

# **Manual of Petroleum Measurement Standards Chapter 19.2**

## **Evaporative Loss From Floating-Roof Tanks**

THIRD EDITION, OCTOBER 2012



AMERICAN PETROLEUM INSTITUTE



# **Manual of Petroleum Measurement Standards Chapter 19.2**

## **Evaporative Loss From Floating-Roof Tanks**

### **Measurement Coordination**

THIRD EDITION, OCTOBER 2012



AMERICAN PETROLEUM INSTITUTE

## Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Users of this standard should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 1220 L Street, NW, Washington, DC 20005.

*Copyright © 2012 American Petroleum Institute*

## Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, [standards@api.org](mailto:standards@api.org).



## Summary of Changes to API MPMS Chapters 19.1, 19.2 and 19.4

The third edition of API Manual of Petroleum Measurement Standards (MPMS) Chapter 19.4 was published following a revision that was carried out concurrently with revisions to Chapter 19.1, published as the fourth edition, and Chapter 19.2, published as the third edition. Primary changes are:

- 1) Consolidation of common material in Chapter 19.4. Material that had previously been included in both Chapters 19.1 and 19.2 has been moved to Chapter 19.4. Chapter 19.4, which was previously *Recommended Practice for Speciation of Evaporative Losses*, now has the title *Evaporative Loss Reference Information and Speciation Methodology*. This Chapter had already contained reference information on the properties of chemicals and typical petroleum liquids, and this information has now been removed from Chapters 19.1 and 19.2. In addition, meteorological data have been moved from Chapters 19.1 and 19.2 to Chapter 19.4. In the revised documents:
  - a) Meteorological data are found in Chapter 19.4,
  - b) Calculation of storage tank temperatures is found in Chapters 19.1 and 19.2 (in that fixed-roof tanks involve calculation of the vapor space temperature in order to determine vapor density, whereas this step is not involved in estimating emissions from floating-roof tanks), and
  - c) Calculation of true vapor pressure is found in Chapter 19.4 (in that this is now calculated in the same manner for both fixed- and floating-roof tanks).
- 2) Reconciliation of nomenclature. Chapters 19.1 and 19.2 previously had different nomenclature for the same variables. These revisions adopt a common set of symbols for both chapters.
- 3) Reorganization of the formats. In addition to common material having been removed from Chapters 19.1 and 19.2, the remaining text has been edited to remove unnecessarily verbose or repetitive language. The summary tables were deemed redundant, and have been deleted.
- 4) Appendices. Appendices have been redesignated as annexes.
- 5) SI units. An annex has been added to each chapter to address SI units.

### Chapter 19.2, third edition

In addition to common reference material being deleted from Chapter 19.2, the following changes have been made:

- 1) Reference to API Technical Reports. References to API TR 2567 (floating roof landings), API TR 2568 (cleaning storage tanks), and API TR 2569 (closed vent IFRTs) have been added.
- 2) Terminology. The following terminology has been revised:
  - a) “Covered floating-roof tank (CFRT)” has been changed to “domed EFRT.”
  - b) “Standing storage loss” has been changed to “standing loss.”
  - c) “Withdrawal loss” has been changed to “working loss.”
  - d) “Solar insolation” has been changed to “insolation.”
- 3) True vapor pressure from liquid surface temperature. The temperature used for calculation of the true vapor pressure has been changed from the liquid bulk temperature to the liquid surface temperature for floating-roof tanks, using the same method to calculate liquid surface temperature as has been used for fixed-roof tanks. This

brings the API methodology into line with the EPA methodology published in AP-42 at the time of publication of this 3rd Edition of the API standard.

- 4) Ladder/Guidepole Combination. An equipment description and factors for ladder/guidepole combinations have been added.
- 5) Effective Throughput. An expression has been added for the sum of changes in liquid level, designated  $\Sigma H_Q$ , for calculating effective throughput.

