, 11, 13, 14)

$$\text{Capital cost} = 190{,}000\ \frac{(249.6)}{(204.1)} = \$234{,}000$$

$$\text{Annual cost} = 67{,}000\ \frac{(249.6)}{(204.1)} = \$82{,}000$$

$$C/B = \frac{\$82{,}000/yr}{.95(255{,}500) + 0.9(17{,}520) + .95(365) + .9(47{,}450) + .9(164{,}250) + .9(1{,}278) + .9(1{,}460)} = \$0.18/lb$$

(7) Cooling and cleaning castings

Emission = (0.48 lb/ton)(36,500 tpy) = 17,520 lbs/yr

<u>Hooding, mechanical collector, fabric filter or scrubber</u>

See (7)
C/B = $0.18/lb

(8) Finishing castings

Emissions = (0.01 lb/ton)(36,500 tpy) = 365 lbs/yr

<u>Hooding, vent to mechanical collector, fabric filter or scrubber</u>

See (7)
C/B = $0.18/lb

(9) Mold sand preparation

Emissions = (1.3 lbs/ton)(36,500 tpy) = 47,450 lbs/yr

<u>Hooding, vent to fabric filter or scrubber</u>

See (7)
C/B = $0.18/lb

(10) Core and mold sand unloading and storage

<u>Mechanical handling</u>

Emissions = (0.03 lb/ton)(36,500 tpy)(15)(.5) = 8,213 lbs/yr

<u>Hooding, vent to mechanical collectors</u>

Capital cost = $33,600
Annual cost = 12,000

$$C/B = \frac{\$12{,}000/yr}{.8\ (8{,}213)} = \$1.83/lb$$

Wet suppression (chemical)

Capital cost = $26,000
Annual cost = 7,000

$$C/B = \frac{\$7,000/yr}{.85\ (8,213)} = \$1.00/lb$$

Enclosure

Capital cost = $15,000
Annual cost = $3,000

$$C/B = \frac{\$3,000/yr}{.5\ (8,213)} = \$0.73/lb$$

Pneumatic handling
Emissions = NA

Vent storage hopper to fabric filter
No data

(11) Core sand and binder mixing
Emissions = (4.5 lbs/ton)(36,500 tpy) = 164,250 lbs/yr

Hooding, vent to mechanical collector or fabric filter

See (7)
C/B = $0.18/lb

(12) Core baking
Emissions = (2.7 lbs/ton)(0.1)(36,500 tpy) = 9,855 lbs/yr

Afterburners

Capital cost = $35,000
Annual cost = $21,000

$$C/B = \frac{\$21,000/yr}{.9\ (9,855)} = \$2.37/lb$$

(13) Core making
Emissions = (.35 lb/ton cores)(.1)(36,500 tpy) = 1,278 lbs/yr

Hooding, vent to fabric filter

See (7)
C/B = $0.18/lb

(14) Mold makeup
Emissions = (0.04 lb/ton)(36,500 tpy) = 1,460 lbs/yr

Hooding, vent to fabric filter or scrubber

See (7)
C/B = $0.18/lb

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2.22 CONCRETE BATCHING PLANTS

2.22.1 Process Description[1]

There are three general types of concrete batching plants. They are batching (into transit-mix trucks) plants, central-mix plants and dry-batching (into flat-bed trucks) plants.

Concrete batching plants store, convey, measure and blend the components for making concrete. The plants are similar in the method by which the solid raw materials (sand, aggregate and cement) are received, stored, transferred and blended, but differ with respect to where the water is added to the mix.[2]

The raw materials are delivered to the plant by rail or truck. The cement is transferred pneumatically (most commonly) or by bucket elevator to elevated storage silos. The sand and aggregate are generally stored on the ground and transferred to elevated bins via belt conveyor or bucket elevator. From the overhead bins, the materials are dropped into weigh hoppers which weigh out the proper amount of each material.

In batching plants that load transit-mix trucks, the weighed aggregates and cement are dropped into a receiving hopper. The required amount of water is injected into the flowing stream of solids as the mixture of material is emptied from the receiving hopper into the transit-mix truck. The transit-mix trucks mix the batch en route to the site where the concrete is to be poured.

Dry-batch plants mix sand, aggregate and cement and then dump this dry mix into flat-bed trucks. These trucks transport the batch to paving machines at the job site where water is added and mixing takes place.

A central-mix plant uses a centrally located mixer to make wet concrete. The wet concrete is emptied into open-bed trucks and transported to the job site where the concrete is to be poured.

A process flow diagram for concrete batching is shown in Figure 2.22-1. One of the fugitive emission sources which is common to all concrete batch plants, but not specifically included in this section, is plant roads. Discussion of this fugitive dust source is presented in Section 2.1. Other fugitive emission sources at concrete batching plants include the sand and aggregate storage areas, transferring and conveying operations, cement unloading, cement silo vents, weigh hopper loading, mixer loading (central-mix plants), transit-mix truck loading operations (batching plants) and flat-bed truck loading operations (dry-batching plants).

2.22.2 Fugitive Dust Emission Factors

The potential sources of fugitive dust from concrete batching are shown in Table 2.22-1, along with the corresponding emission factors. All of these factors are based on either engineering judgment or visual observations. No details are available concerning the methodology of development. The reliability of these types of estimates is poor.

The emission factors for plant haul roads are not included in Table 2.22-1. Emission factors for these sources are listed in Section 2.1.

2.23.3 Particle Characterization

Practically all the fugitive dust generated at concrete batching plants is cement dust since most of the sand and aggregate used is damp. Therefore, this section will only concentrate on particle characteristics of cement dust.

The typical oxide composition of cement dust is as follows.[3]

