11.1 Hot Mix Asphalt Plants

11.1.1 General[1-2,23,42-43]

Hot mix asphalt (HMA) paving materials are a mixture of well-graded, high-quality aggregate (which can include reclaimed asphalt pavement [RAP]) and liquid asphalt cement, which is heated and mixed in measured quantities to produce HMA. Aggregate and RAP (if used) constitute over 92 percent by weight of the total mixture. Aside from the amount and grade of asphalt cement used, mix characteristics are determined by the relative amounts and types of aggregate and RAP used. A certain percentage of fine aggregate (less than 74 micrometers [µm] in physical diameter) is required for the production of good quality HMA.

Hot mix asphalt paving materials can be manufactured by: (1) batch mix plants, (2) continuous mix (mix outside drum) plants, (3) parallel flow drum mix plants, and (4) counterflow drum mix plants. This order of listing generally reflects the chronological order of development and use within the HMA industry.

There are approximately 3,600 active asphalt plants in the United States. Of these, approximately 2,300 are batch plants, 1,000 are parallel flow drum mix plants, and 300 are counterflow drum mix plants. About 85 percent of plants being manufactured today are of the counterflow drum mix design, while batch plants and parallel flow drum mix plants account for 10 percent and 5 percent, respectively. Continuous mix plants represent a very small fraction of the plants in use (≤0.5 percent) and, therefore, are not discussed further.

An HMA plant can be constructed as a permanent plant, a skid-mounted (easily relocated) plant, or a portable plant. All plants can have RAP processing capabilities. Virtually all plants being manufactured today have RAP processing capability.

Batch Mix Plants -

Figure 11.1-1 shows the batch mix HMA production process. Raw aggregate normally is stockpiled near the plant. The bulk aggregate moisture content typically stabilizes between 3 to 5 percent by weight.

Processing begins as the aggregate is hauled from the storage piles and is placed in the appropriate hoppers of the cold feed unit. The material is metered from the hoppers onto a conveyer belt and is transported into a rotary dryer (typically gas- or oil-fired). Dryers are equipped with flights designed to shower the aggregate inside the drum to promote drying efficiency.

As the hot aggregate leaves the dryer, it drops into a bucket elevator and is transferred to a set of vibrating screens where it is classified into as many as 4 different grades (sizes), and is dropped into individual "hot" bins according to size. To control aggregate size distribution in the final batch mix, the operator opens various hot bins over a weigh hopper until the desired mix and weight are obtained. Reclaimed asphalt pavement may be added at this point, also. Concurrent with the aggregate being weighed, liquid asphalt cement is pumped from a heated storage tank to an asphalt bucket, where it is weighed to achieve the desired aggregate-to-asphalt cement ratio in the final mix.

The aggregate from the weigh hopper is dropped into the mixer (pug mill) and dry-mixed for 6 to 10 seconds. The liquid asphalt is then dropped into the pug mill where it is mixed for an

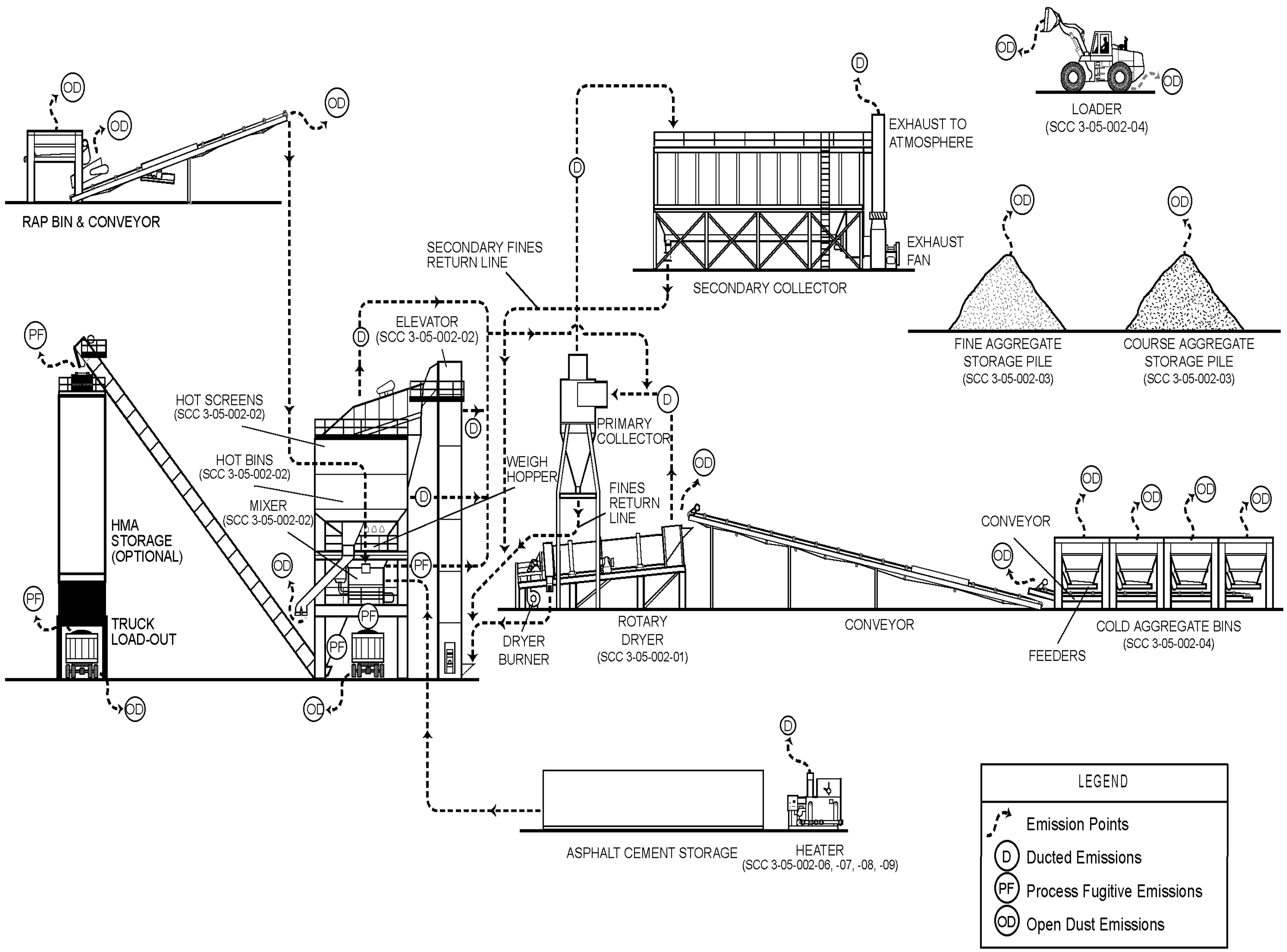

Figure 11.1-1. General process flow diagram for batch mix asphalt plants.[43] (Source Classification Codes in parentheses.)

additional period of time. Total mixing time is usually less than 60 seconds. Then the hot mix is conveyed to a hot storage silo or is dropped directly into a truck and hauled to the job site.

