

Manual of Petroleum Measurement Standards Chapter 19.3—Evaporative Loss Measurement

Part E—Weight Loss Test Method for the Measurement of Deck-Fitting Loss Factors for Internal Floating-Roof Tanks

FIRST EDITION, MAY 1997

REAFFIRMED, FEBRUARY 2023



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. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

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.

All rights reserved. No part of this work may be reproduced, 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, 200 Massachusetts Avenue, NW, Washington, DC 20001.

Copyright © 1997 American Petroleum Institute

FOREWORD

This standard provides rules for testing the deck fittings of internal floating roofs under laboratory conditions to provide evaporative loss factors. It was prepared by Task Group II of the API Environmental Technical Advisory Group (ETAG).

Testing programs conducted by API in 1982 and 1993 provided the information on which the current evaporative loss factors are based for common, generic types of internal floating-roof deck fittings. These deck-fitting loss factors are published in the *API Manual of Petroleum Measurement Standards* (MPMS), Chapter 19.2, for use in estimating the evaporative loss of petroleum stocks from floating-roof tanks. These deck-fitting loss factors and the test methods used to develop them have been widely accepted by oil companies, manufacturers, industry groups, regulatory agencies, and general interest groups. API has not, however, tested or developed evaporative loss factors for proprietary designs of individual manufacturers. By publishing a testing protocol, API is making the test method available to interested parties who wish to test particular deck fittings under the auspices of API.

API certification of an evaporative loss factor developed through this program is subject to the following three-step process:

The testing shall be performed in laboratories licensed by API. The requirements to qualify for licensure are presented in API MPMS 19.3, Part G.

Testing and determination of test results shall be performed as specified herein.

The evaluation of these test results and the certification of an evaporative loss factor for the item tested shall then be conducted in accordance with the API MPMS, 19.3, Part F.

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 federal, state, or municipal regulation with which this publication may conflict.

Suggested revisions are invited and should be submitted to the Measurement Coordinator, American Petroleum Institute, 200 Massachusetts Avenue, NW, Washington, DC 20001.

CONTENTS

	Page
0 INTRODUCTION	1
1 SCOPE	1
2 REFERENCES	1
3 TERMINOLOGY	1
3.1 Definitions	1
3.2 Units of Measurement	2
3.3 Nomenclature	3
4 SUMMARY OF TEST METHOD	3
5 SIGNIFICANCE AND USE	3
6 LIMITATIONS TO THE TEST METHOD	3
6.1 Evaluation of Results	3
6.2 Low Loss Rates	3
7 TEST APPARATUS	3
7.1 Test Apparatus Schematic	3
7.2 Test Room	3
7.3 Test Vessels	4
7.4 Data Acquisition Room	4
8 TEST ITEM	4
8.1 Test Item Assembly	4
8.2 Fitting Attachment	5
8.3 Tall Fittings	5
9 PREPARATION OF APPARATUS	5
9.1 Test Assembly Placement	5
9.2 Test Room Air Temperature Control	5
9.3 Data Acquisition Room Air Temperature Control	5
9.4 Steady State Operation	5
10 INSTRUMENTATION AND CALIBRATION	5
10.1 Accuracy	5
10.2 Data Acquisition System	5
10.3 Weight Measurement	6
10.4 Temperature Measurement	6
10.5 Voltage Measurement	7
10.6 Atmospheric Pressure Measurement	7
11 TEST PROCEDURE	7
11.1 Data to be Recorded	7
11.2 Duration of Test	8

