HAUL ROAD EMISSIONS

Date Initiated:

October 5, 1998

Dates Modified / Updated:

November 2, 2021
January 6, 2022
November 28, 2022
December 2023

1.0 INTRODUCTION:

A haul road is a road or a route used by trucks and other vehicles to move raw materials, final products, waste and other production-related materials into, within, or out of the facility. On site vehicle traffic can produce a significant amount of particulate emissions for several types of industries. The presence of trace metals in haul roads emissions is reported in both literature and site-specific source testing. When calculating emissions from haul roads, it is important to distinguish between paved and unpaved roads, since a paved road (concrete or asphalt) will have different physical characteristics than an unpaved (dirt or gravel) road. While present in both paved and unpaved roads activities, particulate emissions are produced due to direct emissions or fugitive emissions from resuspension of particulates and calculated, differently, for each. The following sections provide a brief discussion of each type, as well as the emission estimation techniques and emission factors, currently used by the San Diego Air Pollution Control District (the District).

2.0 Paved Haul Roads:

2.1 Sources of Emissions in Paved Haul Roads:

Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and resuspension of loose material on the road surface. Resuspended particulate emissions from paved roads originate from, and result in the depletion of, loose material present on the surface (i.e., the surface loading). In turn, that surface loading is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and track-out from unpaved roads and staging areas or wind driven dust. In the absence of continuous addition of fresh material, paved road surface loading usually reaches an equilibrium value in which the amount of material resuspended matches the amount replenished. Because of the importance of the surface loading, available control techniques either attempt to prevent material from being deposited on the surface or to remove (from the travel lanes) any material that has been deposited[1].

2.2 Emission Estimation for Paved Haul Roads:

In general, the road particulate emissions are proportional to the number of vehicle miles traveled, road surface silt conditions, the average vehicles weight of vehicles traveling the road and precipitation.

[1] https://www.epa.gov/sites/default/files/2020-10/documents/13.2.1_paved_roads.pdf

For the purposes of determining haul road emissions, silt is defined as particles equal to or less than 75 micrometers (µm) in physical diameter. Silt loading is defined in AP-42 as "the mass of silt-size material per unit area of travel surface" and is used as a measurement of how much dust is on the road. Silt content represents the proportion of the loose dry surface dust on a road that passes through a 200-mesh screen and is measured using the ASTM-C-136 test method. The surface silt loading provides a reasonable means of characterizing seasonal variability in a paved road emission inventory.[2]

The District's calculation methodology is based on paved roads emissions from resuspension of loose material on the road surface due to vehicle travel; on the United States Environmental Protection Agency (USEPA) Compilation of Air Pollutant Emission Factors, 5th Edition, Volume 1 (AP-42) Chapter 13 – Miscellaneous Sources, Sections 13.2.1 (Paved Roads, revised January 2011)[2]. The following derived empirical equation is used to evaluate the annual particulate emissions of paved road:

$$E_a = (VMT) * [(k) * (sL)^{0.91} * (W)^{1.02} * (1 - \frac{P}{4N})] * (C_i) * (1 - e)$$

$$E_h = \frac{E_a}{(D_a * H)}$$

Where:

E_a = Annual emissions of each contaminant, (lbs/year)

E_h = Maximum hourly emissions of each contaminant, (lbs/hour)

VMT = Vehicle miles traveled on site, (miles/year)

VMT = (Amount Hauled/(Average vehicle weight full – Average vehicle weight empty))

k = Particle size multiplier, (lbs/VMT)

sL = Paved haul road surface silt loading, (in g/m^2). Note: 33.9 g/m^2 = 1 oz/yd^2

W = Average vehicle weight, (tons)

P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period, in the lack of site-specific data, default value of 40 days, as reflected in AP-42, figure 13.2.1-2, will be used.

N = number of days in the averaging period (365 for annual or 8760 hours)

C_i = Concentration of each listed substance in the haul road dust, (lbs/lb)

D_a = Active days during reporting period, (days/year)

H = Hours of operation, (hours/day)

e = Control efficiency, if applicable, (%)

Note: the District has adopted the application of the AP- 42 precipitation correction term to (1-(P/4N)) to account for average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual (or other long-term) average emissions are inversely proportional to the frequency of measurable (> 0.254 mm [0.01 inch]) precipitation. The precipitation correction term can be applied on a daily or an hourly basis. Control efficiencies can be granted for the use of surfactants if proper documentation is provided and approved by the District.

