2.20 BRICK AND RELATED CLAY PRODUCT MANUFACTURING PLANTS

2.20.1 Process Description

The manufacturing plants which produce brick and related clay products such as clay pipe, pottery, and refractory brick (this category does not include ceramic clay manufacturing) usually employ grinding, screening, blending, forming, cutting, drying and firing operations to produce a final product. The basic raw material used in this industry is clay.

Clay is composed of extremely fine crystals or particles of hydrated silicates of aluminum, iron or magnesium with various impurities which include powdered feldspar, quartz, sand, limestone and carbonaceous materials such as coal and pyrities.[1] The unique (and most desirable) properties of clay are that it is plastic when sufficiently pulverized and wetted, rigid when dry, and vitreous when fired at a sufficiently high temperature.[2] Surface clays and shales are mined in open pits while most fine clays are found underground.[3] In general, the industry will use clays that have enough plasticity to be workable, contain a low water of plasticity, exhibit limited dry shrinkage in terms of size and mass, and have limited firing shrinkage.[4]

There are three major technological processes which can be used to manufacture brick or related clay products: the soft-mud process, the stiff-mud process and the dry (or semi-dry) press process.

In the soft-mud process, the clay mixture contains 20 to 30 percent water, and the desired product is formed in molds.[5] This process is particularly suitable for producing bricks from sandy clays that do not extrude well. One disadvantage associated with this process concerns the cost of drying the water from these bricks. Since the clay has a high water content, the drying costs associated with this process will accordingly be higher than those for the stiff-mud and dry press processes.

The stiff-mud process uses clay that has enough water content (15 to 20 percent) to be reasonably workable and has normal drying characteristics. This clay mixture is placed in a screw-type extruder and forced through a die. The extruded clay bar, rectangular in shape, is then cut into the finished product, dried and fired in a kiln.[6] The stiff-mud (or extrusion) process is the predominant method of producing brick and clay products in the United States.

Finally, in the dry (or semi-dry) press process, a clay mixture (4 to 7 percent water) is placed in molds and subjected to extremely high pressures (approximately 5 tons per square inch), and then fired in a kiln.[7] Although the brick or ware produced in this manner is taken directly to the kiln for firing without the intermediary drying process[8], large amounts of energy may still be needed to initially predry the clay so that it can be subjected to the pressing process.

Regardless of which clay process is used, the raw material is subjected to the same grinding, screening and blending processes in order to obtain the specified size and composition. Some plants, however, will eliminate the grinding and screening processes by purchasing finished raw materials. In all other instances, the clay arrives at the plant from a clay mine and is subjected to preliminary crushing.

The crusher normally used for grinding is a pan crusher which consists of one or more grinding wheels or mullers revolving in a pan. The pan may remain stationary while the mullers are driven, or the pan may be driven while the mullers revolve by friction.[9]

Next, the clay is transferred to sizing screens. The proper sized clay particles pass through the screens and are subsequently conveyed to large storage bins. The oversized material from the screens are fed into a hammermill, reduced in size and recycled to the inlet of the screens.

From the storage bins, the clay is supplied to the mixing machines by use of either vibratory feeders or rotary disc-feeders. In the mixing machine (usually a pugmill), water and additives are added.

After mixing, the clay material is formed by means of either the soft-mud, stiff-mud or dry press process. The products of the soft-mud and stiff-mud processes are usually placed in drying rooms before firing in a kiln. In these drying rooms, the drying process is accomplished partially by using waste heat from the kilns.[10] The products of the dry press process go directly into the kilns.

The final step in the production process is the firing of the brick or ware in a kiln. Although several types of kilns are in use today, practically all modern brick and tile plants use a tunnel kiln to fire their ware.[11]

In the operation of a tunnel kiln, the brick or ware moves continuously on cars through the kiln as indicated in Figure 2.20-1.[12] As the ware moves, it is gradually heated, reaching a maximum temperature in the area between the furnaces. The charge is then cooled as it passes out of the kiln. Air is passed through the kiln countercurrent to the direction of movement of the ware. Cold air is forced in the discharge end of the kiln to cool the charge. Some air is withdrawn from this section for use as the primary air for combustion in the burners. The temperatures of the air exiting the kiln range from 320 to 640°F depending upon the length of the preheating zone.

The capacities of tunnel kilns vary from 100 to 250 tons/day.[13]

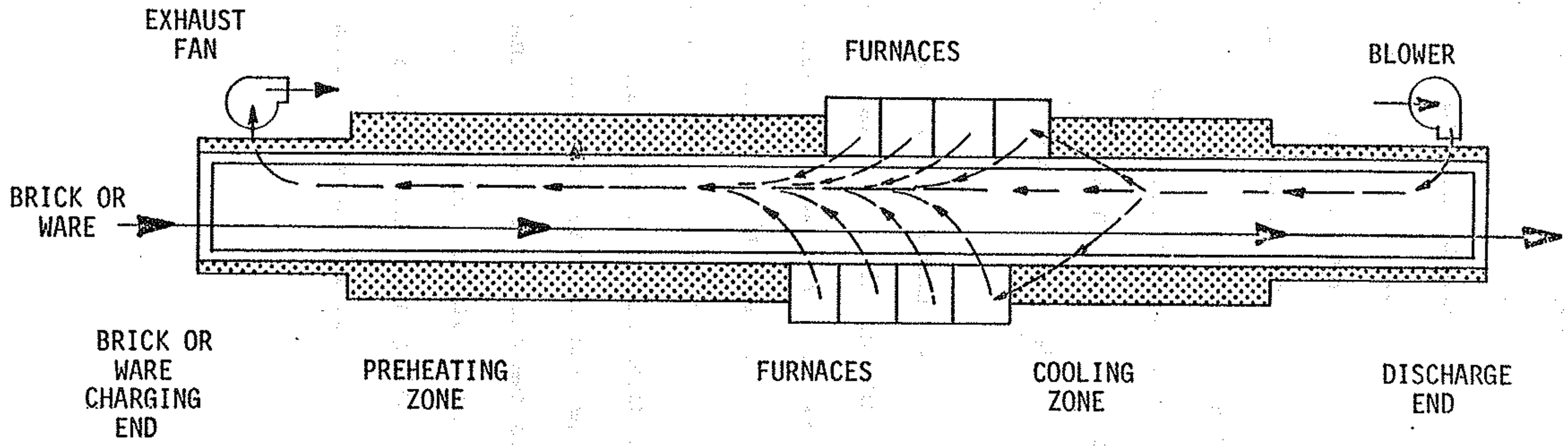

Figure 2.20-1. Tunnel kiln.

The other type of kiln is the periodic (batch) or beehive kiln. In the periodic kiln, as shown in Figure 2.20-2, fires are built in furnaces (B) and heat passes through openings (S) up to the dome of the kiln. The hot gases are deflected downward through the ware, through the flue covers (A) and the under-floor flues (F), into the chimney flue (D), and out the chimney (C).

In all kilns, the firing process subjects the brick or ware to six changes:[14]

1) the chemically uncombined water is driven off;
2) the clay undergoes decomposition along with liberation of the combined water;
3) the combustion and removal of combustible matter occurs;
4) decomposition of impurities occurs,
5) partial combination of some of the impurities with the silica and alumina from the clay occurs, and a molten glassy material is formed; and
6) upon cooling, the glassy material bonds the solid particles together, forming a tough, hard product.

The temperature of the ware is raised slowly to allow the water and products of combustion to escape without damaging the structure of the ware. The temperature (maximum temperature ≈ 2000°F) of the kiln and the length of time the ware is fired determines the amount of glassy material formed.

At brick and related clay products manufacturing plants, the sources of fugitive dust emissions include raw material unloading, primary crushing, and vehicular traffic on plant roadways. The secondary crushing or grinding and screening processes are usually conducted indoors to prevent exposure to moisture; and, therefore, are not sources of fugitive dust emissions. The fugitive dust sources and a process flow diagram are shown in Figure 2.20-3.

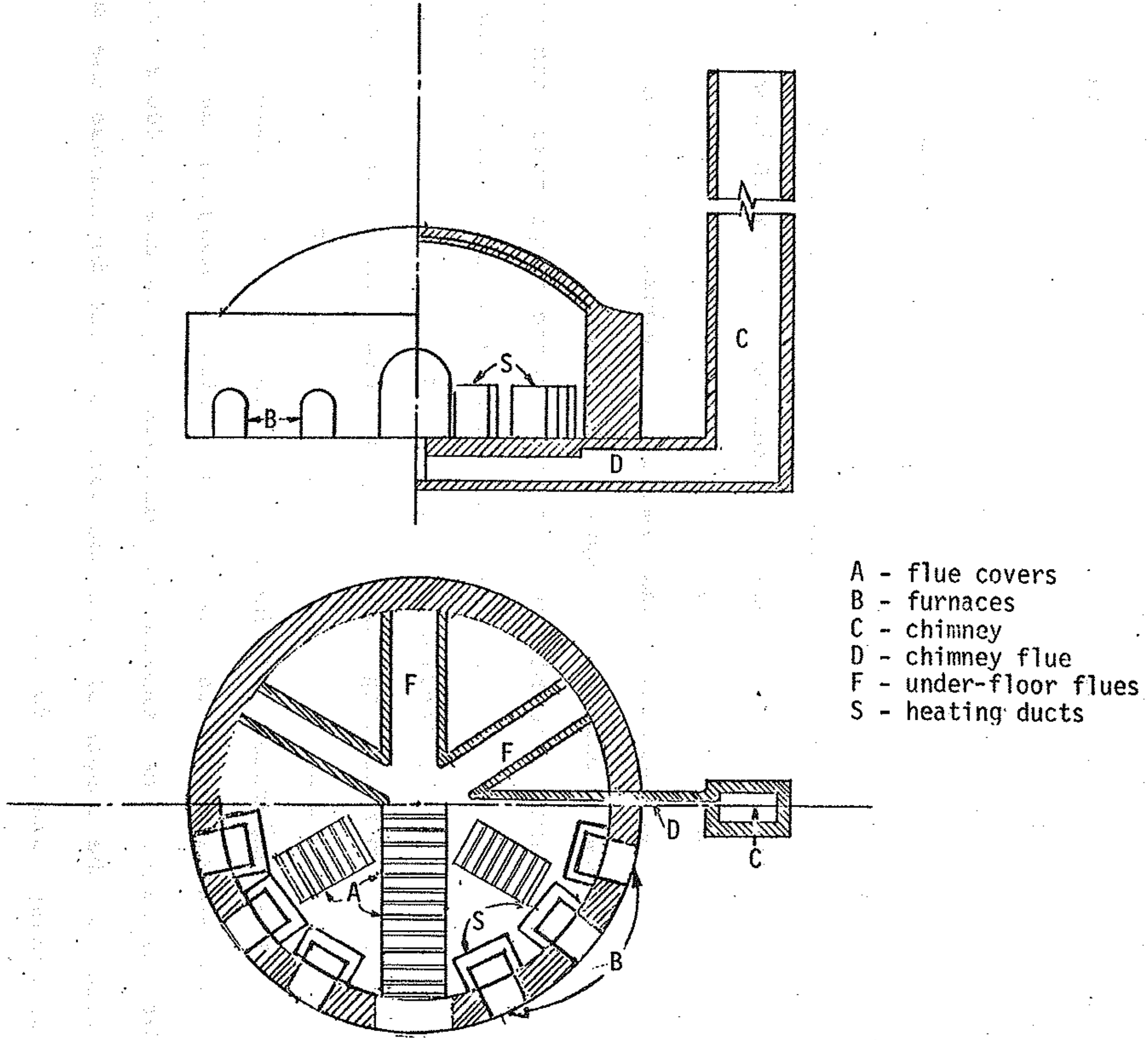

Figure 2.20-2. Periodic kiln.

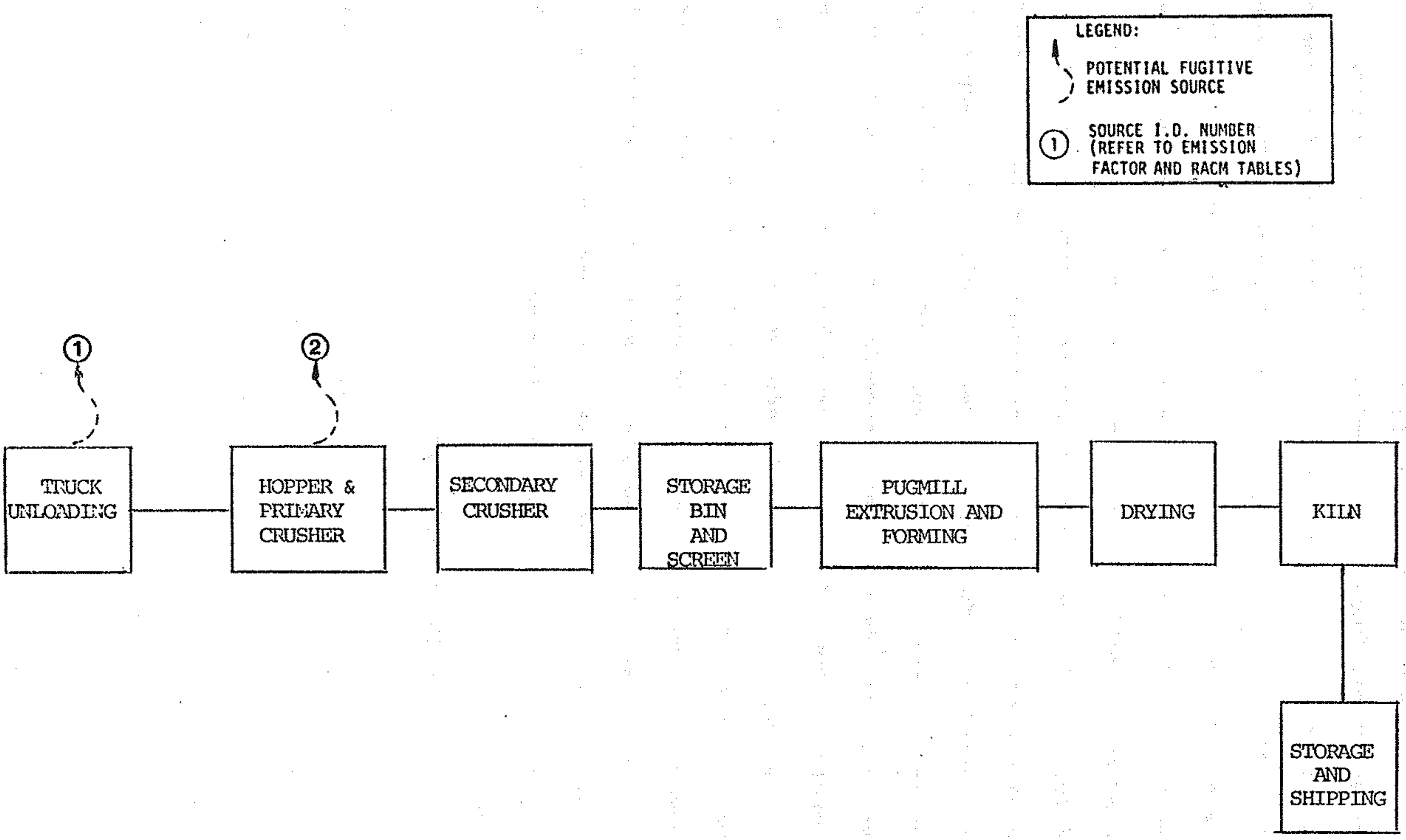

Figure 2.20-3. Simplified process flow diagram for brick and related clay product manufacturing plants and associated fugitive particulate emission sources.

2.20-2 Fugitive Dust Emission Factors

The estimated fugitive dust emission factors for sources at brick and related clay manufacturing plants are identified and summarized in Table 2.20-1. The source of the cited factors is EPA's "Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions". The factors given are based upon engineering estimates and are of questionable accuracy for site specific applications.

No fugitive dust emission factors were found for any other individual process operations such as screening, material transfer or secondary grinding. The major sources of fugitive dust appear to be truck unloading, primary crushing, and traffic on plant haul roads. In those instances where storage, secondary crushing and screening are conducted without adequate enclosure and visible emissions are apparent, measures will have to be adopted to either further enclose such operations or otherwise control such fugitive emissions. In Ohio, however, the majority of these processes are conducted indoors, where little, if any, dust generated escapes into the ambient air.

Since both material handling and haul roads were discussed in detail in Section 2.1, they will be addressed only briefly in this guideline.

2.20.3 Particle Characterization

Chemically, clays are hydrated silicates of aluminum, iron and magnesium with various impurities. The toxicity depends upon the silica (SiO_2) content of the clay. Clay (usually $Al_2O_3.SiO_2.2H_2O$) has a molecular weight of 258.2 grams/mole, is insoluble in water, and can be toxic if it is inhaled at high concentrations over a prolonged period.[16]

TABLE 2.20-1. FUGITIVE DUST EMISSION FACTORS FOR BRICK AND RELATED CLAY PRODUCT MANUFACTURING PLANTS

Source	Emission factor	Reliability rating	Reference
① Truck unloading	0.04 lb/ton unloaded	E	22
② Primary crushing	0.25 lb/ton crushed	E	22

A study conducted by the National Institute for Occupational Safety and Health determined that exposure to respirable free silica was toxic at the concentrations found to exist at a Boulder, Colorado brick manufacturer.[16] A TLV of 30 million particles per cubic foot has been determined for clay.[17]

No particle size distribution data could be found for the identified fugitive dust emissions.

2.20.4 Control Alternatives

Fugitive dust emissions generated by truck unloading and primary crushing can be abated through the application of chemical dust suppressants, enclosure with aspiration to a fabric filter or partial enclosure using a three-sided building.

A typical wet dust suppression system contains the following components: a dust control agent, metering equipment, a distribution system, and control actuators.[18] The dust suppressant should be applied during the unloading operation by use of a spray bar located above the dump hopper. This will reduce the visible dust emissions generated during the dumping operation and subsequent crushing. While no measurements have been made to test the efficiency of this process, it is reported to be about 90 percent efficient.[19]

The fugitive dust may also be captured by a hood or duct located above the unloading area which is aspirated to a fabric filter dust collector.

Lastly, a three-sided enclosure over the truck dumping and crushing area can be an effective measure to reduce the amount of fugitive dust emitted. Many brick and clay product plants employ such a structure over this area, although not generally for purposes of air pollution control.

Although, as previously mentioned, storage, secondary crushing and screening operations are generally conducted indoors with little, if any, discharge of fugitive emissions, adequate control measures such as improving existing enclosures, installing new enclosures, wet suppression devices or other controls may be necessary if the existing facilities are unable to adequately contain the fugitive dust emissions.

Roadways and parking areas on plant property can be a significant sources of fugitive emissions depending upon the type of road surfaces.[21] Road surfaces are separated into two general categories: paved and unpaved. Generally speaking, for paved surfaces, sweeping, flushing, speed reduction and good housekeeping practices are typical methods of control. Dust suppressants, road oiling, paving or vehicular speed reduction are the typical methods cited for the control of fugitive emissions from unpaved roadways.

2.20.5 Recommended Reasonably Available Control Measures (RACM)

The RACM selections for control of fugitive particulate emissions from brick and related clay product manufacturing plants are presented in Table 2.20-2. Recommended control for raw material unloading and primary crushing is the use of a chemical dust suppression system. This system provides good control effectiveness (90 percent) and reduces visible emissions significantly. Recommended control measures for the storage and/or secondary screening and grinding operations located at facilities without adequate enclosures (i.e., visible emissions noted through building openings) will be to either further enclose such operations or install controls (such as wet suppression).

RACM for the control of fugitive dust from roadways are discussed in Section 2.1.1 of this guideline document.

TABLE 2.20-2. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM BRICK AND RELATED CLAY PRODUCT MANUFACTURING PLANTS

Fugitive dust sources	Control alternatives	Control efficiency %	Control costs, Jan. 1980, $		Cost benefit	RACM selection
			Capital	Annualized	$/lb	
① Truck unloading	Three-sided enclosure	50[a]	4,900[b]	800[b]	.04	Wet suppression (chemical)
	Wet suppression (chemical)	95[c]	64,000[d]	15,700[d]	.38	
	Enclosure, vent to fabric filter	99[c]	87,400[e]	21,000[e]	.49	
② Primary crusher	Three-sided enclosure	50[a]	f	f	.04	Wet suppression (chemical)
	Enclosure, vent to fabric filter	99[c]	g	g	.49	
	Wet suppression (chemical)	95[c]	h	h	.38	

[a] Estimate.

[b] Assume 20'x20'x15' enclosure. Based on 75 ton/hr throughput of clay and 250 days per year operation.

[c] No visible emissions after controls. Based on data from Section 2.13 of this guideline.

[d] Assume 75 tons/hr throughput capacity, 250 days per year operation, and the spray covering material handling operations. See Section 2.13.

[e] Assume 20'x20'x15' enclosure with jet pulse baghouse treating 10,000 acfm at 70°F with a 6.5 to 1 air to cloth ratio.

[f] The cost includes those for a three-sided enclosure for truck unloading.

[g] The cost includes those for enclosure and vent to fabric filter for truck unloading.

[h] The cost includes those for wet suppression for truck unloading.

REFERENCES FOR SECTION 2.20

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3. Compilation of Air Pollutant Emission Factors. Third Edition with Supplements 1-9. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina, July, 1979, p. 8.3-1.
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APPENDIX FOR SECTION 2.20

Three sided enclosure

20x20 + 20x15 + 20x20
400 400 300

Total area = 1100 ft^2

Mass = 1100 ft^2 (5.625 lbs/ft^2)(1.2)

Mass = 7425 lbs

Pg. 4-25 GARD Enclosure Cost = (\$.208 + \$.30)(7425 lbs)

Enclosure Cost = \$3,770 labor materials
Dec. 75

Update to Jan. 1980 $(\$3,770)\frac{(249.6)}{(192.1)} = \$4900$

UAE = (4900)(.1598) = 783.02 ≈ 800

Cost benefit

75 tons/hr throughput
2000 hrs/yr operation
150,000 TPY

<u>three-sided enclosure</u> - control efficiency - 50%

EF = .29 lb/ton =

(.29)(150,000) = 43,500 lbs

(.5)(43500) = 21,750

$\frac{800}{21750}$ = \$.036 /lb removed.

<u>Wet suppression</u>

43,500 lbs
(95%)(43,500) = 41,325 lbs

$\frac{15,700}{41,325} = .38$

<u>Enclosure with vent to fabric filter</u>

43,500
(.99)(43,500) = 43,065

$\frac{21,000}{43,065} = .49$

2.21 ASPHALTIC CONCRETE PLANTS

2.21.1 Process Description

Asphaltic concrete is manufactured by combining various proportions of fine and coarse aggregates in a mixer with either a hot asphalt or a cold (cutback or emulsified) asphalt.[1] The aggregates are composed of different sizes of sand and gravel which are highly siliceous with quartzose grains.[2]

There are three different types of hot mix asphaltic concrete plants: batch, continuous and dryer-drum. The batch and continuous processes differ only in the final mixing process (i.e., both have basically the same pattern of material flow up to that point).[3]

In the batch plant, the aggregate is loaded onto the feeder and conveyed to a rotary dryer. After drying, the material is sized, weighed and loaded into the mixer.[4] The hot asphalt is weighed separately and then placed into the mixer where the aggregate becomes evenly coated with asphalt.[5]

In the continuous process, the sized and proportioned aggregate is conveyed to the mixer. A positive displacement metering pump automatically meters the correct amount of asphalt and thoroughly mixes the material in the pugmill. The aggregate and asphalt feeds are positively interlocked to insure that proper proportions of each material are introduced into the mixer. The retention time in the mixer is controlled by an adjustable dam located at the discharge point.[6]

Simplified process flow diagrams of typical continuous and batch plants are shown in Figures 2.21-1 and 2.21-2, respectively.

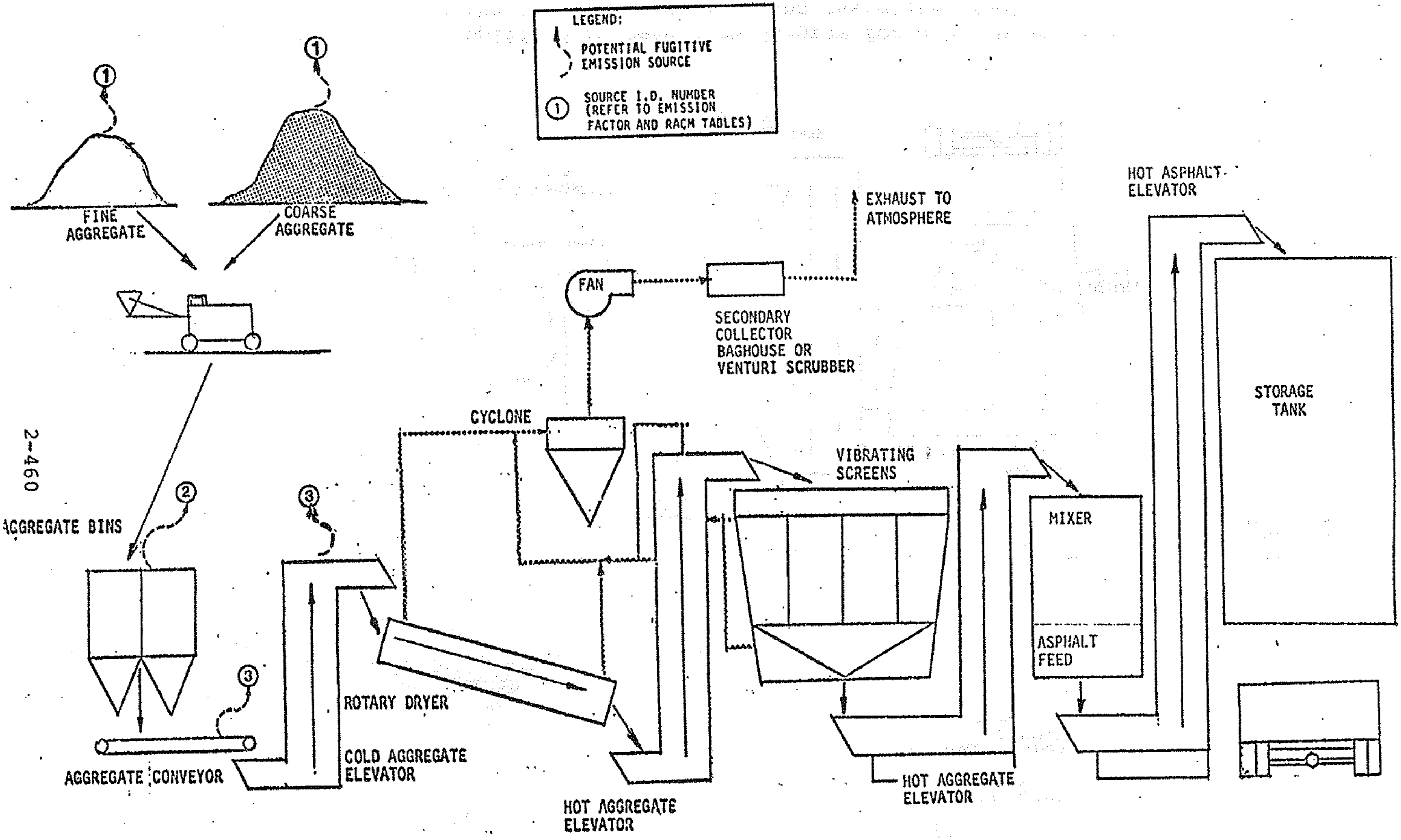

Figure 2.21-1. Simplified process flow diagram for a continuous hot-mix asphaltic concrete plant and associated fugitive particulate emission sources.