	Page
12 CALCULATION OF TEST RESULTS.....	8
12.1 Calibration Corrections	8
12.2 Loss Rate	9
12.3 Vapor Pressure Function	9
12.4 Loss Factor	10
12.5 Multiple Tests.....	10
12.6 Uncertainty Analysis	10
13 REPORT OF TEST RESULTS	10
13.1 Report.....	10
13.2 Loss Rate Curve.....	10
14 PRECISION AND BIAS.....	10
APPENDIX A—LOSS RATE DETERMINATION	13
APPENDIX B—UNCERTAINTY ANALYSIS.....	17
APPENDIX C—METRIC UNITS.....	21
APPENDIX D—BIBLIOGRAPHY.....	23
Figures	
1—Plan View of a Typical Weight Loss Test Facility.....	7
2—Elevation View of a Typical Weight Loss Test Facility (Description of Test Apparatus Typical of Each).....	8
3—Test Assembly	9
4—Typical Loss Rate Curve	11
A-1—Measured and Calculated Weight Loss Versus Time	15
A-2—Corrected and Correlated Weight Loss Versus Time	15
Tables	
1—Nomenclature.....	3
2—Instrument Requirements.....	5
A-1—Nomenclature for Appendix A	13
B-1—Nomenclature for Appendix B	17
B-2—Summary of Example Uncertainty Analysis Results	19

Chapter 19.3—Evaporative Loss Measurement

PART E—WEIGHT LOSS TEST METHOD FOR THE MEASUREMENT OF DECK-FITTING LOSS FACTORS FOR INTERNAL FLOATING-ROOF TANKS

0 Introduction

The purpose of this standard is to establish a uniform method for use in measuring the evaporative loss factors for deck fittings of internal floating-roof tanks. These loss factors are to be determined in terms of loss rate for certification purposes.

It is not the purpose of this standard to specify procedures to be used in the design, manufacture, or field installation of deck fittings. Furthermore, equipment should not necessarily be selected for use solely on the basis of evaporative-loss considerations. Many other factors—such as tank operation, maintenance, and safety—are important in designing and selecting tank equipment for a given application.

1 Scope

This test method may be used to establish evaporative loss factors for deck fittings of internal floating-roof tanks. The test method involves measuring the weight loss of a test assembly over time. This standard specifies the test apparatus, the instruments, the test procedures, and the calculation procedures to be used. It also specifies the variables to be measured and stipulates quality provisions. The format for reporting the values of both the test results and their associated uncertainty are also specified.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2 References

The most recent editions of the following standards contain provisions that through reference in this text constitute provisions of this standard:

API

Manual of Petroleum Measurement Standards

Chapter 19.2, “Evaporative Loss From Floating-Roof Tanks”

Chapter 19.3, Part F, “Evaporative Loss Factor for Storage Tanks Certification Program”

Chapter 19.3, Part G, “Certified Loss Factor Testing Laboratory Registration”

Std 650 *Welded Steel Tanks for Oil Storage*

ASTM¹

E220 *Method for Calibration of Thermocouples by Comparison Techniques*

E230 *Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples*

D323 *Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

3 Terminology

3.1 DEFINITIONS

For the purpose of this standard, the following definitions apply.

3.1.1 data acquisition: The process of receiving signals from the sensors, determining the values corresponding to the signals, and recording the results.

3.1.2 deck: That part of a floating roof which provides buoyancy and structure, and which covers the majority of the liquid surface in a bulk liquid storage tank. The deck has an annular space around its perimeter to allow it to rise and descend (as the tank is filled and emptied) without binding against the tank shell. This annular space is closed by a flexible device called a *rim seal*. The deck may also have penetrations, closed by deck fittings, which accommodate some functional or operational feature of the tank.

3.1.3 deck fitting: The device which substantially closes a penetration in the deck of a floating roof in a bulk liquid storage tank. Such penetrations are typically for the purpose of accommodating some functional or operational feature of the tank.

3.1.4 floating roof: A device that floats on the surface of the stored liquid in a bulk liquid storage tank. A floating roof substantially covers the liquid product surface, thereby reducing its potential for exposure to evaporation. Floating roofs are comprised of a deck, a rim seal, and miscellaneous deck fittings.

3.1.5 indicator: An instrument that displays or records signals received from a sensor. The indicator is typically constructed to express the signal in units that are useful to describe the observed value of measurement. For example, an electronic signal may be received by the indicator as volts, but then displayed as pounds. An indicator may be incorporated into an electronic data acquisition system. An electronic

¹American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428.

data acquisition system typically has the capability to be pre-programmed to record data at prescribed intervals, to analyze the data that has been received, and to electronically store the results.