Parallel Flow Drum Mix Plants -

Figure 11.1-2 shows the parallel flow drum mix process. This process is a continuous mixing type process, using proportioning cold feed controls for the process materials. The major difference between this process and the batch process is that the dryer is used not only to dry the material but also to mix the heated and dried aggregates with the liquid asphalt cement. Aggregate, which has been proportioned by size gradations, is introduced to the drum at the burner end. As the drum rotates, the aggregates, as well as the combustion products, move toward the other end of the drum in parallel. Liquid asphalt cement flow is controlled by a variable flow pump electronically linked to the new (virgin) aggregate and RAP weigh scales. The asphalt cement is introduced in the mixing zone midway down the drum in a lower temperature zone, along with any RAP and particulate matter (PM) from collectors.

The mixture is discharged at the end of the drum and is conveyed to either a surge bin or HMA storage silos. The exhaust gases also exit the end of the drum and pass on to the collection system.

Parallel flow drum mixers have an advantage, in that mixing in the discharge end of the drum captures a substantial portion of the aggregate dust, therefore lowering the load on the downstream collection equipment. For this reason, most parallel flow drum mixers are followed only by primary collection equipment (usually a baghouse or venturi scrubber). However, because the mixing of aggregate and liquid asphalt cement occurs in the hot combustion product flow, organic emissions (gaseous and liquid aerosol) may be greater than in other processes.

Counterflow Drum Mix Plants -

Figure 11.1-3 shows a counterflow drum mix plant. In this type of plant, the material flow in the drum is opposite or counterflow to the direction of exhaust gases. In addition, the liquid asphalt cement mixing zone is located behind the burner flame zone so as to remove the materials from direct contact with hot exhaust gases.

Liquid asphalt cement flow is controlled by a variable flow pump which is electronically linked to the virgin aggregate and RAP weigh scales. It is injected into the mixing zone along with any RAP and particulate matter from primary and secondary collectors.

Because the liquid asphalt cement, virgin aggregate, and RAP are mixed in a zone removed from the exhaust gas stream, counterflow drum mix plants will likely have organic emissions (gaseous and liquid aerosol) that are lower than parallel flow drum mix plants. A counterflow drum mix plant can normally process RAP at ratios up to 50 percent with little or no observed effect upon emissions. Today’s counterflow drum mix plants are designed for improved thermal efficiencies.

Recycle Processes -

In recent years, the use of RAP has been initiated in the HMA industry. Reclaimed asphalt pavement significantly reduces the amount of virgin rock and asphalt cement needed to produce HMA.

In the reclamation process, old asphalt pavement is removed from the road base. This material is then transported to the plant, and is crushed and screened to the appropriate size for further processing. The paving material is then heated and mixed with new aggregate (if applicable), and the proper amount of new asphalt cement is added to produce a high-quality grade of HMA.

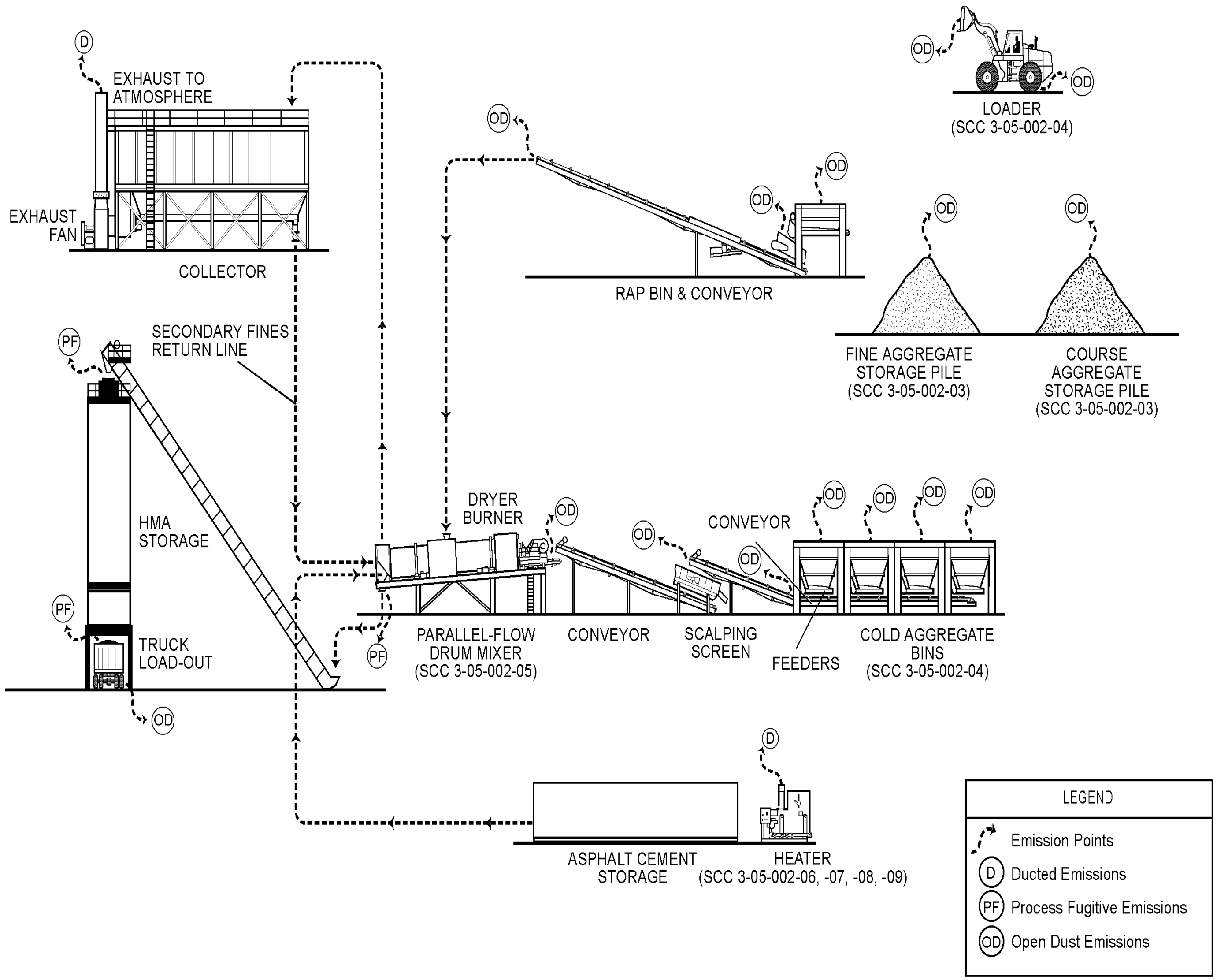

Figure 11.1-2. General process flow diagram for drum mix asphalt plants.[43] (Source Classification Coes in parentheses.)