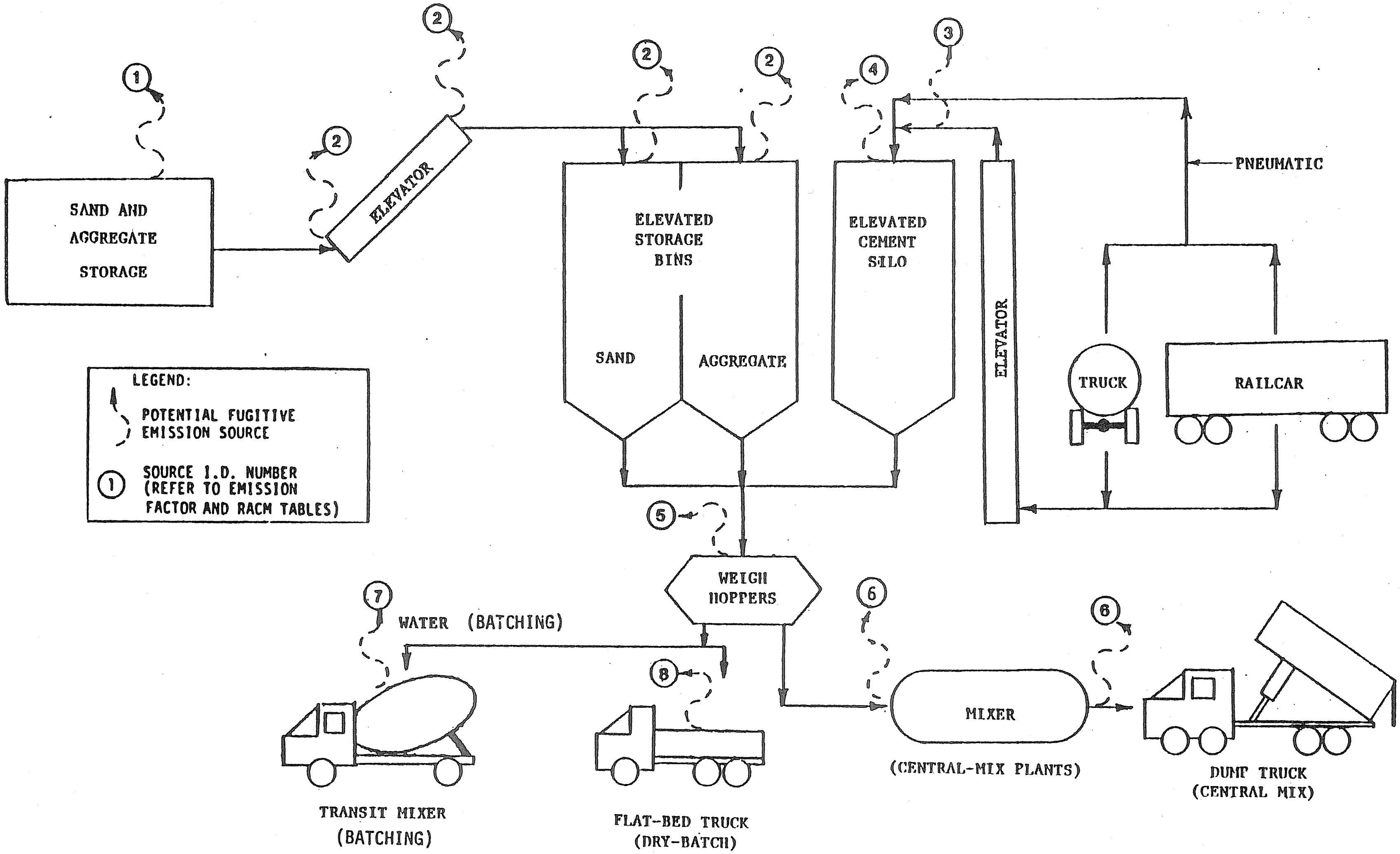

Figure 2.22-1. Simplified process flow diagram for concrete batching and associated fugitive particulate emission sources.

TABLE 2.22-1. FUGITIVE DUST EMISSION FACTORS FOR CONCRETE BATCHING PLANTS

Source	Emission factor	Reliability rating	Reference
(1) Sand and aggregate storage			
loading onto piles	0.04 lb/ton loaded	D	2
vehicular traffic	0.04 lb/ton stored	D	2
wind erosion	0.11 lb/ton stored	D	2
loadout from piles	0.05 lb/ton loaded	D	2
(2) Transfer of sand and aggregate to elevated bins	0.04 lb/ton handled	E	2
(3) Cement unloading to elevated storage silos	0.24 lb/ton unloaded	E	2
(4) Silo vents	0.24 lb/ton unloaded	E	2
(5) Weigh hopper loading of cement, sand and aggregate	0.02 lb/ton loaded	E	2
(6) Mixer loading of cement, sand and aggregate (central-mix plant)	0.04 lb/ton loaded	E	2
(7) Loading of transit-mix truck (batching plant)	0.02 lb/ton	E	2
(8) Loading of flat-bed truck (dry-batching plant)	0.04 lb/ton	E	2

Compound	Fugitive Emission Oxide Composition, Percent By Weight For Cement Dust
Silica	18-23
Al_2O_3	3-8
Fe_2O_3	1-5
CaO	61-66
MgO	0-5
SO_3	2-4
Free Lime	0-2
Minor Compounds	0-1

The American Conference of Governmental Industrial Hygienists has established levels for which airborne chemical compounds could be tolerated without adverse effects on humans.[4] Of the above compounds, aluminum oxide, iron oxide, magnesium oxide and free lime are considered nuisance substances which can be tolerated at relatively high levels. Silica may be hazardous depending upon the amount of quartz contained in the silica. Calcium oxide can be tolerated at levels up to 5 mg/m^3.

Particle size characteristics of the dust vary according to the grades of cement. A range of 10 to 20 percent by weight of particles < 5μm in size is typical for the various grades of cement. Table 2.22-2 summarizes the particle size distribution and bulk density of three common grades of cement.[5]

Table 2.22-2. Physical Characteristics of Three Common Grades of Cement

Characteristic	Weight Percent of Cement		
Particle Size (μm)	Grade I	Grade II	Grade III
0 to 5	13.2	9.6	21.8
5 to 10	15.1	16.6	22.5
10 to 20	25.7	18.8	26.7
20 to 40	29.0	36.6	23.6
40 to 50	7.0	10.4	5.4
50 to 66	5.0	6.0	0
66 to 99	4.0	2.0	0
99 to 250	1.0	0	0
250 (60 mesh)	0	0	0
Bulk Density (lb/ft^3)	54.0	51.5	62.0

2.22.4 Control Methods

This section discusses all available control methods for the fugitive dust emission sources at concrete batching plants.

For the control of fugitive dust emissions from sand and aggregate storage piles, several control methods are available. For loading onto piles, the available control methods are stone ladders, wet suppression (chemical) and telescopic chutes. Loading out operations may be controlled by the use of wet suppression (chemical), watering and underpile conveyors which have a gravity feed to conveyors. For control of wind erosion emissions, the available control methods consist of enclosure (storage bins or silos), wet suppression (chemical) and watering. Lastly, fugitive dust generated by vehicular traffic associated with storage pile activities may be controlled by use of an enclosure, wet suppression (chemical), watering and by using traveling booms rather than vehicles to distribute material.

For control of fugitive dust emissions from plant roadways and parking areas, the reader is referred to Section 2.1.1 of this document.

The amount of fugitive dust generated during the transfer of sand and aggregate from storage to elevated storage bins depends primarily on the surface moisture content of these materials. To ensure that the material is sufficiently moist to prevent dusting, water sprays may be applied at the feed, transfer and discharge points of the belt conveyor or bucket elevator system. To prevent wind losses, most plants partially or completely enclose the conveyor system or use watering and/or chemical dust suppressants.[6] In addition, transfer points may be exhausted to fabric filters for control. Section 2.1.3 and 2.18 further discuss transfer and conveying sources in detail.

