

Compilation of Air Emission Estimating Methods for Petroleum Distribution and Dispensing Facilities

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SECOND EDITION, JULY 2009



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Marketing Segment

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Compilation of Air Emission Estimating Methods for Petroleum Distribution and Dispensing Facilities

1 Introduction

1.1 Scope

This publication is a compilation of methods for estimating emissions associated with activities that may occur at typical petroleum distribution and dispensing facilities. Distribution facilities include bulk terminals, bulk plants, pipeline breakout stations, and pipeline pumping stations. Dispensing facilities are primarily retail service stations. Evaporative losses of volatile organic liquids (VOLs) from distribution and dispensing facilities occur primarily from transfer operations (i.e. refueling of motor vehicles, and the loading or unloading of tank trucks, railcars, and ships or barges), storage tanks, and equipment leaks (i.e. piping components such as valves and pumps).

Emission estimating methods have been developed to quantify total VOL emissions from these sources and to speciate these emissions. Speciation is the determination of the fraction of the total emissions that are attributable to given individual chemical compounds, or species.

Emission estimating methods change over time as more accurate methods are developed, emission controls change, and the compositions of petroleum products change in response to regulations and consumer needs.

1.2 Purpose

The purpose of this publication is to compile the most current and widely accepted emission estimating methods for petroleum distribution and dispensing facilities in one document.

Numerous studies have been conducted to estimate emissions from these facilities. As a result, more than one estimating method is sometimes available for a given emission-generating activity, with the different methods potentially having differing levels of complexity. There is a trade-off between accuracy and complexity of emission estimates. More accurate estimates require more information about the specific activity.

Section 3 of this publication provides the emission estimating methods. Emission estimating methods that can be stated briefly are provided in whole in Section 3; otherwise, the reader is referred to another document for the complete methodology. Section 3 contains three subsections: one for distribution facilities, one for dispensing facilities, and one for miscellaneous activities. Section 4 provides information on the properties of VOLs used to estimate emissions.

2 Definitions

40 *CFR* Part 63, Subpart BBBBBB^[1], Section 63.11100, includes the following definitions related to gasoline distribution facilities.

2.1

bulk gasoline plant

Any gasoline storage and distribution facility that receives gasoline by pipeline, ship or barge, or cargo tank and has a gasoline throughput of less than 20,000 gal/day.

NOTE This differs from the definition implied by 40 *CFR* Part 60, Subpart XX^[2], Section 60.501 and 40 *CFR* Part 63, Subpart R^[3], Section 63.421. These rules do not define a bulk plant, but define a bulk terminal as any gasoline facility which receives gasoline by pipeline, ship or barge, and has a gasoline throughput greater than approximately 20,000 gal/day. This implies that a facility receiving only by cargo tank is a bulk plant, regardless of throughput.

2.2

bulk gasoline terminal

Any gasoline storage and distribution facility that receives gasoline by pipeline, ship or barge, or cargo tank and has a gasoline throughput of 20,000 gal/day or greater.

2.3

equipment

Each valve, pump, pressure relief device, sampling connection system, open-ended valve or line, and flange or other connector in the gasoline liquid transfer and vapor collection systems. This definition also includes the entire vapor processing system except the exhaust port(s) or stack(s).

2.4

gasoline cargo tank

A delivery tank truck or railcar which is loading gasoline or which has loaded gasoline on the immediately previous load.

2.5

pipeline breakout station

A facility along a pipeline containing storage vessels used to relieve surges or receive and store gasoline from the pipeline for re-injection and continued transportation by pipeline or to other facilities.

2.6

pipeline pumping station

A facility along a pipeline containing pumps to maintain the desired pressure and flow of product through the pipeline and not containing storage vessels.

40 *CFR* Part 63, Subpart CCCCCC [4], Section 63.11132, includes the following definition.

2.7

gasoline dispensing facility

GDF

Any stationary facility which dispenses gasoline into the fuel tank of a motor vehicle.

While the regulatory definitions listed above are specific to gasoline, this publication applies to distribution and dispensing facilities for VOLs and is not limited to gasoline.

3 Emission Estimating Methods

3.1 Distribution Facilities

3.1.1 Overview

AP-42, Section 5.2.1, gives an overview of the petroleum distribution system. Table 1 summarizes emission estimating methods for activities at distribution facilities.

3.1.2 Storage Tanks

3.1.2.1 Storing, Filling, and Emptying a VOL in a Storage Tank

EPA offers software (TANKS) to estimate emissions from storage tanks. TANKS is based on the emission estimating procedures from AP-42, Chapter 7, and is available at www.epa.gov/ttn/chief/software/tanks/index.html.

Limitations of the TANKS program are discussed in Annex A.

