

Manual of Petroleum Measurement Standards Chapter 19.3, Part H

Specification for Establishing Evaporative Loss Factors for Floating-roof Tank Devices

SECOND EDITION, APRIL 2022



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Foreword

This edition of API MPMS Ch. 19.3, Part H incorporates API MPMS Ch. 19.3, Part F, 1st Edition, *Evaporative Loss Factor for Storage Tanks Certification Program*, and API MPMS Ch. 19.3, Part G, 1st Edition, *Certified Loss Factor Testing Laboratory Registration*, both of which are withdrawn.

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

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

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Specification for Establishing Evaporative Loss Factors for Floating-roof Tank Devices

1 Scope

The purpose of this standard is to specify requirements for the use of the test methods in API's *Manual of Petroleum Measurement Standards (MPMS)*, Ch. 19.3, Parts A through E to develop evaporative loss factors for floating-roof rim seals, deck fittings, and deck seams (hereinafter referred to as floating-roof devices).

This standard illustrates how other standards of the API *MPMS* Ch. 19.3 series are integrated into an overall loss factor development program to enable the user to develop a loss factor for a given floating-roof device. This standard presents procedures for the evaluations to be performed under such a program, including preparation for protocol testing of individual devices, monitoring of the tests, and analysis and reporting of test results for the purposes of establishing evaporative loss factors.

It is not the purpose of this loss factor development program as given in the *MPMS* Ch. 19.3 series of standards to specify procedures to be used in the design, manufacture, or field installation of floating-roof devices. Furthermore, equipment cannot 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.

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 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 15, *Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries*

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 19.2, *Evaporative Loss from Floating-Roof Tanks*, 4th Edition

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 19.3, Part A, *Wind Tunnel Test Method for the Measurement of Deck-Fitting Loss Factors for External Floating-Roof Tanks*, 1st Edition

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 19.3, Part B, *Air Concentration Test Method for the Measurement of Rim-Seal Loss Factors for Floating-Roof Tanks*, 1st Edition

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 19.3, Part C, *Weight Loss Test Method for the Measurement of Rim-Seal Loss Factors for Internal Floating-Roof Tanks*, 1st Edition

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 19.3, Part D, *Fugitive Emission Test Method for the Measurement of Deck-Seam Loss Factors for Internal Floating-Roof Tanks*, 1st Edition

API *Manual of Petroleum Measurement Standards (MPMS)* Chapter 19.3, Part E, *Weight Loss Test Method for the Measurement of Deck-Fitting Loss Factors for Internal Floating-Roof Tanks*, 1st Edition

API Publication 2517D, *Documentation File for API Publication 2517—Evaporation Loss from External Floating-Roof Tanks*, 1st Edition

ASTM D323,¹ *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

ASTM D5191, *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)*

3 Terms, Definitions, Units of Measurement, and Symbols

For the purposes of this document, the following definitions apply.

3.1 Terms and Definitions

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 that 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 that 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

deck seam

The joint attaching adjacent sheets or panels in the floating-roof deck.

3.1.5

floating roof

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

3.1.6

floating-roof device

A feature of a floating roof such as a deck fitting, rim seal, or deck seam where evaporative losses are possible.

3.1.7

floating-roof standing 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.

3.1.8

instrument

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

¹ American Society for Testing and Materials, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania 19428, astm.org.

3.1.9

loss factor

Factor that indicates the average amount of evaporation loss associated with a device. To obtain the total standing storage evaporative-loss rate for a floating-roof tank, the sum of the evaporative-loss factors for each of the individual devices is modified by certain characteristics of both climate 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.

3.1.10

product factor

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

3.1.11

protocol test

A test performed in accordance with the approved and published standards and procedures of the API *MPMS* Ch. 19.3 series, as applicable.

3.1.12

rim seal

A flexible device attached to the rim of a floating-roof deck that spans the annular space between the deck and the tank shell.

3.1.13

rim-seal gap area

The total cumulative horizontal area of all spaces or openings between the rim seal and the tank shell that provides an unobstructed path for a 0.125-in. diameter probe to pass freely from a position above the rim seal down to the stored product.

3.1.14

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.

