BULK GASOLINE STORAGE TANKS

Date Initiated:

August 10, 1998

Dates Modified / Updated:

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PROCESS DESCRIPTION:

Gasoline bulk storage tanks release ROG vapors containing listed substances into the atmosphere. The majority of emissions can be categorized as bulk storage tank fitting losses, rim seal losses, working losses, deck seam losses, degassing releases, and refilling losses. Emission rates are highly dependent upon the storage tank size, construction, and design as well as annual fuel throughput. Most bulk gasoline storage tanks in San Diego County are equipped with either internal or external floating roofs. Fixed roof tanks are best quantified with the standard gasoline dispensing and storage procedures which can be modified to apply to any individual site's equipment and procedures.

The primary components of the gasoline emissions are benzene, hexane, toluene, xylenes, and a mixture of other nonmethane hydrocarbons. Additional emissions occur at the bulk terminal loading racks and vapor processing units which are quantified separately from the bulk tanks.

Emission estimation techniques for the bulk storage tanks are based upon procedures published by the EPA (AP-42, Section 7.1, (9/97). Additional equipment and emission speciation information was obtained from the San Diego APCD permit files and CAPCOA publications. District estimation techniques for emission inventory purposes are as follows:

Overall Emissions: Overall bulk storage tank emissions are the sum of rim seal, deck fitting, working, deck seam, degassing, and refilling losses. Individual compounds are quantified using a standard vapor speciation profile for reformulated / oxygenated gasoline;

Ea = (Lr + Lwd + Lf + Ld + Ldg + Lrf) x Ci

Eh = Ea / H

Where:

Ea = Annual gasoline emissions, lbs/year

Eh = Maximum hourly gasoline emissions, lbs/hour

Lr = Rim seal losses, lbs/year

Lwd = Withdrawal losses, lbs/year

Lf = Deck fitting losses, lbs/year

Ld = Deck seam losses, lbs/year

Ldg = Degassing emissions, lbs/year

Lrf = Refilling emissions, lbs/year

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

Calculation of emissions from each of the contributing processes listed above depends upon several somewhat complex estimation procedures which must be performed for each individual storage tank. These specific calculation procedures are also from AP-42;

Rim Seal Losses: Emissions from the rim seals around the edges of the bulk storage tank floating roof depend primarily upon the diameter of the tank (i.e.; length of seal), the type of seal, and the type of roof (internal or external). An empirical procedure is provided in AP-42 to calculate these emissions along with 'seal factors' necessary to fit the data.

Lr = (KRa + (KRb x V^n)) x D x Mv x Kc x P* x Ci

Where:

Lr = Rim seal losses, lbs/year

KRa = Zero wind speed rim seal loss factor, lb-mole/ft yr, (Table 7.1-8)

KRb = Wind speed dependent rim seal loss factor, lb-mole/(mph)^n ft yr, (Table 7.1-8)

V = Average ambient wind speed at tank site, mph, (Table 7.1-9)

= 6.9 mph for San Diego County

n = Seal related wind speed exponent, dimensionless, (Table 7.1-8)

D = Tank diameter, ft

Mv = Average vapor molecular weight, lbs/lb-mole

= 66.0 for gasoline vapor RVP 10

K_c = Product factor

= 0.4 for crude oil

= 1.0 for all other organic liquids

P* = Vapor pressure function, dimensionless

= $(P_{va} / P_a) / [1 + (1 - (P_{va} / P_a)^{0.5})^2]$

= 0.122 for gasoline bulk storage in San Diego County

P_{va} = Vapor pressure at daily average liquid surface temperature, psia, (Table 7.1-2)

= 5.7 for Gasoline RVP 10 at 65 F

P_a = Atmospheric pressure, psia

= 14.7 psia at sea level

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

Withdrawal Losses: Emissions caused by the withdrawal of gasoline from the bulk storage tanks consist primarily of liquid fuel remaining on the exposed interior wall surface after the lowering of the floating roof. The emission rate depends upon the storage tank dimensions (exposed surface area per gallon of fuel withdrawn) and the interior wall condition (shell clinkage factor). An estimation procedure is provided in AP-42 to calculate these emissions along with representative 'clinkage factors' necessary to predict the amount of fuel retained on the wall surface.