A typical cement-receiving and storage system is shown in Figure 2.22-2.[7] The receiving hopper is at or below ground level. If it is designed to fit the canvas discharge tube of the hopper truck, little or no dust is emitted at this point. After a brief, initial puff of dust, the hopper fills completely, and the cement flows from the truck without any free fall.

Cement elevators are either the vertical-screw type or the enclosed-bucket type. Because both are totally enclosed, neither emits any dust if in good condition.[8]

The cement silo must be vented to allow the air displaced by the incoming cement to escape. Unless this vent is filtered, a significant amount of dust escapes. Control can be accomplished by venting to a central dust collecting system or a single collector placed on top of each silo. A fabric type of collector is most often used to vent the cement silo. A fabric "sock", that is placed on each silo vent, can be operated without an exhaust fan when the material is delivered to the silo by bucket elevators because it is simply used to filter the small volume of air that is forced out.[9]

Pneumatic transfer of cement to elevated storage silos from trucks and railcars equipped with compressors and pneumatic delivery tubes is finding increased application over cement transfer by bucket elevator.[10] Pneumatic transfer eliminates emissions between the truck or railcar and the cement silo and requires control only at the cement silo vent by fabric filters. In plants receiving cement pneumatically, use of a fabric "sock" (filtered vent used for the gravity filling of cement) is inadequate.[11]

The volume of conveying air required in the pneumatic delivery system is about 350 cfm to 700 cfm depending on the loading cycle, etc.[12] Since the air is being forced into the silo, the baghouse will require a blower in order to relieve the pressure inside the

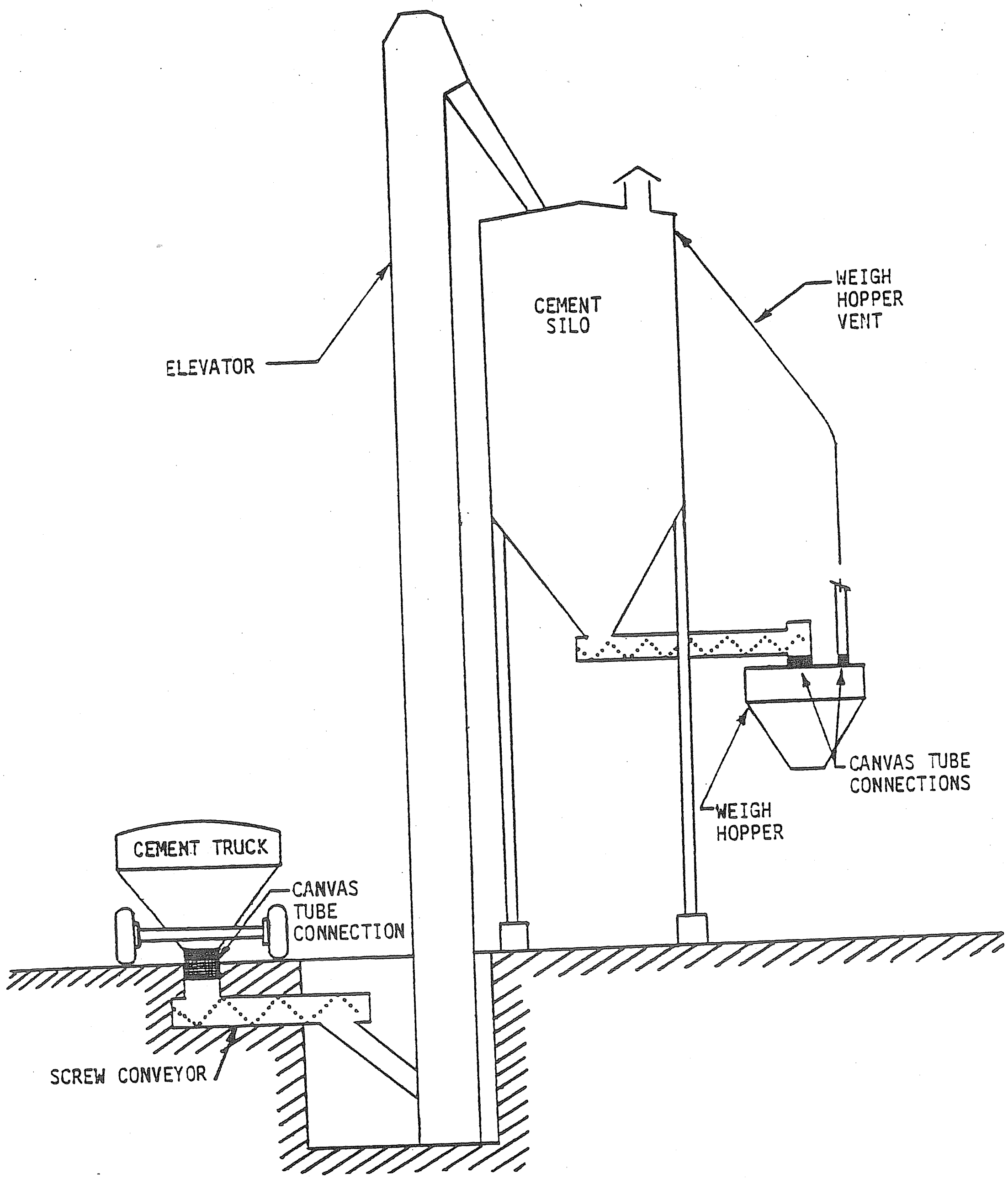

Figure 2.22-2. Cement-receiving and storage system.

silo, and allow flow through the fabric filter. A mechanical shaking mechanism also should be provided to prevent cement from blinding the filter cloth of the baghouse. A vent rate of approximately 1,200 to 1,300 cfm is generally required.[13] The negative pressure created by using a forced draft also prevents dust leakage around access doors and other openings.

Another less expensive type of control measure is to mount a bank of approximately four simple bin vent filters atop the silo. The filtering velocity should not exceed 7 cfm, giving a filter cloth area of approximately 100 square feet for the 700 cfm of air encountered at the end of the cycle. The filter design must include a shaking mechanism to prevent blinding of the filter cloth. The major disadvantage of using a bank of several simple bin vent filters as just described is the possibility of pressure build-up within the silo. If, for some reason, the filter should become blinded, there is a danger of rupturing the silo. Therefore, proper maintenance and regular inspection of the filters are essential.[14]

Where baghouses are used to control other larger cement dust sources as those existing in a dry-batching plant or in a central-mix plant, the cement silo can easily be vented to the same baghouse.[15]

The rapid discharge of sand, aggregate and cement into the weigh hopper generates emissions that may be controlled by venting the displaced air to the individual storage bins and silos or by venting it directly to a central control system.

