Air Permit Reviewer Reference Guide

APDG 6250

Estimating Short Term Emission Rates from Fixed Roof Tanks

Air Permit Division

Texas Commission on Environmental Quality

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Scope

The goal of this document is to provide a methodology to calculate the worst case short term emissions from a vertical fixed roof tank (VFR tank) during routine operations. All calculations and derivations for short term emissions also apply to horizontal tanks. However, this calculation methodology does not apply to pressure vessels capable of handling 29.72 psia or greater, constant level or "surge" tanks (i.e., tanks that have inflow and outflow at the same time), and certain cases where a tank contains mixed phase materials (i.e., water with dense non aqueous phase liquid or crude with dissolved methane) or may otherwise have flash emissions.

Calculation Procedure

Emissions from loading a VFR tank should be calculated using Equation 1:

Equation 1

$$L_{MAX} = \frac{M_V \times P_{VA}}{R \times T} \times FR_M$$

- L_{MAX} (lb/hr) is the maximum potential short term emission rate at worst case conditions (highest liquid surface temperature, vapor pressure, and fill rate).
- M_V (lb/lbmol) is the vapor molecular weight of the VOC.
- P_{VA} (psia) is the vapor pressure of the tank contents at the worst case temperature.
- FR_M (gal/hr) is the maximum filling rate.
- R ((psia × gal)/(lbmol × °R)) is the ideal gas constant (80.273 for the selected units).
- T (Rankine) is the worst case liquid surface temperature. It is TCEQ practice to use either 95°F (554.67°R) or the actual temperature, whichever is higher.

Engineering Derivation

This section derives and explains Equation 1 listed above. Working losses are emissions of VOC that occur during the filling of a VFR tank. In an atmospheric vessel with fixed volume, a rising liquid level causes the displacement of vapors between the liquid surface and the vessel roof (the "headspace"). Emissions can be calculated by taking note of the fact that the total tank volume (liquid volume plus headspace) is a constant, and writing down its derivative, as is done in Equation 3.

Equation 2

$$V_{LIQUID} + V_{HEADSPACE} = Constant$$

Equation 3

$$\frac{d}{dt}V_{LIQUID} + \frac{d}{dt}V_{HEADSPACE} = 0$$

The rate at which the tank liquid volume increases (the derivative of V_{LIQUID} with respect to time) is equal to its filling rate, FR, and the rate at which the headspace volume decreases (the derivative of $V_{HEADSPACE}$ with respect to time) is equal to the volumetric emission rate, ER_{VOL}. Substituting and rearranging Equation 3, we have:

Equation 4

$$FR = ER_{VOL}$$

The mass emission rate is equal to the volumetric emission rate times the density of the vapor space, W_V. This is expressed in Equation 5 when Equation 4 is substituted.

Equation 5

$$ER = W_V \times FR$$

Assuming that the vapor space is of constant density, the vapor VOC density may be rewritten using the ideal gas law:

Equation 6

$$W_V = \frac{M_V \times P_{VA}}{R \times T}$$

All calculations for working losses are based on the relationship in Equation 5. Additional complexities such as incomplete saturation of the vapor space,[i] or pressure differentials between the vessel and the atmosphere introduced by tank breather settings, are accounted for with the use of various correction factors.

Endnote

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[i] When the partial pressure of VOC in the vessel vapor space is equal to its vapor pressure, the vapor space is saturated. When the partial pressure of the VOC in the vessel space is less than its vapor pressure, the vapor space is incompletely saturated.

Summary of Changes to Guidance

Revision Date	Description of Changes
February 2020	Removed historical methodology discussion due to its reliance on a method rendered obsolete by November 2019 update of EPA AP-42. Performed other typographical corrections.
February 2018	Added clarification of product factor (K_P) relative to historical methodology discussion.
September 2014	Original publication of short-term fixed roof tank guidance document.