$$Lwd = [(0.943 \times Q \times C \times W_l) / D] \times [1 + (N_c \times F_c / D)] \times Ci$$

Where:

Lwd = Withdrawal losses, lbs/year

0.943 = Units conversion factor (constant), 1000 ft^3 - gal/bbl^2

Q = Annual gasoline throughput, bbl/yr, (Note 1 barrel = 42 gallons)

C = Shell clinkage factor, bbl/1000 ft2, (Table 7.1-10)

W_l = Average organic liquid density, lbs/gal

= 6.1 lbs/gal for gasoline

D = Tank diameter, ft

N_c = Number of fixed roof support columns, dimensionless

F_c = Effective column diameter, ft

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

Deck Fitting Losses: Emissions of gasoline vapor from bulk storage tank deck fittings depend upon the number and type of fittings on the floating roof of each individual tank. An empirical procedure is provided in AP-42 to predict these emissions along with the 'deck fitting loss factors' necessary to estimate vapor emissions from each type of fixture.

Lf = Ff x P* x Mv x Kc x Ci

Where:

Lf = Deck fitting losses, lbs/year

Ff = Total deck fitting loss factor, lb mole/year

$= [(N_{F1} \times K_{F1}) + (N_{F2} \times K_{F2}) + ... + (N_{Fnf} \times K_{Fnf})]$

N_{Fi} = Number of deck fittings of a particular type (i = 0, 1, 2,..., nf), dimensionless

nf = Total number of fitting types, dimensionless, (Tables 7.1-11 to 7.1-15)

K_{Fi} = Deck fitting loss factor for a particular type of fitting, lb mole/year

$= [K_{Fai} + (K_{Fbi} \times (K_v \times V)^{m_i})]$

K_{Fai} = Zero wind speed loss factor for fitting type 'i', lb mole/year, (Table 7.1-12)

K_{Fbi} = Wind speed dependent loss factor for fitting type 'i', lb mole/year, (Table 7.1-12)

K_v = Fitting wind speed correction factor, dimensionless

= 0.7 for external floating roof tanks

= 0.0 for internal and domed external floating roof tanks

V = Average ambient wind speed, mph

= 6.9 mph for San Diego County

mi = Loss factor for a particular type of deck fitting, dimensionless, (Table 7.1-12)

P^* = Vapor pressure function, dimensionless

= $(P_{va} / P_a) / [1 + (1 - (P_{va} / P_a)^{0.5})^2]$

= 0.122 for gasoline bulk storage in San Diego County

P_{va} = Vapor pressure at daily average liquid surface temperature, psia, (Table 7.1-2)

= 5.7 for Gasoline RVP 10 at 65 F

P_a = Atmospheric pressure, psia

= 14.7 psia at sea level

M_v = Average vapor molecular weight, lbs/lb-mole

= 66.0 for gasoline vapor RVP 10

K_c = Product factor

= 0.4 for crude oil

= 1.0 for all other organic liquids

C_i = Concentration of each listed substance in the gasoline vapor, lbs/lb

Deck Seam Losses: Internal floating roof tanks with bolted decks may have deck seam losses from vapors escaping through gaps. An empirical procedure is provided in AP-42 to predict these emissions along with the 'deck seam loss per unit seam length factor' necessary to estimate emissions from bolted decks. Since there are no remaining bolted floating roof decks in San Diego County, the EASIER inventory data forms and calculation procedures omit this calculation.

$L_d = K_D \times S_D \times D^2 \times P^* \times M_v \times K_c \times C_i$

Where:

L_d = Deck seam losses, lbs/year

K_D = Deck seam loss per unit seam length factor, lb mole/ft year

= 0.0 for welded floating roof decks

= 0.14 for bolted floating roof decks

S_D = Deck seam length factor, ft/ft^2

= L_{seam} / A_{deck}

L_{seam} = Total length of deck seams, ft

A_{deck} = Total deck surface area, ft2

D = Tank diameter, ft

P* = Vapor pressure function, dimensionless

= $(P_{va} / P_a) / [1 + (1 - (P_{va} / P_a)^{0.5})^2]$

= 0.122 for gasoline bulk storage in San Diego County

P_{va} = Vapor pressure at daily average liquid surface temperature, psia, (Table 7.1-2)