Fugitive dust occurring from air displaced as dry materials are discharged from the weigh hopper into the mixer at a central-mix plant can be considerable. A mobile hood placed over the outlet of the discharge end of the mixer coupled with venting to a fabric filter can accomplish effective control. When the mixer is ready to be dumped, this hydraulically operated hood is swung away from the discharge end. For a hood of this type, the indraft face velocity should be approximately 1,000-1,500 ft/min in order to adequately capture the fugitive dust.[16]

At batching plants that load transit-mix trucks, the dropping of a batch from the weigh hopper to the transit mixer can cause cement dust emissions from several points. In the loading of transit-mix trucks, a gathering hopper is usually used to control the flow of materials. Dust can be emitted from the gathering hopper, the truck-receiving hopper and the mixer. The design and location of the gathering hopper can do much to minimize dust emissions. The hopper should make a good fit with the truck-receiving hopper, and its vertical position should be adjustable. Figure 2.22-3 illustrates a design that has been successfully utilized for minimizing these dust emissions.[17] Compressed air cylinders raise and lower the gathering hopper to accommodate trucks of varying heights. A steel plate with a foam rubber backing is attached to the bottom of the gathering hopper and is lowered until it rests on the top of the truck-receiving hopper. Water for the mix is introduced through a jacket around the discharge spout of the gathering hopper and forms a dust-reducing curtain. By discharging the cement hopper into the center of the aggregate stream, and providing choke feed between the weigh hopper and the gathering hopper, dust emissions from the top of the gathering hopper can be minimized. For plants that don't have this type of gathering hopper, an enclosure or a hood vented to a baghouse and made of sheet metal which totally encloses the transit-mix truck-receiving hopper, when in place, may be used.

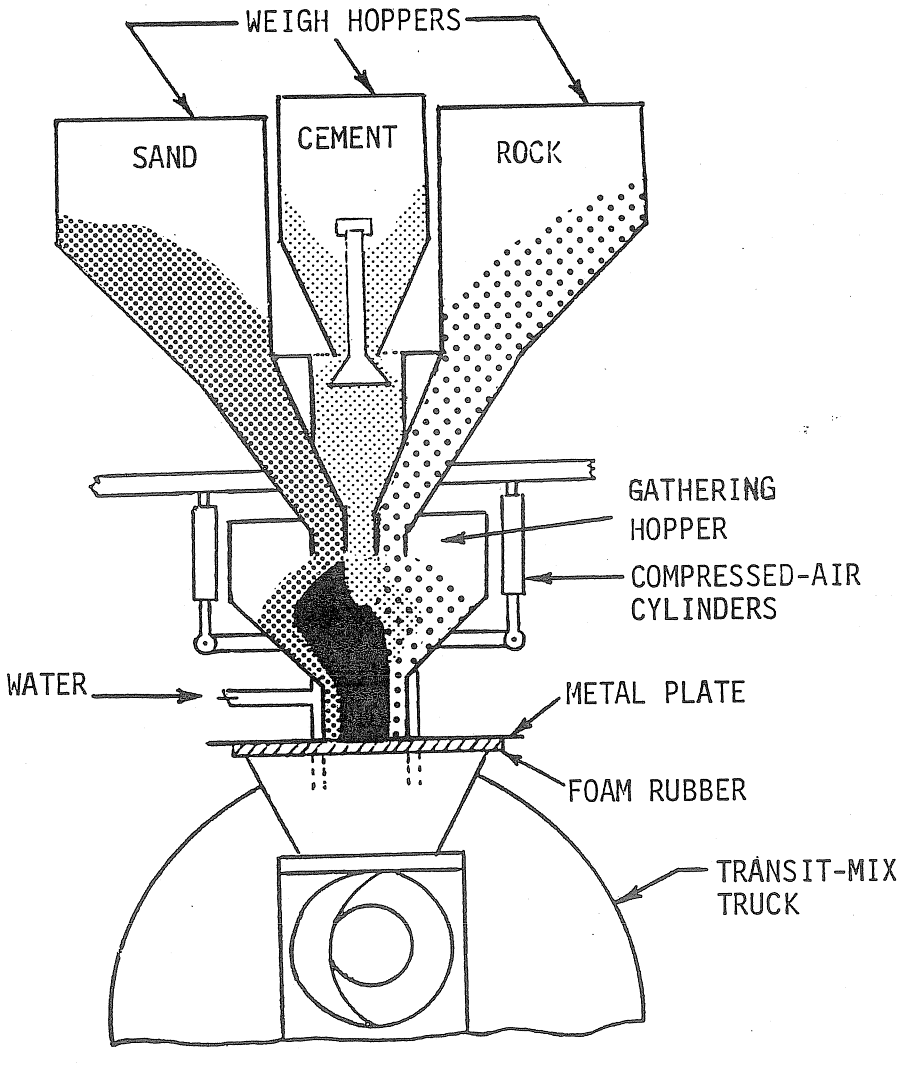

Figure 2.22-3. An adjustable gathering hopper.

Most plants that do dry-batching also do batching with transit-mix trucks; therefore, the weigh hoppers must be high enough to accommodate the transit-mix trucks. Since the receiving hopper of most transit-mix trucks is several feet higher than the top of the flat-bed trucks used to haul the materials in dry-batching, there are considerable fugitive emissions from the fall of material when a dry batch is discharged. Because the plant operator must view the operation and because the truck must have freedom of movement, this is a difficult operation to hood. The truck bed is usually divided into several compartments, and the batch is dropped into each compartment. This necessitates moving the truck after each drop so another compartment of the truck can be loaded. A canopy-type of hood, just large enough to cover one compartment at a time, provides effective dust pickup for venting to a fabric filter and affords adequate visibility. The sides can be made of heavy rubber to give the hood some flexibility and prevent damage if a truck hits it. The hood is sometimes mounted on rails to permit it to be withdrawn and allow batching into transit-mix trucks. The exhaust volume required to collect the dust varies with the shape and position of the hoods. With reasonably good hooding, the required volume is approximately 6,700 to 7,000 cfm.[18]

A conscientious housekeeping program, which includes such measures as prompt cleanup of spills, maintenance of conveying equipment to prevent leaks, and proper handling and disposal of the material collected by fabric filters, is necessary to complete the overall effective control of fugitive emissions at concrete batching plants.

Table 2.22-3 summarizes the available control techniques, their effectiveness and estimated costs, and the RACM selections.

2.22.5 Recommended Reasonably Available Control Measures (RACM)

The RACM selections for concrete batching plant fugitive sources are presented in Table 2.22-3. The recommended control for sand and aggregate stockpiling, as well as the transferring of sand and aggregate to elevated bins, is a wet dust suppression system utilizing a chemical wetting agent. This system gives good control efficiency (estimated 90%[24]) and reduces visible emissions to almost zero percent opacity.[25]

For vehicular traffic at sand and aggregate storage areas, the use of wet suppression (chemical) on unpaved storage areas is recommended. Wetting agents which are sprayed onto the material during processing or at transfer points retain their effectiveness in subsequent storage operations, because they retain surface moisture for extended periods, thereby preventing dusting.