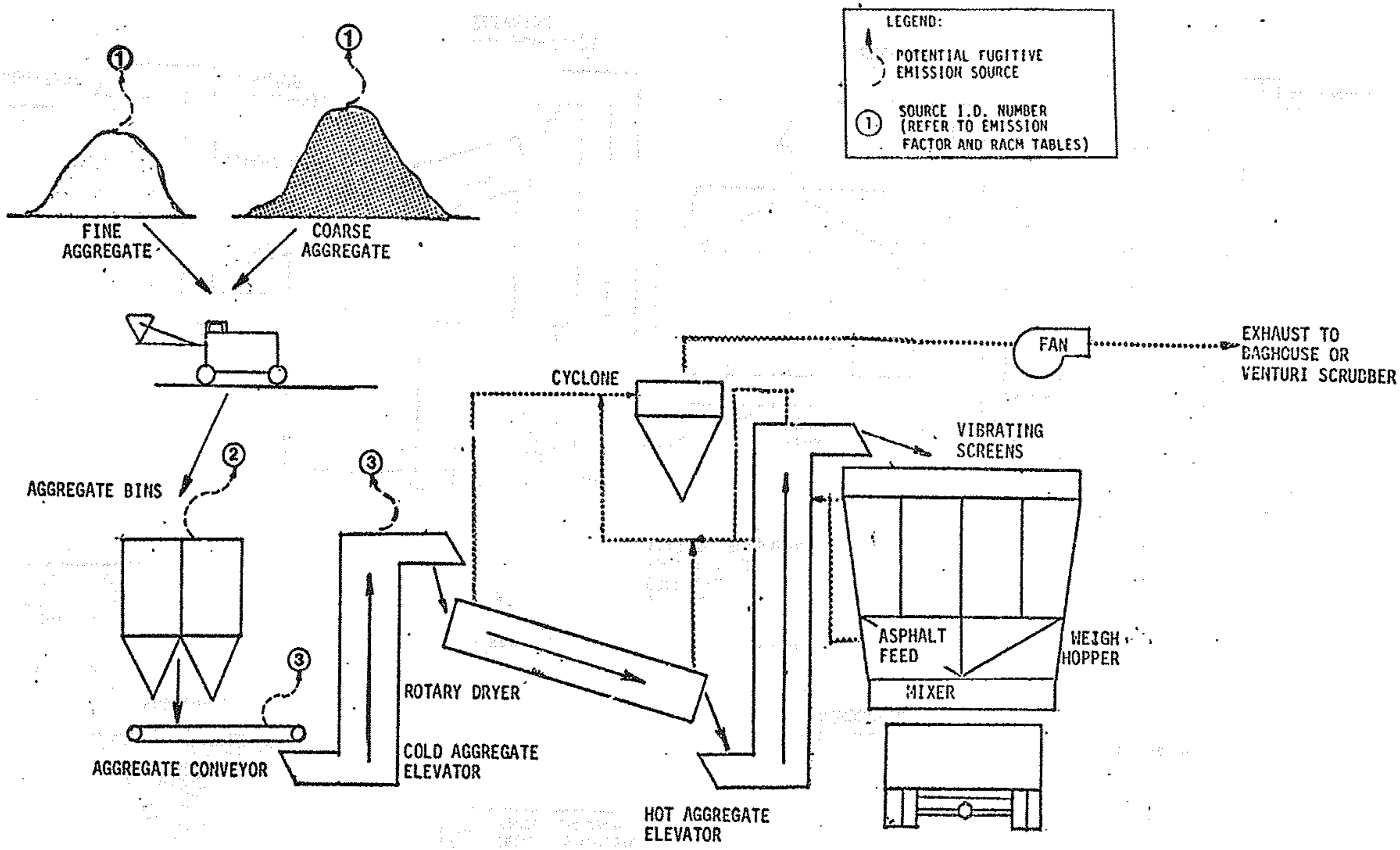

Figure 2.21-2. Simplified process flow diagram for a batch hot-mix asphaltic concrete plant and associated fugitive particulate emission sources.

In the dryer-drum process, the proportioned aggregates are fed to a continuous belt, weighing unit which in turn feeds the dryer-drum.[7] At the same time, an adequate amount of hot asphalt is continosly injected directly into the dryer-drum to coat the aggregates.[8] In the dryer-drum, the asphalt/aggregate mixture is dried to form the desired asphaltic concrete product. This process eliminates the hot screens, feeder bins, and elevators that are used in both the batch and continuous processes.[9] A process flow diagram of a typical dryer-drum plant is shown in Figure 2.21-3.

One process for manufacturing cold-patch asphaltic concrete utilizes a "cutback" asphalt which contains solvents and oils that will give better aggregate coating properties and extended curing times.[10] Cold-patch asphaltic concrete can be made in either a batch or continuous process. The operating measures for the production of cold-patch asphaltic concrete are similar to those for hot-mix asphaltic concrete except that the dryer for the cold-patch process is operated at lower temperatures.[11]

In another process for manufacturing cold-patch asphaltic concrete, an emulsifying agent and water are substituted for the petroleum distillate and oils used in the cutback process.[12] This emulsion is then mixed with aggregate to form cold-patch asphaltic concrete. There are no process or equipment changes associated with the use of emulsified asphalt over the cutback process.[13] The major advantage to the use of emulsified asphalt is that it greatly reduces the amount of volatile organic compound emissions that are released through evaporation of distillate in the curing process since no petroleum distillates are used for making the diluent.[14]

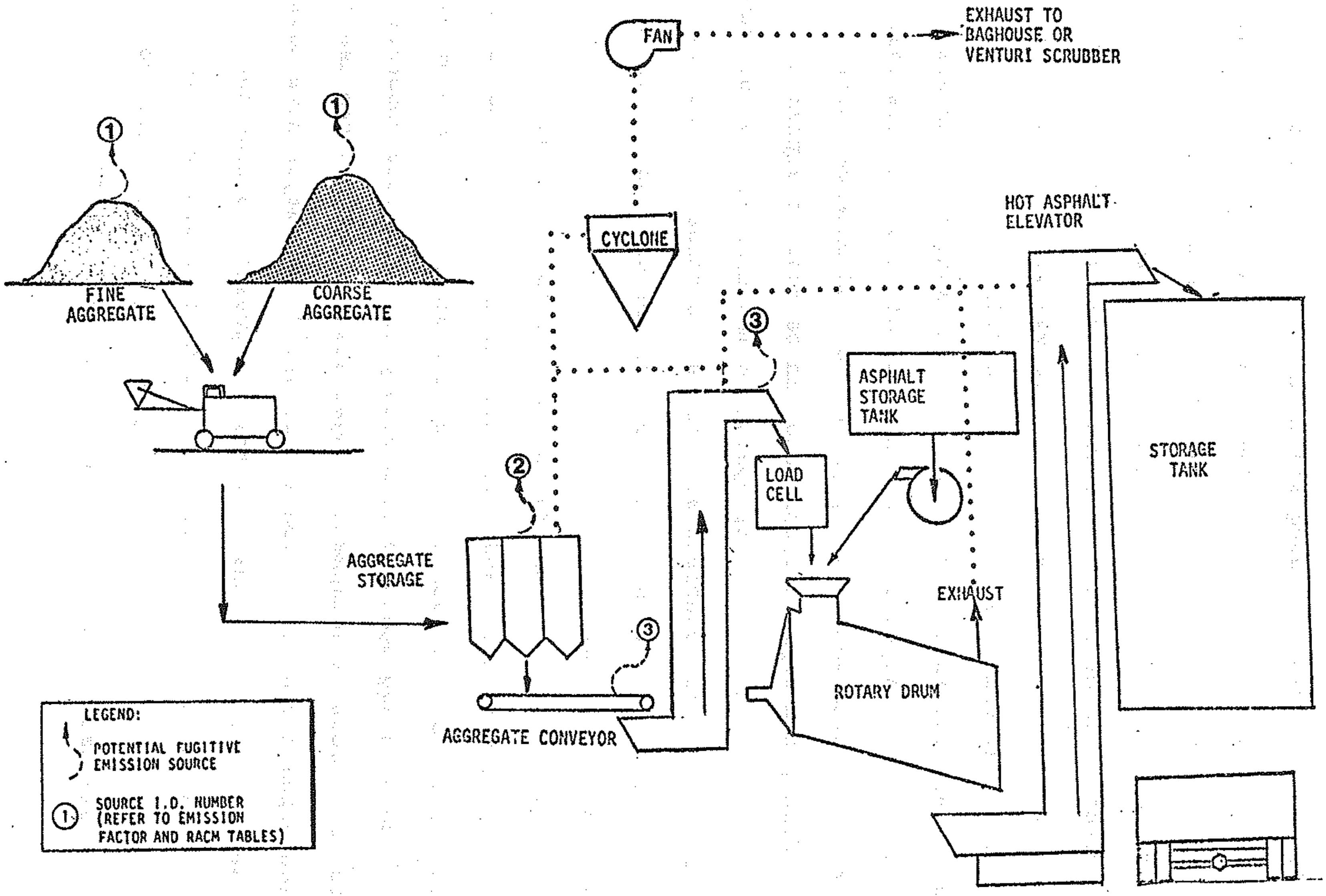

Figure 2.21-3. Simplified process flow diagram for a dryer-drum asphaltic concrete manufacturing plant and asociated fugitive particulate emission sources.

The capacities of asphaltic concrete plants range from 50 to 350 tons per hour with an average capacity of 163 tons per hour.[15] Typically, asphaltic concrete plants fall into two general categories: those that produce less than 100,000 tons per year and those that produce more than 390,000 tons per year.[16]

At asphaltic concrete plants, the major sources of fugitive dust are roadways, aggregate storage piles, and aggregate handling operations. The hot aggregate elevators, their transfer points and the vibrating screens are not considered to be sources of fugitive dust emissions, because these areas are always enclosed and vented to the dust collector for the rotary dryer.[17] Therefore, the above-mentioned enclosed areas will be considered as a part of the "point source" emissions. The emissions resulting from roadways and mineral extraction from quarry pits are discussed in Sections 2.1 and 2.18 of this study.

2.21.2 Fugitive Emission Factors

The uncontrolled fugitive emission factors for the production of asphaltic concrete are presented in Table 2.21-1. The factors vary depending upon the type of operation involved[18] and the composition of the dried aggregate.[19]

The emission factors for the storage of coarse and fine aggregates are derived and discussed in Section 2.1.2 of these guidelines. The emission factors for material transfer operations were obtained from a document entitled "Assessment of Fugitive Particulate Emission Factors for Industrial Processes" (EPA-450/3-78-107), and are based upon similiar material processes in other industries.[20]

The reliability of the fugitive dust emission factors given in Table 2.21-1 have a "D" rating, which means that the factors are based upon engineering judgment and supported by limited test data.[21,22]

TABLE 2.21-1 FUGITIVE DUST EMISSION FACTORS FOR ASPHALTIC CONCRETE MANUFACTURING

Source	Emission factor	Reliability rating	Reference
① Storage of coarse and fine aggregate			
loading onto pile	0.04 lb/ton loaded onto pile	D	40
vehicular traffic	0.013 lb/ton stored	D	40
load out	0.05 lb/ton stored	D	40
wind erosion	0.11 lb/ton stored	D	40
② Unloading coarse and fine aggregate to storage bins	0.1 lb/ton loaded out	D	40
③ Cold aggregate elevator	0.5 lb/ton aggregate	D	40

2.21.3 Particle Characterization

Studies indicate that the fugitive dust particles from asphaltic concrete plants range from 0.1 μm to more than 300 μm,[23] with about 90 percent of the particles less than 10 μm in size.[24] The exact size distribution of the fugitive dust will depend upon the amounts of coarse and fine aggregates used in the asphaltic concrete mix.[25]

The chemical composition of the fugitive dust will vary with the type of aggregate used. Aggregate usually consists of rock, gravel, sand, fines[26] or waste materials such as slag from steel mills and crushed glass.[27] The primary compound found in sand, gravel or glass is silica (SiO_2) or stone quartz. Sand and gravel will contain varying amounts of silica and impurities such as feldspar, mica, limomite and other iron oxides and minerals.[28] Asphalt sand (or gravel) is usually a clean siliceous sand of medium grain and sharpness used for the manufacture of asphalt pavement.[29]

Silica in its pure form is a crystal with a molecular weight of 60.09 grams/gram-mole, a melting point of 1710°C, a boiling point of 2230°C and a vapor pressure of 10 mm of Hg at 1732°C.[30] The prolonged breathing of silica is the chief cause of pulmonary dust disease or silicosis.[31] This disease is characterized by generalized fibrotic changes and the development of miliary nodules in the lungs.[32] As the disease progresses, it substantially impairs breathing capacity and leaves the victim susceptible to tuberculosis, cardiac failure or anoxemia (lack of oxygen) as a result of the destruction of lung tissue.[33]

The major compounds found in slag from steel mills are calcium oxide, magnesium oxide and silica.[34] Calcium oxide (CaO) has a melting point of 2580°C and a density of 3.37 grams/cm^3. It is a powerful caustic to living tissue.[35] Magnesium oxide (MgO) in its pure form has a melting point of 2500°C and a density of 3.65 grams/cm^3. When inhaled it can produce a febrilercation (fever) or leukocytosis (an increase in white blood cells).[36]

2.21.4 Control Methods

The largest potential source of fugitive emissions within the industry results from existing aggregate storage piles and plant roadways.

The control techniques utilized for reducing emissions from aggregate storage piles include the use of enclosures, wind screens, the application of water and/or chemicals and reasonable operating precautions.[37] While total enclosure of the aggregate storage pile is the most effective method of preventing fugitive emissions, it is also the most expensive. Wind screens are an alternative to total enclosure, but they are not as efficient. The use of water and/or chemicals for dust suppression is the most common measure for the control of fugitive emissions.

Roadways and parking areas on plant property can be a significant source of fugitive emissions depending upon the amount of traffic and the type of road surface.[38] Road surfaces are separated into two general categories: paved and unpaved. Generally speaking, for paved surfaces, sweeping, flushing, vehicular speed reduction and good housekeeping practices are typical methods of control. Dust supressants, road oiling, paving or vehicular speed reduction are the typical methods cited for the control of fugitive emissions from unpaved roadways.

The aggregate handling operations involving the removal of aggregate from the storage site and its subsequent transfer to the process operation are generally accomplished by use of a front end loader. The fugitive emissions that result from this phase of the operation are due to spillage and emissions resulting from unloading which are simultaneously compounded by wind generated losses. The control methods that are employed include reasonable care in handling to avoid spillage, the use of enclosures or wind guards wherever possible and the use of wet suppression at the cold storage bins.

The control methods discussed above in reference to aggregate storage piles, roadways and material handling are discussed in detail in Sections 2.1.1, 2.1.2 and 2.1.3 of this document.

2.21.5 Recommended Reasonable Available Control Measures (RACM)

Control for storage piles commonly consists of wet suppression (water or chemical) in the form of a sprinkling system plus a partial enclosure (or wind break). See Section 2.1.2 for a detailed discussion.

The dusting that occurs while loading the aggregate into the cold storage bins is minimized by use of a sprinkling system located at the cold bin.[39] Fugitive dust emissions from loading operations can also be reduced somewhat by lowering load-in drop distances.

For paved roadways the recommended control measure is use of water flushing supplemented by a good housekeeping program to minimize spills and carry-on dirt and mud. For unpaved roads, RACM is the use of oil or other dust suppressants coupled with general speed reduction. Paving is justified only where it would be economical to the individual plant. See Section 2.1.1 for detailed discussion.

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7. Kinsey, S.J., An Evaluation of Control Systems and Mass Emission Rates From Dryer-Drum Hot Asphalt Plants. Journal of The Air Pollution Control Association (Dec. 1976) 26:1163.
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9. Ibid. p. 1164.
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22. Op. cit. Reference 16. p. 1-2.

23. Op. cit. Reference 1. p. 2-327.

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25. Op. cit. Reference 13. 8.1 p. 5.

26. Op. cit. Reference 21. p. 7.18.

27. Op. cit. Reference 1. p. 2-322.

28. Op. cit. Reference 2. p. 453, 454.

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32. Ibid.

33. Ibid. p. 969.

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36. Ibid. p. 783.

37. Reasonably Available Control Measures for Fugitive Dust Sources, PEDCo Environmental Inc., Prepared for Ohio EPA, March 1980 See generally Section 2.1.2.

38. Ibid. Section 2.1.1.

39. Op. cit. Reference 1. p. 328.

40. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Environmental, Inc. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. EPA-450/3-77-010. March 1977, p. 2-325.

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]

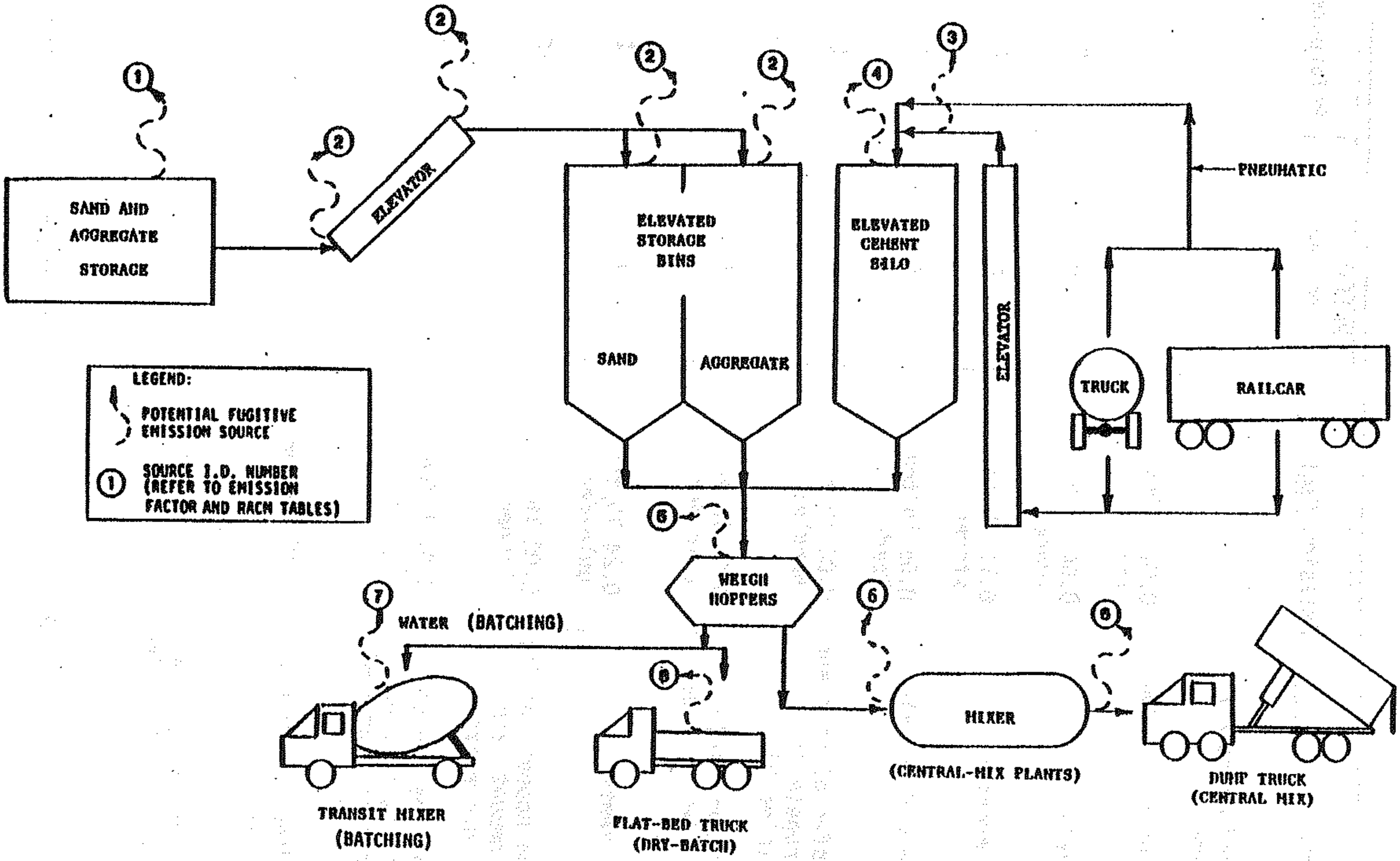

Figure 2.22-1. Simplified process flow diagram for concrete batching and associated fugitive particulate emission sources.

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 $< 5 \mu m$ 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

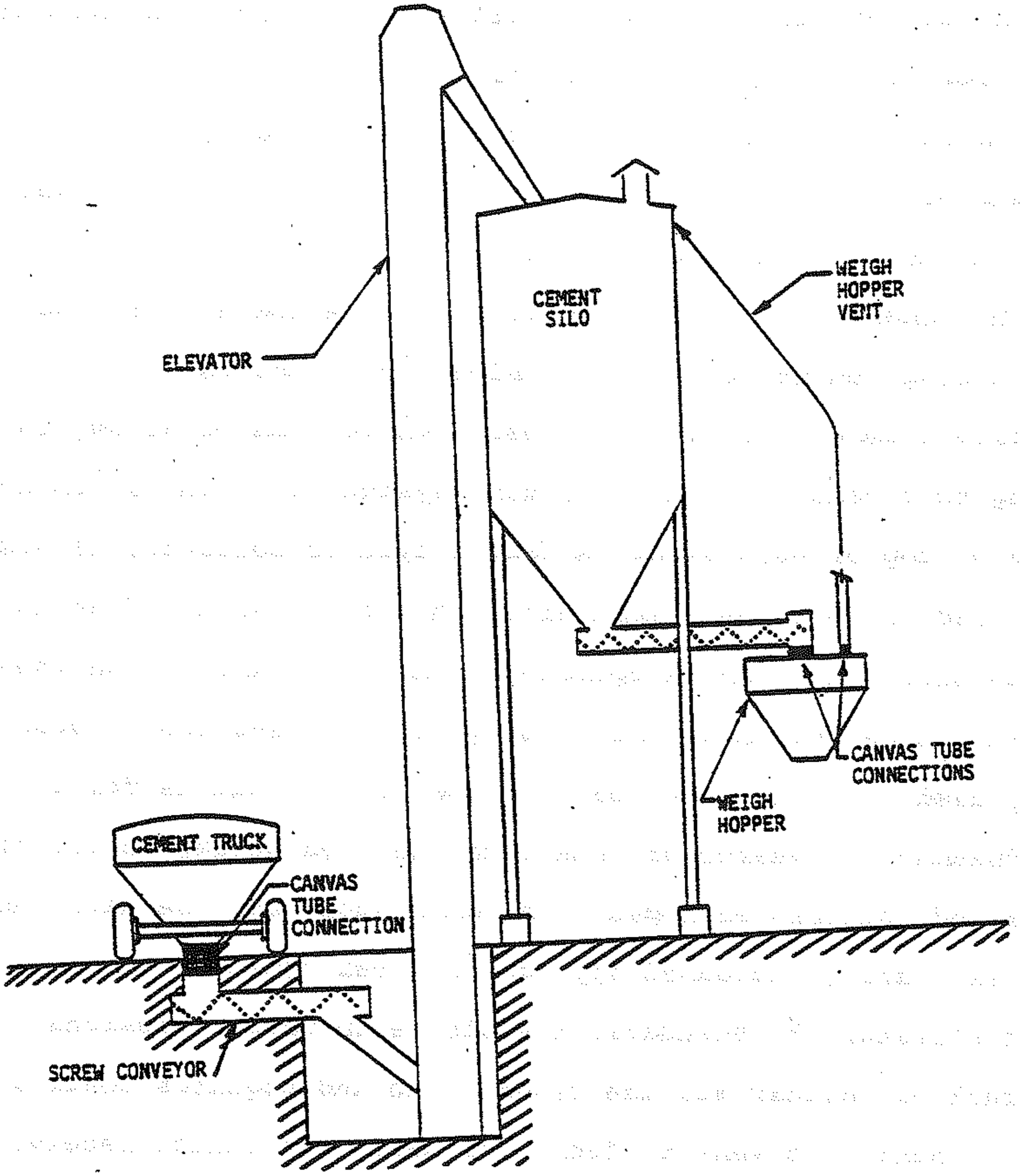

Figure 2.22-2. Cement-receiving and storage system.

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.

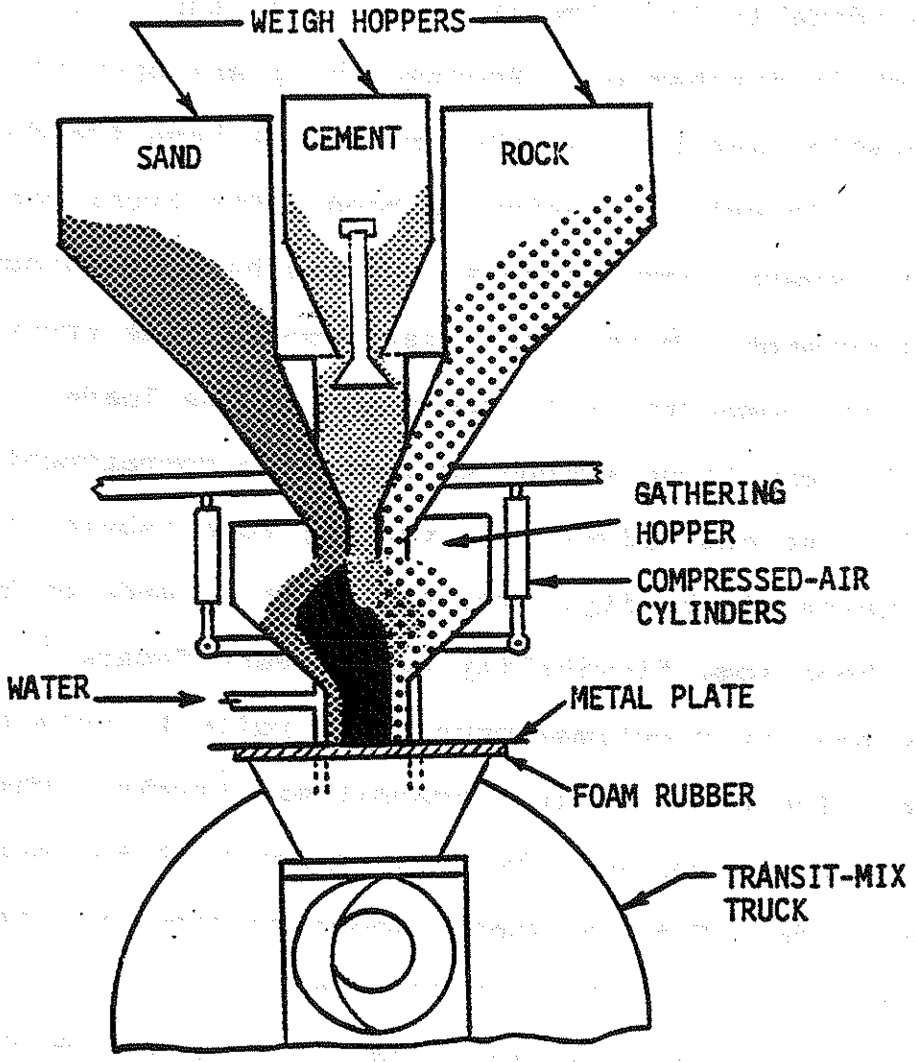

Figure 2.22-3. An adjustable gathering hopper.

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[q]	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.

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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.

APPENDIX FOR SECTION 2.22

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

$40\ \text{ft}^2 \times 5.625\ \text{lb/ft}^2 \times 1.2 = 270$ lbs.

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

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

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

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

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

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

(Fig. 4-20) Labor Cost 350

(p. 4-25) Hood Cost $(165.8)(\$.90/\text{ft}^2) + (\$.108)(1119) = \$270\ \frac{(249.6)}{(198.1)} \approx \$350$

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

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

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

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

(Fig. 4-26) Expansion Joints (4) ($2375)+(2375)+($1625) = $8000 $\frac{(249.6)}{(192.1)}$ = ... 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
$(200)(\$.40) = \$80 \dfrac{(249.6)}{(192.1)} = \$104$
\$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 $\dfrac{(249.6)}{(192.1)} = \$520$

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

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

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

C/B = \$.73/lb TSP Removed

APPENDIX FOR SECTION 2.22

A Typical Concrete Batch Plant Has The Following Data:

390,000 T/yr
2,000 hr/yr

Sources

①② 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.

