

CREMATORY & INCINERATOR OPERATIONS

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1. PROCESS DESCRIPTION:

Natural gas fired crematories and incinerators that combust human remains, animal remains, refuse, agricultural products, or medical waste are sources of carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), volatile organic compounds (VOCs), sulfur oxides (SO_x) and trace toxic substances. Incinerators used for cremation purposes are called "retorts" and the remains are referred to as "charges". Emissions of trace toxic substances may include hydrogen chloride, formaldehyde, benzene, toluene, mercury, hexavalent chromium, PAH's, and other organic gases or heavy metals.

Incinerators typically have a primary burner in the main chamber and a secondary burner/afterburner in the flue stack. Most permits include periodic particulate matter source testing requirements.

Emissions from these processes are highly dependent upon equipment type, control devices, operating conditions, fuel type, process time, charge material composition and operator experience. While default emission factors have been compiled from a variety of EPA reference and other sources for each type of operation, more representative test results should be used to estimate emissions when available.

For both crematories and incinerators, emission factors for NO_x, CO, SO_x, total organic gases or total organic compounds (TOG or TOC), and VOC were based on fuel usage and assumed to be equivalent to a small, uncontrolled, commercial boiler (AP-42 Section 1.4)^{1,2} and its units were converted into units of lbs pollutant/million standard cubic feet (scf) of gaseous fuel burned.

References used to develop default emission factor estimates are:

- Section 1.4 of AP-42 (07/98) from EPA¹
- Sections 2.1 and 2.3 of AP-42 (10/96) from EPA²
- VOC Speciation Profile #1167 (1/90) from EPA³, is Used for TAC,

¹ <https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf>

² https://gaftp.epa.gov/ap42/ch01/s04/final/c01s04_oct1996.pdf

³ <https://nepis.epa.gov/Exec/ZyPDF.cgi/00001VFS.PDF?Dockey=00001VFS.PDF>

- PM Speciation Profile #42320 (1/90) from EPA⁴,
- AB2588 crematory stack testing results from UCSD (1990),
- California Air Toxics Emission Factors from ARB (2000)⁵, and
- CA Air Districts Collective Source Tests for Mercury Emission Factors, see section 2.1

Emission factors for NO_x, CO, SO_x, TOG (TOC), and VOC have been converted into units of lbs pollutant /million scf fuel burned since these emissions are assumed to be most directly associated with fuel usage. Emission factors for total solid particulates (TSP), particulate matter with diameter of 10 micros or smaller (PM10), and trace toxic substances have been converted into units of lbs pollutant / ton charged since these emissions are assumed to be most directly associated with the combusted materials. Emission factor for Mercury is generally due to amalgam in tooth fillings and given in lbs pollutant/charge since these emissions are released per fillings in a charge and not based on ton charged.

District emission estimation techniques for crematory operations are as follows:

$$Ea = Ua \times EF$$

$$Eh = Uh \times EF$$

Where:

Ea = Annual emissions of each listed substance, (lbs/yr)

Eh = Maximum hourly emissions of each listed substance, (lbs/hr)

Ua = Annual charge weight or annual fuel usage, (tons charged/yr, # of charges/yr or mmscf natural gas/yr)

Uh = Max. hourly charge rate or max. hourly fuel usage, (lbs charged/hr, # of charges/hr or mmscf natural gas/hr)

EF = Emission factors for each listed substance, (lbs /ton charged, lb/charge or lbs/mmscf natural gas)

2. EMISSIONS INFORMATION:

The District emission standard for crematories is 0.3 grains/dry standard cubic feet (dscf) @ 12% CO₂⁶, which equates to ~6.5 lbs PM/ton charged. Source tests of newly designed / installed multiple chamber incinerators indicate emissions of ~1/2 the maximum allowable rate. Test results from older equipment in use throughout San Diego County are usually much closer to the limit. A default value of 6.5 lbs PM/ton charged will be used to estimate particulate emissions where site specific emission rates are not provided.

⁴ <https://nepis.epa.gov/Exe/ZyPDF.cgi/00001VZ6.PDF?Dockey=00001VZ6.PDF>

⁵ https://www.arb.ca.gov/app/emsinv/catef_form.html

⁶ [District's Rule 53. Specific Air Contaminants](#)

CO, NO_x, SO_x, TOG (TOC), and VOC emissions are believed to be most accurately estimated with fuel usage data and AP-42 small boiler emission factors. These emissions are assumed to be most closely associated with the fuel usage even though EPA factors provided in AP-42 are reported by charge weight. Since charges have highly variable compositions and process times, the AP-42 values are not used, and the small boiler (external combustion) factors were used as defaults.