Recommended control for cement unloading to elevated storage silos is the use of enclosures. This is feasible because most plants already control these emissions in this way.

The silo vents (pneumatic loading to silo) can be controlled either by a central control system which controls fugitive emissions from cement dust sources, such as those existing in a dry-batching plant or in a central-mix plant, or by a bank of approximately four simple bin vent filters on top of each silo. These controls are advantageous not only for their high degree of particulate control, but also for the added benefit of product recovery.

For silos which are loaded by bucket elevator, RACM is simply the use of fabric "socks". This control method is adequate for such systems because the air displaced from the silo during such loading is minimal.

Where a central collection system is not employed, the weigh hopper emissions may be controlled by venting back to the bins or silos.

TABLE 2.22-3. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM CONCRETE BATCHING PLANTS

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan., 1980 $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
(1) Sand and aggregate storage						
Loading onto pile	Enclosure (stone ladders)	70-99[a,b]	(See Section 2.1)		NA	Wet suppression (chemical)
	Wet suppression (chemical)	80-90[b]	(See Section 2.1)		NA	
	Telescopic chutes	75[b]	(See Section 2.1)		NA	
Loading out	Wet suppression (chemical)	80-90[b]	(See Section 2.1)		NA	Wet suppression (chemical)
	Watering	50[c]	(See Section 2.1)			
	Gravity feed onto conveyor	80[b]	(See Section 2.1)		NA	
Wind erosion	Enclosure	95-99[b]	(See Section 2.1)		NA	Wet suppression (chemical)
	Wet suppression (chemical)	90[b]	(See Section 2.1)		NA	
	Watering	50[b]	(See Section 2.1)		NA	
Vehicular traffic	Enclosure	95-99[c]	(See Section 2.1)		NA	Wet suppression (chemical)
	Wet suppression (chemical)	90[c]	(See Section 2.1)		NA	(good housekeeping)
	Watering	50[c]	(See Section 2.1)		NA	
	Traveling booms to distribute material	no estimate	(See Section 2.1)		NA	
(2) Transfer of sand and aggregate to elevated bins	Enclosure, vent to fabric filter	99[b]	(See Section 2.1)		NA	Wet suppression (chemical)
	Wet suppression (chemical)	95[b]	(See Section 2.1)		NA	
	Watering	50[b]	(See Section 2.1)		NA	
(3) Cement unloading to elevated storage silos	Enclosure[a]	70[d]	860[e]	200[f]	0.13	Enclosure[a]

(continued)

TABLE 2.22-3 (continued)

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan., 1980 $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
(4) Silo vents	Vent to fabric filter[j]	99[g]	107,000[h]	16,300[i]	2.28	Vent to fabric filter[j]
	Fabric "sock"[a]	99[g]	2,300[k]	m	NA	Fabric "sock"[a]
	Vent to fabric filter[l]	99[g]	10,800[n]	3,000[i]	1.42	
	Vent filter[o]	99[g]	5,200[p]	1,500[g]	0.73	Vent filter[o]
(5) Weigh hopper loading of cement, sand, and aggregate	Vent back to bins or silos	95[g]	m	m	NA	Vent back to bins or silos[t]
	Vent to fabric filter	99[g]	q	q	2.28	Vent to fabric filter[j]
(6) Mixer loading of cement, sand, and aggregate (central-mix plant)	Mobile hood, vent to fabric filter	99[g]	q	q	2.28	Mobile hood, vent to fabric filter
(7) Loading of transit-mix truck (batching)	Enclosure	70-99[r]	4,000 to 22,000[r]	m	NA	Enclosure[s]
	Choke feed	90[g]	m	m	NA	
(8) Loading of flat-bed truck (dry-batch)	Canopy-type hood, vent to fabric filter	99[g]	107,000[h]	16,300[i]	2.28	Canopy-type hood, vent to fabric filter[u]

[a] For bucket elevators.

[b] Reference 21. p. 3-6.

[c] Reference 26.

[d] "Weather-tight" system; no active dust collection system.

[e] Based on a 200 ft. conveyor with an enclosure cost of $43/ft. Reference 19. p. 6-3.

[f] Assuming annual cost of approximately 20% of the capital costs.

[g] Engineering judgment.

[h] Reference 20. Based on 10,000 acfm. One system to control emissions from sources 4, 5, 6, & 8.

(continued)

TABLE 2.22-3 (continued)

[i]Reference 20. Based on 2,000 hr/yr operation producing 89,000 tons/yr.

[j]Part of central collection system to control sources 4, 5, 6, & 8 at central mix plants.

[k]Reference 27.

[l]Applicable for plants with pneumatic delivery and no central collection system. Baghouse equipped with mechanical shaking device and blower.

[m]Costs not available.

[n]Reference 22.

[o]Applicable for plants with pneumatic delivery and not utilizing a central collection system. (Bank of approximately 4 simple filtered vents atop the silo).

[p]Reference 22 and 23.

[q]Costs included within those for source 4. One central collection system to control emissions from sources 4, 5, 6, & 8.

[r]Low value, simple enclosure; high value, enclosure plus bag filter.

[s]If an adjustable gathering hopper (choke feed) is not currently being utilized. For plants using such hopper and choke feed, no additional control is required.

[t]Applicable for plants not utilizing a central collection system.

[u]Part of central collection system to control sources 4, 5, & 6.

For mixer loading of cement, sand and aggregate at central-mix plants, RACM is the use of a mobile hood with exhaust to a central fabric filter.

The emissions occurring during the loading of the transit-mix trucks (batching) can be controlled by either enclosure or by choke feeding through the use of an adjustable gathering hopper, whichever is more economically feasible for each specific plant affected.

The use of canopy-type hoods with ventilation to a fabric filter is recommended for the loading of flat-bed trucks at dry-batching plants.

REFERENCES FOR SECTION 2.22

1. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. EPA-450/3-77-010, March 1977. p. 2-311.

2. Compilation of Air Pollutant Emission Factors. Second Edition. U.S. EPA, Office of Air and Water Management, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. July 1979. p. 8.10-3.

3. Personal Communication from Mr. M.M. Reid, Assistant to Technical Director, Lone Star Industries, Inc. Cement and Construction Materials Group to Mr. Don Goodwin, U.S. EPA, Emission Standards and Engineering Division, Research Triangle Park, North Carolina. January 12, 1977.

4. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment. American Conference of Governmental Industrial Hygienists. Cincinnati, Ohio. 1976.