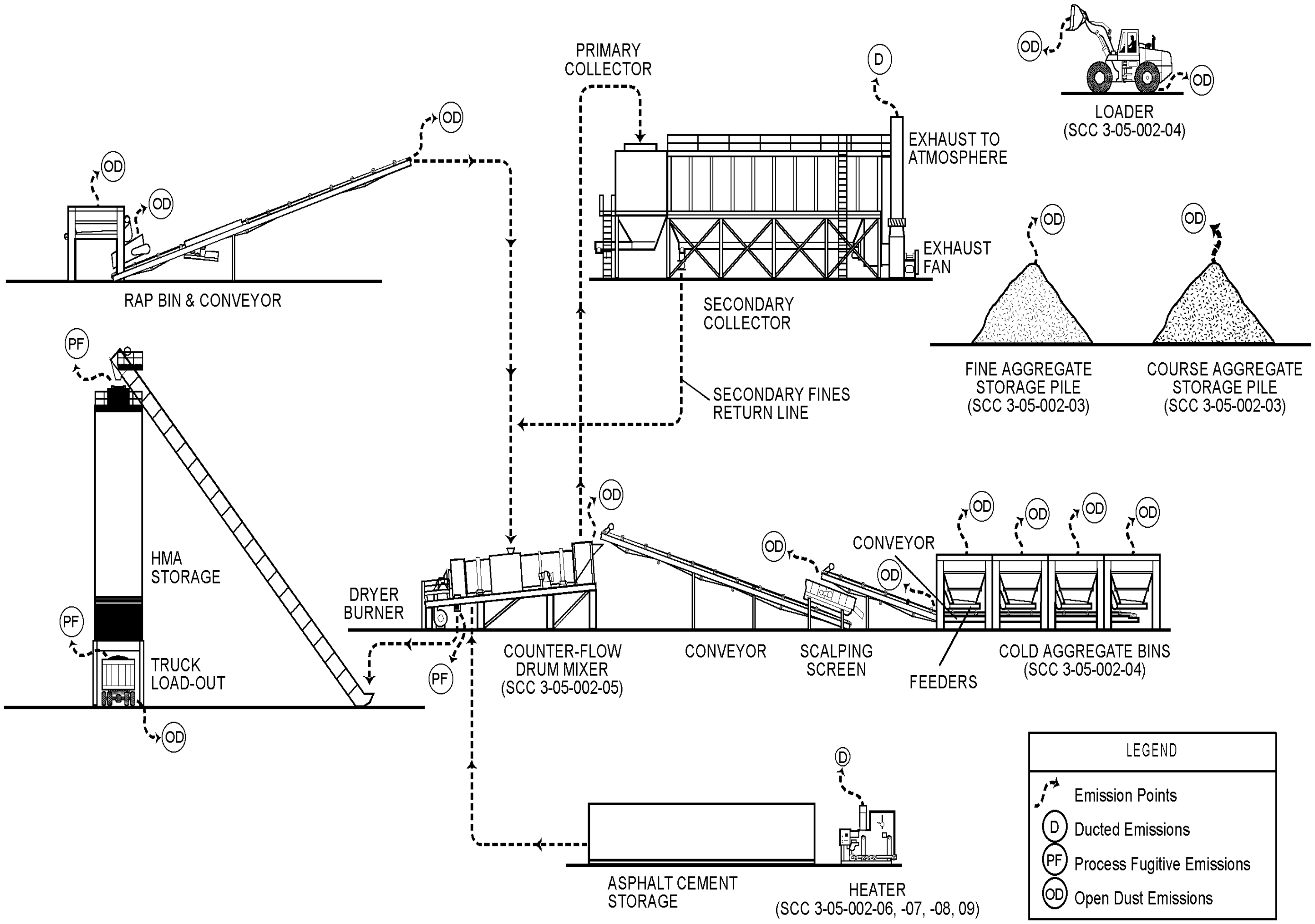

Figure 11.1-3. General process flow diagram for counterflow drum mix asphalt plants.[43] (Source Classification Codes in parentheses.)

11.1.2 Emissions And Controls[23,42-43]

Emission points discussed below refer to Figure 11.1-1 for batch mix asphalt plants, and to Figure 11.1-2 and Figure 11.1-3 for drum mix plants.

Batch Mix Plants -

As with most facilities in the mineral products industry, batch mix HMA plants have 2 major categories of emissions: ducted sources (those vented to the atmosphere through some type of stack, vent, or pipe), and fugitive sources (those not confined to ducts and vents but emitted directly from the source to the ambient air). Ducted emissions are usually collected and transported by an industrial ventilation system having 1 or more fans or air movers, eventually to be emitted to the atmosphere through some type of stack. Fugitive emissions result from process and open sources and consist of a combination of gaseous pollutants and PM.

The most significant source of ducted emissions from batch mix HMA plants is the rotary drum dryer. Emissions from the dryer consist of water as steam evaporated from the aggregate, PM, and small amounts of volatile organic compounds (VOC) of various species (including hazardous air pollutants [HAP]) derived from combustion exhaust gases.

Other potential process sources include the hot-side conveying, classifying, and mixing equipment, which are vented to either the primary dust collector (along with the dryer gas) or to a separate dust collection system. The vents and enclosures that collect emissions from these sources are commonly called "fugitive air" or "scavenger" systems. The scavenger system may or may not have its own separate air mover device, depending on the particular facility. The emissions captured and transported by the scavenger system are mostly aggregate dust, but they may also contain gaseous VOCs and a fine aerosol of condensed liquid particles. This liquid aerosol is created by the condensation of gas into particles during cooling of organic vapors volatilized from the asphalt cement in the mixer (pug mill). The amount of liquid aerosol produced depends to a large extent on the temperature of the asphalt cement and aggregate entering the pug mill. Organic vapor and its associated aerosol are also emitted directly to the atmosphere as process fugitives during truck loadout, from the bed of the truck itself during transport to the job site, and from the asphalt storage tank. In addition to low molecular weight VOCs, these organic emission streams may contain small amounts of polycyclic compounds. Both the low molecular weight VOCs and the polycyclic organic compounds can include HAPs. The ducted emissions from the heated asphalt storage tanks may include VOCs and combustion products from the tank heater.