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

Ac = Area Of Cloth

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

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

Total = 9732 ∿ 10,000 acfm

[REF.20] Baghouse Price (Fig. 4-7) $[2910 + 1.6(3333)]\,\frac{(249.6)}{(192.1)}$ = . . .$10,710

Costs Of Bags (Tables 4-1, 4-2) $3333 \text{ ft}^2 \times 2 \times \$.40/\text{ft}^2 = \$2666.4\ \frac{(249.6)}{(192.1)}$ = ... 3,465

(D) Rectangular Hood (8'x2.4') & Supports Costs
(Fig. 4-17) [L/W Ratio = 4] Plate Area Requirement $1 + 0.615(8)^2 = 40 \text{ ft}^2$

(Fig. 4-19) Labor Cost 150
$40 \text{ ft}^2 \times 5.625 \text{ lb/ft}^2 \times 1.2 = 270$ 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 = \$5000 $\frac{(249.6)}{(192.1)} \approx$ 6,500

(C) Circular Hood (50°θ) + Supports Cost
(Fig. 4-18) Plate Area Requirement $1.343 \times \left(\frac{40}{12}\right)^2 = 165.8 \text{ ft}^2$

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

(Fig. 4-20) Labor Cost 350

(p.4-25) Hood Cost $(165.8)(\$.90/\text{ft}^2)+(\$.108)(1119) = \$270\ \frac{(249.6)}{(198.1)} \approx \$350$

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

(Fig. 4-21) Ductwork Cost 100ft 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

$$C/B = \frac{\$16,304}{[(0.24\ lb/T)(390,000\ T/yr)+(0.02\ lb/T)(390,000\ T/yr) + (0.04\ lb/T)(390,000\ T/yr)+(0.04\ lb/T)(390,000\ T/yr)].99}$$

$$C/B = \frac{\$16,304}{132,600\ lb/yr}$$

C/B = \$0.12/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 $(\$0.35)(2{,}000 \text{ hrs/yr}) = \$700 \left(\frac{249.6}{192.1}\right) \simeq \$910$

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

Capital Charges $PV = R \cdot PV/ \quad n = 10 \quad i = 12\%$

$(5.650) \ R = \$10{,}800$

$R = \$1{,}912$

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

$$C/B = \frac{\$3{,}000}{(0.24 \text{ lb/T})(390{,}000 \text{ T/yr})(.99)}$$

C/B = $0.03/lb TSP removed

2.23 SANDBLASTING OPERATIONS

2.23.1. Process Description

Sandblasting is an industrial process wherein silica sand (or other abrasive material), of varying degrees of abrasiveness, is propelled against a product surface. The sandblasting creates the desired surface texture for a finished product. Although the applications of sandblasting are numerous, the discussion here will be of a general nature and will be limited to manufacturing processes where sandblasting is both a permanent operation, used in conjunction with the processing of a product, and a fugitive dust source.

Sandblasting can be conducted outdoors in the open air or indoors in an enclosure. Reasonably available control measures for sandblasting depend upon how and where the sandblasting is conducted more so than what type of part is being blasted. Therefore, this category will be divided into indoor and outdoor blasting operations.

The most common method of propelling the abrasive is by use of compressed air through either the suction blast method or the direct pressure blast method.[1] In the suction blast method (see Figure 2.23-1), separate hoses are connected directly to the sand supply and air supply, respectively. These hoses are then connected to a sandblasting mechanism. The high velocity of the air through the gun creates a partial vacuum that draws in and expels the sand.[2]

With the direct pressure method (see Figure 2.23-2), the sand supply is located in a container which is under pressure. The abrasive supply tank is the pressure vessel with the compressed air line connected to both the top and bottom discharge line, thereby creating equal pressure above and below the abrasive. This permits the abrasive to flow by gravity into the high volume air stream in the discharge hose which then accelerates the abrasive to the velocity required to do the blast cleaning.[3] The direct blast machines propel from two

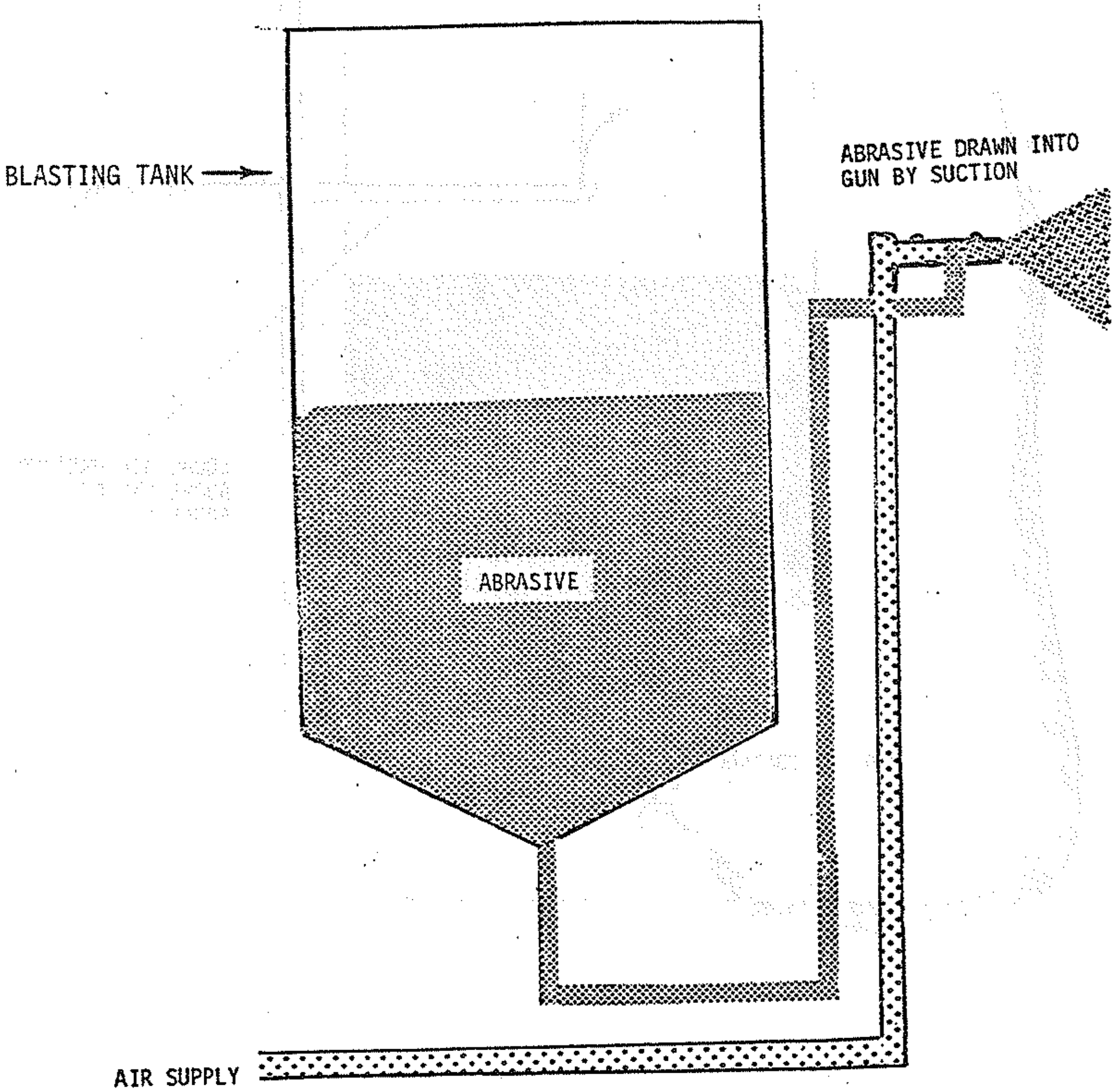

Figure 2.23-1. Suction blast method.

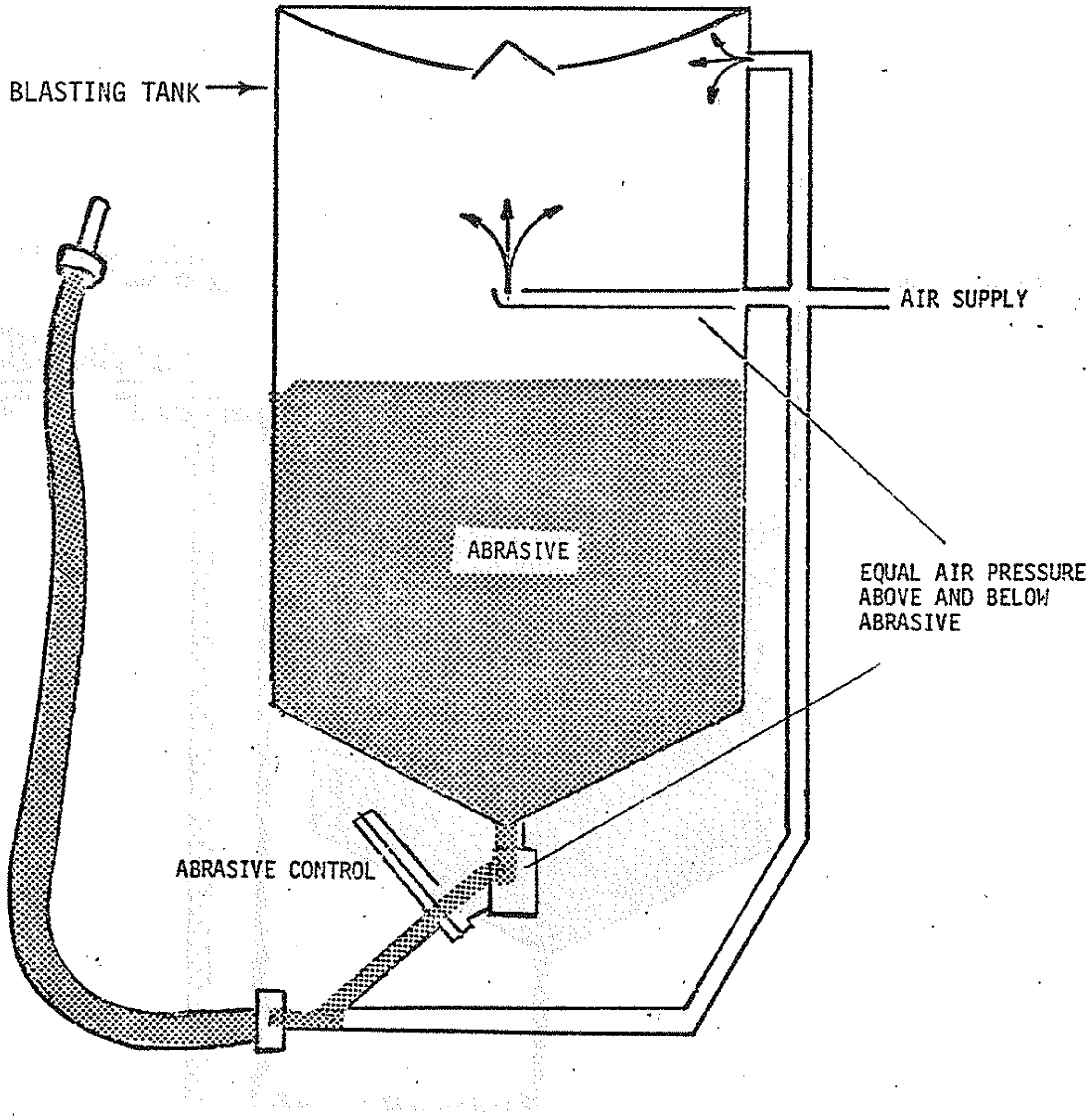

Figure 2.23-2. Direct blast method.

to four times as much abrasive per cubic foot of air (at equal air pressures) than the suction blast method.[4]

Regardless of which method of blasting is used, a large amount of fugitive dust is created when the propelled abrasive impacts upon the product surface, since both the sand and the product surface will fracture.[5] The larger dust particles from this process will settle in the immediate blasting area while the smaller particles of fugitive dust will be transported much greater distances by the ambient air. The greatest source of fugitive dust from a sandblasting operation is the sandblasting itself. Several other fugitive dust sources are associated with a sandblasting operation. As shown in Figure 2.23-3, these sources include roadways, vehicular traffic and material handling and storage.

2.23.2 Fugitive Dust Emission Factors

The fugitive particulate emission factors for the various processes in sandblasting are set forth in Table 2.23-1.

As can be seen from the Table, there is no known published data, for any type of sandblasting, from which a representative emission factor can be obtained. Naturally, the amount of fugitive dust generated is directly related to the type and amount of abrasive being used and the composition of the part being blasted. A rough estimate indicates that sandblasting of pre-cast concrete panels has an emission factor of 1.55 pounds per ton of product.[6] This is only a rough estimate for a specific industry, and its accuracy cannot be ascertained.

2.23.3 Particle Characterization

A typical size analysis of silica sand particles resulting from sandblasting associated with a zinc galvanizing operation[7] will be used to indicate size distribution for sandblasting emissions in general. Table 2.23-2 presents that particle size data.

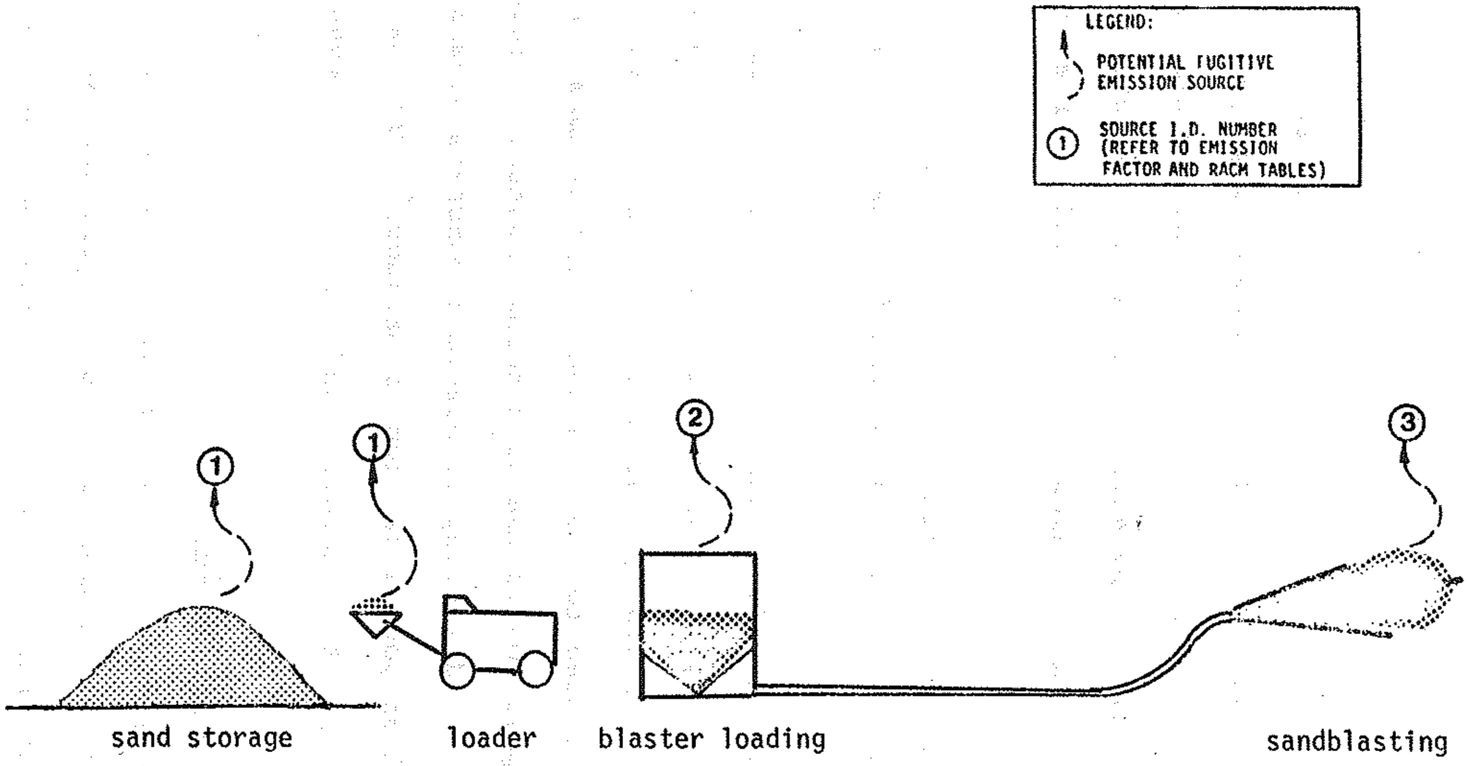

Figure 2.23-3. Simplified process flow diagram for sandblasting and associated fugitive particulate emission sources.

TABLE 2.23-1. FUGITIVE DUST EMISSION FACTORS FOR SANDBLASTING OPERATIONS

Source	Emission factor	Reliability rating	Reference
① Storage of sand loading onto pile	0.04 lb/ton transferred	D	22
vehicular traffic	0.065 lb/ton stored	D	22
load out	0.05 lb/ton transferred	D	22
wind erosion	0.11 lb/ton stored	D	22
② Unloading sand into storage bin on sandblaster	0.04 lb/ton trans-	D	22
③ Sandblasting	1.55 lb/ton of feed(a)	E	24

(a) This emission factor is based upon the blasting of precast concrete panels. Emission factors for blasting of other products are not available.

TABLE 2.23-2. TYPICAL SIZE DISTRIBUTION OF FUGITIVE DUST PARTICLES AS A RESULT OF SANDBLASTING[6]

Particle diameter, µm	Cumulative weight, %
1.6	0.4
2.7	1.8
4.4	5.3
6.6	11.1
8.3	15.6
9.3	18.2
10.4	21.6
11.5	24.6
14.8	33.2
19.8	41.3
26.4	50.1
33.0	58.7
41.2	65.6
49.5	72.1
65.9	82.0
98.9	96.5
147.8	100.0

Silica sand (or silicon dioxide) is a colorless crystal with a molecular weight of 60.09 grams/gram mole, a density of 2.6 grams/cm^3 and a melting point of 1710°C.[8] Silica is the chief cause of pulmonary dust disease, especially silicosis.[9] The duration of exposure required to develop silicosis in sandblasters is estimated at between two and ten years.[10] Silicosis causes the lungs to produce a "diffuse, nodular fibrosis in which the parenchyma and lymphatic system are involved."[11] In advanced stages of this disease, tuberculosis, heart failure or anoxemia may intervene. As a result, massive destruction of lung tissue will produce death in the victim.[12]

Federal and state laws usually require operators to wear air-supplied hoods (helmets) to prevent excessive exposure to particulates. Although the use of well-maintained blasting hoods offers fair protection during blasting, concern has been voiced over the high concentration of suspended respirable dust in the ambient air during non-blasting periods (which exceeds the TLV by several times).[13] Therefore, only wearing hoods during the blasting period may not be the entire solution to preventing silicosis.

2.23.4 Control Methods

Since most enclosures are not able to confine all the dust generated by indoor, dry abrasive blasting and because that dust can impair the operator's vision and make breathing difficult, some controls are almost always employed for these operations. The most widely used and most efficient type of dust collector for this industry is the baghouse (with a superficial face velocity of the gas passing through the filter cloth not to exceed three feet per minute).[14] High efficiency cyclones equipped with a tube-type fabric filter can be used to control the fugitive dust, but this method is not as efficient as a baghouse. High efficiency cyclones have difficulty in collecting the very fine dust particles ($<5\mu m$).[15] The tube-type fabric filter, besides being unable to capture the fine particles, also has a tendency to clog easily, resulting in a loss of draft at the cyclone inlet.

Baghouses are capable of collecting particles that have a diameter of one micron or less with an efficiency of ninety percent.[16] Overall, the baghouse is capable of efficiencies in excess of 99 percent.[17]

It is estimated that building a 1200 ft^3 enclosure (to house the blasting of concrete panels to expose aggregate) and evacuating the blasting operation to a baghouse with a three to one air-cloth ratio would result in a capital expenditure of $41,000 and an annualizied cost of $6,500.[18] A cyclone, on the other hand, with the same capacity and for the same operation would require a capital expenditure of $18,000 and an annualized cost of $1,600.[19]

Wet blast adaptors eliminate between 80 to 90 percent of the dust without lowering sandblasting efficiency.[20] The wet blast adaptor, as illustrated in Figure 2.23-4, is a ring that attaches to the blaster nozzle. The ring has holes which spray water into the blast pattern just after the air and abrasive leave the nozzle. The water is metered by a petcock located at the blast head. The wet blast adaptor is supplied with water from a standard garden hose or faucet.

The capital cost of a wet control system capable of suppressing the dust generated by the above-mentioned concrete panel blasting operation is approximately $400-$500 (wet blast adaptor plus hoses).[21] Operating cost is limited to the cost of water.

The feed-sand is stored in large outdoor storage piles and is transferred to the sandblaster by means of a front end loader. The recommended controls for handling storage piles are discussed in Section 2.1 of this study.

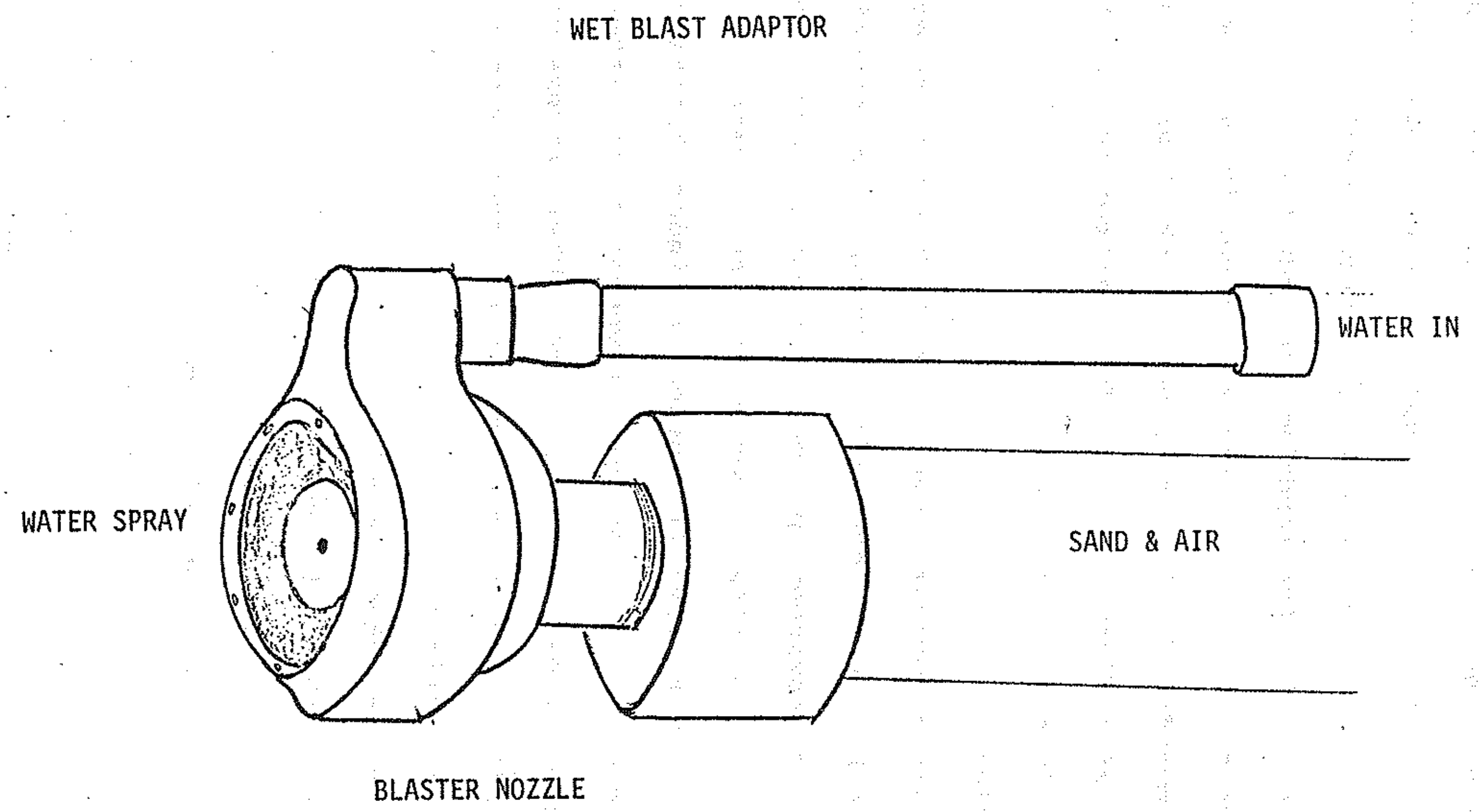

Figure 2.23-4. Wet blast adaptor.

The control of fugitive dust emissions generated on roadways are also discussed in Section 2.1 of this study.

2.23.5 Recommended Reasonably Available Control Measures (RACM)

The recommended RACM for each of the listed fugitive dust emission sources is shown in Table 2.23-3. Selections were based upon considerations of ease of installation, emission control requirements, and current control practices within the sandblasting industry.

The RACM selection for sand storage is wetting with water. No control is recommended for loading sand into the blaster because this source is not a significant fugitive dust emitter due to the low emission and production rates (less than 1/2 ton per hour) for average blasting operations.

For the blasting process itself, two RACM's were selected. They will be compared by use of "cost effectiveness" figures which quantify the cost of control equipment per pound of particulates removed. Where moisture will not affect product quality, a sandblasting water spray attachment may be used (in outdoor or indoor blasting) to control fugitive dust. The cost effectiveness of the water adaptor is $0.01 per pound of particulate removed. Where excessive moisture will adversely affect product quality, an enclosure with a induced draft system to maintain ventilation and visibility is recommended. It is also recommended that the exhaust air be vented to a baghouse. The baghouse system should be cabable of virtually 100 percent collection efficiency. The recommended ventilation rate is 80 fpm across the floor area with an indraft velocity through all openings of 500 fpm and a superficial face velocity of gas passing through the filter cloth not to exceed 3 fpm.[23] The cost benefit of this method of control is approximately $0.17 per pound particulate removed.

TABLE 2.23-3. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM SANDBLASTING OPERATIONS

Fugitive dust sources	Control alternatives	Control efficiencies %	Control costs, Jan. 1980, $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
① Storage of sand	Enclosure, vent to fabric filter	99[a]	87,400[b]	21,000[b]	73.25	Periodic watering
	Enclosure	50[a]	15,000[b]	2,600[b]	9.06	
	Wet suppression (chem.)	95[a]	13,500[b]	2,200[b]	7.67	
	Watering	50[a]	negligible	-	-	
② Unloading sand to storage bin on the sandblaster	Operating precaution	-	-	-	-	Operating precautions
③ Sandblasting	Enclosure with baghouse	99[a]	40,000[c]	6,500[c]	0.17	Enclosure with venting to a baghouse or use of a waterspray attachment.
	Enclosure with high efficiency cyclone and tube-type fabric filter	90[a]	18,000[c]	1,400[c]	0.078	
	Waterspray attachment	80-90[a]	500[c]	500[c]	0.01	

[a] Engineering estimate.

[b] Based upon 20' x 20' x 15' enclosure and jet pulse treating 10,000 acfm. See Section 2.1.2 and 2.13, Table 2.1.2-8 and 2.13-3 of this study.

[c] Assumes blasting capacity of 940 lbs. sand per hour and a baghouse treating 9600 acfm. See Appendix A of this sandblasting category. See reference 20 and 21.

The high efficiency cyclone with tube type fabric filter is not highly favored because it is not as efficient as a baghouse with respect to the collection of small particles. Also, the filter tube is prone to binding or clogging which results in a loss of draft in the cyclone.

REFERENCES FOR SECTION 2.23

1. Air Pollution Engineering Manual (2nd edition), Los Angeles County Air Pollution Control District, May, 1973, PB-225-132, PART I, page 398.