## Contents

|                              | Page  |
|------------------------------|---|
| <b>1</b>                     | <b>Scope</b> . . . . . <b>1</b>   |
| <b>2</b>                     | <b>Normative References</b> . . . . . <b>2</b>  |
| <b>3</b>                     | <b>Symbols</b> . . . . . <b>2</b>   |
| <b>4</b>                     | <b>Procedure for Estimating Loss</b> . . . . . <b>3</b>   |
| 4.1                          | General . . . . . 3   |
| 4.2                          | Standing Loss $L_S$ . . . . . 3   |
| 4.3                          | Working Loss $L_W$ . . . . . 14   |
| <b>5</b>                     | <b>Sample Problems</b> . . . . . <b>16</b>  |
| 5.1                          | General . . . . . 16  |
| 5.2                          | EFRT Sample Problem . . . . . 16  |
| 5.3                          | IFRT Sample Problem . . . . . 20  |
| 5.4                          | Domed EFRT Sample Problem . . . . . 23  |
| <b>6</b>                     | <b>Equipment Descriptions</b> . . . . . <b>27</b>   |
| 6.1                          | Components . . . . . 27   |
| 6.2                          | Types of Floating-Roof Tanks . . . . . 46   |
| <b>7</b>                     | <b>Loss Mechanisms</b> . . . . . <b>48</b>  |
| 7.1                          | General . . . . . 48  |
| 7.2                          | Standing Loss . . . . . 49  |
| 7.3                          | Working Loss . . . . . 50   |
| <b>8</b>                     | <b>Development of Estimation Methods</b> . . . . . <b>51</b>  |
| 8.1                          | General . . . . . 51  |
| 8.2                          | Standing Loss . . . . . 51  |
| 8.3                          | Working Loss . . . . . 56   |
| <b>Annex A</b> (informative) | <b>Development of Rim-Seal Loss Factors</b> . . . . . <b>57</b>                                     |
| <b>Annex B</b> (informative) | <b>Development of Rim-Seal Relationship Between Airflow Rate and Wind Speed</b> . . . . . <b>61</b> |
| <b>Annex C</b> (informative) | <b>Development of Diameter Function</b> . . . . . <b>63</b>   |
| <b>Annex D</b> (informative) | <b>Development of Deck-Fitting Loss Factors</b> . . . . . <b>65</b>                                 |
| <b>Annex E</b> (informative) | <b>Development of Vapor Pressure Function</b> . . . . . <b>71</b>                                   |
| <b>Annex F</b> (informative) | <b>Development of Product Factors</b> . . . . . <b>73</b>   |
| <b>Annex G</b> (informative) | <b>Development of Clingage Factors</b> . . . . . <b>75</b>  |
| <b>Annex H</b> (informative) | <b>Development of Fitting Wind-Speed Correction Factor</b> . . . . . <b>76</b>                      |
| <b>Annex I</b> (informative) | <b>Development of Deck-Seam Loss Factors</b> . . . . . <b>79</b>                                    |
| <b>Annex J</b> (informative) | <b>Documentation Records</b> . . . . . <b>81</b>  |
| <b>Annex K</b> (informative) | <b>SI Units</b> . . . . . <b>82</b>   |
|                              | <b>Bibliography</b> . . . . . <b>83</b>   |
| <b>Figures</b>               |   |
| <b>1</b>                     | <b>EFRT with Pontoon Floating Roof</b> . . . . . <b>29</b>  |
| <b>2</b>                     | <b>EFRT with Double-deck Floating Roof</b> . . . . . <b>30</b>                                      |

## Contents

|     | Page  |
|-----|---|
| 3   | IFRT with Noncontact Deck . . . . . 31  |
| 4   | Domed EFRT . . . . . 32   |
| 5   | Vapor-mounted Primary Seals . . . . . 33  |
| 6   | Liquid-mounted Primary Seals . . . . . 35   |
| 7   | Mechanical-shoe Primary Seals . . . . . 35  |
| 8   | Secondary Seals . . . . . 37  |
| 9   | Access Hatch . . . . . 38   |
| 10  | Fixed-roof Support Column . . . . . 38  |
| 11  | Gauge Float (Automatic Gauge) . . . . . 39  |
| 12  | Gauge Hatch Sample Ports . . . . . 39   |
| 13  | Vacuum Breaker . . . . . 40   |
| 14  | Deck Drains . . . . . 40  |
| 15  | Deck Leg . . . . . 41   |
| 16  | Rim Vent . . . . . 41   |
| 17  | Vertical Ladder . . . . . 42  |
| 18  | Unslotted (Unperforated) Guidepole . . . . . 43   |
| 19  | Slotted (Perforated) Guidepole . . . . . 44   |
| 20  | Ladder/Guidepole Combination . . . . . 45   |
| C.1 | Calculated Losses as a Function of Diameter Exponent . . . . . 64                               |
| D.1 | IFRT Deck Fitting Emission Factors – Effect of Ladder Sleeve on Emission Reduction . . . . . 69 |