3.1.6 instrument: A device used in the measurement process to sense, transmit, or record observations.

3.1.7 internal floating roof: A floating roof that is not exposed to the ambient environmental conditions by virtue of being in a bulk liquid storage tank that has a fixed roof at the top of the tank shell. Internal floating roofs are thus distinguished from external floating roofs, which are located in tanks that do not have a fixed roof to protect the floating roof from environmental exposure. Internal floating roofs are typically designed in accordance with Appendix H of API Standard 650.

3.1.8 loss factor: An expression used to describe the evaporative loss rate characteristics of a given floating-roof device. In order to obtain the total standing-storage evaporative loss rate for a bulk liquid storage tank equipped with a floating roof, the sum of the evaporative loss factors for each of the individual devices is modified by certain characteristics of both the climatic conditions and the stored liquid. The characteristics of the stored liquid are expressed as a vapor pressure function, the stock vapor molecular weight, and a product factor.

3.1.9 product factor: A factor that describes the evaporative loss characteristics of a given liquid product. The product factor, the stock vapor molecular weight, and the vapor pressure function are multiplied by the sum of the loss factors of the individual floating-roof devices to determine the total standing-storage evaporative loss rate of a bulk liquid storage tank equipped with a floating roof.

3.1.10 sensor: An instrument that senses the attribute or measurement information that is to be obtained in a measurement process. This information is then transmitted to the indicator to be displayed or recorded.

3.1.11 standing-storage evaporative loss: Loss of stored liquid stock by evaporation past the floating roof during normal service conditions. This does not include evaporation of liquid that clings to the tank shell and is exposed to evaporation when the tank is being emptied (withdrawal loss), nor does it include vapor loss that may occur when the liquid level is sufficiently low so as to allow the floating roof to rest on its support legs. This does include, however, evaporative losses from the rim seal, deck seams, and deck fittings.

3.1.12 vapor-pressure function: A dimensionless factor, used in the loss estimation procedure, that is a function of the ratio of the vapor pressure of the stored liquid to average atmospheric pressure at the storage location. The vapor-pressure function, the stock vapor molecular weight, and the product factor are multiplied by the sum of the loss factors of

the individual floating-roof devices to determine the total standing-storage evaporative loss rate of a bulk liquid storage tank equipped with a floating roof.

3.2 UNITS OF MEASUREMENT

3.2.1 Basic Units

The unit of length is either the mile, designated *mi*, the foot, designated *ft*, or the inch, designated *in*. The unit of mass is the pound mass, designated *pound* or *lb*. The unit of force is the pound force, designated *pound-force* or *lbf*. The unit of time is either the hour, designated *hr*, or the year, designated *yr*. The unit of temperature is the degree Fahrenheit, designated $^{\circ}F$, or the degree Rankine, designated $^{\circ}R$. The unit of electromotive force is the volt, designated *V*.

3.2.2 Loss Factors

The unit of reporting loss factors is the pound-mole per year, designated *lb-mole/yr*.

The units of the loss factor K_f do not actually indicate pound-moles of vapor loss over time, but rather are units of a factor that must be multiplied by certain coefficients (which are dimensionless) in order to determine actual pound-moles of evaporative loss over time for a given liquid product. To convert the pound-mole per year units of the loss factor to a loss rate in terms of actual pound-moles per year, the loss factor K_f is multiplied by the dimensionless coefficients P^* , which is a function of the product vapor pressure, and K_c , the product factor.

A pound-mole is an amount of a substance the mass of which, when expressed in pounds, is equal to the numerical value of the molecular weight of the substance. To convert the actual pound-moles per year loss rate to pounds per year of a given liquid product, the loss rate ($K_f P^* K_c$) is multiplied by the molecular weight of the product in its vapor phase, M_v , with molecular weight having units of pounds per pound-mole. Additional information may be found in API MPMS 19.2.