The choice of applicable control equipment for the dryer exhaust and vent line ranges from dry mechanical collectors to scrubbers and fabric collectors. Attempts to apply electrostatic precipitators have met with little success. Practically all plants use primary dust collection equipment with large diameter cyclones, skimmers, or settling chambers. These chambers are often used as classifiers to return collected material to the hot elevator and to combine it with the drier aggregate. To capture remaining PM, the primary collector effluent is ducted to a secondary collection device. Most plants use either a baghouse or a venturi scrubber for secondary emissions control.

There are also a number of fugitive dust sources associated with batch mix HMA plants, including vehicular traffic generating fugitive dust on paved and unpaved roads, aggregate material handling, and other aggregate processing operations. Fugitive dust may range from 0.1 µm to more than 300 µm in aerodynamic diameter. On average, 5 percent of cold aggregate feed is less than 74 µm (minus 200 mesh). Fugitive dust that may escape collection before primary control generally consists of PM with 50 to 70 percent of the total mass less than 74 µm. Uncontrolled PM emission factors for various types of fugitive sources in HMA plants are addressed in Section 13.2.3, "Heavy Construction Operations".

Parallel Flow Drum Mix Plants -

The most significant ducted source of emissions is the rotary drum dryer. Emissions from the drum consist of water as steam evaporated from the aggregate, PM, and small amounts of VOCs of various species (including HAPs) derived from combustion exhaust gases, liquid asphalt cement, and RAP, if utilized. The VOCs result from incomplete combustion and from the heating and mixing of liquid asphalt cement inside the drum. The processing of RAP materials may increase VOC emissions because of an increase in mixing zone temperature during processing.

Once the VOCs cool after discharge from the process stack, some condense to form a fine liquid aerosol or "blue smoke" plume. A number of process modifications or restrictions have been introduced to reduce blue smoke including installation of flame shields, rearrangement of flights inside the drum, adjustments of the asphalt injection point, and other design changes.

Counterflow Drum Mix Plants -

The most significant ducted source of emissions is the rotary drum dryer in a counterflow drum mix plant. Emissions from the drum consist of water as steam evaporated from the aggregate, PM, and small amounts of VOCs of various species (including HAPs) derived from combustion exhaust gases, liquid asphalt cement, and RAP, if used.

Because liquid asphalt cement, aggregate, and sometimes RAP, are mixed in a zone not in contact with the hot exhaust gas stream, counterflow drum mix plants will likely have lower VOC emissions than parallel flow drum mix plants. The organic compounds that are emitted from counterflow drum mix plants are likely to be products of a slight inefficient combustion and can include HAP.

Parallel and Counterflow Drum Mix Plants -

Process fugitive emissions associated with batch plant hot screens, elevators, and the mixer (pug mill) are not present in the drum mix processes. However, there may be slight fugitive VOC emissions from transport and handling of the hot mix from the drum mixer to the storage silo and also from the load-out operations to the delivery trucks. Since the drum process is continuous, these plants must have surge bins or storage silos. The fugitive dust sources associated with drum mix plants are similar to those of batch mix plants with regard to truck traffic and to aggregate material feed and handling operations.

Tables 11.1-1 and 11.1-2 present emission factors for filterable PM and PM-10, condensable PM, and total PM for batch mix HMA plants. The emission factors are based on both the type of control technology employed and the type of fuel used to fire the dryer. Particle size data for batch mix HMA plants, also based on the control technology used, are shown in Table 11.1-3.
Tables 11.1-4 and 11.1-5 present filterable PM and PM-10, condensable PM, and total PM emission factors for drum mix HMA plants. The emission factors are based on both the type of control technology employed and the type of fuel used to fire the dryer. Particle size data for drum mix HMA plants, also based on the control technology used, are shown in Table 11.1-6. Tables 11.1-7 and 11.1-8 present emission factors for carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and total organic compounds (TOC) from batch and drum mix plants. Table 11.1-9 presents organic pollutant emission factors for batch plants. Tables 11.1-10 and 11.1-11 present organic pollutant emission factors for drum mix plants. Tables 11.1-12 and 11.1-13 present metal emission factors for batch and drum mix plants, respectively.

Table 11.1-1 (Metric Units). EMISSION FACTORS FOR BATCH MIX HOT MIX ASPHALT PLANTS[a]

	Filterable PM				Condensable PM						Total PM			
Process	PM	EMISSION FACTOR RATING	PM-10[b]	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING	Total	EMISSION FACTOR RATING	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING
Natural gas-fired dryer (SCC 3-05-002-01)														
Uncontrolled	16[c]	E	2.2	E	0.0017[d]	D	0.00039[d]	D	0.0021	D	16	E	2.2	E
Low-energy scrubber[e]	0.039	D	ND		0.0017	D	ND		ND		ND		ND	
Venturi scrubber[e]	0.026	E	ND		ND		ND		ND		ND		ND	
Fabric filter	0.020[f]	D	0.0080	D	0.0014[g]	D	0.00039[h]	D	0.0018[h]	D	0.022[j]	D	0.0098	D
Oil-fired dryer (SCC 3-05-002-01)														
Uncontrolled	16[c]	E	2.2	E	0.0083[d]	D	ND		0.022[d]	D	16	E	2.2	E
Venturi scrubber[e]	0.026	E	ND		0.0083	E	ND		ND		ND		ND	
Fabric filter	0.020[e]	D	0.0080	D	ND		ND		0.022[k]	D	0.042[m]	D	0.030	D

[a] Factors are kg/Mg of product. Filterable PM emission factors were developed from tests on dryers fired with several different fuels. SCC = Source Classification Code. ND = no data.
[b] Particle size data from Reference 23 were used in conjunction with the filterable PM emission factors shown.
[c] Reference 5.
[d] Although no data are available for uncontrolled condensable PM, values are assumed to be equal to the maximum controlled value measured.
[e] Reference 15.
[f] References 15,24,40-41.
[g] Reference 24.
[h] References 24,39.
[j] References 15,24,39-41.
[k] Reference 39.
[m] Reference 40.