3.2 Units of Measurement

3.2.1 Basic Units

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

3.2.2 Loss Factors

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

The pound-mole units of the loss factor (K_f for deck fittings, K_r for rim seals, or K_d for deck seams) do not actually indicate pound-moles of vapor loss over time, but rather are units of a factor that have to be multiplied by certain coefficients (which are dimensionless) to determine actual pound-moles of evaporative loss over time for a given liquid product. To convert the pound-mole units of the loss factor to a loss rate in terms of actual pound-moles, the loss factor (K_f , K_r , or K_d) 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 , K_r , or K_d) $\times$ ($P^* K_c$) 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 can be found in the API MPMS Ch. 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 or U.S. customary units. 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 the equivalent International System of Units (SI) values, but guidance for conversion to SI and other metric units is provided in Annex I.

3.2.5 Velocity

The unit of velocity is the mile per hour, designated *mi/h* or *mph*.

3.3 Symbols

Table 1 provides a description of the symbols and units that are used in this standard.

Table 1—Description of the Symbols and Units

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_d	Deck-seam loss factor	lb-mole/ft yr
K_f	Deck-fitting loss factor	lb-mole/yr
K_r	Rim-seal loss factor	lb-mole/ft yr
L	Deck-fitting loss rate for a single test	lb/h
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
V	Wind Speed	mi/h
NOTE See 3.2 for definitions of abbreviations for the units.		

4 Summary of the Loss Factor Development Program

This loss factor development program includes preparation for protocol testing, performance of the tests, and analysis of the results. Annex A illustrates the overall loss factor development program in the form of flow diagrams for the wind tunnel test method of API *MPMS* Ch. 19.3, Part A.

Preparation for a protocol test includes certain responsibilities of the testing laboratory, as specified in Section 5. Section 6 provides guidance for review of the documentation for a proposed protocol test.

The testing laboratory shall perform the protocol tests as specified in the test methods of the API *MPMS* Ch. 19.3 series of standards. Parts A and E of API *MPMS* Ch. 19.3 address test methods for deck fittings, Parts B and C contain rim-seal test methods, and Part D contains a deck-seam test method. General guidance for the performance of protocol testing is given in Section 7.

Test reports shall conform to the requirements of the testing protocol. Analyze the test data and assign loss factors to the tested devices as specified in Section 8 below.

It is the responsibility of the testing laboratory to document compliance with each applicable requirement of the API *MPMS* Ch. 19.3 series of standards. Documentation of compliance shall always be shown as a measured value compared with a specified requirement rather than simply as a statement certifying compliance.

5 Testing Laboratory Preparation

The process of preparing a testing laboratory under this loss factor development program is outlined in Figure A.1. The requirements for a particular test facility are specified in the corresponding test method of API *MPMS* Ch. 19.3. Figures 1 and 2 illustrate the test facility requirements for the wind tunnel test method of Ch. 19.3, Part A.

The testing laboratory calibrates the test instruments in accordance with the appropriate test method of API *MPMS* Ch. 19.3. The test methods specify the maximum tolerable error, the maximum calibration interval, and the required sensitivity for the test instruments. Table 2 illustrates the instrument requirements for the wind tunnel test method of Ch. 19.3, Part A, 1st Edition.