3.2.3 Pressure

The unit of pressure is the pound-force per square inch absolute, designated *psia*.

3.2.4 System of Units

This standard employs the inch-pound units of the English system. Values shall be referenced to the U.S. National Institute of Standards and Technology (NIST) values (formerly the U.S. National Bureau of Standards). The text of this standard does not include equivalent International System of Units (SI) values, which is the system adopted by the International Organization of Standardization (ISO), but guidance for conversion to SI and other metric units is provided in Appendix C.

3.3 NOMENCLATURE

The following table describes the symbols and provides their units.

Table 1—Nomenclature

Symbol	Description	Units
A_p	Constant in the vapor pressure equation	dimensionless
B_p	Constant in the vapor pressure equation	°R
K_c	Product factor	dimensionless
K_f	Deck-fitting loss factor	lb-mole/yr
L	Deck-fitting loss rate	lb/hr
L_f	Deck-fitting loss rate	lb/yr
M_v	Molecular weight of stock vapor	lb/lb-mole
P	True vapor pressure of the stock	psia
P_a	Atmospheric pressure	psia
P^*	Vapor-pressure function	dimensionless
T	Stock liquid temperature	°R or °F

Note: See 3.2 for definitions of abbreviations for the units.

4 Summary of Test Method

The test method described in this standard uses a weight loss procedure to measure a rate of evaporative loss. A test assembly containing a volatile test liquid of known properties, such as normal-hexane, is suspended from load cells. The weight loss of the test assembly is measured over time. The test data is then corrected for variations in temperature and atmospheric pressure during the period of the test, and a loss rate is determined. The corrected loss rate is then factored for the properties of the test liquid in order to determine an evaporative loss factor for that test assembly.

5 Significance and Use

This test method establishes a procedure for measuring the evaporative loss factor for deck fittings of internal floating-roof tanks. The testing is to be performed in a laboratory that has been approved by API for this purpose, in accordance with API MPMS 19.3, Part G. The values determined by this method are to be evaluated in accordance with MPMS 19.3, Part F, in order to assign an API-certified loss factor to the particular deck fitting tested. The laboratory approval procedure, the test method, and the evaluation method together constitute a procedure by which manufacturers of floating roofs may obtain API-certified loss factors for deck fittings of their proprietary design.

6 Limitations to the Test Method

6.1 EVALUATION OF RESULTS

The results of this test method are not intended to be used apart from their evaluation in accordance with MPMS 19.3, Part F.

6.2 LOW LOSS RATES

This test method is not valid for deck fittings that have a loss rate lower than the specified tolerance of the instruments or lower than the observed range of drift of the load cells.

7 Test Apparatus

7.1 TEST APPARATUS SCHEMATIC

Figures 1 and 2 are schematics of the test apparatus to be used to obtain the measurements necessary for developing a certified evaporative loss factor for a deck fitting of an internal floating roof. The test apparatus is comprised of certain test equipment and instrumentation arranged in a test room and a data acquisition room.

7.2 TEST ROOM

The test room is to be large enough to house the test equipment, instrumentation, and personnel required for the test method, except that the data acquisition system is housed in a separate room, as described in 7.4. The test room shall be constructed and controlled such that the air temperature in the test room is capable of being maintained within $\pm 5^\circ\text{F}$ of a selected test room temperature for the duration of the test period.

7.2.1 Insulation

The test room should be insulated to aid in the control of the air temperature within the room.

7.2.2 Air Temperature Control System

The test room shall have a dedicated temperature controller for maintaining the air temperature in the test room. The test room may also have a dedicated heater and air conditioner.

7.2.3 Air Ventilation System

The test room shall be equipped with an air ventilation system to provide sufficient ventilation of the test room to limit buildup of evaporated test liquid within the room. The test room shall be equipped with a ventilation blower to withdraw a steady stream of ventilation air from the test room. However, the flow rate of ventilation air must be limited so as not to cause a disturbance that affects the load cell readings.