The following table summarizes the default values used by the District for some of the Equation's variables:

TABLE (1): DEFAULT VALUES - PAVED HAUL ROADS

Variable	Variable Description	Default Values and Ranges
k	PM-30 Particle size multiplier (lbs/VMT)	0.011 (PM-30, from AP-42 Table 13.2.1-1)
k	PM-10 Particle size multiplier (lbs/VMT)	0.0022 (PM-10, from AP-42 Table 13.2.1-1)
sL	Road surface silt loading	13.6 g/m2 (Usually 7 to 70, Note: this default Median value of District test data (Table.2) will be used as default, unless the site provided site specific ST data or requested the use of AP-42 default values)
sL	Road surface silt loading	0.40 oz./yd2 (typical range is 0.21 to 2.1, Note: this default Median value of District test data (Table.2) will be used as default, unless the site provided site specific ST data or requested the use of AP-42 default values)
e	Control Efficiency	95% for watering at 2-hr intervals. 90% for watering at 4-hr intervals.
e	Control Efficiency	80% for watering at unknown frequency.
e	Control Efficiency	0% (if sweeping only, note: sweeping is accounted for in the site specific sL)

Table (2): SUMMARY OF DISTRICT'S HAUL ROADS SAMPLES

COMPANY NAME	UNPAVED ROAD SILT PERCENTAGE (% -200 MESH)	PAVED ROAD SILT LOADING (OZ/SQ YD)
Nelson & Sloan, Lakeside	0.104	0.19
Nelson & Sloan, Birch	0.057	NA
Nelson & Sloan, Otay	0.107	0.459
South Coast Matis., Carlsbad	0.055	0.224
Wyroc, Vista	0.098	0.251
Sim J. Harris, Miramar	0.06	0.386
V.R. Dennis, Mission Gorge	0.068	2.866
Asphalt Inc., Lakeside	0.144	0.521
East County Materials, Hester's Granite Pit	0.104	NA
H.G. Fenton, Carroll Canyon	0.08	0.172
H.G. Fenton, Mission Valley	0.092	0.634
CCAC, Carroll Canyon	0.071	0.283
H.G. Fenton, Pala	0.148	NA
Nelson & Sloan, San Marcos	0.135	NA
R.E. Hazard, Carroll Canyon	0.139	1.332
Superior Ready Mix, Mission Gorge	0.072	0.712
South Coast Matis., Escondido	0.142	2.347

3.0 Unpaved Roads:

3.1 Sources of Emissions in Unpaved Haul Roads:

When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.[2] Emissions caused by hauling can be minimized by paving, windbreaks, frequent water and/or environmentally friendly chemical applications, and using gravel as a means of dust suppression.[5]

3.2 Emission Estimation for Unpaved Haul Roads:

The particulate emissions of concern from unpaved roads are particulate matter (PM) including PM less than 10 microns in aerodynamic diameter (PM-10) and PM less than 2.5 microns in aerodynamic diameter (PM-2.5). The quantity of dust emissions from a given segment of unpaved road varies with the volume of traffic, the condition of the road, the number of vehicles passes, the vehicle characteristics (e.g. vehicle weight, speed and number of wheels), the properties of the road surface material being disturbed (e.g. silt content, moisture content), and the climatic conditions (e.g., frequency and amounts of precipitation). Dust emissions from unpaved roads have been found to vary directly with the fraction of silt in the road surface material[3].

The District bases its calculation methodology of unpaved roads emissions from resuspension of loose material on the road surface due to vehicle travel; on the United States Environmental Protection Agency (USEPA) Compilation of Air Pollutant Emission Factors, 5th Edition, Volume 1 (AP-42) Chapter 13 – Miscellaneous Sources, 13.2.2 (Unpaved Roads, revised January 1995)[4]. The following derived empirical equation is used to evaluate the annual particulate emissions of unpaved road:

$$E_a = (VMT) * [(k) * (5.9) * (\frac{s}{12}) * (\frac{S}{30}) * (\frac{W}{3})^{0.7} * (\frac{w}{4})^{0.5} * (\frac{(365 - p)}{365})] * (C_i) * (1 - e)$$

$$E_h = \frac{E_a}{(D_a * H)}$$

Where:
E_a = Annual emissions of each contaminant, (lbs/year)
E_h = Maximum hourly emissions of each contaminant, (lbs/hour)
VMT = Vehicle miles traveled on site, (miles/year)
k = Particle size multiplier, (dimensionless)
s = Unpaved haul road surface material silt content, (weight %)
S = Mean vehicle speed, (miles/hour)
W = Mean vehicle weight, (tons)
w = Number of vehicle wheels, (dimensionless)
p = Days with precipitation, (days/year).
C_i = Concentration of each listed substance in the haul road dust, (lbs/lb)

[2] https://www.epa.gov/sites/default/files/2020-10/documents/13.2.2_unpaved_roads.pdf
[3] https://www.epa.gov/sites/default/files/2020-10/documents/ap-42_13.2.2_background_report_unpaved_roads.pdf
[4] https://www.epa.gov/sites/default/files/2020-10/documents/ap-42_13.2.2_background_report_unpaved_roads.pdf

D_a = Active days during reporting period, (days/year)
H = Hours of operation, (hours/day)
e = Control efficiency, if applicable, (%)

The following table summarizes the default values used by the District for some of the Equation's variables:

TABLE (3): DEFAULT VALUES - UNPAVED HAUL ROADS

Variable	Variable Description	Default Values and Ranges
k	PM-30 Particle size multiplier (lbs/VMT)	0.80 (PM-30, from AP-42 Section 13.2.2)
k	PM-10 Particle size multiplier (lbs/VMT)	0.36 (PM-10, from AP-42 Section 13.2.2)
s	Surface material silt content	15% (Usually 4 to 20, test data), Note: the District will use this default value, unless the site provided site specific ST data or requested the use of AP-42 default values.
p	Annual precipitation >0.01 in.	40 days/year for San Diego County
e	Control Efficiency	95% for watering at 2-hr intervals. 90% for watering at 4-hr intervals.
e	Control Efficiency	80% for watering at unknown frequency.