5. Air Pollution Engineering Manual. Second Edition. U.S. EPA, Office of Air and Water Programs, Office of Air Quality Planning and Standards. Publication No. AP-40. Research Triangle Park, North Carolina. May 1973. p. 336.

6. Op. cit. Reference 2. p. 2-316.

7. Op. cit. Reference 5. p. 336.

8. Ibid. p. 335.

9. Op. cit. Reference 2. p. 2-318.

10. Ibid. p. 2-316.

11. Op. cit. Reference 5. p. 335.

12. Op. cit. Reference 2. p. 2-318.

13. Ibid. p. 2-318.

14. Op. cit. Reference 5. p. 335.

15. Ibid. p. 336.

16. Op. cit. Reference 2. p. 2-319.

17. Op. cit. Reference 5. p. 337.

18. Op. cit. Reference 2. p. 2-320.

19. Bohn R., T. Cuscino, Jr., and C. Cowherd, Jr. Fugitive Emissions from Integrated Iron and Steel Plants. Midwest Research Institute, Kansas City, Mo. Prepared for U.S. EPA, Research Triangle Park, North Carolina. EPA-600/2-78-050. March 1978. p. 6-3.

20. Industrial Gas Cleaning Institute, Inc. Nonmetallic Minerals Industries Control Equipment Costs. Prepared for U.S. EPA, Research Triangle Park, North Carolina. Contract No. 68-02-1473, Task No. 19, February 1977.

21. Ela, R.E. Cement Minerals Yearbook, 1973. Volume I. Metals, Minerals, and Fuels. U.S. Department of the Interior. Bureau of Mines. Washington, D.C. 1975. p. 3-6.

22. Gard, Inc. Capital and Operating Costs of Selected Air Pollution Control Systems. EPA-450/3-76-014, May 1976.

23. Personal Communication between Bob Moran, Wheelabrator-Frye, and James A. Cummings, Ohio EPA. Jan. 1980.

24. Op. cit. Reference 2. p. 3-15.

25. Ibid. p. 3-39.

26. Ibid. p. 2-38.

27. Personal Communication between Paul Norris, Kramer-Norris Equipment Company, and James A. Cummings, Ohio EPA. Jan. 1980.

A Typical Concrete Batch Plant Has The Following Data:

89,000 T/yr concrete produced
2,000 hr/yr

Raw material quantities were calculated on the basis of the following percentages (by weight) of the concrete produced:

sand & aggregate	85%
cement	10%
water	5%

Sources

(1) (2) Covered in PEDCo's Write-up In Section 2.1, General Fugitive Dust Sources.

(3) From PEDCo's Write-up On Material Handling In Section 2.1.

$$C/B = \frac{\$200}{(0.24\ lb/T)\ (89{,}000\ T/yr)\ (.10)\ (.70)} = \$0.13/lb\ \text{TSP Removed}$$

(4) Central Collection System - For Sources 4, 5, 6, & 8.

		cfm thru duct	filter velocity
(A)	Bin & Silo Vents	700	3 fpm
(B)	Weigh Hopper	32	3 fpm
(C)	Mixer	2500	3 fpm
(D)	Flat-bed Truck Loading	6500	3 fpm
	Total = 9732 ≃ 10,000 acfm		

Ac = Area of Cloth

$$3\ fpm = \frac{10{,}000\ acfm}{Ac}$$

$$Ac = 3{,}333\ ft^2$$

[REF. 22] Baghouse Price (Fig. 4-7) $[2910 + 1.6\ (3333)]\ \frac{(249.6)}{(192.1)} = .\$10{,}710$

Costs of Bags (Tables 4-1, 4-2) $3333\ ft^2 \times 2 \times \$.40/ft^2 = \$2666.4$

$\frac{(249.6)}{(192.1)} = ... 3{,}465$

(D) Rectangular Hood (8' x 2.4') & Supports Costs
(Fig. 4-17) [L/W Ratio = 4] Plate Area Requirement $1 + 0.615(8)^2 = 40\ ft^2$

(Fig. 4-19) Labor Cost 150

40 ft^2 x 5.625 lb/ft^2 x 1.2 = 270 lbs.

(p. 4-25) Hood Cost LG + \$.208/lb (8)(4) + (.208)(270) $\approx$ \$90

$\frac{(249.6)}{(192.1)}$ = .. 120

(Fig. 4-21) Ductwork Cost 100 ft x \$50/ft = \$5,000 $\frac{(249.6)}{(192.1)}$ 6,500

(C) Circular Hood (50° θ) + Supports Cost

(Fig. 4-18) Plate Area Requirement 1.343 x $\frac{(40)^2}{(12)}$ = 165.8 ft^2

(165.8)(5.625)(112) = 1119 lbs.

(Fig. 4-20) Labor Cost 350

(p. 4-25) Hood Cost (165.8)(\$.90/ft^2) + (\$.108)(1119) =

\$270 $\frac{(249.6)}{(198.1)}$ $\approx$ \$350

plus, Hydraulics for Swing-away ($\approx$\$1,000) \$1,000 + \$350 = ... 1,350

(Fig. 4-21) Ductwork Cost 100 ft x \$50/ft = \$5,000 $\frac{(249.6)}{(192.1)}$ $\approx$ 6,500

(A) & (B) (Fig. 4-21) Ductwork Cost (50'+50' = 100') 100 ft x $25/ft = $2500 $\frac{(249.6)}{(192.1)} \approx$ $3,250

(Fig. 4-24) Elbow Ducts (4) ($850)+($850)+($350) = $2400 $\frac{(249.6)}{(192.1)} \approx$ 3,120

(Fig. 4-26) Expansion Joints (4) ($2375)+(2375)+($1625) = $8000 $\frac{(249.6)}{(192.1)} \approx$ 10,400

(Fig. 4-40) Fans (23", Class II, Backwardly Curved, 4" ΔP) 1200 rpm, 8 bhp $1600 $\frac{(249.6)}{(192.1)} =$ 2,079

(Table 4-5) Motor 68 + 18(8) = $212 $\frac{(249.6)}{(192.1)} =$ 275

(Table 4-5) Mag. Starter 150 + 2.5(8) - .00005(8^3) $173 $\frac{(249.6)}{(192.1)} =$ 225

Total Cost =...... $48,494

(4) Central Collection System Capital Costs

1)	Equipment Costs (control device + aux.'s)	=	$48,494
2)	Tax & Freight (7% of 1)	=	3,395
3)	Installation Costs (75% of 1)	=	36,371
4)	Subtotal (1 + 2 + 3)	=	88,260
5)	Engineering (10% of 4)	=	8,826
6)	Subtotal (4 + 5)	=	97,086
7)	Contingencies (10% of 6)	=	970
8)	Total Capital Costs (6 + 7)	=	$106,795