Extensive AB2588 source testing was performed by ARB in Sacramento during 1990 to identify toxic air contaminant emission rates from crematories. These test results are supported by local AB2588 results from the UCSD Medical Center and Bonner Hall incinerators / crematories. Trace amounts of several listed substances were detected in the exhaust stack including benzene, toluene, xylenes, formaldehyde, hydrogen chloride, hydrogen fluoride, mercury, arsenic, chromium, and lead.

The district has currently adopted three sets of VOC and toxic air contaminants (TACs) for three types of specialized incinerators: Refuse Incinerators, Medical waste Incinerators, and Agricultural Products Incinerators. While toxic emission factors for refuse incinerators are based on Section 2.1 of AP-42 (10/96), those of Medical Waste incinerators are based on uncontrolled emissions data in Section 2.3 of AP-42 (7/93 Reformatted 1/95). For both types, using district approved site-specific emission factors when available is encouraged. Toxic emission factors for Agricultural Products Incinerators are based on EPA PM Speciation Profile-42320 and its VOCs Speciation is based on wood combustion EPA VOC Speciation Profile-1167. No methane value was identified in profile-1167, therefore Compound values are assumed to be based on lbs pollutant/lb VOC.

2.1 Mercury Emissions:

In the environment, mercury exists in three forms: metallic (elemental) mercury, inorganic compounds, and organic compounds; and all are toxic⁷. Human Cremation can contribute a significant amount of elemental mercury as a component of dental amalgam, as it comprises approximately 50% of the amalgam mixture⁷.

When individuals with amalgam fillings are cremated; the temperature of cremation far exceeds the boiling point of mercury, so nearly all the mercury present in the teeth of a cremated body will vaporize and be released to the atmosphere⁸. Also due to the high temperatures present in the crematories primary chamber, almost all the mercury is released in the first hour of cremation. The source tests conducted in Cypress View-San Diego revealed that the amount of Mercury emitted by the end of a 60-minute run was similar to that emitted by the end of a 120 minutes run. Exposure to high concentrations of elemental mercury vapor, such as for workers in occupational settings, may lead to adverse health effects⁹.

Human remains mercury emission factor adopted by the District is an average of the more recent source tests conducted in: San Diego Air Pollution Control District (SDAPCD) and Bay Area Air Quality Management District (BAAQMD) as seen in Table (1). Some studies suggest that mercury emissions associated with cremation will decrease over time as there is an increased use

⁷ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7728964/#CR37>

⁸ United States. Department of Health and Human Services. Committee to Coordinate Environmental Health and Related Programs. Subcommittee on Risk Management · 1993

⁹ <https://www.epa.gov/mercury/health-effects-exposures-mercury>

of alternative, non-mercury amalgam. In order to account for this decrease, the District will continue to review recent source tests and update the mercury emission factor, as appropriate.

Table (1) Mercury Emissions Factor

Air District	Facility Name	City	Date of Test	Average Mercury Emissions (lb/body)
BAAQMD	Irvington Memorial Crematory	Fremont	2/9/2007	0.00424
BAAQMD	SE Combined Services of California	Oakland	12/4/2017 to 12/7/2017	0.00318
BAAQMD	Catholic Cremation Services	Hayward	3/31/2009	0.00308
BAAQMD	Evergreen Cemetery	Oakland	9/10/2014	0.00009
SDAPCD	Cypress View	San Diego	11/04/2021	0.00032
Average Approved EF				0.00218

3.0 ASSUMPTIONS / LIMITATIONS:

- Cardboard shrouds may be used during cremation, including cremations that are source tested. The chemical composition of other shrouding materials should be considered when applying these emission factors to individual facilities. The use of plastic and wood containers could result in different emission factors.
- Emission factors based on crematorium source testing should not be used for incinerators charged with refuse, medical waste, plastics, trash, contraband, hazardous waste, or other materials not consistent with human / animal remains. Emission factors for specialized incinerators are best developed from site specific testing.
- TAC Emissions are assumed to vaporize at the incinerator temperature equivalent to the corresponding emission factor. Therefore, TAC emissions are assumed to be released within one hour.