2. Ibid, p. 398.

3. Ibid, p. 398.

4. Ibid, p. 398.

5. Ibid, p. 401.

6. Ohio EPA files.

7. Op. cit. Reference 1, p. 401.

8. Irving Sax, Dangerous Properties of Industrial Materials, 3rd edition, 1968, VanNostrand Reinhold, p. 1088.

9. Ibid.

10. Ibid.

11. Ibid.

12. Ibid.

13. American Industrial Hygene Assoc. Journal, "The Efficiency of Protective Hoods Used by Sandblasters to Reduce Silica Dust Exposure" Feb. 75, V 36, p. 140.

14. Op. cit. Reference 1, p. 401.

15. Ibid. p. 91.

16. Ibid. p. 106.

17. Capital and Operating Costs of Selected Air Pollution Control Systems, GARD, May 1976, p. 2-16.

18. See Appendix A for calculations.

19. Ibid. See Appendix A.

20. Based upon blast cleaning equipment selection guides from Clemco Industries and Anderson Blast Cleaner Co.

21. Conversation with Miles McGregor, of Marietta Concrete, Marietta, Ohio by Ohio EPA, November 1979.

22. Technical Guidance for Control of Industrial Process Fugitive Emissions, EPA-450/3-77-010, March, 1977, pp. 2-17 and 2-35.

23. Op. cit. Reference 1, p. 401.

24. Ohio EPA files.

APPENDIX FOR SECTION 2.23

COST OF CONTROL

Assume:

Enclosure 6'W x 10'H x 20'L Total volume = 1,200 ft^3

80 fpm flow rate across the floor area (vent. rate)

3 fpm superficial face velocity of gas through filter cloth.

8 changes of air/min. = 9,600 ft^3/min.

GARD p. 2-20: 3,200 ft^2 = net filter cloth area required

GARD p. 4-10: Intermittent, pressure, baghouse = \$8,500

GARD p. 4-15: Filter cloth cost = 1,310

GARD p. 4-58: Fan motor, 20 Hp, Class II, 3 1/2" DP = 2,000
9,600 cfm

GARD p. 4-24: Hood + duct
L/W = 20/6 = 3.3
LABOR \$700
$\text{MTL.} = 200\ \text{ft}^2 (5.625)(1.2) = \$1{,}350$
2,050

GARD Fig. 4-60: Operational Cost, \$0.75 per hour
@ 2040 hours per year 1,530

Baghouse	\$ 8,500	
Fabric filter	1,310	
Fan	2,000	
Hood and duct	2,050	
Subtotal	\$13,860	
Tax + Freight (7%)	970	
Subtotal	\$14,830	
Installation (@75%)	11,122	(GARD p. 4-89)
Subtotal	\$25,952	
Engineering (10%)	2,595	
Subtotal	\$28,547	
Contingency (10%)	2,855	
Total equipment cost	\$31,402	effective 12/1975

Adjust capital cost to 1980 value

JAN INDEX 1976: 192.1
JAN INDEX 1980: 249.6

$\frac{(249.6)}{(192.1)}(31,402) = \$40,800$ Capital investment in terms of Jan. 1980 $

Assume:

Equipment life = 20 years
Cost of capital = 15%
Net emission 18.8 lbs/HR @ 2040 Hrs/yr. (Plant data)

GARD 3-3 UAE = 40,800 (.1598) = <u>$6,520</u>

Cost Benefit = $\frac{\$6,520/\text{yr}}{38,352 \text{ lbs mtl.}} = \$0.17$

<u>High Efficiency Cyclones</u>

pg. 11-22 Industrial Ventilation - $0.20/cfm in 1968

(25,000 cfm)($0.20/cfm) = $5,000

PEDCo memo: $\frac{(\text{Jan. 1980 } 250)}{(\text{Jan. 1968 } 125)}(5,000 \text{ Jan. 1968}) = \$10,000$

January 1980 cost of $10,000

Table 4-12 of GARD Manual — Installation cost is 75% of equipment cost

($10,000)(.75) = $7,500 installation cost

Table 4-12 GARD — Maintenance estimated at 2% of equipment cost
$200

page 4-24 GARD — Hood and Ductwork
$(\$2,050)\frac{(249)}{(182)} = \$2,804$

page 4-58 GARD — Fan Motor
$(\$3,500)\frac{(249)}{(182)} = \$4,790$

Figure 4-60 GARD — $(\$0.75 \text{ per hour})(2040 \text{ hours/yr})\frac{(249)}{(182)} = \$2,090$

Equipment cost

high efficiency cyclone	10,000
fan/motor	4,790
hood and ductwork	2,800
	17,590

1) Equipment costs (control device + auxiliaries) = $17,590

2) Tax and freight (@7% of 1)* = 1,230

3) Installation costs (Table 4-12) = 7,500

4) Subtotal (1 + 2 + 3) = 16,320

5) Engineering (@ 10% of 4)* = 1,632

6) Subtotal (4 + 5) = 17,952

7) Contingencies (@ 10% of 6)** = 1,795

8) Total capital costs (6 + 7) = 19,747

Life of cyclone is estimated at 20 years
Cost of capital (i) assumed to be 15% compounded annually over a period (n) of 20 years

page 3-4 GARD Uniform Annual Equivalent $= PW \frac{[(i)(1 + i)^n]}{[(1 + i)^n - 1]}$

PW = present worth
i = interest rate
n = period of years

Table A-10 GARD UAE = ($19,747)(.1598) = $2,870

$$\text{Cost effectiveness} = \frac{\text{annualized cost}}{\text{lb tsp removed}}$$

$$= \frac{\$2,870}{(95\%)(38352)} = \$\frac{.078}{\text{lb}}$$

Sand storage:

Assume: 940 lb sand/hr. required to maintain operations (Plant file).

2000 HRS/YR of operation

1,880,000 lbs/yr or 940 tons per. yr. sand stored

Losses from sand storage pile

$$\frac{.04\ \text{lb}}{\text{ton}}(940) = 37.6\ \text{lbs}$$

$$\frac{.065\ \text{lb}}{\text{ton}}(940) = 61.1\ \text{lbs}$$

$$(0.05)(940) = 47\ \text{lbs}$$

$$0.11\ (940) = 103.4\ \text{lbs}$$

$$0.04\ (940) = \underline{37.6\ \text{lbs}}$$

$$286.7\ \text{lbs}$$ sand emitted from storage pile.

Cost effectiveness of:

(a) enclosure

$$\frac{\$2,600}{286.7\ \text{lbs}} = \$\frac{9.06}{\text{lb}}$$

(b) enclosure with vent to fabric filter

$$\frac{\$21,000}{286.7\ \text{lbs}} = \$\frac{73.25}{\text{lb}}$$

(c) chemical suppression

$$\frac{\$2,200}{286.7\ \text{lb}} = \frac{\$7.67}{\text{lb}}$$

2.24 PETROLEUM REFINERIES

2.24.1 Process Description

Petroleum refineries vary in physical size and degree of complexity. Defining a typical refinery is difficult because few refineries have the same number and types of processes.[1] The processes used by a particular refinery are indicated by the capacity of that refinery, the type of crude being refined, the products to be produced and the degree of technological sophistication. This section will only briefly discuss the fundamental processes commonly found in the approximately 247 U.S. petroleum refineries.[2] Figure 2.24-1 illustrates the refinery operations that are discussed herein.

Crude oil storage is accomplished by the use of tanks of varying size and is designed to provide adequate quantities of feedstock for the smooth and uninterrupted operation of the refinery.[3]

Crude desalting is accomplished by one of two methods.[4] The first method, known as chemical desalting, is accomplished by water-wash desalting in the presence of chemicals, followed by heating and gravity separation. In the second method, electrostatic desalting, the water-wash emulsion is separated from the oil by a high voltage electrostatic field which simultaneously removes the impurities. Among the impurities removed by the desalting are ammonia, phenol, sulfides, suspended solids and salts that can damage or poison the catalysts used in the cracking operations. Electrostatic desalting is in greater use than chemical desalting.

Crude oil fractionation separates crude petroleum into intermediate fractions of specified boiling point ranges.[5] Several of the alternative methods of fractionation are topping, atmospheric and vacuum fractionation, and three-stage crude distillation.

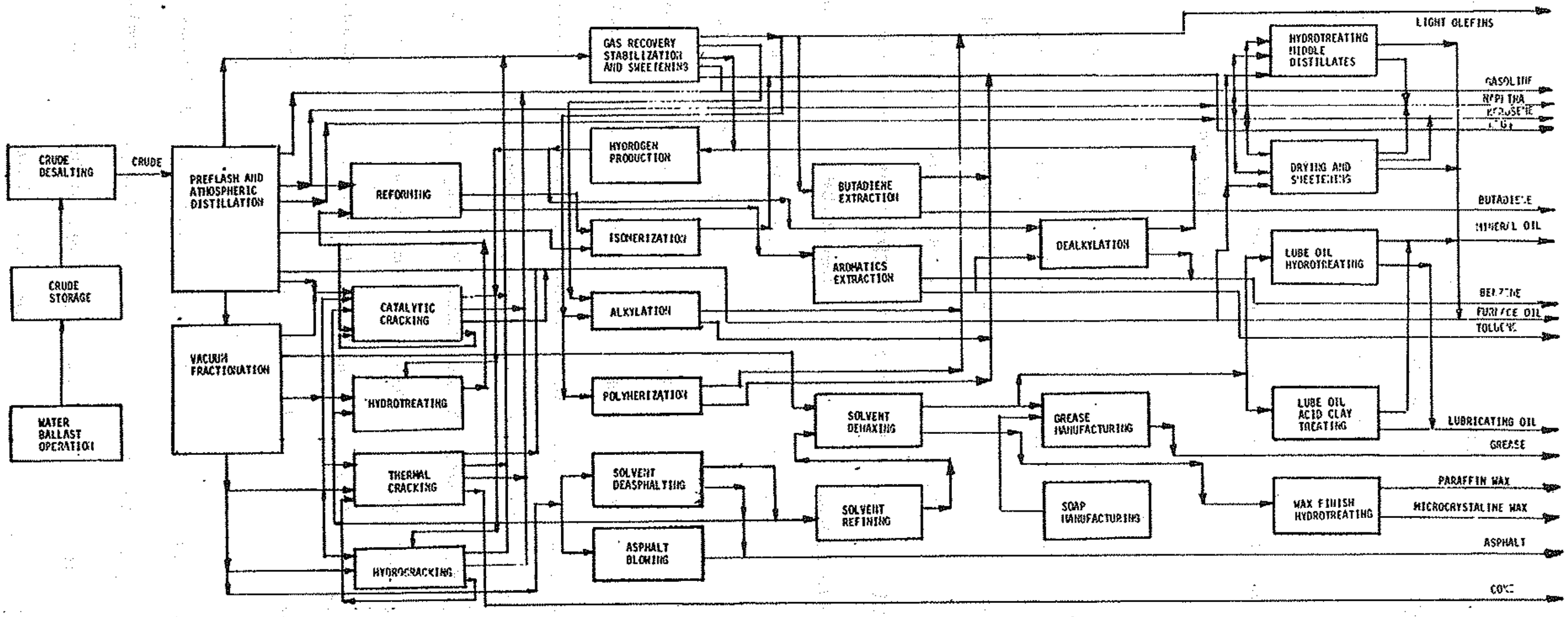

Figure 2.24-1. Simplified process flow diagram for petroleum refineries.

Topping is an economical method of separating the very light distillates from the crude oil by a process of skimming.[6] Skimming is usually carried out in a single column which has several side draw products or in a series of topping towers. This process is carried out at lower temperature and higher pressure conditions than would be required in atmospheric distillation.

In atmospheric and vacuum fractionation,[7] the crude oil is heated and subjected to an atmospheric fractionation process where the vaporized distillate is separated into gasoline, naphtha, kerosene, and light and heavy diesel oils. The bottoms from the atmospheric tower are heated and pumped through a vacuum fractionation where additional heavy gas and deasphalting feedstocks are recovered. Three stage crude distillation is a combination of equipment usually consisting of an atmospheric fractionating stage, and two vacuum fractionating stages.

The term thermal cracking includes visibreaking and coking operations.[8] In each of these operations, heavy gas-oil fractions (from vacuum stills) are broken down into lower molecular weight fractions by heating, but without the use of a catalyst. Typical thermal cracking conditions are 410°-600°C and 41.6-69.1 atmospheres pressure. Delayed coking is a form of thermal cracking where the feed is held at high temperatures long enough for the coke to form and settle out (425° - 490°C and 4 atmospheres pressure).[9] Products of thermal cracking include domestic heating oils, catalytic cracking feedstocks, and other light hydrocarbons.

Catalytic cracking breaks heavy fractions into lower molecular weight fractions and produces large volumes of high octane gasoline stocks, furnace oils and other useful middle molecular weight distillates.[10] The presence of the catalyst allows the cracking to be achieved at lower temperatures and pressures than thermal cracking, and the catalyst inhibits the formation of undesirable polymerized products. Cracking catalyst may be composed of synthetic and/or natural silica-alumina, treated bentonite clay, Fullers' earth, alumina hydrosilicates and bauxite. Catalyst may come in the form of beads, pellets or powders which can be used in fixed, moving or fluidized beds.

Hydrocracking is a catalytic cracking process that is carried out in the presence of hydrogen.[11] Hydrocracking is performed at lower temperatures and pressures than catalytic cracking. The molecular weight distribution of the products is similar to catalytic cracking, but with reduced sulfur, nitrogen and olefin content.

Polymerization units are used to convert olefin feedstocks (primarily polypropylene) into higher octane polymer units.[12] The polymerization unit consists of a catalytic reactor, an acid removal section and a gas stabilizer. The catalyst used is phosphoric acid or sulfuric acid. Polymerization is currently a marginal process since alkylation is a more efficient conversion process.

Alkylation is the reaction of an isoparaffin and an olefin, in the presence of a catalyst, at carefully controlled temperatures and pressures, to produce a high octane alkylate for use as a gasoline blending component.[13] This process also produces propane and butane. Sulfuric acid is the most widely used catalyst.

Isomerization involves the rearrangement of a hydrocarbon chain in order to obtain higher octane motor fuels.[14] Higher octane fuels are usually obtained indirectly because the isomerization process converts normal paraffins to the isoparaffins (usually isobutane) that feed the alkylation process which ultimately produces high octane alkylates used in gasoline blending. The isomerization process occurs by passing the heated normal paraffins through a catalytic hydrogen reactor which converts the n-paraffins to high octane isomers. Next, the hydrogen is removed and the synthetic isomers are retained as product.

Reforming is a process which is used to upgrade and convert low octane naphtha, cracked naphthas and heavy gasolines into desirable aromatics and high octane blending stocks.[15] This is basically a mild decomposition process carried out in the presence of a platinum catalyst. Naphthene rings are dehydrogenated to form aromatic rings during this process, with hydrogen being a significant by-product.

Solvent deasphalting is a form of solvent refining, the purpose of which is to recover lube or catalytic cracking feedstocks from asphaltic residuals and to produce asphalt as a by-product.[16] In propane deasphalting, which is the predominant solvent deasphalting technique used in the refinery industry, liquid propane and vacuum reduced crude are introduced into an extraction tower which produces a deasphated oil solution overhead and an asphalt bottoms product. Both of these product streams still contain propane which is then removed by means of a propane evaporator (for overheads) and a flash drum (for bottoms). The recovered propane is recycled to an extraction tower for reuse.

Solvent dewaxing is another form of solvent refining in which wax is removed from lubricating oil stocks by promoting crystallization of the wax.[17] Solvents which are used for this process include furfural, phenol, cresylic acid-propane (Duo-Sol), methyl ethyl ketone and sulfur-benzene. This process yields salt-free waxes, and wax-free lube oils, aromatics and recovered solvents.

Aromatic extraction is a solvent refining process used to obtain high purity aromatics by employing glycols and water as the solvent.[18] The solvent and hydrocarbons are introduced into a countercurrent extraction column. The vapor mixture is removed and stripped of solvent, leaving the aromatic compounds of benzene, toluene and xylene. The solvent is recovered and recycled to the extraction column.

Hydrotreating is a process where crude oil fractions, both straight run and cracked, are decomposed in the presence of hydrogen to produce petroleum fractions with low sulfur and nitrogen content.[19] The feed is treated with hydrogen, heated and charged to a catalytic reactor where the impurities and high grade products are separated.

Grease is primarily a soap and lube oil mixture, the manufacture of which requires careful attention to the qualitative aspects of the process itself.[20] The soap and oil are introduced to a high dispersion contactor or scraper kettle where the components are heated and mixed thoroughly. The finished grease is then packed or subject to further processing in the grease polisher as required by product specifications.

Drying and sweetening are forms of product finishing. Sweetening is a process where the sour odor of an oil is removed by oxidation of the mercaptans, hydrogen sulfide and dissolved free sulfur.[21] Drying is accomplished by salt filters or absorptive clay beds.

Lube oil finishing is a process that further refines solvent or dewaxed lube oil stocks by contact filtration so that the lube oil can be used for blending and compounding.[22] Clay absorbant is added to the oil, and the mixture is heated to the maximum contact pressure. The oil is then removed by filtration.

Blending and packaging are the final steps in producing a finished product. These are processes where additives of various types are blended into finished gasolines, oils and greases.[23] The blending is done in bulk form. These are relatively clean processes because care is taken that no product is lost through spillage.

Petroleum refineries have a large number of chemical processes, the great majority of which are only of passing interest since they are not sources of fugitive dust emissions. There are, in fact, very few sources of fugitive dust in petroleum refineries.[24] The potential sources of fugitive particulate emissions from petroleum refineries include plant roadways, parking areas, vehicular traffic and coke storage piles and material handling operations.

The fugitive particulate emissions resulting from plant roadways, parking areas and vehicular traffic are adequately discussed in Section 2.1.1 of this manual. Included in the referenced section are subsections that address the fugitive emission factors, control methods, and RACM selections for the types of sources.

The coke generated by the coking process is normally not a source of fugitive emissions because the coke is removed from the reactor in a wet state. The removal process consists of the use of horizontal water jets operated at high pressures.[25] The coke is then dewatered, dried and stored in piles. The storage of coke is a potential source of fugitive dust, and is discussed in Sections 2.1.2, 2.1.3 and 2.2.1 of this manual. The unloading, handling and transfer of coke are also discussed in the above-mentioned sections.

REFERENCES FOR SECTION 2.24

1. Harold R. Jones, Pollution control in the Petroleum Industry. New Jersey, 1973, p.31.
2. Development Document For Proposed Effluent Limitations Guidelines and New Source Performance Standards For Petroleum Refining, EPA 440/1-73/014, USEPA, December, 1973, p. 1.
3. Ibid, p. 25.
4. Ibid, p. 26.
5. Ibid, p. 26.
6. Kirk-Othmer, Encyclopedia of Chemical Technology, 2nd., Volume 15, (New York) 1970, p. 18.
7. Op. cit. Reference 1. p. 9.
8. Op. cit. Reference 2. p. 31.
9. Compilation of Air Pollutant Emission Factors (3rd. Ed.) USEPA, Research Triangle Park, North Carolina, 1977, §9.1-5.
10. Op. cit. Reference 2. p. 32.
11. Ibid, p. 34.
12. Ibid, p. 35.
13. Ibid.
14. Ibid, p. 37.
15. Ibid, p. 37.
16. Ibid, p. 38.
17. Ibid.
18. Ibid, p. 39.
19. Ibid.
20. Ibid, p. 40.
21. Ibid, p. 40.
22. Ibid, p. 43.
23. Ibid, p. 41.
24. Ibid, p. 43.
25. Op. cit. Reference 7, p. 23.

2.25 AGRICULTURAL CHEMICAL MANUFACTURING PLANTS

2.25.1 Process Description

In discussing this manufacturing category, a distinction should first be drawn between the fertilizer manufacturing industry and fertilizer mixing and blending plants. Mixing and blending plants (which are thoroughly discussed in Section 2.12 supra.) are characterized by the three distinct production techniques of ammoniation-granulation, bulk blending and liquid-mix,[1] all of which produce different types of fertilizers containing more than one of the primary plant nutrients (nitrogen, phosphorus and potassium).[2] These mixing and blending plant operations may or may not involve a chemical reaction between the raw materials.[3] Agricultural chemical manufacturing, on the other hand, will always involve a chemical reaction, and the end product is usually a fertilizer which contains just one of the primary plant nutrients. Sodium nitrate, anhydrous ammonia, urea, ammonium nitrate and potash are examples of single nutrient fertilizers.[4] Mono or diammonium phosphate and potassium nitrate are examples of manufactured multi-nutrient fertilizers.

Other factors that distinguish these two industries are the size and complexity of the production facilities. The fertilizer manufacturing plants tend to be quite larger than their mixing and blending counterparts in terms of average annual capacity and are much more sophisticated from a technical standpoint.

Since the only agricultural chemical manufactured in Ohio in any significant amount is urea, this guideline will address only those fugitive dust emission sources which are related to urea manufacture. The same problems will, however, be encountered in the manufacture of a solid form of fertilizer other than urea. Also, the solutions to those problems would be analogous to those discussed herein for urea.

Urea is manufactured either as a liquid or as a solid product.[5] The manufacture of urea in liquid form is not a significant source of fugitive dust emissions because the process itself only involves the handling and transfer of raw materials and finished products in their liquid phases. The solid urea manufacturing process includes all the processes that are needed for the production of urea solution in addition to the equipment and processes necessary to form the solid product (See Figure 2.25-1).

A typical plant capacity is 77,300 tons per year, and it is estimated that, on an industry-wide basis, 38 percent of the urea sold in the United States is in the liquid form. The remaining 62 percent of the urea is converted to solid prills or granules prior to sale.[6]

Urea is synthesized in a reactor by the reaction of liquid ammonia and carbon dioxide at high temperatures and pressures to first yield an intermediary product known as ammonium carbamate (NH_2COONH_4) which is simultaneously dehydrated in the same reactor vessel to form urea (NH_2CONH_2).[7] The aqueous urea solution is then concentrated by either crystallization or vacuum evaporation.[8] Solid urea is then made by prilling or by a form of granulation.[9]

In the prilling process, the concentrated urea solution is sprayed from a nozzle located inside a large cylindrical prilling tower (approximately 100 feet in height), and as the droplets fall they are cooled and solidified by an upward flow of air.[10] The solid prills, which generally range from 10-14 mesh,[11] fall onto a conveyor belt and are delivered to storage.[12] Conventional prilling towers produce approximately 15 percent of the solid urea in use today.[13]

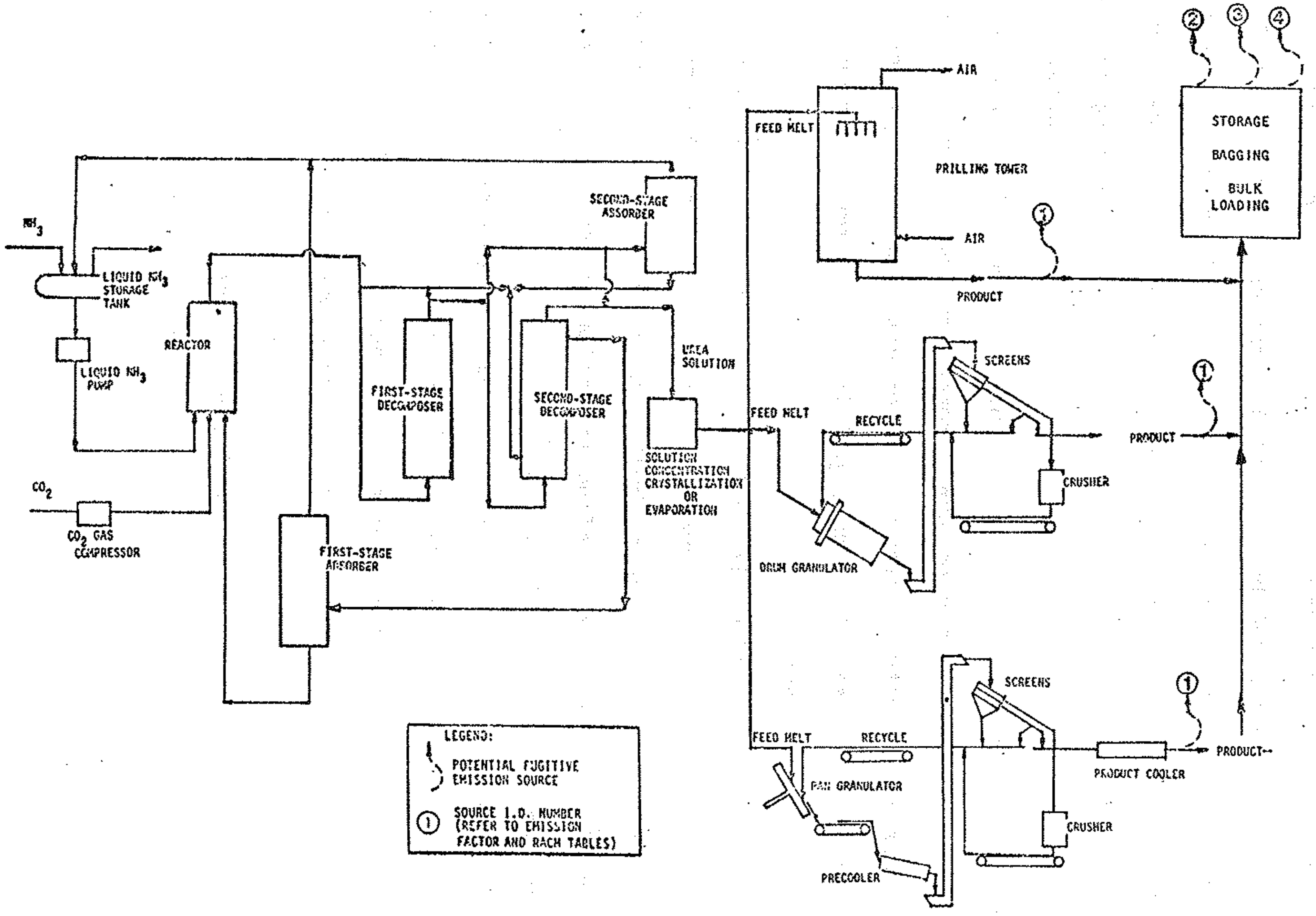

Figure 2.25-1. Simplified process flow diagram of the urea manufacturing process and associated fugitive particulate emission sources.

Due to the technical difficulties and large expenditures that companies are facing in bringing prilling towers into compliance with state and federal particulate emission regulations, granulation is becoming a more desirable method of producing solid urea.[14] The granules are produced by the solidification of successive layers of melt on the surfaces of seed particles.[15] As granules become the proper size (between 8 and 12 mesh),[16] they are removed from the granulation process and conveyed to screens for sizing and storage.[17]

It should be noted that, as a general rule, granules will generate less dust and will cake less during handling and storage than prilled products because granules are stronger and more abrasion resistant.[18] Granulation, however, cannot produce granules small enough for use as a feed grade urea; therefore, prilling will remain a necessary production process.[19]

The final product is cooled, if necessary, sized and stored indoors in piles via an overhead conveyor. Later this material is transferred from storage to bulk loading or bagging by conveyor belts.[20] The storage, loading and shipping operations are normally conducted in the same building.[21]

Regardless of which method is used to manufacture the solid product, the sources of fugitive dust emissions are essentially the same for both processes, because the solids are subject to virtually the same handling, transfer and loading operations.

The fugitive dust emissions from urea manufacturing plants are indicated in Figure 2.25-1, and result from four sources:

1. material transfer and conveying operations,
2. storage,
3. bagging, and
4. bulk loading.

2.25.2 Fugitive Dust Emission Papers

Although particulates are emitted during storage, material handling, bagging and bulk loading operations, individual fugitive dust emission factors for these specific urea manufacturing operations are unavailable.