Table 11.1-2 (English Units). EMISSION FACTORS FOR BATCH MIX HOT MIX ASPHALT PLANTS[a]

Process	Filterable PM				Condensable PM						Total PM			
	PM	EMISSION FACTOR RATING	PM-10[b]	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING	Total	EMISSION FACTOR RATING	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING
Natural gas-fired dryer (SCC 3-05-002-01)														
Uncontrolled	32[c]	E	4.5	E	0.0033[d]	D	0.00078[d]	D	0.0041	D	32	E	4.5	E
Low-energy scrubber[e]	0.077	D	ND		0.0033	D	ND		ND		ND		ND	
Venturi scrubber[e]	0.052	E	ND		ND		ND		ND		ND		ND	
Fabric filter	0.040[f]	D	0.016	D	0.0027[g]	D	0.00078[g]	D	0.0035[h]	D	0.044[j]	D	0.020	D
Oil-fired dryer (SCC 3-05-002-01)														
Uncontrolled	32[c]	E	4.5	E	0.017[d]	E	ND		0.045[d]	D	32	E	4.5	E
Venturi scrubber[e]	0.052	E	ND		0.017	E	ND		ND		ND		ND	
Fabric filter	0.040[e]	D	0.016	D	ND		ND		0.045[k]	D	0.085[m]	D	0.061	D

[a] Factors are lb/ton of product. Filterable PM emission factors were developed from tests on dryers fired with several different fuels. SCC = Source Classification Code. ND = no data.
[b] Particle size data from Reference 23 were used in conjunction with the filterable PM emission factors shown.
[c] Reference 5.
[d] Although no data are available for uncontrolled condensable PM, values are assumed to be equal to the maximum controlled value measured.
[e] Reference 15.
[f] References 15,24,40-41.
[g] Reference 24.
[h] References 24,39.
[j] References 15,24,39-41.
[k] Reference 39.
[m] Reference 40.

Table 11.1-3. SUMMARY OF PARTICLE SIZE DISTRIBUTION FOR BATCH MIX HOT MIX ASPHALT PLANTS[a]

Particle Size, µm[b]	Cumulative Mass Less Than Or Equal To Stated Size (%)[c]				
	Uncontrolled	Cyclone Collectors	Multiple Centrifugal Scrubbers	Gravity Spray Towers	Fabric Filters
2.5	0.83	5.0	67	21	33
5.0	3.5	11	74	27	36
10.0	14	21	80	37	40
15.0	23	29	83	39	47
20.0	30	36	84	41	54

[a] Reference 23, Table 3-36. Rounded to two significant figures.
[b] Aerodynamic diameter.
[c] Applies only to the mass of filterable PM.

Table 11.1-4 (Metric Units). EMISSION FACTORS FOR DRUM MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D (except as noted)

Process	Filterable PM		Condensable PM			Total PM[b]	
	PM	PM-10[c]	Inorganic	Organic	Total	PM	PM-10
Natural gas-fired dryer (SCC 3-05-002-05)							
Uncontrolled	9.4[d]	2.2	0.014[e]	0.027[f]	0.041	9.4	2.2
Venturi scrubber	0.017[g]	ND	ND	0.010[f]	ND	ND	ND
Fabric filter	0.0070[h]	0.0022	ND	ND	0.0019[j]	0.0089	0.0041
Oil-fired dryer (SCC 3-05-002-05)							
Uncontrolled	9.4[d]	2.2	0.012[e]	0.0013[e]	0.013[e]	9.4	2.2
Venturi scrubber	0.017[g]	ND	ND	ND	ND	ND	ND
Fabric filter	0.0070[h]	0.0022	0.012[k]	0.0013[k]	0.013[k]	0.020	0.015

[a] Factors are kg/Mg of product. Tests included dryers that were processing reclaimed asphalt pavement (RAP). Because of the limited data available, the effect of RAP processing on emissions could not be determined. Filterable PM emission factors were developed from tests on dryers firing several different fuels. SCC = Source Classification Code. ND = no data.
[b] Total PM emission factors are the sum of filterable PM and total condensable PM emission factors. Total PM-10 emission factors are the sum of filterable PM-10 and total condensable PM emission factors.
[c] Particle size data from Reference 23 were used in conjunction with the filterable PM emission factors shown.
[d] References 31,36-38.
[e] Although no emission test data are available for uncontrolled condensible PM, values are assumed to be equal to the maximum controlled value measured.
[f] References 36-37.
[g] References 29,32,36-37,40.
[h] References 25-28,31,33,40. EMISSION FACTOR RATING: C.
[j] Reference 39.
[k] References 25,39.

Table 11.1-5 (English Units). EMISSION FACTORS FOR DRUM MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D (except as noted)

Process	Filterable PM		Condensable PM			Total PM[b]	
	PM	PM-10[c]	Inorganic	Organic	Total	PM	PM-10
Natural gas-fired dryer (SCC 3-05-002-05)							
Uncontrolled	19[d]	4.3	0.027[e]	0.054[f]	0.081	19	4.4
Venturi scrubber	0.033[g]	ND	ND	0.020[f]	ND	ND	ND
Fabric filter	0.014[h]	0.0045	ND	ND	0.0037[j]	0.018	0.0082
Dryer (oil-fired) (SCC 3-05-002-05)							
Uncontrolled	19[d]	4.3	0.023[e]	0.0026[e]	0.026[e]	19	4.3
Venturi scrubber	0.033[g]	ND	ND	ND	ND	ND	ND
Fabric filter	0.014[h]	0.0045	0.023[k]	0.0026[k]	0.026[k]	0.040	0.031

[a] Factors are lb/ton of product. Tests included dryers that were processing reclaimed asphalt pavement (RAP). Because of the limited data available, the effect of RAP processing on emissions could not be determined. Filterable PM emission factors were developed from tests on dryers firing several different fuels. SCC = Source Classification Code. ND = no data.
[b] Total PM emission factors are the sum of filterable PM and total condensable PM emission factors. Total PM-10 emission factors are the sum of filterable PM-10 and total condensable PM emission factors.
[c] Particle size data from Reference 23 were used in conjunction with the filterable PM emission factors shown.
[d] References 31,36-38.
[e] Although no emission test data are available for uncontrolled condensable PM, values are assumed to be equal to the maximum controlled value measured.
[f] References 36-37.
[g] References 29,32,36-37,40.
[h] References 25-28,31,33,40. EMISSION FACTOR RATING: C.
[j] Reference 39.
[k] References 25,39.

Table 11.1-6. SUMMARY OF PARTICLE SIZE DISTRIBUTION FOR DRUM MIX HOT MIX ASPHALT PLANTS[a]

Particle Size, µm[b]	Cumulative Mass Less Than Or Equal To Stated Size (%)[c]	
	Uncontrolled	Fabric Filters[d]
2.5	5.5	11
10.0	23	32
15.0	27	35

[a] Reference 23, Table 3-35. Rounded to two significant figures.
[b] Aerodynamic diameter.
[c] Applies only to the mass of filterable PM.
[d] Includes data from two out of eight tests where about 30% reclaimed asphalt pavement was processed using a split feed process.

