Particulate Matter (PM) Emission Factors For Processes/Equipment at Asphalt, Cement, Concrete, and Aggregate Product Plants

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This document provides emission factors for estimating **total suspended particulate matter (PM) emissions (not PM_{10})** for **individual** emission source at aggregate (sand and gravel), brick and tile, hot mix asphalt, cement, concrete batch plants. These factors are also applicable to emission sources other than processes identified in recently adopted Rules 1156 and 1157.

The factors and equations are extracted from the US EPA AP-42 document. Some of the complex equations are simplified with either default settings or assumptions that are applicable to the conditions and operations existing in the South Coast Air Basin as shown in the Reference column of the attached table. Emission factors with an asterisk (*) are not published in the EPA AP-42. These emission factors are determined using the agreed control efficiencies that were established during rule development and also are listed in the Reference column.

Facility is encouraged to apply specific parameters that are applicable to its operations to calculate emissions from the equipment/processes including the results from approved source tests and efficiencies of the add-on control equipment. Supporting documents must be submitted with the annual emission report to show the use of such parameters or source test results in calculating annual emissions.

In the absence of specific parameters and/or source tests, facility can calculate its annual emissions using the factors provided in the attached table and the following equation.

$$E = TP \times EF$$

Where: E = Emission (tons/year)

TP = Annual Throughput

EF = Emission Factor

The unit for TP in this equation must be consistent with the unit of EF. For example, if EF is in pound per ton of material transferred (lbs. /ton), then TP must be tons of transferred material. For unique emission sources, additional data must be used in determining the factor (EF or TP) before it can be used in emission calculation as discussed in the following notes:

Note 1: For mining/quarrying, **emission factor** is expressed in pound per blast (lbs. /blast) for TSP (Total Suspended Particulate) ≤ 30 µm and is calculated as:

$$EF = 0.000014 \times A^{1.5}$$

Where: A = Total horizontal blasted area in squared foot (ft^2), provided that the blast depth is less than 70 ft. Not for vertical face of a bench.

Reference: EPA, AP-42, Table 11.9-1, July 1998

In this case, the throughput (TP) is number of blast per year.

Note 2: For road emissions (E) caused by vehicle traffic, the **throughput** is expressed in annual vehicle miles traveled (VMT) as follows:

$$\text{TP} = \text{VMT} = \text{Road Length} \times \left(\frac{\#\,\text{Truck Trips}}{\text{Day}}\right) \times \left(\frac{\#\,\text{Days}}{\text{Year}}\right) \times \left(\frac{1\text{Mile}}{5{,}280\text{ft}}\right)$$

Where: Road Length = One-way distance in feet (ft.) of paved or unpaved road within the facility, used by haul trucks and non-haul trucks.

Truck Trips = the number of roundtrips the vehicle made.

Definitions: Haul Road: an unpaved road used by haul trucks to carry materials from the quarry to different locations within the facility.

Non-Haul Road: unpaved and/or paved road used by non-haul trucks to carry materials from one location to another location within the facility, usually between the facility's entrance/exit to loading/unloading/processing areas.

Note 3: In addition to PM emissions, VOC emissions are also expected from asphalt product during loading out and silo filling operations. **Emission factor** (lbs. /ton of product loaded) is expressed in as follows:

ASPHALT LOAD-OUT (Drum Mix or Batch Mix Plant)

$$\text{EF}_{\text{PM}} = 0.000181 + 0.00141(-\text{V})e^{((0.0251)\times(T+460)-20.43)}$$
$$\text{EF}_{\text{VOC}} = 0.0172(-\text{V})e^{((0.0251)\times(T+460)-20.43)}$$

Reference: EPA, AP-42, Table 11.1-14, March 2004

SILO FILLING

$$\text{EF}_{\text{PM}} = 0.000332 + 0.00105(-\text{V})e^{((0.0251)\times(T+460)-20.43)}$$
$$\text{EF}_{\text{VOC}} = 0.0504(-\text{V})e^{((0.0251)\times(T+460)-20.43)}$$

Reference: EPA, AP-42, Table 11.1-14, March 2004

Where: V = Asphalt Volatility (in negative %); (Default: -0.5%)

T = Asphalt Product Mix Temperature (degree F); (Default: 325 ºF)