However, in one instance, since no quantitative test data was available, a worst case estimate was made for bagging and bulk loading operations based upon a known particle size distribution for prilled urea. The size distribution data indicated that approximately 0.015 percent of the prilled product was less than 44 μm in size;[22] therefore, it was assumed that all of these particles would become airborne during the bagging and bulk loading operations. This assumption yielded an estimated combined emission factor of 0.30 pounds of particulate per ton of bulk loaded or bagged product. Although, the actual emission factor may be less than the estimated value of 0.30 pounds per ton, this worst case estimate will be used for bulk loading. This fugitive dust emission factor is presented in Table 2.25-1. A similar emission factor was not used for bagging operations, since such factor represents operation in outdoor areas. Generally bagging operations are performed indoors.

The emission factor (designated as Source 1) which reflects the amount of dust emissions generated by the belt conveyors and material transfer points is also known. The fugitive dust emission rates will vary depending upon the conveyor used, belt speed, and type of material being transferred (i.e., prills, granules, coated, uncoated).[23]

Fugitive dust losses will also occur at storage piles. It is estimated that 67 percent of the losses occur as a result of loading onto piles, equipment movement in the storage area and loadout from piles.[24]

TABLE 2.25-1. FUGITIVE DUST EMISSION FACTORS FOR UREA MANUFACTURING

Source	Emission factor	Reliability rating	Reference
① Transfer and conveying	NA	-	-
② Storage	NA	-	-
③ Bagging	NA	-	-
④ Bulk loading	0.3 lb/ton loaded	E	22

2.25.3 Particle Characterization

Fugitive particulate emissions from solid urea manufacturing facilities are 99 percent urea in composition $(CO\ [NH_2]_2)$.[25] Urea is a colorless crystal or powder with a molecular weight of 60.1 gram/gram mole, a melting point of 132.7°C and a density of 1.335 grams/cm^3.[26] It is not considered a hazardous material, and no threshold limit value (TLV) has been assigned to it.[27]

Biuret $[(NH_2\ CO)_2\ NH]$ is the main impurity present in solid urea at concentrations between 0.1 and 1.0 percent, while other impurities are estimated at less than 0.1 percent.[28] Biuret is formed when solid urea is heated to a temperature of 130°C at atmospheric pressure.[29] Although biuret is toxic to plant life, it is not hazardous to animals, and no TLV has been assigned to it either.[30]

No data was found concerning the particulate size distributions for the fugitive dust emissions.

2.25.4 Control Methods

A summary of the fugitive emission control alternatives is presented in Table 2.25-2.

Telescopic chutes or loading spouts are used during the bulk loading of railroad cars to control the fugitive dust that is generated. The adjustable spouts extend into the openings of the railroad cars, thereby reducing the free fall distance of the urea during the loading operation. Telescopic spouts can also be aspirated so as to capture the emissions generated and vent them to a fabric filter.

A fabric filter system can be used to contain emissions generated by the in-plant material handling, i.e., the conveyor belts, transfer points and bagging. Fugitive emissions generated in handling the urea during transfer and storage can also be reduced by closing doors and windows in the storage and loading areas and minimizing product spillage.

2.25.5 Recommended Reasonably Available Control Measures (RACM)

The recommended RACM for each fugitive emission source are listed in Table 2.25-2. The RACM's were selected on the basis of the degree of controls needed to meet state emission control regulations, current practice in the industry, ease of application or installation, and economics.

An adjustable loading spout which is aspirated to a fabric filter is recommended for the bulk loading of railroad cars. These adjustable spouts will minimize the free fall distance during the loading process, thereby eliminating a large portion of the fugitive emissions that would otherwise occur. The aspiration device will then capture the dust that is actually generated. These are relatively inexpensive control devices which will provide a substantial measure of protection at a reasonable cost.

A hooding system over transfer points, conveyor belts, bagging, and storage operations which is ducted to a fabric filter is recommended for use in the prevention of fugitive emissions from these operations.

TABLE 2.25-2. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM AGRICULTURAL CHEMICAL MANUFACTURING PLANTS

Fugitive dust sources	Control alternatives	Control efficiency %	Control costs, Jan. 1980, $		Cost benefit $/lb	RACM selection
			Capital	Annualized		
① Transfer and conveying	Hooding, vent to fabric filter	99[a]	429,300[b]	57,500[b]	-	Hooding, vent to fabric filter
② Storage	Hooding, vent to fabric filter	99[a]	c	c	-	Hooding, vent to fabric filter
③ Bagging	Hooding, vent to fabric filter	99[a]	c	c	-	Hooding, vent to fabric filter
④ Bulk loading	Telescopic chutes ←	75[a]	4,500[d]	900[d]	-	Telescopic chutes with aspiration to fabric filter
	Telescopic chutes with aspiration to fabric filter	99[a]	e	e	1.25[f]	

[a] Engineering estimate.

[b] Estimated cost for hooding, duct work and 124,000 acfm fabric filter. See Appendix. Includes control material handling, storage, bagging and bulk loading.

[c] Cost of control technique is included under the control alternative for transfer and conveying.

[d] Estimated cost of one telescopic chute; see Section 2.12.4 of this guideline.

[e] Cost of aspiration is included under the control alternative for transfer and conveying. This cost does not include the cost of the telescopic chutes.

[f] Cost of analysis based upon a plant production of 150,000 tons/year.

REFERENCES FOR SECTION 2.25

1. PEDCo, Environmental, Inc., Reasonable Available Control Measures for Fugitive Dust Sources, Ohio EPA, March 1980, Section 2.12.1.

2. Monsanto Research Corporation, Source Assessment Fertilizer Mixing Plants, March 1976, EPA#600/2-76-032C, p. 3.

3. Ibid. p. 4.

4. Kirk-Othmer, Encyclopedia of Chemical Technology, (New York, 1968) Vol. 9, pg. 50-53.

5. Search, W.J., and Reznik, R.B., Source Assessment: Urea Manufacture. USEPA, Research Triangle Park, NC 1977. EPA-600/2-77 -107, p. 12.

6. Ibid. p. 7.

7. Ibid. p. 12.

8. Ibid. p. 30.

9. Ibid. p. 31.

10. Ibid. p. 31.

11. Op. cit. Reference 18. p. 116, figure 2.

12. Op. cit. Reference 5. p. 31.

13. Ibid. p. 5.

14. Richard P. Ruskan, "Prilling vs. Granulation", Chemical Engineering, June 7, 1976, 114.

15. Ibid. p. 115.

16. Ibid. p. 116.

17. Ibid.

18. Op. cit. Reference 14.

19. Ibid.

20. Op. cit. Reference 5. p. 38.

21. Ibid. p. 45.

22. Ibid. p. 47.

23. PEDCo Environmental, Inc., Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions, USEPA 450/3-77-010, Research Triangle Park, NC 1977. p. 2-6.

24. Ibid. p. 2-32.

25. Op. cit., Reference 5. p. 39.

26. Sax, Irving N., Dangerous Properties of Industrial Materials, 5th edition, (New York, 1979), p. 467.

27. Op. cit., Reference 5. p. 39.

28. Ibid.

29. Ibid.

30. Ibid. p. 83.

APPENDIX FOR SECTION 2.25

Calculations for control alternatives and resulting cost benefits for urea manufacturing operations.

Dust sources to be controlled and the air flow estimated .

1. Conveyor belt transfer points:
   (100 m^3/min of air)(10 transfer points) = 1000 m^3/min
2. Bagging operations:
   (400 m^3/min)(2 bag loaders) = 800 m^3/min
3. Bulk loading operation:
   (400 m^3/min)(2 chutes) = 800 m^3/min
4. Storage area estimate 800 m^3/min

Total air flow required = 3500 m^3/min
converting to acfm = 124,000 acfm

Using the guidelines provided in "Capital and Operating Costs of Selected Air Pollution Control System" GARD, Inc., EPA-450/3-76-014 May 1976, the following cost estimates were obtained.

Table 2-2 air to cloth ratio is 8 or 9 for a pulse jet fabric filter used in phosphate fertilizer manufacturing

Page 4-9

$$\text{net filter cloth area} = \frac{\text{gas volume entering baghouse}}{\text{required air to cloth ratio}}$$

$$\text{net filter cloth area} = \frac{124{,}000 \text{ acfm}}{9}$$

$$= 13{,}800 \text{ ft}^2$$

Table 4-1 and 4-2 determines the cost of the filter cloth

$$(13{,}800 \text{ ft}^2)(1.09)\left(\frac{.55}{\text{ft}^2}\right) = \$8{,}260$$

Figure 4-7 on page 4-10 gives the cost of a pulse jet baghouse as $95,000

Figure 4-17 and 4-19 and the equations on page 4-25 provide the data necessary to calculate the cost of the ductwork.

Bulk loading-assume 4'x4' hood requires 40 ft^2 of 10 Ga. Carbon steel.

labor $200
material $100

60' straight duct of 24" diameters 1/8" plate at $25 per foot - material $1500

Material Handling and transfer and bagging

Fig. 4-18, 19	10 hoods @ 4'x4'	1 hood @ 4'x8'
	800 ft^2 mtl.	250 ft^2 mtl.
	$2500 labor	$350 labor
	$1600 mtl. cost	$100 mtl. cost

Figure 4-21 assume use of 300' of 24" duct made of 1/8" plate at $25 per foot
$7500 -

Total hood and duct cost
$10,800 material
$ 3,100 labor
$13,900

Fan and motor -

Figure 4-40 Class III fan is used with 98" fan wheel diameter operating at 1600 RPM costs $15,000

Figure 4-41 a drip proof motor of 125 BHP will cost $18,000

Total Cost of Fan and Motor is $33,000

Total Equipment Purchse Price
effective 1975 is $150,100

page 3-1	1)	Equipment costs (control device + auxiliaries)	=$150,100
	2)	Tax and freight (@7% of 1)	= 10,500
	3)	Installation costs (Table 4-12) (75% of 1)	= 112,500
	4)	Subtotal (1 + 2 + 3)	= 273,100
	5)	Engineering (@ 10% of 4)	= 27,310
	6)	Subtotal (4 + 5)	= 300,400
	7)	Contingencies (@ 10% of 6)	= 30,000
	8)	Total capital costs (6 + 7)	= 330,400

prices effective December, 1975

Total capital cost can be updated to January 1980 dollar values using the Chemical Engineering Cost Index, plus an assumed annual escalation rate of 10 percent (as per PEDCo memo attached).

$$\frac{(\text{January 1980 - 249.6})}{(\text{January 1976 - 192.1})}(\text{330,400 effective Dec. 1975})$$

January 1980 price of $429,300

Page 3-3 Uniform Annual Equivalent = $PW \left[\frac{i(1 + i)^n}{(1 + i)^n - 1}\right]$

PW = present worth
n = # periods over which annual payments take effect
i = discount rate

assume cost of capital to be 12% and equipment life 20 years

UAE = (429,300)(.1338) = 57,450 ≈ 57,500

Cost benefit analysis:

Emission factor = $\frac{0.30 \text{ lbs}}{\text{ton bulk loaded}}$

annual production rate = 151,600 tons

pounds emitted = 45,500 lbs.

Cost benefit = $\frac{\text{annual cost of control}}{\text{lbs TSP removed}}$

$= \frac{\$57,500}{45,500} = \$\frac{1.26}{\text{lb}}$

2.26 BULK GASOLINE TERMINALS AND PLANTS

2.26.1 Process Description

Bulk gasoline terminals receive gasoline from refineries by way of pipeline, tanker or barge; store it in aboveground storage tanks; and subsequently dispense it via tank trucks to bulk gasoline plants and service stations for further distribution.[1]

The bulk storage of gasoline is accomplished by the use of various types of closed cylindrical tanks which are designed to prevent the escape of volatiles and minimize the contamination of the stored material.[2]

The capacities of bulk terminal storage tanks range from 500,000 to 5,000,000 gallons per tank.[3] An average terminal has 4.5 storage tanks.[4]

Each terminal contains one or more loading racks which are used to load the incoming tank trucks.[5] These racks are equipped with an array of process control equipment to control flow rates and assure safety in operation.[6] The majority of gasoline loading is accomplished by use of the top submerged filling method.[7] The other commonly used method of loading tank trucks is the bottom fill method.[8] Another method, not in common use in Ohio, is the splash loading method which, as the name suggests, results in significant turbulence and liquid-vapor contact during the loading process.[9]

There were an estimated 50 bulk gasoline terminals in Ohio as of 1977.[10] The daily throughput per terminal ranges from 30,000 gallons per day to over 600,000 gallons per day.[11]

Bulk gasoline plants receive gasoline from the bulk gasoline terminals via tank trucks and subsequently distribute the gasoline to service stations and other small commercial accounts.[12]

The capacities of bulk plant storage tanks range from 13,000 to 20,000 gallons per tank. An average facility has three storage tanks having an average, total storage capacity of 49,000 gallons.[13]

The daily throughput for a bulk plant varies from 2,000 to 20,000 gallons per day.[14] A USEPA study indicates that, on a nationwide basis, 50 percent of all bulk plants have a daily throughput of less than 4,000 gallons per day.[15] It is assumed that this figure also characterizes the size distribution of bulk gasoline plants in Ohio.[16]

In addition to storage tanks, the bulk plants also have loading racks for the filling of tank trucks.[17] The splash-fill method is used in 50 percent of the bulk plants, while submerged filling is used in the other 50 percent.[18]

Figures 2.26-1 and 2.26-2 are simplified process flow diagrams of a typical bulk gasoline plant and terminal. The various loading systems are shown in Figures 2.26-3 through -5.

Fugitive dust emissions from a bulk gasoline plant or terminal result primarily from vehicular traffic on paved and unpaved roads within the facility. The available emission factors, control technologies and RACM selections for these emissions are discussed in detail in Section 2.1.1 of this manual.

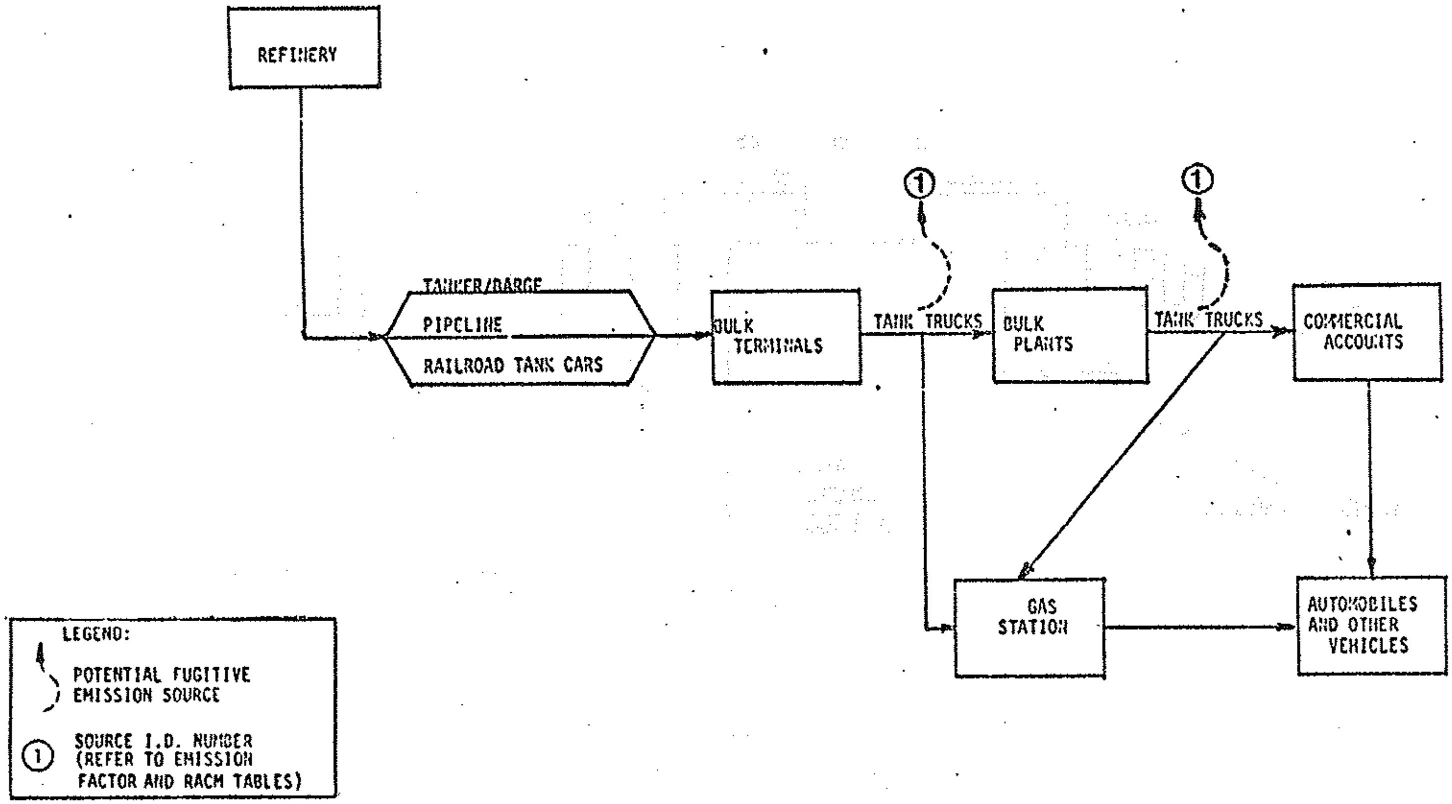

Figure 2.26-1. Simplified process flow diagram for bulk gasoline distribution and storage and associated fugitive particulate emission sources.

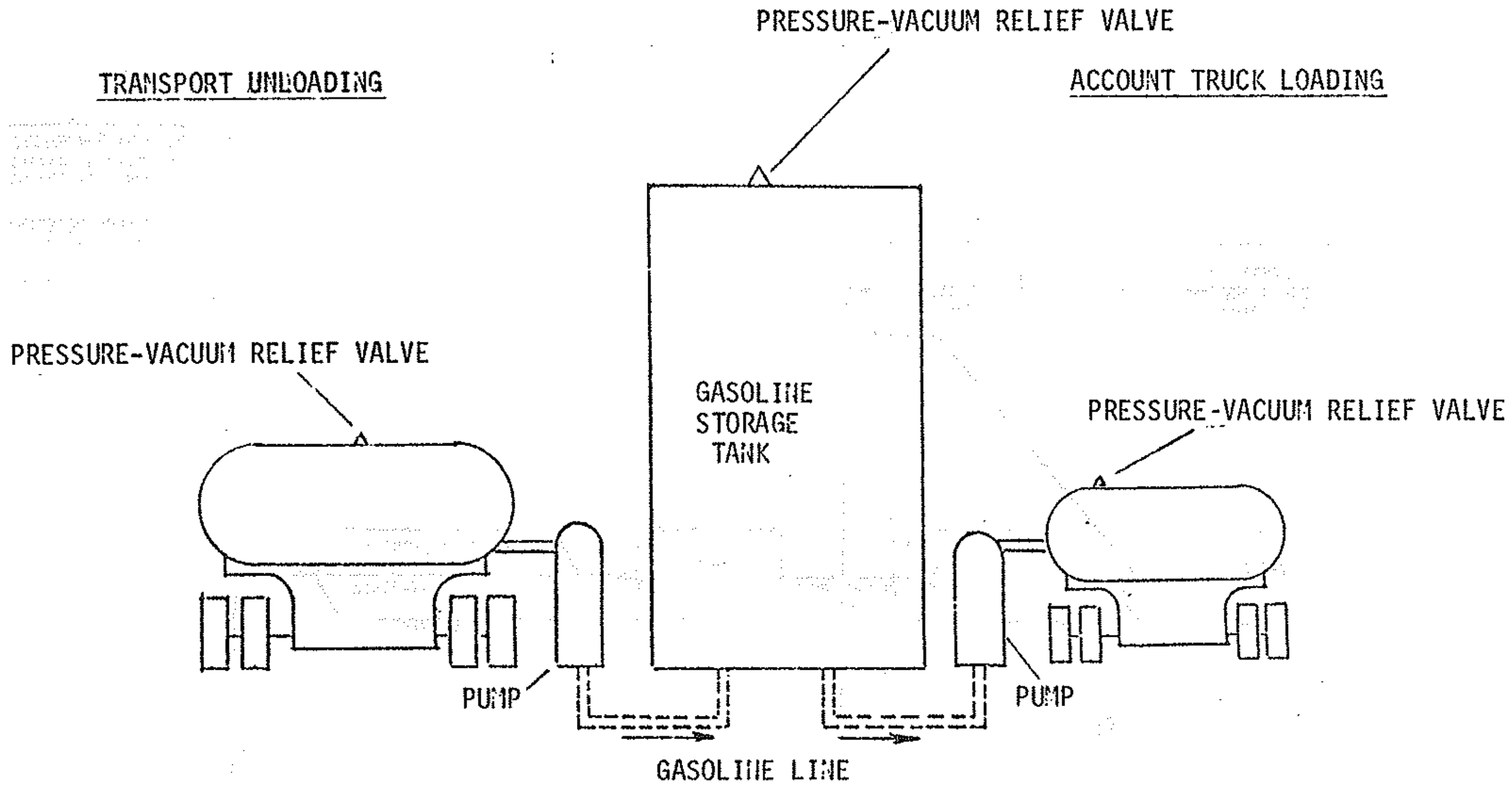

Figure 2.26-2. Simplified process flow diagram for bulk gasoline storage.

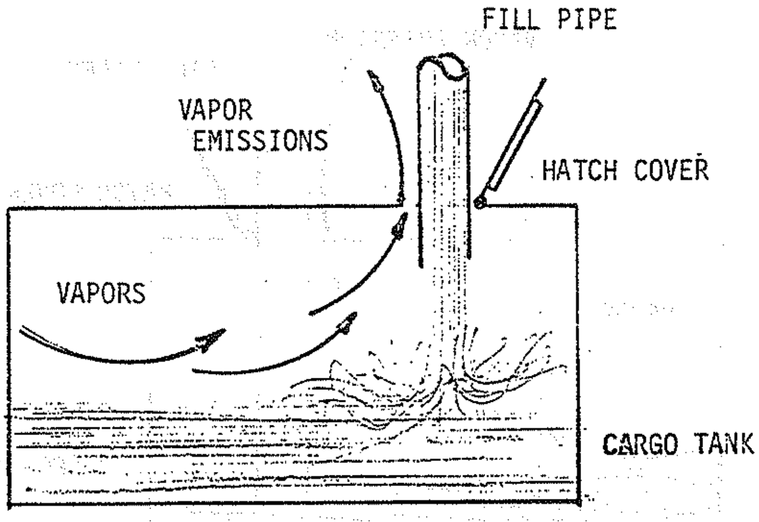

Figure 2.26-3. Splash loading method.[19]

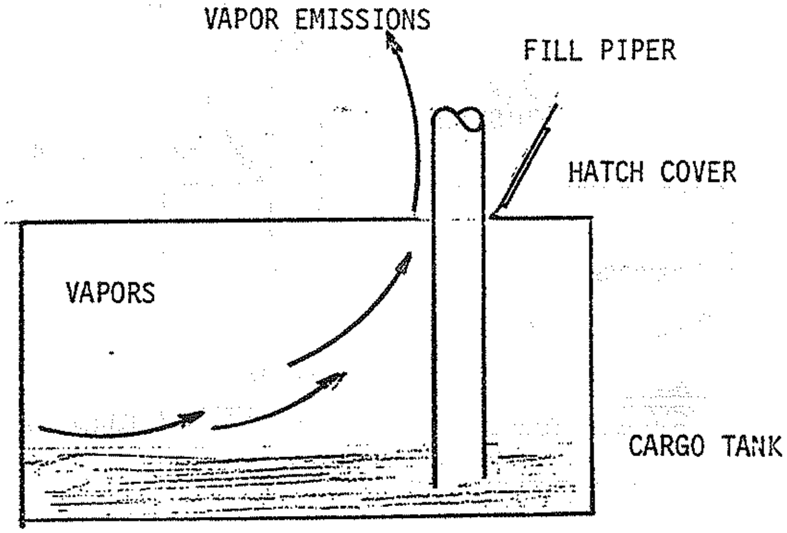

Figure 2.26-4. Submerged fill pipe.[19]

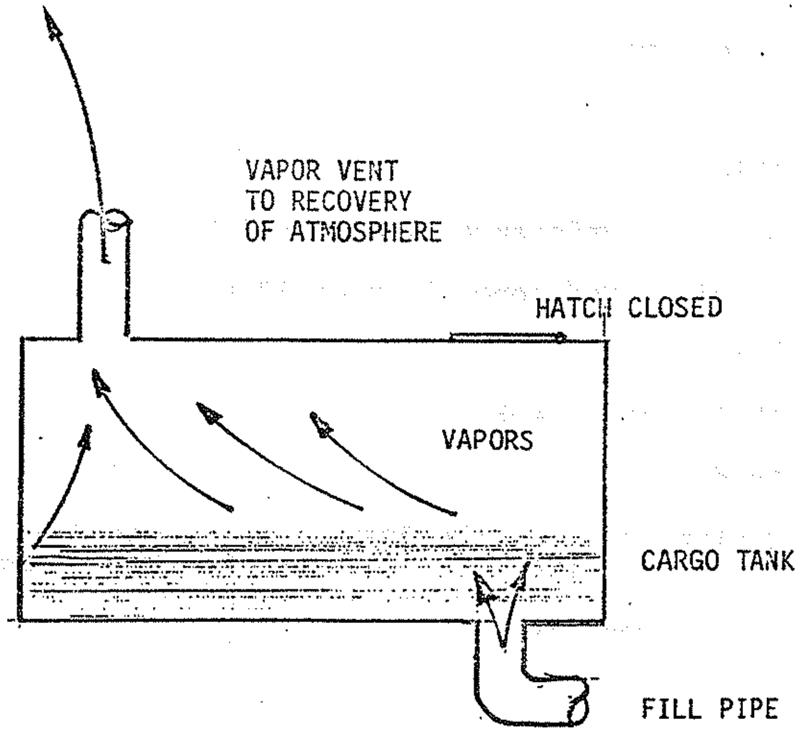

Figure 2.26-5. Bottom fill loading.[19]

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2.27 CARBON BLACK PLANTS

2.27.1 Process Description.

Carbon black refers to a large family of industrial carbons manufactured by the partial combustion or thermal decomposition of hydrocarbons in the vapor phase.[1] In contrast, coke is manufactured by the pyrolysis of solids.[2]

In the United States, two major processes are used for the manufacture of carbon black: the oil furnace process and the thermal process.[3]

In the thermal process, natural gas is injected into a heated refractory chamber where it decomposes to form carbon black.[4] Because this reaction is endothermic, it is necessary to alternately use the natural gas to bring the furnace to the proper temperature and then inject the gas into the furnace for decomposition. This is done in a cyclical process.[5]

In the oil furnace process, a liquid hydrocarbon feedstock is injected continuously into the combustion zone of a natural gas fired furnace where it is decomposed to form carbon black.[6] This process accounts for approximately 90% of the total carbon black produced in the United States today.[7]

Currently, there are 30 carbon black plants in this country that use the oil furnace process. These plants have a combined capacity of 2.1×10^6 tons/yr.[8] Individual plant capacities vary from 25.3×10^3 to 195.1×10^3 tons per year.[9]

A "typical" carbon black plant is one that uses the oil furnace process and which has an annual production capacity of 5.7×10^4 tons/yr.[10,11]

Feed materials used in the oil furnace process consist of natural gas, pre-heated crude oil and air.[12] The oil is pre-heated to 200°C - 370°C.[13] The preferred feedstock oil is high in aromaticity, is free of coke or other gritty materials and contains low levels of asphaltenes, sulfur and alkali metals.[14]

The reactor for this process consists of a refractory lined steel furnace which is from 1.5m to 9m in length and 0.15m to 0.76m in internal diameter.[15] The natural gas is burned to completion to produce temperatures of 1320°C to 1540°C.[16] The preheated oil is atomized with air and sprayed into the center of the zone of the hot combustion gases.[17] The oil is cracked to hydrogen, carbon and by-products consisting of carbon oxides, water, methane, acetylene and other hydrocarbons.[18] The specific design and construction features of various reactors are dictated by product specifications and economics.[1] The reactor converts 35 to 65 percent of the feedstock carbon content to carbon black, depending upon the type of feedstock and the desired product quality.[20]

The hot combustion gases from the reactor, which contain the suspended carbon black particles, are initially cooled to about 540°C by a water spray in a quench area located in the reactor outlet.[21] This gas stream is ultimately cooled to a temperature of 230°C by a quench tower.[22]

The carbon black is recovered from the reactor effluent stream by use of a fiberglass type fabric filter in a baghouse.[23] The collected carbon black is subsequently passed through a hammermill and then pneumatically conveyed to a cyclone and bag filter combination where the carbon black is collected in a surge bin.[24]

Next, the carbon black is fed to a pelletizer via a screw conveyor.[25] The resulting pellets are spherical with a 1.6mm to 3.2mm diameter.[26] The pellets are then conveyed to a dryer for the removal of water.[27]

The dried carbon black pellets are screened and conveyed to large storage bins via bucket elevators.[28] The oversized particles are recycled to the hammermill and reprocessed.[29] From the storage bin the product can be bagged or bulk loaded into hopper-type railroad cars.[30]

Figure 2.27-1 is a simplified process flow diagram of the oil furnace process.