= 5.7 for Gasoline RVP 10 at 65 F

P_a = Atmospheric pressure, psia

= 14.7 psia at sea level

Mv = Average vapor molecular weight, lbs/lb-mole

= 66.0 for gasoline vapor RVP 10

Kc = Product factor

= 0.4 for crude oil

= 1.0 for all other organic liquids

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

Degassing Emissions: Occasionally, bulk gasoline storage tanks must be emptied and degassed to allow for repair activities both inside the tank and on the floating decks. Degassing bulk storage tanks results in organic emissions from both the evacuated vapor space and any evaporated liquid remaining on the walls, floor, or deck. The San Diego County APCD Vapor Recovery staff has developed the following calculation procedure to estimate these emissions. Note: AP-42 has an equation for standing idle losses (L_{sl}) which accounted in this calculation.

$L_{dg} = (L_{vapor\ space} + L_{walls} + L_{roof} + L_{floor}) \times C_i$

Where:

Ldg = Degassing emissions, lbs/year

= **[(0.462 x D^2) + (0.707 x D)] x Ci** (Note: this is an simplification of ($L_{vapor\ space}$ + L_{walls} + L_{roof} + L_{floor}) equations below.

D = Bulk storage tank diameter, ft

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

$L_{vapor\ space}$ = Vapor space evacuation losses, lbs/year

= **0.315 x D^2** (assuming the following information)

= (3.14 x D^2 / 4) x H x (1/385) x Mv x 0.39 where;

3.14 = Pi, (dimensionless mathematical function used to calculate interior tank volume)

D **=** Bulk storage tank diameter, ft

H = Average height of roof when tank is vented, ft, (Assume 6 ft)

(1/385) = Conversion factor, lb moles gas/ft3

Mv = Molecular weight of gasoline vapor, lbs/lb mole, (Use 66.0 for gasoline vapor)

0.39 = Mole fraction of gasoline vapor in vented space assuming a liquid temperature

of 65 F and a partial pressure of 5.7, (i.e.; 5.7 psia / 14.7 psia)

L_{walls} = Liquid evaporation losses from the side walls of the vented tank, lbs/year

= **0.707 x D** (assuming the following information)

= **3.14 x D x H x 0.25 x 0.15** where;

3.14 = Pi, (dimensionless mathematical function used to calculate wall surface area)

D = Bulk storage tank diameter (also twice the radius), ft

H = Height of roof when tank is vented, ft, (Use 6 ft if unknown)

0.25 = Assumed average thickness of liquid on tank walls after draining, millimeters

0.15 = Conversion factor for gasoline liquid, lbs/mm ft2

L_{roof} = Liquid evaporation losses from the inside roof of the vented tank, lbs/year

= **0.029 x D^2** (assuming the following information)

= **(3.14 x D^2 / 4) x 0.25 x 0.15** where;

3.14 = Pi, (dimensionless mathematical function used to calculate roof surface area)

D = Bulk storage tank diameter, ft

H = Average height of roof when tank is vented, ft, (Assume 6 ft)

0.25 = Assumed average thickness of liquid on interior roof after draining, millimeters

0.15 = Conversion factor for gasoline liquid, lbs/mm ft2

L_{floor} = Liquid evaporation losses from the floor of the vented tank, lbs/year

= **0.118 x D^2** (assuming the following information)

= **(3.14 x D^2 / 4) x 0.1 x 1.5** where;

3.14 = Pi, (dimensionless mathematical function used to calculate floor surface area)

D **=** Bulk storage tank diameter, ft

H = Average height of roof when tank is vented, ft, (Assume 6 ft)

0.1 = Assumed average thickness of liquid on floor after draining, centimeters

1.5 = Conversion factor for gasoline liquid, lbs/cm ft2

Refilling Emissions: After degassing and repairing the bulk gasoline storage tanks, a refilling operation must occur which generates gasoline vapor emissions. Liquid fuel surges into the tank from below and forces vapors out the vents until the liquid surface meets the floating roof and begins to raise the structure. The San Diego County APCD Vapor Recovery staff has developed the following calculation procedure to estimate these emissions. Note: AP-42 has an equation for filling losses (L_{fl}) which accounted in this calculation.