Annualized Costs

Capital Charges R · PV = PV /n=30 i=12%
R · (8.055) = $106,795
R = $13,258

Operating Costs (Fig. 46) ($.35/hr)(2,000 hr/yr) = $700 $\frac{(249.6)}{(192.1)}$ = $910

Maintenance (Table 4-12) $2136

Total Annual Costs = $13,258 + $910 + $2,136 = $16,304

C/B (Central mix plants, sources 4, 5, & 6) = $\frac{\$16,304}{[(89,000)(.10)(.24)+(89,000)(.95)(.02) + (89,000)(.95)(.04)](.99)}$

C/B = $2.28/lb TSP removed

C/B (Dry-batching, Sources 4, 5, & 8) = $\frac{\$16,304}{[(89,000)(.10)(.24)+(89,000)(.95)(.02) + (89,000)(.95)(.04)](.99)}$

C/B = $2.28/lb TSP removed

Silo Vent Emissions

Cement Elevator . . . . Pneumatic Delivery

Silo Capacity = 250 ft^3

Filter Velocity = 3 fpm

Cloth Area = 200 ft^2

Air Flow Rate = 350 cfm during most of loading cycle, increasing to 700 cfm at end of cycle.

Control Device: Baghouse equipped with blower to relieve pressure built up within the silo, and a mechanical shaking mechanism.

Capital Costs

[Ref. 22]

Baghouse	$4,197
Fabric	208
Fan w/motor	892
Equipment	5,297
Tax, freight (7%)	371
Maintenance (2%)	106
Install (75%)	3,973
Subtotal	9,747
Engr. (10%)	975
Subtotal	10,722
Contingency (10%)	107

Total Capital Investment = $10,829 (Jan.'80) ≈ $10,800

Annual Costs

Operating Costs ($0.35)(2,000 hrs/yr) = $700 $\frac{(249.6)}{(192.1)}$ ≈ $910

Maintenance (2%)(10,800) = $216

Capital Charges PV = R · PV/ n = 10 i = 12%

(5.650) R = $10,800

R = $1,912

Total Annual Costs = $216 + $910 + $1,912 ≈ $3,000

$$C/B = \frac{\$3,000}{(0.24\ lb/T)(89,000\ T/yr)(.10)(.99)}$$

C/B = $1.42/lb TSP removed

Silo Vent Emissions

[Ref. 5]	Cement Elevator	....	Pneumatic Delivery
	Filter Velocity		7 fpm
	Cloth Area	≃	100 ft^2
	Air Flow Rate	=	700 cfm
	Control Device:		Bank of approximately 4 simple filtered vents atop the silo; should provide shaking mechanism to prevent blinding of cloth.

[Ref. 23] Collector with shaker ≃ $2/cfm (collector sizing):

700 cfm x 2 (2 to 1) = 1400 cfm x $2.00 = $2800 (Jan. '80)

Bags: [Table 4-2] (2)(100) = 200

$$(200)(\$.40) = \$80 \; \frac{(249.6)}{(192.1)} = \$104$$

$2800 + $104 = $2,904

Capital Costs

1.	Equipment Costs (control device & aux.'s)	=	$2,904
2.	Tax & Freight (7% of 1)	=	203
3.	Installation Costs (40% of 1)	=	1,162
4.	Subtotal (1 + 2 + 3)	=	4,269
5.	Engineering (10% of 4)	=	427
6.	Subtotal (4 + 5)	=	4,696
7.	Contingencies (10% of 6)	=	470
8.	Total Capital Costs	=	$5,166

Annualized Costs

Operating Costs [Fig. 4-60] ($0.25)(2,000 hrs/yr) = $400

$$\frac{(249.6)}{(192.1)} = \$520$$

Maintenance [Table 4-12]: $103

Capital Charges PV = R · PV/n = 10 i = 12%

(5.650) R = $5,166

R = $ 914

Total Annual Costs = $520 + $103 + $914 = $1,537

$$C/B = \frac{\$1,537}{(0.24 \text{ lb/T})(89,000 \text{ T/y})(.10)(.99)}$$

$$C/B = \frac{\$1,537}{2,114.6 \text{ lb/yr}}$$

C/B = $.73/lb TSP Removed

put all the cost estimates on exactly the same basis, but it was attempted to adjust the estimates to be compatible on the basis of year of dollars, size of application, indirect costs (where possible) and annual fixed capital charges (where possible).

The costs were all adjusted to reflect January, 1980 dollars using the Chemical Engineering Cost Index. Applicable index values, including those published after the initial preparation of this document, are as follows:

Annual Index	Monthly Index		
1970 = 125.7	January 1979	=	225.9
1971 = 132.2	July 1979	=	239.3
1972 = 137.2	January 1980	=	249.6*
1973 = 144.1	January 1980	=	248.5
1974 = 165.1	July 1980	=	263.6
1975 = 182.4	January 1981	=	276.6
1976 = 192.1	July 1981	=	303.1
1977 = 204.1	January 1982	=	308.7
1978 = 218.8	January 1982	=	311.8**
1979 = 238.7	July 1982	=	314.2
1980 = 261.2	January 1983	=	315.5
1981 = 297.0			
1982 = 314.0			

*Represents an estimate of the actual index (248.5) which was unavailable at the time this document was initially prepared.

**As of January, 1982, the Chemical Engineering Cost Index was updated and streamlined for greater accuracy. The January, 1982 index (308.7) using the old system is shown above for comparison. All index values after January, 1982, including the 1982 annual index, are based on the new system. For information on the revisions to the cost index, see "CE Plant Cost Index--Revised" in <u>Chemical Engineering</u>, Apr. 19, 1982, p. 153.

To update costs to January, 1980, the multiplier was the January 1980 index of 249.6 divided by the index value reflecting the year of the available estimate.

For cases where costs were unavailable for different process capacities, an appropriate factor was used to scale costs to the selected "typical" size. Where no better data were available, the 0.6 scale factor, as illustrated in the following equation, was used:

$$Cn = r^{0.6}Cp$$

where Cn is the new updated cost,
Cp is the previous cost, and
r is the ratio of the new to previous process capacity.

Where various equipment pieces were excluded, a price estimate was made using the GARD manual. This included items such as fans, ducts, dampers, etc.

Where installation costs were missing, the appropriate values from the GARD manual were used (i.e., ESP's = 75% of equipment, venturi scrubbers = 140% of equipment and fabric filters = 75% of equipment).

In cases where indirect capital charges were not included, an assumed value of 40 percent of direct installed cost was used as a conservative estimate of the costs of engineering, construction and field expense, construction fees, performance tests, shakedown and contingencies.

Where fixed annual capital charges were not available, a value of 17 percent of the turnkey investment was assumed.

APPENDIX B

LISTING OF CHEMICAL DUST SUPPRESSANTS

Appendix B contains a listing of chemical suppressants. Table B-1 presents limited information on various chemical suppressants concerning product type, costs, uses and application rates. This information was obtained from "Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions" and from suppliers. Information presented is as complete as was made available by the suppliers. Note that these are 1976 costs unless otherwise specified.