Table 11.1-7 (Metric And English Units). EMISSION FACTORS FOR BATCH MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D

	CO		CO_2		NO_x		SO_2		TOC[b]	
Process	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Natural gas-fired dryer (SCC 3-05-002-01)	0.17[c]	0.34[c]	17[d]	35[d]	0.013[c]	0.025[c]	0.0025[e]	0.0050[e]	0.0084[f]	0.017[f]
Oil-fired dryer (SCC 3-05-002-01)	0.035[e]	0.069[e]	19[g]	39[g]	0.084[e]	0.17[e]	0.12[e]	0.24[e]	0.023[f]	0.046[f]

[a] Factors are kg/Mg and lb/ton of product. Factors are for uncontrolled emissions, unless noted. SCC = Source Classification Code.
[b] Factors represent TOC as methane, based on EPA Method 25A test data.
[c] References 24,34,39.
[d] References 15,24,39.
[e] Reference 39. Dryer tested was fired with #6 fuel oil. Dryers fired with other fuel oils will have different SO_2 emission factors.
[f] References 24,39.
[g] References 15,39.

Table 11.1-8 (Metric And English Units). EMISSION FACTORS FOR DRUM MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D

	CO		CO_2		NO_x		SO_2		TOC[b]	
Process	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Natural gas-fired dryer (SCC 3-05-002-01)	0.028[c]	0.056[c]	14[d]	27[d]	0.015[c]	0.030[c]	0.0017[c]	0.0033[c]	0.025[c]	0.051[c]
Oil-fired dryer (SCC 3-05-002-01)	0.018[e]	0.036[e]	19[f]	37[f]	0.038[g]	0.075[g]	0.028[g]	0.056[g]	0.035[g]	0.069[g]

[a] Factors are kg/Mg and lb/ton of product. Factors represent uncontrolled emissions, unless noted. Tests included dryers that were processing reclaimed asphalt pavement (RAP). Because of limited data, the effect of RAP processing on emissions could not be determined. SCC = Source Classification Code.
[b] Factors represent TOC as methane, based on EPA Method 25A test data.
[c] Reference 39. Includes data from both parallel flow and counterflow drum mix dryers. Organic compound emissions from counterflow systems are expected to be smaller than from parallel flow systems. However, the available data are insufficient to accurately quantify the difference in these emissions.
[d] References 30,39.
[e] Reference 25.
[f] References 25-27,29,32-33,39.
[g] References 25,39. Includes data from both parallel flow and counterflow drum mix dryers. Organic compound emissions from counterflow systems are expected to be smaller than from parallel flow systems. However, the available data are insufficient to accurately quantify the difference in these emissions. One of the dryers tested was fired with #2 fuel oil (0.003 kg/Mg [0.006 lb/ton]) and the other dryer was fired with waste oil (0.05 kg/Mg [0.1 lb/ton]). Dryers fired with other fuel oils will have different SO_2 emission factors.

Table 11.1-9 (Metric And English Units). EMISSION FACTORS FOR ORGANIC POLLUTANT EMISSIONS FROM BATCH MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D (except as noted)

Process	Pollutant		Emission Factor		Ref. Nos.
	CASRN	Name	kg/Mg	lb/ton	
Natural gas-fired dryer (SCC 3-05-002-01)	91-57-6	2-Methylnaphthalene[b]	3.8×10^{-5}	7.7×10^{-5}	24,39
	83-32-9	Acenaphthene[b]	6.2×10^{-7}	1.2×10^{-6}	34,39
	208-96-8	Acenaphthylene[b]	4.3×10^{-7}	8.6×10^{-7}	34,39
	75-07-0	Acetaldehyde	0.00032	0.00064	24
	67-64-1	Acetone	0.0032	0.0064	24
	120-12-7	Anthracene[b]	1.5×10^{-7}	3.1×10^{-7}	34,39
	100-52-7	Benzaldehyde	6.4×10^{-5}	0.00013	24
	71-43-2	Benzene	0.00017	0.00035	24,39
	56-55-3	Benzo(a)anthracene[b]	2.3×10^{-9}	4.5×10^{-9}	39
	205-99-2	Benzo(b)fluoranthene[b]	2.3×10^{-9}	4.5×10^{-9}	39
	207-08-9	Benzo(k)fluoranthene[b,c]	1.2×10^{-8}	2.4×10^{-8}	34
	78-84-2	Butyraldehyde/ Isobutyraldehyde	1.5×10^{-5}	3.0×10^{-5}	24
	218-01-9	Chrysene[b]	3.1×10^{-9}	6.1×10^{-9}	39
	4170-30-3	Crotonaldehyde	1.5×10^{-5}	2.9×10^{-5}	24
	100-41-4	Ethyl benzene	0.0016	0.0033	24,39
	206-44-0	Fluoranthene[b]	1.6×10^{-7}	3.1×10^{-7}	34,39
	86-73-7	Fluorene[b]	9.8×10^{-7}	2.0×10^{-6}	34,39
	50-00-0	Formaldehyde	0.00043	0.00086	24,39
	66-25-1	Hexanal	1.2×10^{-5}	2.4×10^{-5}	24
	74-82-8	Methane	0.0060	0.012	39
	91-20-3	Naphthalene[b]	2.1×10^{-5}	4.2×10^{-5}	34,39
	85-01-8	Phenanthrene[b]	1.6×10^{-6}	3.3×10^{-6}	34,39
	129-00-0	Pyrene[b]	3.1×10^{-8}	6.2×10^{-8}	34,39
	106-51-4	Quinone	0.00014	0.00027	24
	108-88-3	Toluene	0.00088	0.0018	24,39
	1330-20-7	Xylene	0.0021	0.0043	24,39
Oil-fired dryer (SCC 3-05-002-01)	91-57-6	2-Methylnaphthalene[b]	3.0×10^{-5}	6.0×10^{-5}	39
	206-44-0	Fluoranthene[b]	1.2×10^{-5}	2.4×10^{-5}	39
	50-00-0	Formaldehyde[c]	0.0016	0.0032	39,40
		Methane	0.0022	0.0043	39
	91-20-3	Naphthalene[b]	2.2×10^{-5}	4.5×10^{-5}	39
	85-01-8	Phenanthrene[b,c]	1.8×10^{-5}	3.7×10^{-5}	39
	129-00-0	Pyrene[b]	2.7×10^{-5}	5.5×10^{-5}	39

[a] Factors are kg/Mg and lb/ton of hot mix asphalt produced. Factors represent uncontrolled emissions, unless noted. CASRN = Chemical Abstracts Service Registry Number. SCC = Source Classification Code.
[b] Controlled by a fabric filter. Compound is classified as polycyclic organic matter (POM), as defined in the 1990 Clean Air Act Amendments (CAAA).
[c] EMISSION FACTOR RATING: E.