Sources of fugitive dust emissions within the carbon black industry include roadways, vehicular traffic, bulk loading of railroad cars, bagging operations, and the storage of pelletized carbon black.

2.27.2 Fugitive Dust Emission Factors

Unfortunately, there is a lack of information regarding both the quantity and quality of the carbon black particles which are lost to the atmosphere from each of the sources of fugitive dust.

One literature source does give 0.2 lb/ton as a fugitive emission factor for a representative carbon black plant.[31] This emission factor, however, includes emissions generated by the following:[32]

1. cleaning of clogged process equipment;
2. leaks in all process equipment including vents on storage bins, and the pneumatic conveying system;
3. spillage during the bulk loading of boxcars or bagging operations; and
4. general maintenance and repair work.

Therefore, the above-mentioned fugitive emission factor is rendered less meaningful by the fact that it combines too many emission sources, some of which cannot be considered as sources of fugitive dust.

2.27.3 Particle Characterization

Carbon black prior to pelletization consists of very small particles, 18nm-55nm in diameter, with a density of 24-59 kg/m^3.[33] These particles have a fluffy character and generally consist of 90 to 99 percent elemental carbon, with oxygen, hydrogen and sulfur comprising the other major constituents.[34]

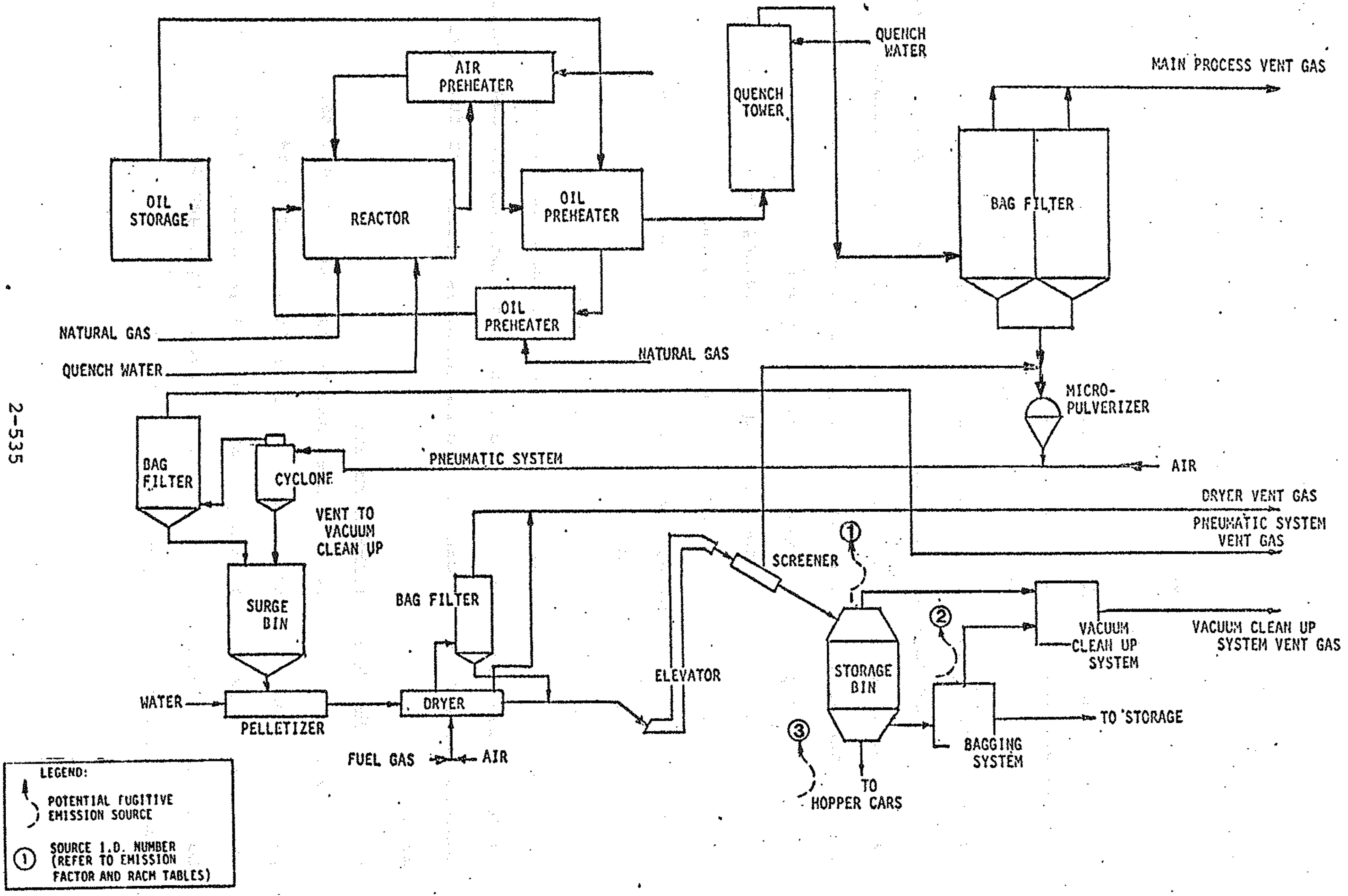

Figure 2.27-1. Simplified process flow diagram for carbon black plants and associated fugitive particulate emission sources.

There is no evidence of carbon black toxicity in humans, despite the fact that it contains trace amounts of polynuclear aromatic compounds known to be carcinogenic.[33]

The physical characteristics, in terms of size and size distribution, of those particles that are generated when pelletized carbon black is handled and stored are unknown. Their chemical properties are identical with the unagglomerated carbon black.

2.27.4 Control Methods

Controls are generally employed to reduce the amount of carbon black that is emitted into the atmosphere from storage bins. If a plant has a vacuum clean-up system (2/3 of all U.S. plants have such systems) that is used to collect carbon black dust that is emitted or accidentally spilled from in-plant process machinery, then the storage bin can be vented to this existing clean-up system. An alternative would be to install a fabric filter unit on each vent of the storage tank which would help to prevent carbon black from entering the atmosphere.

Fugitive emissions that result from the loading of railroad hopper-cars and bagging operations can be controlled by the use of a set of carefully placed vacuum hoses connected to the existing plant vacuum clean-up system. The emissions from bulk loading may also be vented to the existing bagging machine exhaust system which is used to collect the carbon black dust during bagging operations. This dust is discharged into a small pulsation-type bag filter. Finally, some plants will employ two separate pulse-jet bag filters with one designated to capture the dust emissions that result from bulk loading of railroad cars and the other to control dust emissions from the bagging operation. All recovered carbon black is returned to the process.

The control of fugitive emissions from roadways is adequately discussed in Section 2.1 of this guide.

2.27.5 Recommended Reasonably Available Control Measures (RACM)

Since specific data regarding fugitive emissions from carbon black plants are unavailable, general industrial practice will be used as an indicator of what RACM should be.

For storage bins, RACM is either venting the bins to an existing vacuum clean-up system or installing a non-aspirated fabric filter over the vent to collect the particulate emissions.

For the bulk loading of railroad cars, a vacuum clean-up system can be used to prevent an excessive build-up of carbon black dust and to capture any spilled carbon black. Other alternatives include installation of a pulse-jet fabric filter system or venting the emissions to the bagging machine exhaust system.

The bagging operation may be ducted to the existing vacuum clean-up system or use may be made of vacuum bagging systems that are hermetically sealed to prevent emissions of carbon black during bagging. Finally, a separate pulse-jet type fabric filter may be used to collect the emissions from this fugitive dust source.

Table 2.27-1 summarizes the available control technologies, their effectiveness and RACM selections.

TABLE 2.27-1. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM CARBON BLACK PLANTS

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan. 1980, $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
① Vents on storage bins	Aspirate bins to vacuum clean-up system	99+	-	-	NA	All the control alternatives listed for the fugitive dust sources can be considered RACM for that dust source. No single control alternative was chosen as RACM since these control alternatives are highly plant specific.
	Install fabric filter unit over storage bin vents	99+	-	-	NA	
② Carbon black bagging operation	Bagging machine exhaust system	99+	-	-	NA	
	Aspirate to vacuum clean-up system	99+	-	-	NA	
	Install pulse jet fabric filter system	99+	-	-	NA	
③ Bulk loading of hopper cars	Aspirate to vacuum clean-up system	99+	-	-	NA	
	Install pulse jet fabric filter system	99+	-	-	NA	
	Vent to bagging machine exhaust system	99+	-	-	NA	

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34. Ibid. p. 17.

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2.28 MUNICIPAL INCINERATION

2.28.1 Process Description

Municipal incineration is a controlled combustion process for reducing municipal refuse to gases and a residue containing little or no combustible material. Although most municipal incinerators are designed solely to reduce the volume of refuse for ultimate disposal, the heat generated by the incineration process can also be efficiently utilized for production of electric power or steam.

During combustion, the moisture in the refuse is first evaporated, and then the combustible portion is vaporized and oxidized. The major end products of incineration are carbon dioxide, water vapor and non-combustible ash.

The component subsystems of a municipal incinerator are:

(1) refuse holding and charging system,
(2) combustion chambers,
(3) air supply system,
(4) residue handling system, and
(5) air pollution control equipment.

These components are shown schematically in Figure 2.28-1, along with the associated fugitive dust sources.[1]

There are numerous municipal incinerator designs in use, employing different grate types or combustion chamber configurations. Common mechanical grate types are traveling, reciprocating and rocking. Furnace types include rectangular and rotary kiln, with either refractory or waterwall interiors.[2]

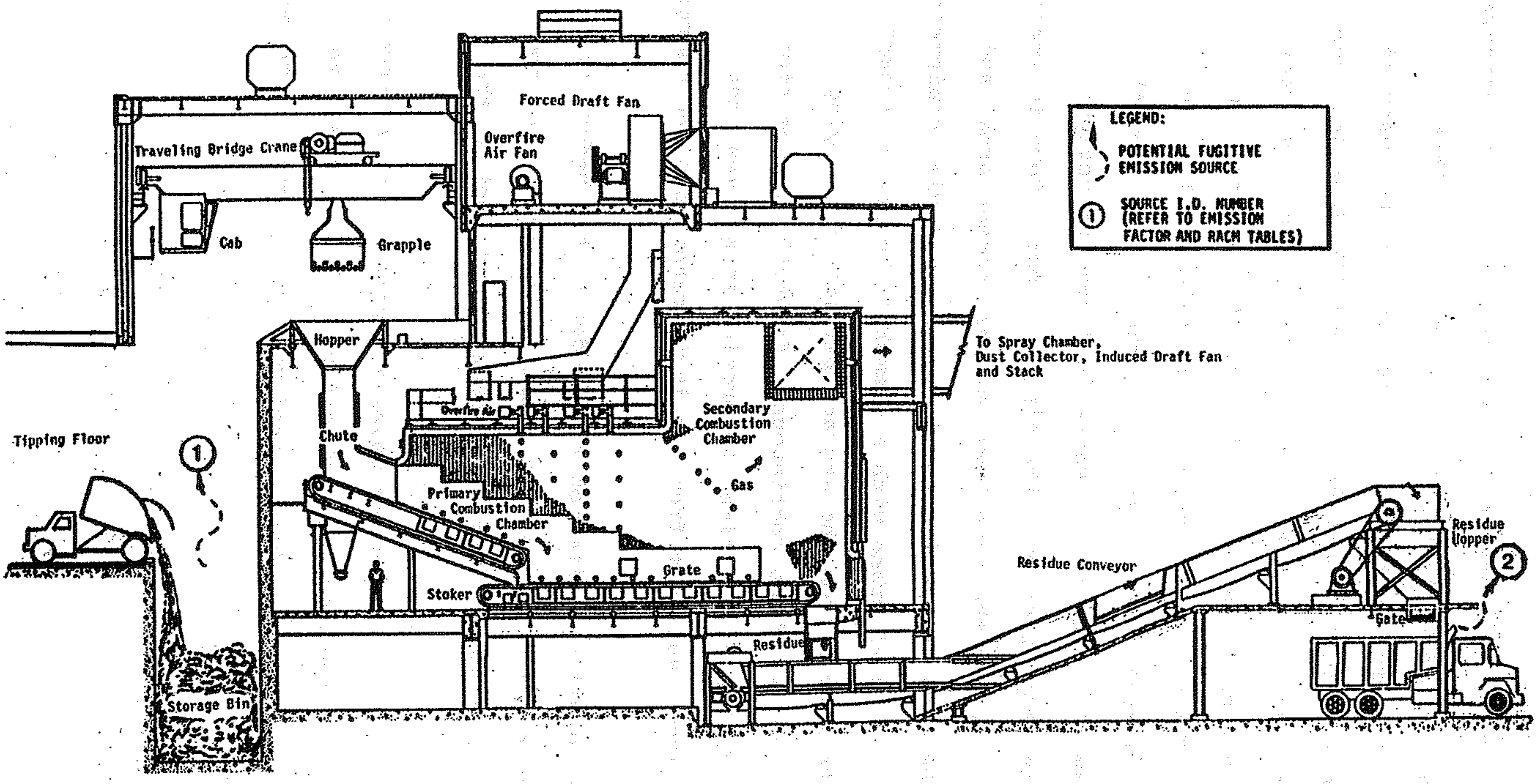

Figure 2.28-1. Simplified process flow diagram of a municipal incinerator and associated fugitive particulate emission sources.

Refuse is delivered by trucks to the storage pit at the incinerator. Before dumping, the trucks usually pass over a scale, so that the total daily weight of refuse entering the facility can be measured and recorded. The size of the storage pit is usually dependent upon such factors as the capacity of the furnace, the emergency storage required in the event of furnace breakdowns and the refuse truck pickup schedules. The refuse trucks enter the tipping floor and normally (at large installations) back up to the pit and dump the refuse. At some small incinerators, waste is dumped directly into the furnace charging hopper or onto the tipping floor. Some incinerators have the charging floor on the same level as the storage area, and transferring can be done with a front-end loader or special equipment.

Typically, an elevated crane with a clamshell bucket or grapple is used to lift the refuse from the storage pit into a charging hopper and gravity chute, which continuously feeds the incinerator. The chute is kept filled at all times to provide an air seal and prevent escape of smoke and heat from the incinerator into the charging area.

The refuse is usually ignited on the feeder stoker before it is dumped onto the burner stoker. Air is supplied for combustion and temperature control through the grate, sidewalls and roof of the combustion chamber.

In all incinerators, combustion gases are passed into a secondary combustion chamber to complete the combustion of the gases and entrained solids. Combustion gases are then cleaned prior to exhausting through the stack.[3]

Residue from the combustion process is discharged from the end of the burning grate into ash hoppers. The hoppers are usually quench tanks which reduce the fire hazards of handling the residue and control dust entrainment from the ash. Lastly, a drag apron pan conveyor continuously removes the wet residue from the bottom of the incinerator.[4]

The remainder of the residue in the incinerator is in the form of siftings and fly ash. The siftings are either manually removed from beneath the grates through clean-out doors or are collected in troughs and mechanically conveyed to the residue hopper. Fly ash captured in gas-cleaning devices may be handled separately or in combination with the other residue.

Most municipal incineration systems are designed to allow dump trucks to load the residue directly from the drag-out conveyor for delivery to a landfill or other disposal site.

Potential sources of fugitive dust from the municipal incineration process are as follows:

1. tipping floor and storage pit area (refuse unloading, crane loading, etc.),
2. ash handling and disposal systems, and
3. road surfaces.

2.28.2 Fugitive Dust Emission Factors

The fugitive dust emission factors for the various sources of fugitive dust from municipal incineration are presented in Table 2.28-1. Except for simply recognizing that fugitive emissions exist at such facilities, the literature surveyed contained only one source of data concerning fugitive dust emission factors. This source provided an emission factor for fly ash handling and disposal which was described as an engineering estimate without details as to the derivation. The reliability of this factor should be considered as very poor.

TABLE 2.28-1. FUGITIVE DUST EMISSION FACTORS FOR MUNICIPAL INCINERATION

Source	Emission factor	Reliability rating	Reference
① Refuse dumping, handling	NA	—	—
② Ash handling, disposal	20-100 lbs/ ton ash handled	E	5

NA = Not available

Also, no specific emission factors were found in the literature for the dumping of refuse or for an analogous operation.

Emission factors for fugitive dust emissions from roadways are presented in Section 2.1.1 of this study.

2.28.3 Particle Characterization

There are two types of fugitive dust particles that are generated at municipal incineration systems. These are the dust carried by the refuse brought to the incinerator and the fly ash caused by incineration of the refuse. (Particle characteristics for dust from roadways are discussed in Section 2.1.1.) Particle size and density data are limited for fugitive dust generated during refuse dumping and handling.

The composition of refuse varies from municipality to municipality. Table 2.28-2 shows the range in composition of residential solid wastes in 21 U.S. cities.[6] The moisture content of solid waste is a particularly important variable because of its affect on the "heat content" of the waste material. Moisture content may also affect solid waste density and ease of handling.

As shown in Table 2.28-3, the primary combustible elements in refuse are carbon and hydrogen, with much lower amounts of sulfur and nitrogen. Some constituents of the ash may also oxidize during incineration. The net result of effective combustion is the conversion of the carbon in the trash to carbon dioxide (CO_2), and hydrogen to water (H_2O). Sulfur is converted to sulfur oxides (primarily SO_2); some nitrogen is converted to nitrogen oxides; and organic chlorides are converted to hydrogen chloride (HCl).[7]

TABLE 2.28-2.

RANGE IN COMPOSITION OF RESIDENTIAL SOLID WASTES IN 21 U.S. CITIES[6]

Component	Percent Composition By Weight		
	Low	High	Average
Food waste	0.8	36.0	18.2
Garden waste	0.3	33.3	7.9
Paper products	13.0	62.0	43.8
Metals	6.6	14.5	9.1
Glass and ceramics	3.7	23.2	9.0
Plastics, rubber and leather	1.6	5.8	3.0
Textiles	1.4	7.8	2.7
Wood	0.4	7.5	2.5
Rock, dirt, ash, etc.	0.2	12.5	3.7

TABLE 2.28-3. TYPICAL COMPOSITION OF MUNICIPAL SOLID WASTE [7]

Category	Weight % (as fired)	Component	Weight %
Metal	8.7	Moisture (H_2O)	28.16
Paper	44.2	Carbon (C)	25.62
Plastics	1.2		
Leather and rubber	1.7	Oxygen (O)	21.21
Textiles	2.3	Hydrogen (H)	3.45
Wood	2.5	Sulfur (S)	0.10
Food waste	16.6	Nitrogen (N)	0.64
Yard waste	12.6	Ash	20.82
Glass	8.5		
Miscellaneous	1.7		
	100.0		100.0

In addition, there is the possible presence of toxic materials, for example, heavy metals (mercury and lead), beryllium, pesticides, asbestos and solvents. Typical hazardous wastes are listed in Table 2.28-4.[8] It is impossible to completely prevent the entry of such wastes into the municipal wastes.[9]

Particulate matter that has been identified in incinerator stack emissions consists of smoke, soot, fly ash, grit, dirt, carbonaceous flakes, aldehydes, organic acids, esters, fats, fatty materials, phenols, hydrocarbons and polynuclear hydrocarbons. The size of the particles range from less than 5 microns to 200 microns and larger.[10] Particle density typically ranges from 2 to 3 g/cm^3.[11]

Table 2.28-5 gives the breakdown of particle size and other physical properties of particulate matter gathered in the area between the combustion chambers and the gas-cleaning devices for three test incinerators, each with a different grate system.[12]

Very little data have been published on the chemical composition of the particulate matter. The few results that have been published show that fly ash emissions from municipal incinerators may consist of an average of from 5 to 30 percent organic matter and from 70 to 95 percent inorganic matter. A chemical analysis that gives the various inorganic constituents of incinerator fly ash from the South Shore incinerator in New York City is presented in Table 2.28-6.[13]

A rather detailed elemental analysis of ashed incinerator stack effluent and collector catch was presented by Jens and Rehm.[14] The incinerator tested was equipped with a wet impingement control system. Results of two test runs are summarized in Table 2.28-7.[15]

TABLE 2.28-4. EXAMPLES OF HAZARDOUS WASTES IN MUNICIPAL SOLID WASTE

- Paint, solvents, gasoline, kerosene, oils
- Highly flammable plastics, dusts, shavings
- Explosives and pyrophoric materials
- Organic chemicals, including toxic materials such as pesticides, phenols, and chlorinated compounds
- Other toxic materials such as mercury, lead, and arsenic compounds, and wastes which contain appreciable amounts of toxic materials (e.g. lead-containing waste crankcase oil and paint)
- Acids, caustics, other reactive chemicals
- Biologically active materials, e.g., pharmaceutical wastes and some pathological wastes from veterinarians and hospitals
- Radioactive wastes
- Pressurized containers
- Contaminated containers

TABLE 2.28-5. PHYSICAL PROPERTIES OF PARTICLES LEAVING FURNACE [12]

	Installation Number *		
	1	2	3
% of total sample collected in cyclone	77.0	77.5	63.0
% of total sample collected in baghouse	23.0	22.5	37.0
Specific gravity, g/cm^3	2.65	2.70	3.77
Bulk density, lb/ft^3	-	30.87	9.4
Loss on ignition @ 150°C, %	18.5	8.15	30.4
Analysis			
% By weight < 2 microns	13.5	14.6	23.5
% By weight < 4 microns	16.0	19.2	30.0
% By weight < 6 microns	19.0	22.3	33.7
% By weight < 8 microns	21.0	24.8	36.3
% By weight < 10 microns	23.0	26.8	38.1
% By weight < 15 microns	25.0	31.1	42.1
% By weight < 20 microns	27.5	34.6	45.0
% By weight < 30 microns	30.0	40.4	50.0

* Each incinerator had a different grate system. The furnace capacities ranged from 120 to 250 tons per day.

TABLE 2.28-6. CHEMICAL ANALYSIS OF FLYASH SAMPLES FROM SOUTH SHORE INCINERATOR, NEW YORK CITY, BY SOURCE[13]
(percent by weight)

Component	Source of Sample		
	Upper flue	Expansion chamber	Emitted
Organic	0.5	0.6	10.4
Inorganic	99.5	99.4	89.4
Silica as SiO_2	50.1	54.6	36.1
Iron as Fe_2O_3	5.3	6.0	4.2
Alumina as Al_2O_3	22.5	20.4	22.4
Calcium as CaO	7.9	7.8	8.6
Magnesium as MgO	1.8	1.9	2.1
Sulfur as SO_3	4.3	2.3	7.6
Sodium and potassium oxides	8.1	7.0	19.0

TABLE 2.28-7. SPECTROGRAPHIC ANALYSIS OF ASHED INCINERATOR PARTICULATE MATTER[15]

Element	Stack effluent, percent ashed material	Collector catch, percent ashed material
Silicon	5+ -	10+ -
Manganese	0.1 - 1.0	0.1 - 1.0
Chromium	0.1 - 1.0	0.1 - 1.0
Nickel	1.0 - 10+	0.001 - 0.01
Copper	0.1 - 1.0	0.01 - 0.1
Vanadium	0.001 - 0.01	0.01 - 0.1
Iron	0.1 - 5.0	0.5 - 5.0
Tin	0.001 - 0.5	0.05 - 0.5
Aluminum	0.1 - 10	1 - 10
Zinc	1 - 10	1 - 10
Magnesium	1 - 10	1 - 10
Titanium	0.5 - 5.0	0.5 - 5.0
Silver	0.001 - 0.01	0.001 - 0.1
Boron	0.01 - 0.1	0.01 - 0.1
Barium	0.1 - 1.0	0.1 - 1.0
Beryllium	0.001 - 0.01	0.001 - 0.01
Calcium	10+ -	10+ -
Sodium	1 - 10	1 -
Lead	0.01 - 0.5	0.1 - 1.0
Sulfur	-	0.620 -
Phosphorus	1.140 - 1.460	1.760 -
Silicate	5.4 -	-

2.28.4 Control Methods

Dust generated in the tipping floor and storage pit areas of a municipal incineration system during refuse dumping, crane loading, and hopper charging can be troublesome. Enclosing the tipping area is considered desirable for dust control, odor confinement, reduction of wind-blown refuse, noise reduction, and night and weekend storage of vehicles. Many incinerators, in the interest of low first cost, are equipped with only a canopy over the tipping bays, or nothing at all.[16]

Wetting the solid waste in the storage pit by use of water sprays is frequently used as a means of dust control. The problems with this technique are that wet residue often results in incomplete burning and higher emissions, and refuse with high moisture content can corrode downstream equipment.[17] Also, more BTU's are required for complete combustion of the wet residue, which results in higher energy costs for operating the incinerator.

Exhaust hoods over the dumping areas can reduce dust.[18] The dust-laden air flows through ducts to a fabric filter. Some incinerators, to intercept the dust from refuse dumping, design inlet ports along the top of the pit that draw air over the tipping floor and storage bin. Often combustion air for the furnace is taken from this area. The negative air pressure produced in the area by this method does an effective job of preventing the escape of dust-laden air from the building, helps housekeeping, prevents any odor from leaving the plant, and improves safety by helping to remove smoke and heat during a pit fire. Also, carefully designed and engineered truck entrance doors and dumping arrangements can minimize the "upset" which occurs when trucks enter or leave the building.[19]

Enclosed material handling systems to permit positive exhaust of air through purification systems is a preferred design for municipal incinerators. Dust-laden air can be processed in fabric filters or ducted to the furnace.[20]

Fly ash handling and disposal operations present no problems if the ash is wet. Some plants reduce dust problems by intermixing ash with wet residue or by topping off the truck with a layer of wet residue. However, dry fly ash is difficult to handle and can be easily picked up and scattered by the wind. The handling of dry fly ash can be controlled by applying a wetting agent, covering the ash in the trucks during hauling, and minimizing the free fall distance of the ash during loading. At the disposal site, emissions from dumping operations can be controlled by wet suppression and minimizing the free fall distance of the ash. Emissions from wind erosion at the disposal site may be controlled by covering with dirt or stable material, revegetation or chemical stabilization.

Roads are a major source of fugitive emissions at municipal incinerators. Details on the control options and costs are presented in Section 2.1. Table 2.28-8 summarizes the available control technologies, their effectiveness, estimated costs, and RACM selections.

2.28.5 Recommended Reasonably Available Control Measures (RACM)

The recommended control technique for refuse dumping and handling in the tipping floor and storage pit area is utilizing air ports in the dumping area and venting to a fabric filter. This would give the most effective control and is already in use at many facilities.

The selected RACM for control of fly ash handling and disposal consist of using wet suppression, minimizing free fall distances and covering of the haul trucks to and from the disposal site. Furthermore, the covering of the disposed fly ash with dirt is also recommended.