Lrf = (3.14 x D^2 / 4) x H x (1/385) x Mv x 0.39 x Ci

= 0.315 x D^2 x Ci

Where:

Lrf = Refilling emissions (after degassing operations), lbs/year

3.14 = Pi, (dimensionless mathematical function used to calculate interior tank volume)

D = Bulk storage tank diameter, ft

H = Average height of roof when tank is vented, ft, (Assume 6 ft)

(1/385) = Conversion factor, lb moles gas/ft3

Mv = Molecular weight of gasoline vapor, lbs/lb mole, (Use 66.0 for gasoline vapor)

0.39 = Mole fraction of gasoline vapor in vented space assuming a liquid temperature

of 65 F and a partial pressure of 5.7, (i.e.; 5.7 psia / 14.7 psia)

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

Hourly Emission Estimates: Average hourly emissions are estimated by dividing annual emissions by the hours of operation.

Eh = (Ea x Ci) / Hrs

where:

Eh = Hourly emission estimate, lbs/hour

Ea = Annual emission estimate, lbs gasoline vapor/year

Ci = Concentration of each listed substance in the gasoline vapor, lbs/lb

Hrs = Hours of bulk storage tank operation, hours/year

EMISSIONS INFORMATION:

Emission estimation procedures and factors are based on information from EPA AP-42 (Section 7.1). Gasoline speciation data is from both the EPA (NESHAPS Document 453/R-94-002a) and CAPCOA (Air Toxics Hot Spots Industry wide Risk Assessment Guidelines).

Gasoline Speciation Data	Weight % Vapor	Weight % Liquid
Benzene	0.4 %	1.0 %
Ethyl Benzene	0.1 %	1.6 %
Hexane, Isomers of	1.4 %	1.8 %
Toluene	1.1 %	8.0 %
Xylene, Isomers of	0.4 %	2.4 %
2,2,4-Trimethylpentane	0.7 %	0.8 %

ASSUMPTIONS / LIMITATIONS:

- Emission estimation procedures are based upon AP-42 methods for floating roof storage tanks containing organic liquids. Fixed roof storage tanks may not be accurately quantified with these procedures.

- Gasoline vapor speciation is based on information in the EPA NESHAPS Document for the Gasoline Distribution Industry (vapor speciation for reformulated / oxygenated fuel) and the CAPCOA Industry wide Risk Assessment Guidelines (liquid speciation).

- Emissions of organic vapors containing listed substances from tanks storing diesel, distillate oil, kerosene, jet fuel, motor oil, lubricants, machining oils, and residual oil are assumed to be below reporting levels. Aviation gas, however, should be considered equivalent to gasoline unless site specific information indicates otherwise.

- Retail gasoline storage and dispensing equipment should not be evaluated with these estimation techniques. Separate calculation procedures have been developed for these processes and equipment.

- Facilities tend to misreport the annual "tank refilling" activities needed to complete the above equations. Refilling emissions are calculated by the District only after a degassing operation when the tank vents are left open to properly raise the floating roof. Emissions from typical refilling operations with closed vents are included in the rim seal and withdrawal estimates. To avoid overestimating refilling emissions, the database calculation procedure uses the "number of degassing events" to estimate refilling emissions.

- For rim seal losses, deck fitting losses and deck seam losses, AP-42 assumes continuous emissions throughout the year (24 hours/day x 365 days/year = 8760 hours/year). The District implements this assumption. However, these emissions would not occur when there is no organic liquid in the tank.

FORMS:

Use the reporting form for all sizes of bulk gasoline storage tanks. Verify the accuracy of the permit equipment description. Do not report diesel, distillate, or jet fuel fuel storage.

Due to the complexity of rim seal and fitting losses, emission rates for these releases are typically calculated separately and entered into the database as constants (lbs released / year) and (lbs released / hr). Since the emission rates are only dependent upon tank size and design, the emissions are unaffected by throughput. The District database is not currently programmed to perform these tank specific calculations.