Table 11.1-10 (Metric And English Units). EMISSION FACTORS FOR ORGANIC POLLUTANT EMISSIONS FROM DRUM MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D (except as noted)

Process	Pollutant		Emission Factor		Ref. Nos.
	CASRN	Name	kg/Mg	lb/ton	
Natural gas- or propane-fired dryer[b] (SCC 3-05-002-05)	91-58-7	2-Chloronaphthalene[c]	8.9×10^{-7}	1.8×10^{-6}	39
	91-57-6	2-Methylnaphthalene[c]	3.7×10^{-5}	7.4×10^{-5}	39
	83-32-9	Acenaphthene[c]	6.4×10^{-7}	1.3×10^{-6}	35,39
	208-96-8	Acenaphthylene[c]	4.2×10^{-6}	8.4×10^{-6}	35,39
	120-12-7	Anthracene[c]	1.0×10^{-7}	2.1×10^{-7}	35,39
	71-43-2	Benzene	0.00060	0.0012	39
	56-55-3	Benzo(a)anthracene[c]	1.0×10^{-7}	2.0×10^{-7}	39
	50-32-8	Benzo(a)pyrene[c]	4.6×10^{-9}	9.2×10^{-9}	39
	205-99-2	Benzo(b)fluoranthene[c]	5.1×10^{-8}	1.0×10^{-7}	35,39
	192-97-2	Benzo(e)pyrene[c]	5.2×10^{-8}	1.0×10^{-7}	39
	191-24-2	Benzo(g,h,i)perylene[c]	1.9×10^{-8}	3.9×10^{-8}	39
	207-08-9	Benzo(k)fluoranthene[c]	2.6×10^{-8}	5.3×10^{-8}	39
	218-01-9	Chrysene[c]	1.8×10^{-7}	3.5×10^{-7}	39
	53-70-3	Dibenz(a,h)anthracene[c,e]	1.3×10^{-9}	2.7×10^{-9}	39
	100-41-4	Ethylbenzene[e]	0.00015	0.00029	39
	206-44-0	Fluoranthene[c]	3.0×10^{-7}	5.9×10^{-7}	35,39
	86-73-7	Fluorene[c]	2.7×10^{-6}	5.3×10^{-6}	35,39
	50-00-0	Formaldehyde	0.0018	0.0036	35,39
	50-00-0	Formaldehyde[d,e]	0.00079	0.0016	40
	193-39-5	Indeno(1,2,3-cd)pyrene[c]	3.6×10^{-9}	7.3×10^{-9}	39
	74-82-8	Methane	0.010	0.021	39
	71-55-6	Methyl chloroform[e]	2.4×10^{-5}	4.8×10^{-5}	35
	91-20-3	Naphthalene[c]	2.4×10^{-5}	4.8×10^{-5}	35,39
	198-55-0	Perylene[c,e]	6.2×10^{-9}	1.2×10^{-8}	39
	85-01-8	Phenanthrene[c]	4.2×10^{-6}	8.4×10^{-6}	35,39
	129-00-0	Pyrene[c]	2.3×10^{-7}	4.6×10^{-7}	35,39
	108-88-3	Toluene	0.00010	0.00020	35,39
	1330-20-7	Xylene	0.00020	0.00040	39
Oil-fired dryer[c] (SCC 3-05-002-05)	91-57-6	2-Methylnaphthalene[c]	8.5×10^{-5}	0.00017	39
	208-96-8	Acenaphthylene[c]	1.1×10^{-5}	2.2×10^{-5}	39
	75-07-0	Acetaldehyde	0.00065	0.0013	25
	67-64-1	Acetone	0.00042	0.00083	25

Table 11.1-10 (cont.).

Process	Pollutant		Emission Factor		Ref. Nos.
	CASRN	Name	kg/Mg	lb/ton	
	107-02-8	Acrolein	$1.3x10^{-5}$	$2.6x10^{-5}$	25
	120-12-7	Anthracene[c]	$1.8x10^{-6}$	$3.6x10^{-6}$	39
	100-52-7	Benzaldehyde	$5.5x10^{-5}$	0.00011	25
	71-43-2	Benzene	0.00020	0.00041	25
	78-84-2	Butyraldehyde/Isobutyraldehyde	$8.0x10^{-5}$	0.00016	25
	4170-30-3	Crotonaldehyde	$4.3x10^{-5}$	$8.6x10^{-5}$	25
	100-41-4	Ethylbenzene	0.00019	0.00038	25
	86-73-7	Fluorene[c]	$8.5x10^{-6}$	$1.7x10^{-5}$	39
	50-00-0	Formaldehyde	0.0012	0.0024	25,39
	50-00-0	Formaldehyde[d,e]	0.00026	0.00052	40
	66-25-1	Hexanal	$5.5x10^{-5}$	0.00011	25
	590-86-3	Isovaleraldehyde	$1.6x10^{-5}$	$3.2x10^{-5}$	25
	74-82-8	Methane	0.0096	0.020	25,39
	78-93-3	Methyl ethyl ketone	$1.0x10^{-5}$	$2.0x10^{-5}$	25
	91-20-3	Naphthalene[c]	0.00016	0.00031	25,39
	85-01-8	Phenanthrene[c]	$2.8x10^{-5}$	$5.5x10^{-5}$	39
	123-38-6	Propionaldehyde	$6.5x10^{-5}$	0.00013	25
	129-00-0	Pyrene[c,e]	$1.5x10^{-6}$	$3.0x10^{-6}$	39
	106-51-4	Quinone	$8.0x10^{-5}$	0.00016	25
	108-88-3	Toluene	0.00037	0.00075	25
	110-62-3	Valeraldehyde	$3.4x10^{-5}$	$6.7x10^{-5}$	25
	1330-20-7	Xylene	$8.2x10^{-5}$	0.00016	25

[a] Factors are kg/Mg and lb/ton of hot mix asphalt produced. Table includes data from both parallel flow and counterflow drum mix dryers. Organic compound emissions from counterflow systems are expected to be less than from parallel flow systems, but the available data are insufficient to quantify accurately the difference in these emissions. CASRN = Chemical Abstracts Service Registry Number. SCC = Source Classification Code.
[b] Tests included dryers that were processing reclaimed asphalt pavement (RAP). Because of limited data, the effect of RAP processing on emissions could not be determined.
[c] Controlled by a fabric filter. Compound is classified as polycyclic organic matter (POM), as defined in the 1990 Clean Air Act Amendments (CAAA).
[d] Controlled by a wet scrubber.
[e] EMISSION FACTOR RATING: E