TABLE 2.28-8. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM MUNICIPAL INCINERATION

Fugitive dust sources	Control alternatives	Control efficiency %	Control costs, Jan., 1980 $		Cost benefit $/lb	RACM selection
			Capital	Annualized		
① Refuse dumping, handling	Air ports in storage pit with vent to furnace	90[a]	139,000[b]	24,500[b]	NA	Air ports in storage pit with vent to furnace; or hooding, vent to fabric filter[c]
	Hooding, vent to fabric filter	98[a]	d	d	NA	
	Water sprays in storage pit	50[e]	d	d	NA	
② Ash handling, disposal	Wet suppression	50 to 100[f]	49,700[g]	22,300[h]	0.01	Wet suppression, cover haul trucks, minimize free fall distances.
	Cover haul trucks	99[a]	50[i]	d	NA	
	Minimize free fall distances	NA	d	d	NA	

NA = not available

[a] Based on engineering judgment.

[b] Based on 500 ton/day municipal refuse incinerator with two (2) continuous feed refractory wall furnaces, 360 days/yr operation. Reference 21.

[c] RACM selection dependent upon existing design characteristics.

[d] Data not available.

[e] From Section 2.1.3, Material Handling.

[f] Reference 5. p. 2-27.

[g] Reference 22. p. 4-8.

[h] Reference 22. p. 4-11.

[i] Based on $0.40/ft^2 of covering material to cover 125 ft^2. Reference 23.

For roadways which are in relatively constant use, a paving/cleaning program can best alleviate fugitive dust; however, in some cases the cost may be prohibitive. A program of oiling can provide good control at a reasonable cost and is recommended for infrequently used roads or in situations where a paving program would be impractical due to high costs. For more detailed information with respect to fugitive dust control for roadways, see Section 2.1.1.

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APPENDIX FOR SECTION 2.28

Venting storage pit area to furnace

Capital Costs

1)	Equipment costs (control device + aux's)	$ 60,000
2)	Tax + freight (7% of 1)	$ 4,200
3)	Installation costs (75% of 1)	$ 45,000
4)	Subtotal (1 + 2 + 3)	$ 109,200
5)	Engineering (10% of 4)	$ 10,920
6)	Subtotal (4 + 5)	$ 120,120
7)	Contingencies (10% of 6)	$ 12,012
8)	Total Capital costs (6 + 7)	$ 132,132

$$\$132{,}132 \times \frac{(249.6)}{(238.0)} \approx \$139{,}000$$

Annual Costs

a. PV = R · PV/ n = 30 i = 12%
$139,000 = (8.055) · R
$17,256 = R

b. Maintenance (2%)($139,000) = $2,780

c. Electric (ref. 24) $4,500

d. Total Annual Costs = $17,256 + $2,780 + $4,500 = $24,536

Wet suppression costs

Capital Costs

NMI p. 4-8 Equipment Cost = $18,460 $\frac{(249.6)}{(204.1)}$ = $22,575

1)	Equipment costs (control device + aux's)	$22,575
2)	Tax + freight (7% of 1)	$ 1,580
3)	Installation costs (75% of 1)	$16,931
4)	Subtotal (1 + 2 + 3)	$41,086
5)	Engineering (10% of 4)	$ 4,109
6)	Subtotal (4 + 5)	$45,195
7)	Contingencies (10% of 6)	$ 4,520
8)	Total Capital costs (6 + 7)	$49,715

Annual Costs

a. PV = R · PV/ n = 20 i = 12%
$49,715 = (7.469) · R
$6,656 = R

NMI p. 4-11

$$\text{b. Annual costs} \quad \$12{,}810 \ \frac{(249.6)}{(204.1)} = \$15{,}666$$

Total annual costs = $15,666 + $6,656 = $22,322

$$C/B = \frac{\$22{,}322/\text{yr}}{(500\ \text{t/d})(360\ \text{d/yr})(20\ \text{lbs/ton})(.50)} = \frac{22{,}322}{270{,}000} = \$0.01/\text{lb}$$

TSP removed

2.29 SALT PROCESSING OPERATIONS

2.29.1 Process Description

Approximately 27 million tons of dry salt are produced each year in the United States and Canada. Some 13 million tons of it are used as deicing salt, the largest single usage.[1]

Salt is conveyed from the mine to sizing equipment (crushing and screening), which separate the salt into different grades as needed. (Table 2.29-1 shows the specifications for some of the different grades of salt.)[2] Generally, such salt processing is done inside buildings.

After crushing and screening, the salt is conveyed to silos, to open storage piles or directly to transportation equipment (barge, rail or truck). From the storage piles, the salt is conveyed to barge, rail or truck via a conveyor. Sometimes, trucks may be loaded with salt by front-end loaders. Front-end loaders may also dump the salt from the storage piles into a hopper located above a boat loading conveyor. It takes about 12-13 hours to load a boat at a rate of 1,000 tons per hour.[3]

After the salt is transported to the purchaser's facility, the salt is unloaded from the barge, railcar or truck to storage piles. The salt from a ship is usually unloaded by either a self-unloading conveyor or by a clamshell and conveyor. Rail cars and trucks dump their loads, usually on the ground, and the salt is loaded onto storage piles with front-end loaders.

Front-end loaders are also used for loading trucks that either apply the salt directly to the streets or transport it to other storage areas for distribution at a later time.

GRADE	SIZING DISTRIBUTION								PURITY, % SODIUM CHLORIDE*
	1/2"	3/8"	#4	#8	#12	#16	#30	PAN	
R.O.M.	0-1%	1-5%	20-30%	25-35%	10-15%	8-12%	5-15%	5-17%	
	7/10"	2M	3/8"	5/16"	1/4"	#12	PAN		
COARSE	0-2%	2-10%	5-12%	50-75%	9-15%	2-5%	0-2%		90-93
	3/8"	1/4"	#4	#8	#12	#16	#30	PAN	
"CC" MEDIUM	0%	8-16%	12-18%	38-45%	13-20%	8-15%	1-8%	0-2%	96.5 to 98
	#12	#14	#16	#20	#30	#40	PAN		
NORTHERN FINE	0-2%	0-2%	2-10%	30-50%	22-30%	5-15%	5-25%		97-98
	#12	#14	#16	#20	#30	#40	PAN		
SPECIAL FINE	0-1%	0-1%	2-7%	30-55%	25-30%	7-16%	5-25%		97-98
	#12	#20	#30	#40	#70	#100	PAN		
"F.C."	0-1%	3-11%	10-17%	16-22%	24-46%	10-20%	3-23%		96-97.5

*All other impurities are magnesium, calcium and sulfates.

Table 2.29-1. Specification guidelines for different grades of salt.

Fugitive dust emissions can occur during the addition of salt onto a pile, during wind disturbance of the pile, during the loading of the weigh hopper, during ship, railcar or truck loading and unloading, and during the movement of vehicles in the storage area.

A process flow diagram for salt processing operations is shown in Figure 2.29-1. Each potential fugitive dust source is identified in the Figure.

2.29.2 Fugitive Dust Emission Factors

A survey of the literature revealed that there has been no effort to quantify the emissions from salt processing operations. No specific emission factors for other industrial sources were discovered that could even be considered analogous to such operations.

2.29.3 Particle Characterization

The particle size of fugitive dust from salt storage piles may vary depending on the disturbance of the pile in the loading and unloading operations. Fugitive dust from salt piles is mostly in the range of 2 μm to 5 μm in size.[4] The salt consists of sodium chloride (about 95 percent), moisture, calcium-magnesium salts and insoluble matter (about 5 percent).[5] This is the only particle size information available in the literature for salt processing operations.

The corrosive nature of salt on concrete, construction materials and moving metal parts distinguishes this aggregate from the materials discussed in Sections 2.1.2 and 2.1.3, "Aggregate Storage Piles" and "Material Handling", respectively. With the storing and handling of salt, rusting and corrosion are more frequent and severe.

2.29.4 Control Methods

Alternative control techniques for the fugitive dust emission sources are presented in Table 2.29-2 along with their estimated control effectiveness and costs. Due to the corrosive nature of salt, controls normally used for storage and handling of other materials are not always applicable to salt. This has to be considered when evaluating control methods.

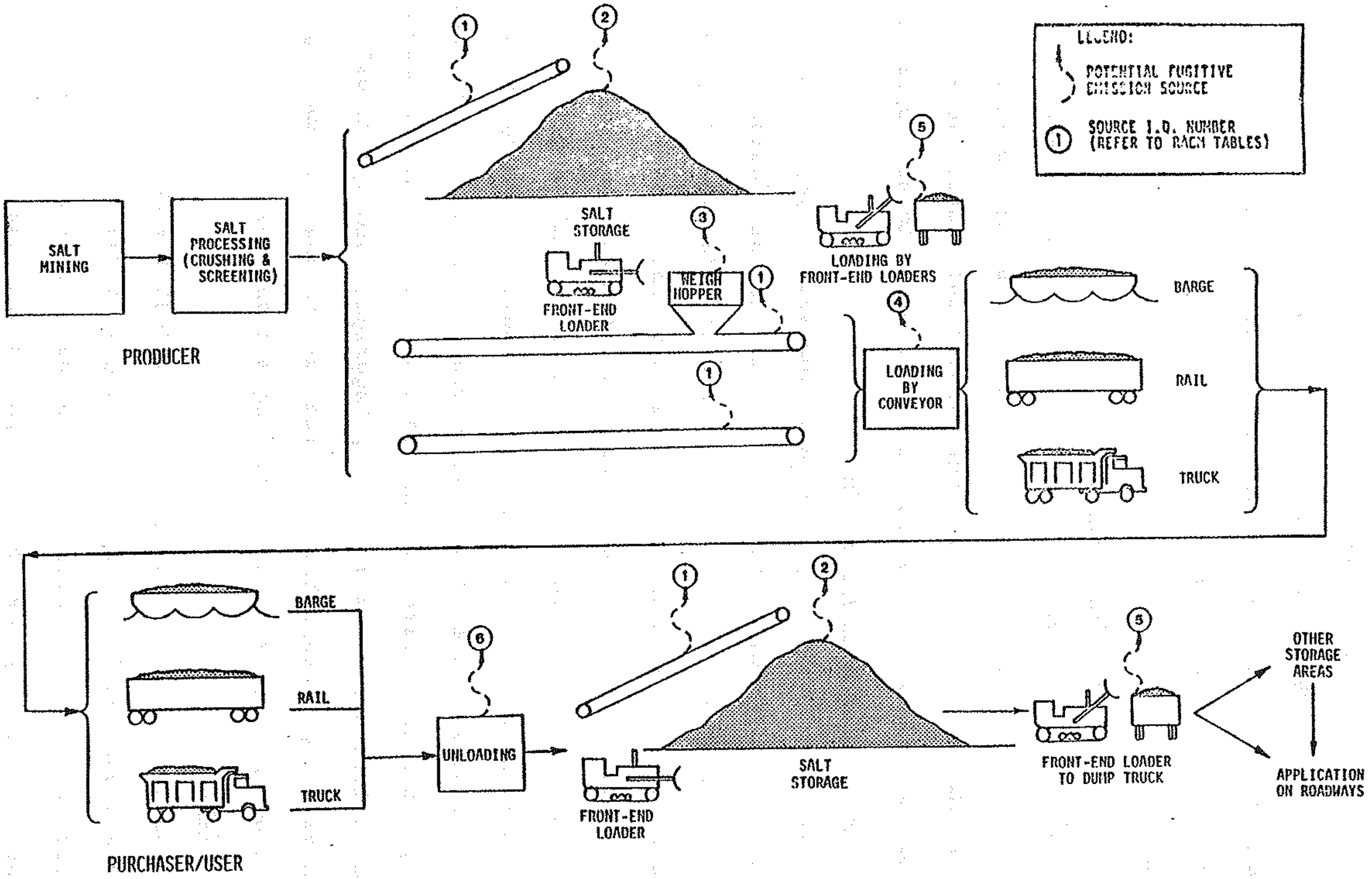

Figure 2.29-1. Simplified process flow diagram for salt processing operations and associated fugitive particulate emission sources.

Effective dust control during conveying operations, whether conducted at the mine or at the purchaser's/user's facility, requires either partial or complete enclosure of the conveyor system.

When salt is loaded onto storage piles, fugitive dust is generated from the fall of the material from the conveyor onto the pile. Keeping the free-fall distance to a minimum, by utilizing height-adjustable stackers and telescopic chutes, can further reduce the fugitive emissions.

Salt is not highly deliquescent. It does not readily dissolve upon exposure to normal atmospheric moisture. Even large unprotected salt stockpiles, directly exposed to rainfall, suffer little loss. Most moisture is retained by the outer layers of the salt pile and later evaporates. The salt forms a protective crust that sheds rainfall. The larger the pile, the less exposed surface area per ton of salt, and the lower the loss ratio even when carried in open storage for prolonged periods. This natural crusting reduces the dust problem that usually occurs with an exposed pile, unless the pile is being frequently worked with a front-end loader.

The Salt Institute highly recommends that all salt be stored in enclosed, permanent facilities.[6] If salt must be stored outside, it is essential that it be placed on an impermeable pad and properly covered to prevent possible detrimental effects on the environment. Run-off should be properly controlled. Temporary covering materials that may be used include tarpaulins and polyethylene, polyurethane or polypropylene covers. These materials are also available with reinforcement for added strength. Canvas covers generally have to be replaced once a year.

Sufficient cover material should be provided at the base of the pile to allow for shrinkage and sealing. To join flexible coverings, they should be lapped and sewn together with a two-inch standing seam, using a Finkbine sewing machine or equivalent. All regular seam sections should be double stitched, and all top seams should be triple stitched using polyester thread. This gives a relatively waterproof and durable seam for most coverings mentioned previously. Taping of sewn seams improves waterproofing.

Old tires lashed together with rope or cable and placed uniformly over the flexible cover provide a suitable tie-down weighting method. To keep the wind from "peeling" covers off salt piles, weights, such as timber (including railroad ties) or concrete anchor blocks, should be placed around the base of the pile.

There are several reasons why salt should be stored in a roofed enclosure, especially small amounts under 500 tons. Smaller tonnages of salt stored in an outdoor stockpile, if not properly covered, will take on moisture that will cause lumps to form in the material and form an excessive frozen crust. Wet and heavy caked salt is harder to handle with loaders and to move through spreaders. It is relatively simple to put small amounts of salt inside for better quality control and easier loading and handling with spreaders. Lastly, inside storage lessens the possibility of contaminating streams and wells with salt run-off and greatly reduces fugitive dust emissions.[7]

The best storage method for deicing salt is the ground level storage shed or building.[8] Storage structure size and costs will vary with individual needs. There are as many types of storage buildings as there are ideas. Many facilities have developed their own particular style. Most buildings, of course, are let for bid, but there are also many that are built with spare or used materials and with captive labor.

Dome-type structures are sometimes used for storing up to 6,000 tons of salt. One advantage of dome storage is that its aerodynamic shape presents no "flat barrier" to rain, hail or wind, thereby keeping physical stress to a minimum. There also is little wasted space, and no supporting posts or beams to get in the way. A dome structure is built to last approximately 50 years.[9]

Salt is often stored in wood, concrete or steel silos or bins which are elevated on legs or placed directly on the ground. Bin or silo storage often costs more initially than a building or shed. The storage capacity of a bin or silo is less than in ground-level storage, and only dry salt can be stored. One advantage to this storage method is that it allows rapid, one-man loading of spreaders when salt is needed during winter storms.

Front-end loaders are generally used for loading out the salt from storage piles. Precautionary measures such as loading out from the downwind side of the storage pile, keeping drop distances to a minimum and speed reduction will help reduce the fugitive dust emissions from this operation.

To control dusting which occurs when front-end loaders are loading the weigh hoppers for conveyors, wind guards may be used. Wind guards can also be used to control the fugitive dust emissions from loading trucks with front-end loaders.

Truck and railcar loading of salt by conveyor can generate fugitive dust emissions. These fugitive emissions can be controlled by enclosing the loading stations and/or by utilizing adjustable chutes.

During the loading of a barge or ship by conveyor, the salt usually falls a considerable distance into a hold. This results in the liberation of a cloud of dust. A telescopic loading spout kept extended as close to the salt surface as possible will reduce the free-fall distance and the dust emissions.

Effective dust control during truck and railcar unloading generally requires the use of a suitable enclosure or shed over the receiving area. Wind guards sometimes are used where front-end loaders move the salt that has been unloaded.

Vessel unloading is primarily done by a retractable bucket type elevator (marine leg). This is lowered into the hold of the vessel. Some generation of fugitive dust occurs in the hold as the salt is scooped out and also at the top of the marine leg where the salt is discharged onto a conveyor. To control these emissions the marine leg should be completely enclosed. Also, by curtailing or minimizing the unloading of a vessel during days with high winds, fugitive emissions can be further reduced.

At both the salt producer's facility and the purchaser's/user's facility, trucks should be covered after loading and prior to departure.

2.29.5 Recommended Reasonably Available Control Measures (RACM)

The recommended RACM for control of fugitive emission sources from salt processing operations are designated in Table 2.29-2. These techniques have been used in the industry and are very effective in reducing fugitive dust emissions.

It is recommended that the fugitive dust emissions occurring from the conveyors be controlled by total enclosure of the conveyor.

The fugitive dust emissions generated during the loading of salt onto piles by conveyors can be controlled by keeping the free fall distance of the material to a minimum through the use of telescopic chutes.

TABLE 2.29-2. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM SALT PROCESSING OPERATIONS

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan. 1980 $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
① Conveying	Partial (top) enclosure	70[a]	4,300[b]	c	d	Total enclosure
	Total enclosure	90[e]	8,600[f]	c	d	
② Salt storage piles						
Loading onto piles	Telescopic chutes	75[e]	8,500[e]	c	d	Telescopic chutes
	Adjustable stacker	25[e]	c	c	d	
Wind erosion	Covering pile	95[e]	16,000[g]	c	d	Covering piles (for large piles > 500 tons)
	Enclosure	90[c]	h	c	d	Enclosure (for smaller piles ≤ 500 tons)
Loading out	Precautions	50[e]	c	c	d	Precautions
③ Weigh hopper loading (front-end loader)	Wind guards	50[e]	c	c	d	Wind guards
④ Loading by conveyor						
Truck, railcar	Adjustable chutes	75[e]	c	c	d	Adjustable chutes and enclosure
	Enclosure	70[e]	c	c	d	
Vessel	Telescopic loading spout	75[e]	c	c	d	Telescopic loading spout
⑤ Loading trucks by						
front-end loaders	Wind guards	50[e]	c	c	d	Wind guards and precautions
	Precautions	50[e]	c	c	d	

(continued)

TABLE 2.29-2 (continued)

Fugitive dust sources	Control alternatives	Control efficiency %	Control costs, Jan. 1980 $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
⑥ Unloading						
Truck, railcar	Wind guards	50[e]	c	c	d	Enclosure
	Enclosure	70[e]	c	c	d	
Vessel	Enclosure of marine leg	75[e]	c	c	d	Enclosure of marine leg and precautions
	Precautions	50[e]	c	c	d	

[a] "Weather-tight" system; no active dust collection system. Reference 10.

[b] Reference 10, p. 6-3. Based on $43/ft and assuming 100 ft conveyor.

[c] Costs not available.

[d] Cost benefit not calculated due to lack of emission factor.

[e] Reference 10.

[f] Reference 10, p. 6-3. Based on $86/ft and assuming 100 ft conveyor.

[g] Based on $0.32/ton of salt and assuming 50,000 tons of salt. Reference 11.

[h] Cost dependent upon size and type of enclosure.

For storage pile fugitive emissions caused by wind disturbance of the pile, the recommended control technique is covering the pile or complete enclosure.

To control fugitive dust emissions from loading the weigh hopper by front-end loaders, wind guards may be employed.

Emissions resulting from loading trucks and railcars by conveyor should be controlled by utilizing adjustable chutes and enclosures. A telescopic loading spout is recommended for controlling fugitive dust emissions during the loading of vessels by conveyor. The recommended control technique for loading trucks with front-end loaders consists of providing wind guards along with operating precautions.

Unloading trucks and railcars causes fugitive dust emissions which can be controlled by enclosing the unloading station. Enclosure of the marine leg and receiving hopper, and operating precautions should be used to control the dust from vessel unloading.

REFERENCES FOR SECTION 2.29

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10. 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.

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2.30 GALVANIZING PLANTS

2.30.1 Process Description

Zinc galvanizing involves the art of coating clean, oxide-free iron or steel materials with a thin layer of zinc. The article to be coated is properly cleaned, completely immersed in a molten zinc bath (at 840°F to 860°F), and withdrawn with enough of the molten zinc adhering as a surface film to give the desired coating properties.[1]

Galvanizing operations can be conducted on a batch basis, as in the coating of nuts and bolts, guardrails, etc., or on a continuous basis, as in the coating of wire or chain link fencing. These operations may be found in job shops or as captive operations in large plants.[2]

Typically, the basic steps which are followed in cleaning and galvanizing an iron or steel article consist of the following:[3]

(1) degreasing in a hot, alkaline solution;
(2) rinsing thoroughly in a water rinse;
(3) pickling in a hot, acid bath;
(4) rinsing thoroughly in a water rinse;
(5) prefluxing in a zinc ammonium chloride solution;
(6) immersing the article in molten zinc through a flux cover (usually zinc ammonium chloride); and
(7) finishing (dusting with ammonium chloride to produce a smooth finish).

The process flow diagram shown in Figure 2.30-1 depicts a typical batch or continuous operation.

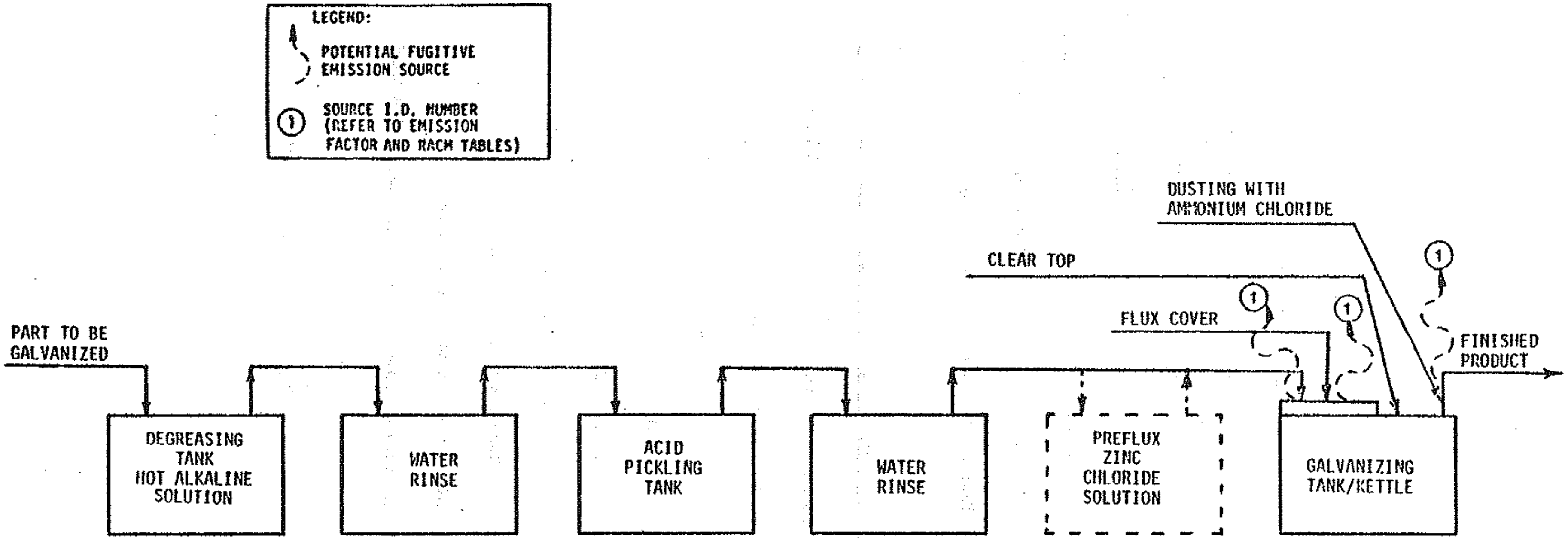

Figure 2.30-1. Simplified process flow diagram for galvanizing plants and associated fugitive particulate emission sources.

When considering the air pollution aspects of a galvanizing operation, one might be inclined to omit the first five steps because they do not normally produce excessive air contaminant emissions. Improper degreasing does, however, increase the generation of air contaminants when the article is immersed in the hot zinc. Moreover, the stripping of zinc coatings in the pickling tanks can cause excessive acid mists to be generated.[5]

The main fugitive emission problem in the galvanizing process is caused by steps (6) and (7) mentioned above. It has been observed that grayish-white particulate fumes are emitted whenever the kettle flux cover is disturbed, when fresh flux is added and when galvanized articles are dusted with ammonium chloride.[6]

The two kettle fluxes in common use are ammonium chloride and zinc ammonium chloride plus a foaming agent such as glycerine, wood flour or sawdust. The foaming agent is used to provide a deeper flux layer and to extend the life of the flux.[7]

A flux cover is used to remove any oxide film that forms as an article is being transported from the last rinse tank to the galvanizing kettle and to exclude air from the part as it enters the zinc bath. It serves as a preheating and drying medium to reduce spattering or explosions in the molten zinc and distortions of thin metal sections. Heat loses from the kettle are also reduced due to the flux cover.[8]

Also, some plants may use "dry" galvanizing as opposed to the normal "wet" galvanizing technique which uses a kettle flux. With "dry" galvanizing no kettle flux is used. Only a preflux is used just before the galvanizing kettle. The emissions from this technique are considerably less than with "wet" galvanizing.

Flux agitation occurs to some extent each time an object is immersed in the molten zinc through the flux cover. If the objects are smooth and dry, the agitation is not great, and the amount of fuming is low. When the agitation of the flux cover is severe, a correspondingly larger amount of fumes is discharged. Also, mechanical actions that break some of the bubbles making up the flux cover release fume-forming gases.[9]

When fresh flux is placed on a kettle, it takes some time to form a foaming cover. Dense fumes escape during the agitation and during the time necessary for the fresh flux to be absorbed by and to become part of the foam.

To obtain brighter, smoother finishes, especially on small items, they are dusted with finely ground ammonium chloride (NH_4Cl) immediately after being removed from the molten zinc bath. The articles dusted are still at a temperature well above the decomposition temperature of ammonium chloride; thus, much of the NH_4Cl is converted to fumes by the operation. Although only small amounts of dusting fluxes are used, dense fumes are normally created.[10]

2.30.2 Fugitive Dust Emission Factors

The estimated fugitive dust emission factor for galvanizing plants is shown in Table 2.30-1. There is no specific emission factor for continuous, batch or dusting operations. The emission factor is an average of emissions from these operations, and is based upon a report by the Los Angeles County Air Pollution Control District, written in 1966.[12] Contact with the Los Angeles County APCD revealed that this report, probably unbound, is no longer available. Also, the reported data were most probably the results of source tests conducted on galvanizing plants in the Los Angeles area before 1960.[13] The reliability of this factor should be considered as fair.

2.30.3 Particle Characterization

The appearance and composition of the fumes discharged from galvanizing operations vary according to the operation being conducted. For example, the galvanizing of nuts, bolts and other small articles does not create much agitation of the flux cover, and emissions are slight. Some fumes are, however, generated when the articles are dusted with ammonium chloride upon removal from the zinc bath. An analysis of these fumes revealed that essentially only ammonium chloride was present.[14] However, fumes from galvanizing operations may also contain substantial amounts of compounds other than ammonium chloride, such as zinc chloride and zinc oxide.

When many different articles are galvanized, some disturb the flux and produce more fumes than others. For example, the galvanizing of chain link fence material continuously agitates the flux cover and results in a continuous discharge of fumes from the kettle.