7.2.4 Access Doors

The test room shall be equipped with an equipment access door large enough to permit installation or removal of a test assembly. The test room shall also be equipped with a smaller personnel access door to permit inspection of a test assembly during a test period.

7.2.5 Support Frame

The test room shall be equipped with a support frame for use in supporting a test assembly during the test period. The test assembly is to be supported by a hanger apparatus that is suspended from load cells that are attached to the support frame. The hanger apparatus shall accommodate leveling of the test assembly.

7.2.6 Spill Pan

It is advisable to place a spill pan under the test assembly to collect any spillage of the test liquid that may occur during filling and emptying operations.

7.3 TEST VESSELS

An item to be tested shall be mounted in the lid of a test vessel which shall be supported by a hanger apparatus that is suspended from the load cells. The test vessel, including its lid, shall be leaktight. The test vessel shall contain the test liquid.

7.3.1 Test Vessel Size

The size of the test vessel may vary to accommodate different sizes of test items. The test vessel shall be deep enough to allow the level of the test liquid surface to be within ± 1 inch of a specified level. The level of the liquid surface is determined from the reference distance described in 8.2.

The test vessel shall be of sufficiently large diameter that the evaporative loss of test liquid that occurs during the test does not result in a change in the elevation of the test liquid surface of more than 1 inch during the course of the test.

Test items that exhibit very low loss rates will require load cells that are capable of sensing smaller changes in weight than would be required for testing items with greater loss rates. This requirement may result in the use of a load cell with a reduced load capacity for testing low loss rate items, thereby limiting the size of the test vessel. This may generally be accomplished by using a test vessel of a smaller diameter, in that the low loss rate will result in a minimal change in the level of the test liquid surface.

7.3.2 Test Liquid

The test liquid shall be normal-hexane (n-hexane) or iso-hexane, technical grade or better. During a test, the temperature of the test liquid shall not be permitted to exceed its normal boiling-point temperature. A sample of the test liquid shall be tested to determine the Reid vapor pressure of the mixture in accordance with ASTM D 323.

The required quantity of test liquid may be reduced by floating it on top of water. The depth of the test liquid layer shall be sufficient to ensure that it completely covers the water at every exposed surface, inside and outside the test fitting, for the duration of the test. The depth of the test liquid

layer must also be sufficient to ensure that the change in vapor pressure of the test liquid as a result of evaporation of lighter hydrocarbon components does not cause the test liquid vapor pressure to decrease by more than 5 percent during the test.

7.3.3 Emptying and Filling

All penetrations of or attachments to the test vessel, including those for emptying and filling, must be leak tight. A method of indicating the liquid level in the test vessel must be provided to control initial filling and for monitoring purposes during a test. The preferred method of indicating the liquid level is by means of a sight tube, but other methods that do not result in any loss of test liquid product or its vapors may also be used.

7.4 DATA ACQUISITION ROOM

The data acquisition room is to be large enough to house the data acquisition system and personnel required for the test method. The data acquisition room shall be constructed and controlled such that the air temperature in the room is capable of being maintained within $\pm 5^\circ\text{F}$ of a selected test room temperature for the duration of the test period.

7.4.1 Insulation

The data acquisition room should be insulated to aid in the control of the air temperature within the room.

7.4.2 Air Temperature Control System

The data acquisition room shall have a dedicated temperature controller for maintaining the air temperature in the data acquisition room. The data acquisition room may also have a dedicated heater and air conditioner.

7.4.3 Circulation Fan

The data acquisition room shall be equipped with a fan that circulates the air within the room so as to reduce air temperature variations within the room.

8 Test Item

8.1 TEST ITEM ASSEMBLY

The test items to be tested according to this test method are deck fittings for internal floating-roof tanks. Items to be tested shall be full-scale samples of the deck fittings, except as noted in 8.3. These samples shall be constructed according to the manufacturer's standard practice, and shall include all features typical to actual use. Figure 3 is a schematic of a representative test item assembly that includes the test item, test vessel, and test liquid.