Table B-1 (continued). CHEMICAL DUST SUPPRESSANTS, THEIR COST, USES, AND APPLICATION RATES[a]

Company/address phone/contact	Product name/ product type	Cost	Uses/comments	Density, dilution and application rates
Dubois Chemical Dubois Tower Cincinnati, Ohio 513-762-6000 Mr. Burger	Floculite 600	100 lb - $2.81/lb 1000 lb - $2.74/lb	Used in waste water treatment from mines. Also helps keep down dust on haul roads.	1-2 lb/1000 gal
Mona Industries, Inc. 65 E. 23rd St. Paterson, NJ 07524 201-274-8220 Mr. George Lowry	Monawet Mo-70E	500 lb drums 1-50 drums - $0.455/lb Bulk - $0.385/lb	Used in coal industry as dust suppresant	0.1 percent in water, must be reapplied when water evaporates
AMSCO Division Union Oil Company of California 14445 Alondra Blvd. La Miroda, Calif. 90638 714-523-5120 Dr. Ralph H. Bauer	Res AB 1881 Styrene Butadiene		Soil stabilizer particularly in conjunction with wood fiber mulches. Free pumping in conventional hydroseeding equipment. Not to be applied in soils with pH less than 6.0.	8.2 ± 0.1 lb/gallon
Nalco Chemical Co. 2901 Butterfield Oak Brook, IL 60521 312-887-7500 Mr. R.E. Finch	Nalco 8800	55 gl. drums[b] .83¢ to .43¢ per pound. Bulk .593¢	Dust suppressant use with water sprays at transfer points, dump stations, etc.	Range from 1 to 200 to 1 to 2500 water as needed
	Nalco 8801	55 Gal. Drums:[b] $.41 to $.543/lb. Bulk: $.32/lb.	Dust Suppressant. Use with water sprays, longwalls, cont. miners. Transfer points.	Dosage from 1 in 1000 to 1 in 3500
	Nalco 8803	55 Gal. Drums:[b] $.940/lb. to $1.040/lb.	Tailings binder for revegetation and soil stabilization.	1 to 100 with water at .25 gallons of solution per square yard.
	Nalco 8806	Bulk: $1.36/gal.[b] Drums: Available by special order only.	Long-lasting road dust suppressant. Can in some cases eliminate watering for 60-90 days.	Neat at an average .25 gallons per square yard. Application Service available.

[a] Mention of company or product names is not to be considered as an endorsement by the Ohio Environmental Protection Agency.

[b] 1980 prices.

Table B-1 (continued). CHEMICAL DUST SUPPRESSANTS, THEIR COST,

USES, AND APPLICATION RATES[a]

Company/address phone/contact	Product name/ product type	Cost	Uses/comments	Density, dilution and application rates
Nalco Chemical Co. 2901 Butterfield Oak Brook, IL 60521	Nalco 8820	55 gl. drums[b] .565/lb. to .750/lb. Bulk .511/lb.	Binding agent for revegetation Pile binder prevents windage loss and conserves raw material	1 to 10 water at dosages ranging from .1 gallon to .3 gallons per square yard.
MATESON CHEMICAL CORPORATION Easton Division 1025 E. Montgomery Ave. Phila., PA 19125 (215) 423-3200 Mr. Mark Mateson	DUST-SET®, Dust Abator	55-gal. drum[b] 1-4 7.40/gal. 5-9 7.38/gal. 10-39 7.35/gal. > 39 7.30/gal.	Surfactant & protective adherent resinous media for dusty areas with high human density.	8.7 lbs. per gallon 1.500 ± 200 dil. margin 1 dil. gal. = 100 $ft.^2$
Midwest Industrial Supply, Inc. P.O. Box 8431 Canton, Ohio 44711 (216) 499-7888 Bob Vitale	SOIL-SEMENT™ Acrylic resin emulsion	55 gallon drums[c] $1.96/gallon Bulk $.99/gallon	Binds fugitive dust from all sources (haul roads, parking and yard areas, stockpiles, ash, tailings). Stops dust; reduces rutting, potholes; increases load bearing strength; does not wash away or leach out. Mix with water and spray. Clean. Excellent weatherability to rain and ultraviolet light.	Heavy traffic - 1 gal/40 ft^2 Parking lot - 1 gal/60 ft^2 Road berm - 1 gal/80 ft^2 Yard area - 1 gal/80 ft^2 Ash, tailings - 1 gal/100 ft^2
	COALBINDER™	55 gallon drums[b] $2.27/gallon Bulk $2.04/gallon	Designed for use in coal industry as a dust suppressant: coating over open transport vessels to prevent transportation losses; eliminates airborne particulate matter on stockpiles.	Open transport vessels - 1 gal/300 ft^2 Stockpiles - 1 gal/300 ft^2

[a] Mention of company or product names is not to be considered as an endorsement by the Ohio Environmental Protection Agency.

[b] 1980 prices.

[c] 1981 prices.

Table B-1 (continued). CHEMICAL DUST SUPPRESSANTS, THEIR COST, USES, AND APPLICATION RATES[a]

Company/address phone/contact	Product name/ product type	Cost	Uses/comments	Density, dilution and application rates
Liquid Calcium Chloride Sales, Inc. P.O. Box 215 Kawkawlin, Mi. 48631 (517) 684-5860 Mr. Melvin Gerard Jr.	Liquidow (38%) Dowflake (77-80%) Calcium Chloride	$ 32.00 ton[c] $160.00 ton	Surface stabilization and dust control material. Attracts moisture from the air binding aggregate particles and fines together. Resists evaporation.	172 gals per ton 8 lbs per gal water yields 1.4 final volume gals. (350 gals per ton) Application rate: 1 gal per 50-60 sq. ft.
Neyra Industries, Inc. 5391 Wooster Road Cincinnati, OH 45226 (513) 321-5500 Mr. Bernie Schlake	Resinex 60 Cold water emulsion of petroleum derived resins.	55 gallon drums[b] $ .63/gallon Bulk $ .38/gallon	Unpaved haul roads, parking areas, stockpile access roads; non-toxic, non-corrosive, waterproof and stable after application. May be stored 12 months or longer. Applied diluted with any type of equipment used to apply water.	8.33#/gallon 1:5 Dilution: .75 to 1.25 gals/sq. yard (for parking lots and dirt roads) 1:8 Dilution: .3 to 1.0 gals/sq. yard for thin layer or loose dirt. 1:10 Dilution: for improved compaction of all unpaved surfaces and erosion prevention

[a] Mention of company or product names is not to be considered as an endorsement by the Ohio Environmental Protection Agency.

[b] 1980 prices.

[c] 1981 prices.