3.0 Trace Metals Emissions in Haul Roade:

Haul road dust that is generated will contain several trace metals at Parts Per Million by Weight (PPMW) levels[5]. Default trace metal concentrations for San Diego County have been developed by analyzing multiple haul road silt samples taken from several mineral products industry sites. Typical haul road trace metal dust concentrations for San Diego County are as follows:

TABLE 3. HAUL ROAD DUST TRACE METAL CONCENTRATIONS

Trace Metals	Range Detected in SD County (ppmw)	Suggested Default Value
Arsenic	1 to 50	20
Beryllium	0.5 to 2	1
Cadmium	1 to 1.5	1
Chromium (total)	5 to 60	50
Copper	20 to 650	100
Lead	5 to 120	50
Manganese	200 to 1200	500
Mercury	0 to 10	5
Nickel	3 to 25	20
Selenium	3 to 5	5
Silica (crystalline)	10% to 75%	10%
Zinc	30 to 300	200
Asbestos	Not Detected	0

4.0 EMISSIONS INFORMATION:

Haul road particulate emissions are nearly impossible to quantify through source testing

[5] Reference: Pagotto C, Rémy N, Legret M, Le Cloirec P. Heavy metal pollution of road dust and roadside soil near a major rural highway. Environ Technol. 2001 Mar;22(3):307-19. doi: 10.1080/09593332208618280. PMID: 11346288.

procedures. EPA and its contractors appear to have developed an empirical procedure to estimate emissions and then 'fitted' critical variables to the predicted curve. Theoretically, this procedure is applicable to both low speed plant haul roads and high speed freeways. Typical controlled emission rates for plant haul roads range from 0.5 to 2.5 lbs PM10 / vehicle mile traveled. Higher estimates usually fail to account for control efficiencies associated with wetting the road surface. Lower estimates usually indicate an underestimated silt loading value for the facility's on-site haul road. It is often more difficult to obtain accurate information regarding vehicle types, weights, haul road lengths, and number of trips than it is to decide upon representative emission estimation technique default variables.

5.0 ASSUMPTIONS / LIMITATIONS:

- Use site specific test data instead of default values as appropriate. Default values should be used where site specific data is highly questionable.
- No additional control efficiency should be granted for activities which are already accounted for by the silt loading value (i.e.; sweeping, etc.).
- While the use of mean vehicle weights and speeds may be acceptable for freeway estimates, these values tend to highly distort the quantification of emissions from facility haul roads. Haul road information should be collected and processed separately for each distinct vehicle type and function.
- The total number of vehicle trips and associated carrying capacities should coincide with the reported material imports and exports.
- Vehicle exhaust pipe emissions are not quantified by this procedure. An accurate estimate of tail pipe emissions depends upon representative fuel combustion emission factors for the vehicles and fuels used. These emissions must be quantified separately from haul road dust.
- Some District emission estimation techniques already include miscellaneous vehicular traffic in the default particulate emission factors. Care should be taken not to "double count or omit" on-site vehicles.
- The Office of Environmental Health Hazard Assessment (OEHHA) has adopted a chronic reference exposure level (REL) for respirable crystalline silica, cristobalite (CAS 14464-46-1) and quartz (CAS 14808-60-7). The REL is based on the PM4 fraction of crystalline silica which is expected to have associated health risks. The District has chosen to implement a health protective value of 7.95% default PM4 to PM10 ratio from published data[1] in order to more accurately estimate the health risks associated with respirable crystalline silica. If available, the District recommends using District approved site-specific data to refine the PM4 to PM10 ratio. The District's current default crystalline silica emission factor is based on local test results, which is 10% of the PM10 default emission factor. The PM4 to PM10 ratio can be accurately applied to the crystalline silica default emission factor since the test results were sized to -10 micron which was used to represent the average composition of PM10. Both crystalline silica as PM10 and respirable crystalline silica as PM4 should be estimated

[1] Richards, J. R., Brozell, T., Rea, C. E., Boraston, G., & Hayden, J. (2009). PM_4 Crystalline Silica Emission Factors and Ambient Concentrations at Aggregate-Producing Sources in California. Journal of the Air & Waste Management Association, 59(11), 1287–1295. https://doi.org/10.3155/1047-3289.59.11.128