Table 11.1-11 (Metric And English Units). EMISSION FACTORS FOR ORGANIC POLLUTANT EMISSIONS FROM HOT MIX ASPHALT HOT OIL HEATERS[a]

EMISSION FACTOR RATING: E

Process	Pollutant		Emission Factor	
	CASRN	Name	kg/L	lb/gal
Hot oil heater fired with No.2 fuel oil (SCC 3-05-002-08)	83-32-9	Acenaphthene[b]	6.4×10^{-8}	5.3×10^{-7}
	208-96-8	Acenaphthylene[b]	2.4×10^{-8}	2.0×10^{-7}
	120-12-7	Anthracene[b]	2.2×10^{-8}	1.8×10^{-7}
	205-99-2	Benzo(b)fluoranthene[b]	1.2×10^{-8}	1.0×10^{-7}
	206-44-0	Fluoranthene[b]	5.3×10^{-9}	4.4×10^{-8}
	86-73-7	Fluorene[b]	3.8×10^{-9}	3.2×10^{-8}
	50-00-0	Formaldehyde	0.0032	0.027
	91-20-3	Naphthalene[b]	2.0×10^{-6}	1.7×10^{-5}
	85-01-8	Phenanthrene[b]	5.9×10^{-7}	4.9×10^{-6}
	129-00-0	Pyrene[b]	3.8×10^{-9}	3.2×10^{-8}
	19408-74-3	1,2,3,7,8,9-HxCDD	9.1×10^{-14}	7.6×10^{-13}
	39227-28-6	1,2,3,4,7,8-HxCDD	8.3×10^{-14}	6.9×10^{-13}
		HxCDD	7.4×10^{-13}	6.2×10^{-12}
	35822-46-9	1,2,3,4,6,7,8-HpCDD	1.8×10^{-12}	1.5×10^{-11}
		HpCDD	2.4×10^{-12}	2.0×10^{-11}
	3268-87-9	OCDD	1.9×10^{-11}	1.6×10^{-10}
		TCDF[b]	4.0×10^{-13}	3.3×10^{-12}
		PeCDF[b]	5.8×10^{-14}	4.8×10^{-13}
		HxCDF[b]	2.4×10^{-13}	2.0×10^{-12}
		HpCDF[b]	1.2×10^{-12}	9.7×10^{-12}
	67562-39-4	1,2,3,4,6,7,8-HpCDF	4.2×10^{-13}	3.5×10^{-12}
	39001-02-0	OCDF	1.4×10^{-12}	1.2×10^{-11}

[a] Reference 34. Factors are kg/L and lb/gal of fuel consumed. Table includes data from both parallel flow and counterflow drum mix dryers. Organic compound emissions from counterflow systems are expected to be less than from parallel flow systems, but available data are insufficient to quantify accurately the difference in these emissions. CASRN = Chemical Abstracts Service Registry Number. SCC = Source Classification Code.

[b] Compound is classified as polycyclic organic matter (POM), as defined in the 1990 Clean Air Act Amendments (CAAA).

Table 11.1-12 (Metric And English Units). EMISSION FACTORS FOR METAL EMISSIONS FROM BATCH MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D (except as noted)

Process	Pollutant	Emission Factor		Ref. Nos.
		kg/Mg	lb/ton	
Dryer (SCC 3-05-002-01)	Arsenic[b]	$3.3x10^{-7}$	$6.6x10^{-7}$	34,40
	Barium	$7.3x10^{-7}$	$1.5x10^{-6}$	24
	Beryllium[b]	$1.1x10^{-7}$	$2.2x10^{-7}$	34
	Cadmium	$4.2x10^{-7}$	$8.4x10^{-7}$	24,34
	Chromium	$4.5x10^{-7}$	$8.9x10^{-7}$	24
	Copper	$1.8x10^{-6}$	$3.7x10^{-6}$	24,34
	Hexavalent chromium[b]	$4.9x10^{-9}$	$9.7x10^{-9}$	34
	Lead	$3.7x10^{-7}$	$7.4x10^{-7}$	24,34
	Manganese	$5.0x10^{-6}$	$9.9x10^{-6}$	24,34
	Mercury	$2.3x10^{-7}$	$4.5x10^{-7}$	34
	Nickel	$2.1x10^{-6}$	$4.2x10^{-6}$	24,34
	Selenium[b]	$4.6x10^{-8}$	$9.2x10^{-8}$	34
	Zinc	$3.4x10^{-6}$	$6.8x10^{-6}$	24,34

[a] Factors are kg/Mg and lb/ton of hot mix asphalt produced. Emissions controlled by a fabric filter. SCC = Source Classification Code.
[b] EMISSION FACTOR RATING: E.

Table 11.1-13 (Metric And English Units). EMISSION FACTORS FOR METAL EMISSIONS FROM DRUM MIX HOT MIX ASPHALT PLANTS[a]

EMISSION FACTOR RATING: D

Process	Pollutant	Emission Factor		Ref. Nos.
		kg/Mg	lb/ton	
Dryer[b] (SCC 3-05-002-05)	Arsenic	$5.5x10^{-7}$	$1.1x10^{-6}$	25,35
	Barium	$2.4x10^{-6}$	$4.8x10^{-6}$	25
	Cadmium	$2.2x10^{-7}$	$4.4x10^{-7}$	25,35
	Chromium	$6.0x10^{-6}$	$1.2x10^{-5}$	25
	Copper	$3.1x10^{-6}$	$6.1x10^{-6}$	25
	Lead	$1.7x10^{-6}$	$3.3x10^{-6}$	25,35
	Manganese	$5.5x10^{-6}$	$1.1x10^{-5}$	25
	Mercury	$3.7x10^{-9}$	$7.3x10^{-9}$	35
	Nickel	$7.5x10^{-6}$	$1.5x10^{-5}$	25
	Phosphorus	$2.8x10^{-5}$	$5.5x10^{-5}$	25
	Silver	$7.0x10^{-7}$	$1.4x10^{-6}$	25
	Zinc	$2.1x10^{-5}$	$4.2x10^{-5}$	25,35

[a] Factors are kg/Mg and lb/ton of hot mix asphalt produced. Emissions controlled by a fabric filter. SCC = Source Classification Code.
[b] Feed material includes RAP.

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