Table 1—Emission Estimating Methods for Activities at Distribution Facilities (Routine and Non-routine)

Activity	API 1673 Section	API Reference	EPA Reference
Storing a VOL (including filling and emptying) in the following types of storage tanks:			
a) fixed-roof tanks	3.1.2.1	API <i>MPMS</i> Ch. 19.1 [5]	AP-42 [6], Section 7.1.3.1
b) floating-roof tanks	3.1.2.1	API <i>MPMS</i> Ch. 19.2 [7]	AP-42, Section 7.1.3.2.1
c) closed-vent IFRTs	3.1.2.1	API 2569 [8]	
d) variable vapor space tanks	3.1.2.1		AP-42, Section 7.1.3.3
Landing a floating roof in a tank that stores a VOL	3.1.2.2	API 2567 [9]	AP-42, Section 7.1.3.2.2
Cleaning a storage tank that contained a VOL	3.1.2.3	API 2568 [10]	
Loading a VOL into a ship or barge (uncontrolled)	3.1.3.1	API <i>MPMS</i> Ch. 19.5 [11], Section 4.1	AP-42 [12], Section 5.2.2.1.1 and Tables 5.2-1, 5.2-2 and 5.2-6
Loading ballast water into a ship or barge that previously held crude oil (uncontrolled)	3.1.3.2	API <i>MPMS</i> Ch. 19.5, Section 4.2	AP-42, Section 5.2.2.1.2 and Table 5.2-4
Loading a VOL into a cargo tank (uncontrolled)	3.1.3.3		AP-42, Section 5.2.2.1.1 and Tables 5.2-1 and 5.2-5
Loading a VOL into a cargo tank (controlled)	3.1.3.4		AP-42, Section 5.2.2.1.1
Leaking a VOL from equipment	3.1.4	API 4653 [13], Table ES-2	EPA-453/R-95-017 [14], Tables 2-1 and 2-3
Spilling a VOL (pool exposed to wind)	3.1.5 a)		EPA 550-B-99-009 [15], Appendix B.2
Spilling a VOL (pool not exposed to wind)	3.1.5 b)		EPA EIIP Vol II, Ch 16 [16], Section 3.7.1
Miscellaneous activities	3.3	References for these activities are listed in Table 5	

3.1.2.1.1 Fixed-roof Tanks

API *MPMS* Ch. 19.1 and AP-42, Section 7.1.3.1, provide emission estimating methods for fixed-roof tanks. The method given in each document is the same.

3.1.2.1.2 Floating-roof Tanks with Open Vents (Freely Vented)

API *MPMS* Ch. 19.2 and AP-42, Section 7.1.3.2.1, provide emission estimating methods for floating-roof tanks with open vents. The emission estimating method for floating-roof tanks given in API *MPMS* Ch. 19.2 is the same as that given in AP-42, Section 7.1.3.2, with the following exceptions:

- 1) API *MPMS* Ch.19.2 specifies that the true vapor pressure of the stock is to be calculated from the average stock storage temperature (i.e. the liquid bulk temperature), whereas AP-42, Section 7.1.3.2, specifies that the true vapor pressure of the stock is to be calculated from the average liquid surface temperature;
- 2) API *MPMS* Ch.19.2 specifies a deck seam loss per unit seam length factor of 0.34, whereas AP-42, Section 7.1.3.2 specifies a deck seam loss per unit seam length factor of 0.14.

3.1.2.1.3 Closed-vent Internal Floating-roof Tanks (IFRTs) (Non-freely-vented IFRTs)

As discussed in API 2569, emissions from closed-vent IFRTs may be approximated as 5 % less than emissions from IFRTs with open vents determined in accordance with 3.1.2.1 b).

API 2569 compares emissions from closed-vent IFRTs with emissions from open-vent IFRTs and shows that closing the vents on IFRTs reduces emissions slightly. This reduction is a function of stock volatility, turnover rate, the rate at

which vapors pass through the floating roof, tank height, pressure/vacuum vent settings, and stock temperature. API 2569 concludes that, given the high uncertainty associated with the methods evaluated, an assumption of a 5 % reduction in emissions from an IFRT due to use of closed vents would be a reasonable approach for estimating emissions from these tanks.

3.1.2.1.4 Variable Vapor Space Tanks

Emissions from tanks with an expandable vapor storage capacity are addressed in AP-42, Section 7.1.3.3.

3.1.2.2 Landing a Floating Roof

The estimating method given in AP-42, Section 7.1.3.2.2, is the same as in API 2567. AP-42, Section 7.1.3.2.2, includes the stipulation of the saturation factor being set equal to 0.6 for calculating the upper-bound limit on standing-idle loss for drain-dry tanks, where the appropriate value for this factor is not as apparent in API 2567. The following clarifications may be helpful.