### Tables

|     |   |
|-----|---|
| 1   | Rim-Seal Loss Factors . . . . . 5   |
| 2   | Deck-Fitting Loss Factors . . . . . 8   |
| 3   | Typical Number of Columns $N_{fc}$ for Tanks with Column-Supported Roofs . . . . . 10   |
| 4   | Typical Number of Vacuum Breakers $N_{fvb}$ and Deck Drains $N_{fdd}$ for API 650 Appendix C Decks (EFRTs and Domed EFRTs) . . . . . 10 |
| 5   | Typical Number of Deck Legs $N_{fdl}$ for API 650 Appendix C Floating Roofs . . . . . 11  |
| 6   | Deck-Seam Length Factors $S_d$ . . . . . 13   |
| 7   | Clingage Factors $C_L$ for Steel Tanks (bbl/1000 ft <sup>2</sup> ) . . . . . 15   |
| 8   | Effective Column Diameter $D_C$ for Typical Column Construction . . . . . 15  |
| D.1 | Summary of Deck Fittings Selected for Data Regression, and Associated Loss Factors for Each . . . . 68                                  |
| D.2 | Emission Factors for IFRT Ladder Sleeves . . . . . 70   |
| D.3 | IFRT Emission Factor Comparison for a Ladder/Guidepole Combination . . . . . 70   |

# Chapter 19.2—Evaporative Loss From Floating-Roof Tanks

## 1 Scope

This standard contains methodologies for estimating the total evaporative losses of hydrocarbons from external floating-roof tanks (EFRTs), freely vented internal floating-roof tanks (IFRTs), and domed external floating-roof tanks (domed EFRTs).

The methodologies provide loss estimates for general equipment types based on laboratory, test-tank, and field-tank data.

Types of floating roofs, rim-seal systems, and deck fittings are described for information only.

The equations estimate average annual losses from floating-roof tanks for various types of tank construction, floating-roof construction, rim-seal systems, and deck fittings, as well as for various liquid stocks, stock vapor pressures, tank sizes, and wind speeds (EFRTs).

The equations were developed for:

- a) stocks with a true vapor pressure greater than approximately 0.1 psia,
- b) average wind speeds ranging from 0 miles per hour (mph) to 15 mph (EFRTs), and
- c) tank diameters greater than 20 ft.

The estimation techniques become more approximate when these conditions are not met.

When this standard is used to estimate losses from non-freely vented (closed vent) internal or domed external floating-roof tanks (tanks vented only through a pressure-vacuum relief vent, blanketed with an inert gas, vented to a vapor processing unit, or otherwise restricted from being freely vented), refer to the methodology in API TR 2569<sup>[7]</sup>.

The equations are not intended to be used in the following applications.

- a) To estimate losses from unstable or boiling stocks (i.e. stocks with a true vapor pressure greater than the atmospheric pressure at the tank location) or from petroleum liquids or petrochemicals for which the vapor pressure is not known or cannot readily be predicted.
- b) To estimate losses from tanks in which the materials used in the rim seal, deck fittings, or deck seams have either deteriorated or been significantly permeated by the stored stock.
- c) To estimate losses from storage tanks which do not have a floating roof.
- d) To estimate losses from landing floating roofs (API TR 2567<sup>[8]</sup> addresses this).
- e) To estimate losses from cleaning storage tanks (API TR 2568<sup>[9]</sup> addresses this).

The estimation procedures were developed to provide estimates of typical losses from floating-roof tanks that are properly maintained and in normal working condition. Losses from poorly maintained tanks can be greater. Because the loss equations are based on equipment conditions that represent a large population of tanks, a loss estimate for a group of floating-roof tanks will be more accurate than a loss estimate for an individual tank. The estimation can be improved by using detailed field information, including climatic data and operational data for the appropriate time period.

Evaporative-loss considerations are not the only criteria for equipment selection. Many other factors not addressed in this standard, such as tank operation, maintenance, and safety, are important in designing and selecting tank equipment for a given application.