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Operation/Emission Sources	Emission Factor UNCONTROLLED	 *CONTROLLED*	Unit	References And Assumptions
ROAD EMISSIONS FROM VEHICLE TRAFFIC • **PAVED ROAD** $E = VMT \times k \times (sL)^a \times (W)^b$ Where: E = PM emissions TP = VMT = annual vehicle mile traveled (see **Note 2**) $EF = k \times (sL)^a \times (W)^b$ k = particle size multiplier a, b = constants sL = road surface silt loading (g/m^2) W = average weight (tons) of the vehicle	**Aggregate / Crushed Material Plants** EF = 7.56 **Hot Mix Asphalt Plants** EF = 10.49 **Concrete Batching** EF = 2.18 **Cement/Other Plants** EF = 1.81	*EF = 1.51** *EF = 2.10** *EF = 0.44** *EF = 0.36**	lb/VMT lb/VMT lb/VMT lb/VMT	AP-42, Jan 2011 Chapter13.2.1.3, Equation 1 Assumptions: k = 0.011, a = 0.91, b = 1.02 W_{Loaded} = 30 tons $W_{Unloaded}$ = 5 tons $W_{Unloaded\ for\ concrete\ Batching}$ = 12 tons Aggregate / Crushed Material sL = 53 g/m^2 [Table 13.2.1-3] Hot Mix Asphalt sL = 76 g/m^2 [Table 13.2.1-3] Cement / Concrete / Others sL = 11 g/m^2 [Table 13.2.1-3] Control Efficiency for chemical stabilizer = 80%

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Operation/Emission Sources	Emission Factor UNCONTROLLED	<u>*CONTROLLED*</u>	Unit	References And Assumptions
• **UNPAVED ROAD** $E = VMT \times k \times \left(\frac{S}{12}\right)^a \times \left(\frac{W}{3}\right)^b$ Where: E = PM emissions TP = VMT = annual vehicle mile traveled (see **Note 2**) $EF = k \times \left(\frac{S}{12}\right)^a \times \left(\frac{W}{3}\right)^b$ k = particle size multiplier a, b = constants S = surface material silt content (%) W = average weight (tons) of the vehicle	**Aggregate Plants** HAUL VEHICLE EF = 16.82 NON-HAUL VEHICLE EF = 9.54 **Other Plant** HAUL VEHICLE EF = 15.08 NON-HAUL VEHICLE EF = 5.71	<u>*EF = 3.36**</u> <u>*EF = 1.91**</u> <u>*EF = 3.02**</u> <u>*EF =1.14**</u>	lb/VMT lb/VMT lb/VMT lb/VMT	AP-42, Nov 2006 Assumptions: [Table 13.2.2-2] k = 4.9, a = 0.7, b = 0.45 HAUL W_{Loaded} = 120 tons $W_{Unloaded}$ = 45 tons $S_{Aggregate}$ = 8.3% [Table 13.2.2-1] S_{Others} = 7.1% [Table 13.2.2-1] NON-HAUL W_{Loaded} = 30 tons $W_{Unloaded}$ = 5 tons $S_{Aggregate}$ = 10% [Table 13.2.2-1] S_{Others} = 4.8 % [Table 13.2.2-1] Control Efficiency for chemical stabilizer = 80%

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Operation/Emission Sources	Emission Factor UNCONTROLLED	 *CONTROLLED*	Unit	References And Assumptions
OPEN STORAGE PILE TP = annual tonnage of material stored Emissions include wind erosion, vehicle traffic in vicinity of storage piles, and material handling	Active EF = 0.42 Inactive EF = 0.11 Active/Inactive EF = 0.33	*EF = 0.042** *EF = 0.011** *EF = 0.033**	lb/ton lb /ton lb/ton	AP-42, Chapter 11.19.1, Sand and Gravel Processing Final Report, Table 4-1, April 1995 Control Efficiency = 90% (page 2-13)
MINING/QUARRYING • **DRILLING** TP = number of hole drilled	EF = 1.3		lb/hole	AP-42, July 1998 Chapter 11.9, Table 11.9-4
• **BLASTING** (see **Note 1**) TP = number of blast	EF = 0.000014 (A) $^{1.5}$ for TSP ≤ 30 µm		lb /blast	Chapter 11.9, Table 11.9-1

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Operation/Emission Sources	Emission Factor UNCONTROLLED	 *CONTROLLED*	Unit	References And Assumptions
LOADING / UNLOADING				
• **CONVEYOR TRANSFER POINT** For a system of multiple transfer points, this EF must be multiplied by the number of transfer points (where materials drop from one point to another). Refer to Rule 1157 definition for more detail.	**Aggregate/Crushed Miscellaneous Base/ Asphalt Plants**			AP-42, Aug 2004 Chapter 11.19.2, Table 11.19.2-2
	EF = 0.003	*EF = 0.00014*	lb /ton	(controlled by wet suppression)
	Concrete Batching and Others			AP-42, June 2006 Chapter 11.12, Table 11.12-2
	SAND:			
	EF = 0.0021	*EF = 0.00011**	lb /ton	Control Efficiency = 95%
	AGGREGATE:			
	EF = 0.0069	*EF = 0.00035**	lb /ton	AP-42, June 2006 Chapter 11.12, Table 11.12-2 Control Efficiency = 95%
• **WEIGHT HOPPER / SURGE BIN**				Chapter 11.12, Table 11.12-2
	EF = 0.0048	*EF = 0.00024**	lb /ton	AP-42, June 2006 Chapter 11.12, Table 11.12-2 Control Efficiency = 95%
• **SILOS**				
Cement	EF = 0.73	*EF = 0.00099*	lb/ton	Chapter 11.12, Table 11.12-2
Cement Supplements (Fly Ash)	EF = 3.14	*EF = 0.0089*	lb /ton	