TABLE 2.30-1. FUGITIVE DUST EMISSION FACTORS FOR GALVANIZING PLANTS

Source	Emission factor	Reliability rating	Reference
① Galvanizing kettle	5 lbs/ton zinc used	D	11

The average particle size of galvanizing emissions is approximately 2 microns.[15] The actual particle size distribution varies slightly from galvanizing process to galvanizing process; however, a typical particle-size analysis of emissions from a baghouse serving a job-shop, zinc-galvanizing kettle is given below.[16]

Particle diameter, µm	Cumulative weight, %
1.7	0.0
2.1	2.6
2.8	11.5
3.5	21.0
5.6	41.5
8.3	62.5
10.4	70.0
11.8	74.0
13.9	80.5
25.0	88.5
41.7	92.0
83.4	99.0
104.0	100.0

Under some circumstances the fumes may have different characteristics, but these are attributed to the influence of additional contaminants. For example, Table 2.30-2 shows a comparison of the catch from an electrostatic precipitator serving a chain link fencing process kettle with the catch from a baghouse serving a job shop kettle.[17] The material collected by the baghouse was dry and powdery, but it did agglomerate and was difficult to shake from the bags with ordinary bag-shaking procedures. The material taken from the precipitator was sticky and had the general appearance of thick grease. Table 2.30-2 shows that the fumes are different chemically, which

TABLE 2.30-2. CHEMICAL ANALYSES OF THE FUMES COLLECTED BY A BAGHOUSE AND BY AN ELECTROSTATIC PRECIPITATOR FROM ZINC GALVANIZING KETTLES

Component	Fumes collected in a baghouse (job shop kettle), wt %	Fumes collected in a precipitator (chain link galvanizing), wt %
NH_4Cl	68.0	23.5
ZnO	15.0	6.5
$ZnCl_2$	3.6	15.2
Zn	4.9	-
NH_3	1.0	3.0
Oil	1.4	41.4
H_2O	2.5	1.2
C	2.8	-
Not identified	-	9.2

explains their different appearance after being collected. The oil in the fumes collected by the precipitator undoubtedly came from a film of oil on the chain link fence material that was vaporized as the fence material was charged into the hot zinc. Since ammonium chloride vaporizes at 662°F and the zinc bath temperature is usually between 840° and 860°F, it is not surprising that NH_4Cl makes up the bulk of the particulate emissions. However, zinc and zinc chloride have very low vapor pressures at normal galvanizing temperatures, and one would expect neither of them to vaporize to any great extent. It is believed that the discharge of these materials is the result of mechanical entrainment and occurs when wet objects are galvanized or when objects are immersed rapidly through the flux layer.[18]

Lynam[19] discusses the health problem of the particulate galvanizing emissions. The main health problems are associated with zinc chloride ($ZnCl_2$) and zinc oxide (ZnO), which can cause metal fume fever when high concentrations are inhaled. The Occupational Safety and Health Association (OSHA) threshold limit values are:

$ZnCl_2$ - 1 mg/m^3, and
ZnO - 5 mg/m^3.

A literature search did not reveal any measurements of the airborne concentrations of these compounds in the vicinity of a galvanizing kettle.[20]

2.30.4 Control Methods

In order to properly control the extremely fine particulate emissions from a galvanizing kettle serving a continuous galvanizing operation or batch operation using a flux cover, the fumes generated must be conducted to an efficient control device. Fume arresting equipment commonly used to capture the effluent from this process include the following: scrubbers, which produce the least satisfactory results; precipitators, where oil mists are a significant part of the air contaminants to be captured; and baghouses, where there is little or no oil mist entering the exhaust system. While a baghouse requires less maintenance than precipitators for this application, the temperature inside the baghouse must be kept above the dew point (150°F) even when not in use, to prevent condensation on the bags.[21] Some plants use bags that are injected with lime, which is a mixture of 60% $Ca(OH)_2$ and 40% $Mg(OH)_2$, in order to improve the removal efficiency for ammonium chloride.

As the configuration of the galvanizing kettle varies, it is necessary to vary the air pollution control system to capture the extremely fine particulate emissions caused by this process.[22]

In job shops, the headroom needed makes necessary the use of either high-canopy or room-type hoods. This hooding design allows for overhead materials handling equipment to be used and gives the operators unimpaired access to the kettle. The amount of ventilation volume required with high-canopy hoods increases considerably with the height of the hood; therefore, the size of the collector must be large enough to accommodate the large air volumes required. A slot hood (high inlet velocity) should be used only when the area of fume generation is small, such as with a flux box of a chain link fence-galvanizing kettle in a continuous operation. The slot velocities needed to overcome the thermal draft for the entire surface of a large kettle are high and require large air volumes which cool the surface of the zinc bath. This cooling effect creates problems in applying a good zinc coating and increases fuel consumption. When a slot hood can be used, the amount of ventilation required is smaller than that required with high-canopy hoods; thus, control devices are correspondingly smaller.[23]

Low-canopy hoods can be used on a kettle when headroom is not required. These hoods permit lower ventilation rates for adequate fume capture; therefore, smaller control devices can be used.[24]

Emissions from plants using the "dry" galvanizing technique are normally negligble, and won't require a control device except in cases where severe visible emissions occur.

A reduction in the amount of ammonium chloride used for finishing galvanized articles will significantly reduce visible emissions from galvanizing kettles.[25]

Table 2.30-3 summarizes the available control techniques, their effectiveness, estimated costs, and RACM selections.

2.30.5 Recommended Reasonably Available Control Measures (RACM)

The RACM selections for galvanizing plant fugitive dust emission sources are presented in Table 2.30-3. As indicated, the recommended control for continuous galvanizing operations and batch operations using a flux cover is to hood and vent the galvanizing kettles to a fabric filter. This system gives good control efficiency and reduces visible emissions to almost zero percent opacity.

In the case of batch fed operations using the "dry" galvanizing technique (no flux cover), control devices should be required for the galvanizing kettles only if severe visible emissions (into the ambient air) are evident.

TABLE 2.30-3. A SUMMARY OF THE CONTROL ALTERNATIVES, EFFICIENCIES AND COSTS, AND THE RACM SELECTIONS FOR FUGITIVE DUST EMISSIONS FROM SOURCES AT GALVANIZING PLANTS

Fugitive dust sources	Control alternatives	Control efficiency, %	Control costs, Jan. 1980 $		Cost benefit, $/lb	RACM selection
			Capital	Annualized		
① Galvanizing kettle:						
Batch fed operations						
(no flux cover)	No control (emissions negligible)	-	-	-	-	No control[a]
(with a flux cover)	Canopy hood, vent to fabric filter	90-99[b]	205,400[c]	34,500[d]	1.28	Canopy hood, vent to fabric filter
	Canopy hood, vent to scrubber	NA	NA	NA	NA	
Continuous fed operations	Slot hood, vent to fabric filter	90-99[b]	95,500[e]	16,600[f]	0.42	Slot hood, vent to fabric filter
	Slot hood, vent to precipitator	80-95[g]	215,200[h]	34,100[f]	0.97	
	Slot hood, vent to scrubber	90[i]	375,000[j]	105,700[f]	2.67	

NA = Not available

[a] Except when severe visible emissions are evident.

[b] No visible emissions after control per Reference 3.

[c] Based on 4'w x 25'l x 3'h kettle configuration.

[d] Reference 26. Based on 6,000 hr/yr operation, galvanizing 75,000 tons/yr of steel guardrail.

[e] Reference 1 and 26. Calculated for 4000 ft^2 of cloth and an exhaust rate of 10,000 acfm.

[f] Reference 26. Based on 6,000 hr/yr operation, galvanizing 110,000 tons/yr of steel coils.

[g] Reference 3. p. 20.

[h] Reference 26 and 27.

[i] Reference 26 and 27.

[j] Quoted cost for high efficiency, variable throat venturi scrubber system. Reference 27.

[k] Control required only if there are visible emissions from the kettle discharge point into the ambient air.

REFERENCES FOR SECTION 2.30

1. Air Pollution Engineering Manual, Second Edition. Danielson, J.A. (ed.). U.S. EPA. Research Triangle Park, North Carolina. May 1973. p. 402.
2. Field Operations and Enforcement Manual for Air Pollution Control, Volume III: Inspection Procedures for Specific Industries. Prepared by Pacific Environmental Services, Inc., Santa Monica, California. August, 1972. p. 7.16.1.
3. Emissions From Hot-Dip Galvanizing Process. Final Report. Prepared by Pacific Environmental Services, Inc., Santa Monica, California. March, 1976. p. 2.
4. Op. cit. Reference 3. p. 14.
5. Op. cit. Reference 1. p. 402.
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7. Op. cit. Reference 2. p. 403.
8. Op. cit. Reference 1. p. 402.
9. Ibid. p. 404.
10. Op. cit. Reference 3. p. 4.
11. Compilation of Air Pollutant Emission Factors. Second Edition. U.S. EPA, Office of Air and Water Mangement, Office of Air Quality Planning and Standards. Publication No. AP-42. Research Triangle Park, North Carolina. August 1977.
12. Hammond, W.F., "Data on Non-Ferrous Metallurgical Operations", Los Angeles County Air Pollution Control District, 434 South San Pedro Street, Los Angeles, California (November 1966).
13. Op. cit. Reference 3. p. 23.
14. Op. cit. Reference 1. p. 404.
15. Ibid. p. 404.
16. Ibid. p. 407.
17. Ibid. p. 404.
18. Lemke, E.E., W.F. Hammond, and G. Thomas, "Air Pollution Control Measures for Hot-Dip Galvanizing Kettles", J. Air Pollution Control Assoc., 10, 70-77(1960).

19. Lynam, D.R., "OSHA Health Requirements for the Galvanizing Industry", Presented at the 38th Annual Meeting of the American Hot-Dip Galvanizing Association, Houston, Texas (March 13-17, 1973).

20. Op. cit. Reference 3. p. 10.

21. Op. cit. Reference 2. p. 7.16.6.

22. Op. cit. Reference 2. p. 7.16.3.

23. Op. cit. Reference 1. p. 405.

24. Ibid. p. 406.

25. Op. cit. Reference 3. p. 6.

26. GARD, Inc. Capital and Operating Cost of Selected Air Pollution Control Systems, EPA-450/3-76-014, May 1976.

27. Ducon Company, Inc., Subsidary of United States Filter Corp., 147 East Second Street, Mineola, New York, 11501, Mr. Paul T. Hubbard, Manager Technical Services.

APPENDIX FOR SECTION 2.30

BATCH FED OPERATIONS

Canopy Hood, Vent to Fabric Filter

Assume:	Kettle	4'w 25'l 3'h
	Hood	10'w 40'l
	Indraft velocity	100 fpm
	Exhaust rate	30,000 cfm
	Duct diameter	52.5"
	Filter area	15,000 ft^2
	Filter velocity	2 fpm

Capital Costs

Ref. 26. p. 4-12.	Baghouse	\$50,000	
Ref. 26. p. 4-15.	Bags	7,500	[(\$.40)(15,000)(2)]
Ref. 26. p. 4-28.	Labor	1,250	$[\$49 + \$5.2\ 1 + \$0.62\ 1^2]$
NMI p. 3-4.	Ductwork	5,330	
NMI p. 3-4.	Fan w/motor	7,700	
	Equipment costs =	\$71,780	

1)	Equipment costs (control devices + aux.'s)	\$71,780
2)	Tax & freight (7% of 1)	5,025
3)	Installation costs (75% of 1)	53,835
4)	Subtotal (1 + 2 + 3)	130,640
5)	Engineering (10% of 4)	13,064
6)	Subtotal (4 + 5)	143,704
7)	Contingencies (10% of 6)	14,370
8)	Total capital costs	\$158,074

$$\$158{,}074\ \frac{(249.6)}{(192.1)} = \$205{,}390 \text{ or } \approx \underline{\$205{,}400}$$

Annual Costs

Maintenance . . . $205,400 x 2% = $4,108

Operating cost . . . $(\$.75/\text{hr})(6{,}000\ \text{hr/yr})\dfrac{(249.6)}{(192.1)} = \$5{,}847$

Capital charges:

$$\begin{aligned} PV &= r \cdot PV\ /\ n = 30 \quad i = 12\% \\ r \cdot (8.055) &= \$205{,}400 \\ r &= \$25{,}500 \end{aligned}$$

Total annual costs . . . $4,108 + $5,847 + $25,500 = $35,455 or ≃ $34,500

Cost Benefit (C/B)

$$C/B = \frac{\$34{,}500}{(75{,}000\ \text{ton/yr})(0.08^{*})(5\ \text{lb/ton})(.90)} = \$1.28/\text{lb TSP removed per year}$$

* Reference 3. p. 24. (8% of process weight rate is approximately equal to amount of zinc used)

CONTINUOUS FED OPERATIONS
Slot Hood, Vent to Fabric Filter

Exhaust rate = 10,000 acfm
Filter area = 3,000 ft^2
Filter velocity = 2.5 fpm

Capital Costs

Ref. 26. p. 4-12.	Baghouse	=	$20,000
Ref. 26. p. 4-15.	Bags	=	3,200
NMI p. 3-4.	Fan w/motor	=	3,500
NMI p. 3-4.	Ductwork	=	7,000
	Total equipment costs	=	$33,700

1)	Equipment costs (control device + aux.'s)	$33,700
2)	Tax & freight (7% of 1)	2,359
3)	Installation costs (75% of 1)	25,275
4)	Subtotal (1 + 2 + 3)	61,334
5)	Engineering (10% of 4)	6,133
6)	Subtotal (4 + 5)	67,467
7)	Contingencies (10% of 6)	6,747
8)	Total capital costs (6 + 7)	$74,214

$$\$74{,}214\ \frac{(249.6)}{(192.1)} \approx \underline{\$96{,}500}$$

Annualized Costs

Ref. 26. p. 4-89. Maintenance . . . $76,500 · (2%) = $1,930

Ref. 26. p. 4-88. Operating costs . . $.35 (6,000 hr/yr) =

$$\$2{,}100\ \frac{(249.6)}{(192.1)} = 2{,}729$$

Capital charges:

$$\begin{aligned} PV &= r \cdot PV \,/\, n = 30 \quad i = 12\% \\ r\,(8.055) &= \$96{,}500 \\ r &\approx \$11{,}980 \end{aligned}$$

Total annualized costs = $1,930 + $2,729 + $11,980 ≈ $16,600

Cost Benefit (C/B)

$$C/B = \frac{\$16{,}600}{(110{,}000\ \text{ton/yr})(0.08^{*})(5\ \text{lb/ton})(.90)} = \$0.42/\text{lb TSP removed per year}$$

* Reference 3. p. 24. (8% of process weight rate is approximately equal to amount of zinc used)

CONTINUOUS FED OPERATIONS
Slot Hood, Vent to Electrostatic Precipitator

Exhaust rate = 1700 cfm
Slot velocity = 2,000 fpm
Slot area = 122.4 in.^{2}
Length = 120 in.
Width = 1.02 in.

Drift velocity = 1.66 fps
Duct = 12 1/2"
X-sect. Area = 17 ft^2
(100 fpm)

Ref. 26. p. 4-1. $A = 1700\ \text{cfm} \cdot \ln(1-.99)/(1.66\ \text{f/s} \cdot 60\ \text{s/m}) = 78.6\ \text{ft}^2$

Ref. 26. p. 4-2. $P = \$75{,}000 + 2.56\,A = \$75.201\ \frac{(249.6)}{(192.1)} = \$97{,}711$

Capital Costs

1)	Equipment costs (control device + aux.'s)	$97,711
2)	Tax and freight (7% of 1)	6,840
3)	Installation costs (75% of 1)	73,283
4)	Subtotal (1 + 2 + 3)	177,834
5)	Engineering (10% of 4)	17,783
6)	Subtotal (4 + 5)	195,617
7)	Contingencies (10% of 6)	19,562
8)	Total capital costs (6 + 7)	$215,179 or ≈ $215,200

Annualized Costs

Ref. 26. p. 4-89. Maintenance . . (2%)($215,200) = $4,304

Ref. 26. p. 4-86. Operating costs. . ($.40/hr)(6,000 hr/yr) =

$$\$2{,}400\ \frac{(249.6)}{(192.1)} = \$3{,}118$$

Capital charges:

$$PV = r \cdot PV / n = 30 \quad i = 12\%$$
$$r\ (8.055) = \$215{,}200$$
$$r = \$26{,}716$$

Total annualized costs = $4,304 + $3,118 + $26,716 ≈ $34,100

Cost Benefit (C/B)

$$C/B = \frac{\$34{,}100}{(110{,}000\ \text{ton/yr})(0.08^{*})(5\ \text{lb/ton})(.80)} = \$0.97/\text{lb TSP removed per year}$$

* Reference 3. p. 24. (8% of process weight rate is approximately equal to amount of zinc used)

CONTINUOUS FED OPERATION
Slot Hood, Vent to Scrubber

Ref. 27. 45" Pressure drop
2 Fans . . . 13,000 cfm, 150hp & 9,000 cfm, 100hp

Capital Costs

Ref. 27.	1)	Equipment cost (Jan.'80)	$125,000
Ref. 26. p. 4-89.	2)	Installation costs (140% of 1)	175,000
	3)	Tax and freight (7% of 1)	8,750
	4)	Subtotal (1 + 2 + 3)	308,750
	5)	Engineering (10% of 4)	30,875
	6)	Subtotal (4 + 5)	339,625
	7)	Contingencies (10% of 6)	33,963
	8)	Total capital costs	$373,583 or ≈ $375,000

Annualized Costs

Ref. 26. p. 4-89. Maintenance . . $375,000 (13%) = $48,750

Ref. 26. p. 4-87. Operating costs . . $2,500 + $5,500 = $8,000

$$\frac{(249.6)}{(192.1)} = \$10,395$$

Capital charges:

$$PV = r \cdot PV / n = 30 \quad i = 12\%$$
$$r \cdot (8.055) = \$375,000$$
$$r = \$46,555$$

Total annualized costs = $48,750 + $10,395 + $46,555 = $105,700

Cost Benefit (C/B)

$$C/B = \frac{\$105,700}{(110,000 \text{ ton/yr})(0.08^{*})(5 \text{ lb/ton})(.90)} = \$2.67/\text{lb TSP removed per year}$$

* Reference 3. p. 24. (8% of process weight rate is approximately equal to amount of zinc used)

APPENDIX A

COST ESTIMATION GUIDELINES FOR RACM FOR FUGITIVE DUST

In estimating costs for the various industries and general sources addressed in the study, only general costs of typical control devices as applied on a typical plant configuration were obtained. This description is abstract and nonspecific but reflects the nature of the costs. It was not the purpose of this project to develop detailed costs for <u>any</u> site-specific application of a particular control measure. Caution must be exercised in the use of the cost data to assure that costs are not erroneously applied to a specific plant. Cost estimates are of order-of-magnitude accuracy, and a site visit with a detailed evaluation of specific equipment layouts is necessary to obtain meaningful costs for a specific plant.

For the actual industry cost estimates, both capital and annualized costs were estimated. Sources utilized included the GARD manual, the IGCI "Nonmetallic Minerals Industries Control Equipment Costs" and other industry specific references that contained applicable cost data. Each reference contained costs based on different years, different methods of calculating indirect costs, differences in inclusion or exclusion of auxiliary equipment, different methods of calculating fixed capital charges, different interest rates, etc. It would have been impossible to 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

1970 = 125.7
1971 = 132.2
1972 = 137.2
1973 = 144.1
1974 = 165.1
1975 = 182.4
1976 = 192.1
1977 = 204.1
1978 = 218.8
1979 = 238.7
1980 = 261.2
1981 = 297.0
1982 = 314.0

Monthly Index

January 1979 = 225.9
July 1979 = 239.3
January 1980 = 249.6*
January 1980 = 248.5
July 1980 = 263.6
January 1981 = 276.6
July 1981 = 303.1
January 1982 = 308.7
January 1982 = 311.8**
July 1982 = 314.2
January 1983 = 315.5

*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 Chemical Engineering, 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. Information was obtained from "Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions". Information presented is as complete as was made available by the producers. Note that these are 1976 costs.

Table B-1. 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
Dow Chemical Co. 2020 Dow Center Midland, Mich. 517-636-1000 Mr. Harold Filter	XFS - 4163L Styrene-Butadiene	55 gallon drums 1 drum - \$2.65/gal 25 drums - \$2.15/gal Bulk - \$1.90/gal	Mulches such as straw, wood cellulose fiber and fiberglass. Used to prevent wind loss of mulches during stabilization periods such as reseeding periods.	8.5 lbs/gal. 40 gallons XFS - 4163L: 360 gallons water 400 gallons/acre
Witco Chemical Corp. Golden Bear Division Post Office Box 378 Bakersfield, Calif. 93302 805-399-9501 Mr. William Canessa	Coherex Cold water emulsion of petroleum resins	55 gallon drums 1-10 drums - \$0.65/gal >10 drums - \$0.63/gal Bulk - \$0.38/gal	Unpaved haul roads and stockpiles. Can be used around human or animal habitats - very clean - no heat required. Can be stored for 12 months or longer. Must be protected from freezing - unless freeze stable type is used. Can be spread through any type of equipment used to spread water.	8.33 lb/gal. 1:4 dilution, 1-1.5 gal/yd^2 for parking lots and dirt roads. 1:7 dilution 0.5 to 1 gal/yd^2 for thin layer or loose dirt, light traffic, service roads. 1:10 dilution for aid in packing surface
	Semi-pave Cold asphalt cutback with antistrip agent	55 gallon drums 1-10 drums - \$0.68/gal >10 drums - \$0.64/gal Bulk - \$0.39/gal	Penetration of unpaved areas - low traffic volume roads - parking lots, etc. Can be handled without heat if ambient temperature is 50°F or higher.	250 gallons/ton 0.6 to 0.8 gal/yd^2
American Cyanamid Wayne, New Jersey 07470 201-831-1234 Mr. L. S. Randolph	Aerospray 52 binder	55 gallon drums 1-4 drums - \$0.69/lb 5-11 drums - \$0.66/lb 12-22 drums - \$0.63/lb 23-53 drums - \$0.61/lb >53 drums - \$0.59/lb Bulk - \$0.55/lb	Seed membrane protection, excavation, construction, slope stabilization	8.8 lb/gallon 2:1 1 gallon/100 ft^2

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

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
E. F. Houghton & Co. Valley Forge Tech. Center Madison & Van Buren Ave. Norristown, PA 19401 215-739-7100 Mr. Todd Sutcliffe	Surfax 5107	55 gallon drums 1-4 drums - $4.44/gal 5-9 drums - $4.41/gal 10-39 drums - $4.38/gal >39 drums - $4.35/gal	Coal loading, quarries, cement plants, crushers, sintering plants.	8.5 lb/gallon 1:1000 or higher
	Rezosol 5411-B Polymer	55 gallon drums 1-4 drums - $0.415/lb 5-9 drums - $0.41/lb 10-39 drums - $0.405/lb >39 drums - $0.40/lb	Storage piles, railcars, road sides.	8.75 lb/gal 1:30 40 gal/1000 ft^2, recommended 2 applications
Monsanto 800 N. Lindbergh Blvd. St. Louis, MO 63166 314-694-3453 Mr. James A. Cooper	Gelvatol 20-90 Polyvinyl alcohol resin	50 lb/bags 500 lb - $0.905/lb 2,000 lb - $0.80/lb 10,000 lb - $0.77/lb 30,000 lb - $0.74/lb >30,000 lb - <$0.725/lb	Surfactant and protective colloid in emulsion polymerization.	30-40 lbs/ft^3 10 to 20 percent by weight
	Gelva Emulsion S-55 Polyvinyl acetate homopolymer	55 gallon drums 1-3 drums - $0.27/lb 4-19 drums - $0.26/lb >19 drums - $0.25/lb Bulk - $0.205/lb	Adhesives	500 lb/55 gallon drum 1% by weight
Air Products & Chemicals, Inc. 5 Executive Rd. Suedesford Road Wayne, PA 19087	Vinol 540 Polymer (water soluble)	50 lb bags 500 lb - $0.80/lb 2,000 lb - $0.77/lb 10,000 lb - $0.74/lb 32,000 lb - $0.725/lb 120,000 lb - $0.72/lb	Two grades: 1) soluble in water (washed away with rain), 2) relatively insoluble in water.	1 to 7 percent by weight Slurried in cold water or heated to insure complete mixture in solution
Union Carbide Corp. West St. & Madisonville Rd Cincinnati, Ohio 45227 513-292-0206 Mr. Wm. Mike Brown	DCA-70		Stabilize steep grades, tailings ponds. Not for vegetation growth.	9.25 lb/gal 2:1

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

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
Enzymatic Soil of Tucson 6622 N. Los Arboles Cr. Tucson, Arizona 85704 602-297-2133 Mr. Bob Mundell	Enzymatic SS	55 gallon drums $7.60/gallon	Hold down dust on haul roads, tailings, stock pile. Will retard growth of weeds or plants. Seal lakes, stock tanks, stabilize odors around stock pens.	8.34 lb/gal 1:1000 1000 gallon/20 to 30 yd^3
Asphalt Rubberizing Corp. 1111 S. Colorado Blvd. Denver, Colorado 80222 303-756-3012 Mr. Jewell Benson	Peneprime Low-viscosity, special hard-base asphalt cutback	10,000 gal lots $0.45/gal	Control of wind, rain or water erosion of soils. Applied to roads and streets to allay dust and stabilize surface to carry traffic. Does not allow seed germination. Very light applications (0.2-0.4 G.S.Y.) may accelerate seed germination due to warming of black surface. Applications above 0.4 G.S.Y. inhibit plant growths through hardness and toughness of the crust formed. Plant growths through the crust may be further inhibited by addition of several oil-soluble sterilants. Sterilants kill plant as it emerges. The material may be applied at temperatures as low as 75°F by conventional asphalt distribution equipment.	0.85 S.G. dust abatement - 0.2 gal/yd^2 erosion control - 0.5-1.0 gal/yd^2

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

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
Johnson-March Co. 3018 Market St. Philadelphia, PA 19104 215-222-1411 Mr. Sam Jaffe	Compound-MR (regular)	55 gallon drums 1-3 drums - \$6.00/gal 4-11 drums - \$5.00/gal >11 drums - \$3.35/gal	Usually used with a spray system or storage piles, conveying systems.	1:1000 water applied as needed
	Compound-SP-301	1-4 drums - \$1.80/gal 5-9 drums - \$1.75/gal 10-44 drums - \$1.70/gal >45 drums - \$1.65/gal	Used on haul roads, parking lots, stabilizing cleared areas, aid in vegetation growth.	1 gal/100 ft^2 ± depending on conditions. Application lasts 6 months to a year
	Compound-MR (super-concentrate)	\$6.75/gal	Same as Compound-MR (regular)	1:3500 water
	Compound-SP-400	1-4 drums - \$3.50/gal 5-9 drums - \$3.40/gal 10-44 drums - \$3.30/gal >44 drums - \$3.20/gal	Same as Compound SP-301	Same as Compound SP-301 Application lasts 1 to 5 years
	Coal Tarp	\$0.75-\$1.00/gal	Designed for use in coal industry: coating over rail cars, trucks to prevent transportation losses, etc. Prevents seed germination.	
Grass Growers P. O. Box 584 Plainfield, NJ 07061 201-755-0923 Mr. Elsner	Tarratack-1	\$2.25/lb	Mulch binder used for stabilizing any type of grass to be grown.	5 lb: 250 gal water, mixed with wood fiber mulch (40 lb/acre) 5 lb: 150 gal water, mixed with hay or straw (40 lb/acre)
	Tarratack-2	\$2.75/lb	Same as Tarratack-1	Mixed with hay or straw 40 lb/acre
	Tarratack-3	\$3.25/lb	Same as Tarratack-1	Mixed with wood fiber only

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

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.

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[b] 1980 prices.

Table B-1 (continued). CHEMICAL DU 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

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[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.	8.338/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

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[b] 1980 prices.

[c] 1981 prices.