- a) The same filling loss equation (API 2567, Equation 21) can be used for all tank configurations:

$$L_F = \left(\frac{PV_V}{RT} \right) M_V (C_{sf} S)$$

This equation includes the C_{sf} factor used in the filling loss equation for external floating-roof tanks and can be used in the filling loss equation for internal floating-roof and drain-dry tanks by setting its value equal to 1.0 for the latter two tank configurations so as to not change the estimated emissions.

- b) The value of the saturation factor S used in the calculation of an upper-bound limit on standing-idle loss for drain-dry tanks is 0.6.
- c) A more accurate expression from API *MPMS* Ch. 19.1 for the vapor space expansion factor K_E can be used as an alternate to the expression given for K_E in API 2567:

$$K_E = \frac{\Delta T_V}{T} + \frac{\Delta P}{P_a - P}$$

- d) An upper-bound limit on the estimation of filling loss for tanks with a liquid heel may be determined from the initial amount of available liquid less the amount attributed to standing idle loss, plus the vapors generated by the incoming liquid upon refilling. This may be expressed as:

$$(5.9D^2 h_{le} W_l - L_s) + \frac{0.15PV_V M_V}{RT}$$

3.1.2.3 Tank Cleaning

API 2568 provides emission estimating methods for tank cleaning episodes.

3.1.3 Loading Ships, Barges, and Truck and Rail Cargo Tanks

The equation given in this edition of API 1673 for estimating emissions from the loading of VOLs is given as Equation 1 in AP-42, Section 5.2. This equation is a function of a saturation factor that depends upon the loading scenario.

The loading loss equation accounts for the vapor pressure and vapor molecular weight of the VOL being loaded, as well as for the temperature at which the loading occurs, but the use of emission factors does not accommodate accounting for these parameters. The Second Edition of API 2514A^[17] specified emission factors for estimating emissions from the loading of marine vessels, but when this document was rewritten in 2009 (API *MPMS* Ch. 19.5, First Edition), these emission factors were converted into equivalent saturation factors so that the loading loss equation could be applied.

This edition of API 1673 is based on the use of the loading loss equation. Saturation factors given in this edition of API 1673 for the loading of cargo tanks were obtained from AP-42, Section 5.2, and saturation factors for the loading of marine vessels were obtained from API *MPMS* Ch. 19.5. There is an inconsistency between these sources in the manner in which the loading loss equation is applied, in that AP-42, Section 5.2, defines the temperature variable as the temperature of the bulk liquid loaded, whereas API *MPMS* Ch. 19.5 defines the temperature variable as the temperature of the ullage (i.e. the temperature of the vapor space). While the vapor pressure should be calculated at the temperature of the liquid, the temperature variable in the loading loss equation is the temperature used in calculating the vapor density, and thus it would seem that the temperature of the vapor space would be the more correct value for this variable.

3.1.3.1 Loading VOLs into Ships or Barges (Uncontrolled)

The loss from a liquid loading episode, L_L , is:

$$L_L \text{ lb/(\text{thousand gallons loaded})} = 12.46 K_S P_{VA} M_V/T_V$$

where

K_S is the saturation factor (API *MPMS* Ch. 19.5, Table 2);

P_{VA} is true vapor pressure of the liquid loaded (psia);

M_V is the molecular weight of the stock vapors (lb/lb-mol);

T_V is the absolute temperature of the ullage (the unfilled volume of a compartment) ($^{\circ}\text{R}$).

There are a number of scenarios that may be described for the loading of petroleum liquids into marine vessels, with each having an associated saturation factor for the loading loss equation. Saturation factors for the loading of gasoline and crude oil into marine vessels are provided in API *MPMS* Ch. 19.5. Saturation factors for the loading of other petroleum liquids are provided in AP-42, Section 5.2. Furthermore, saturation factors for the loading of gasoline and crude oil can be calculated from the emission factors given in AP-42.

AP-42, Section 5.2.2.1.1, presents a method for estimating emissions from crude oil loading which separates the emissions into arrival and generated components. This methodology provides similar results to those given in API *MPMS* Ch. 19.5.

3.1.3.2 Loading Ballasting Water into Ships or Barges (Uncontrolled)

The loss for a ballast water loading episode, L_L , is:

$$L_L \text{ lb/(\text{thousand gallons loaded})} = 12.46 K_S P_{VA} M_V/T_V$$

where

K_S is the saturation factor (API *MPMS* Ch. 19.5, Table 3);

P_{VA} is the true vapor pressure of the crude oil unloaded (psia);

M_V is the vapor molecular weight of the crude oil unloaded (lb/lb-mol);

T_V is the absolute temperature of the ullage (the unfilled volume of a compartment) ($^{\circ}\text{R}$).

If volume of the ballast water loaded into compartments that previously contained crude oil is unknown, it can be estimated as 17 % of the volume of the crude oil unloaded.