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• **CONCRETE LOADING (Truck Mix)**	EF = 1.118	<u>*EF = 0.098*</u>	lb /ton	Chapter 11.12, Table 11.12-2
• **CONCRETE LOADING (Central Mix)**	EF = 0.572	<u>*EF = 0.0184*</u>	lb /ton	Chapter 11.12, Table 11.12-2
• **ASPHALT PRODUCTS LOAD OUT** (see **Note 3)**	**PM:** <u>*EF = 0.00052*</u> Organic PM (for TAC estimates): EF: <u>0.00034</u> **VOC:** <u>*EF = 0.0042*</u>		lb /ton lb /ton lb /ton	Chapter 11.1, Table 11.1-14 V=-0.5, T=325 º F **TAC emissions should be estimated using AP-42, 3/2004 Tables 11.1-15 and 11.1-16**
• **ASPHALT SILO FILLING** (see **Note 3)**	**PM:** <u>*EF = 0.00059*</u> Organic PM (for TAC estimates): EF: <u>0.00025</u> **VOC:** <u>*EF = 0.0122*</u>		lb /ton lb /ton lb /ton	Chapter 11.1, Table 11.1-14 V=-0.5, T=325 º F **TAC emissions should be estimated using AP-42, 3/2004 Tables 11.1-15 and 11.1-16**

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Operation/Emission Sources	Emission Factor		Unit	References And Assumptions
	UNCONTROLLED	*CONTROLLED*		
CRUSHING				AP-42, Jan 1995
• **SECONDARY SCREENING and Crushing**	EF = 0.014*	*EF = 0.00031*	lb/ton	Chapter 11.6, Table 11.6-4 (controlled by fabric filter)
				AP-42, Aug 2004
• **TERTIARY CRUSHER**	EF = 0.0054	*EF = 0.0012*	lb /ton	Control Efficiency = 97.8%
				Chapter 11.19.2, Table 11.19.2-2 (controlled by wet suppression)
• **FINE CRUSHER**	EF = 0.039	*EF = 0.003*	lb /ton	Chapter 11.19.2, Table 11.19.2-2 (controlled by wet suppression)
SCREENING				AP-42, Aug 2004
• **COARSE**	EF = 0.025	*EF = 0.0022*	lb /ton	Chapter 11.19.2, Table 11.19.2-2 (controlled by wet suppression)
• **FINE**	EF = 0.30	*EF = 0.0036*	lb /ton	Chapter 11.19.2, Table 11.19.2-2 (controlled by wet suppression)
• **SAND**	EF = 0.21*	*EF = 0.0083*	lb /ton	AP-42, Nov 1995 Chapter 11.19.1, Table 11.19.1-1 (controlled by venturi scrubber) Control Efficiency = 96.1%

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Operation/Emission Sources	Emission Factor		Unit	References And Assumptions
	UNCONTROLLED	*CONTROLLED*		
GRINDING	EF = 8.5	*EF = 0.0062*	lb/ton	AP-42, Aug 1997 Chapter 11.3, Table 11.3-2 (controlled by fabric filter)
CEMENT MILLING				
• Raw Mill	EF = 1.2*	*EF = 0.012*	lb/ton	AP-42, Jan 1995
• Finish Grinding Mill	EF = 0.8*	*EF = 0.008*	lb/ton	Chapter 11.6, Table 11.6-4 (controlled by fabric filter) Control Efficiency = 99%
OTHER PROCESS/EQUIPMENT				
• **DRYER**				AP-42, Nov 1995
SAND and GRAVEL	EF = 2.0	*EF = 0.039*	lb /ton	Chapter 11.19.1, Table 11.19.1-1 (controlled by wet scrubber)
BATCH MIX ASPHALT	EF = 32	*EF = 0.042*	lb /ton	AP-42, Mar 2004 Chapter 11.1, Table 11.1-1 (controlled by fabric filter)
DRUM MIX ASPHALT	EF = 28	*EF = 0.033*	lb /ton	Chapter 11.1, Table 11.1-3 (controlled by fabric filter)
BRICK MANUFACTURING	EF = 0.187		lb /ton	Chapter 11.3., Table 11.3-1

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Operation/Emission Sources	Emission Factor UNCONTROLLED	 *CONTROLLED*	Unit	References And Assumptions
KILNS				
• BRICK (natural gas fueled)	EF = 0.96		lb/ton	AP-42, Aug 1997 Chapter 11.3., Table 11.3-1
• CEMENT, DRY PROCESS	EF = 109*	*EF = 1.09*	lb/ton	Chapter 11.6, Table 11.6-2
• CLINKER COOLER	EF = 14.7 *	*EF = 0.147*	lb/ton	(controlled by fabric filter) Chapter 11.6, Table 11.6-2 (controlled by fabric filter) Control Efficiency = 99%