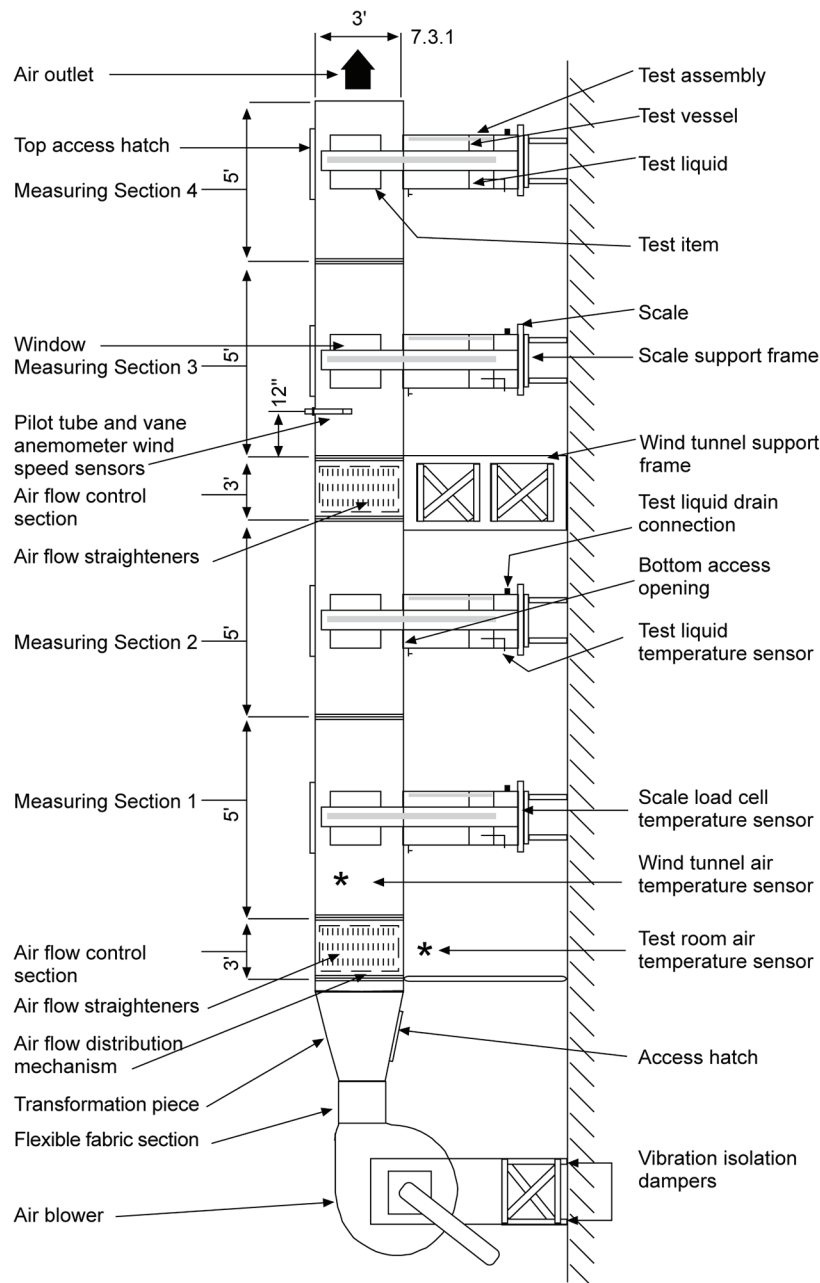
The testing laboratory also programs the data acquisition system (DAS) as specified in the test methods of the API *MPMS* Ch. 19.3 series of standards. This programming includes corrections for instrument bias and temperature effects that may be applicable. The wind tunnel test method of API *MPMS* Ch. 19.3, Part A, for example, requires dead-weight testing of the load cells through a range of temperatures to establish a load cell temperature correction coefficient. Appendix A of API *MPMS* Ch. 19.3, Part A, 1st Edition, describes two procedures for determining this correction coefficient. The procedure given in A.3 of API *MPMS* Ch. 19.3, Part A, 1st Edition, shall be acceptable for assigning a temperature correction coefficient to a scale or load cell if the coefficient of determination, r^2 , is greater than or equal to 0.99 for the linear regression of measured weight loss, W_{mi} , on the temperature of the load cell, T_{mi} , resulting in the model:

$$\widehat{W}_{mi} = a + dT_{mi}$$

This calculation is presented in more detail in B.3.5 of Annex B, which summarizes the statistical calculations required by API *MPMS* Ch. 19.3, Part A, 1st Edition.

Upon completion of the instrument calibrations and DAS programming, the test facility shall be operated to demonstrate compliance with the allowable variations specified in the test methods. The allowable variations for the wind tunnel test method of API *MPMS* Ch. 19.3, Part A are summarized in Table B.2. API *MPMS* Ch. 19.3, Part A, further requires that a velocity profile survey be conducted for the wind tunnel. Annex C of this standard outlines a procedure for the wind tunnel velocity profile survey.

Having demonstrated that all instruments and equipment are functioning within acceptable limits, the testing laboratory shall perform tests of standard devices as required by 6.4. Annex D stipulates the standard devices for deck-fitting, rim-seal, and deck-seam testing, and specifies the method for determining whether the test results are acceptable.



NOTE 1 Citations are to API MPMS Chapter 19.3, Part A, 1st edition.

NOTE 2 Perform velocity surveys at 5 mph, 10 mph, and 15 mph (see 7.3.4.1 of API MPMS Chapter 19.3, Part A, 1st edition).

NOTE 3 Locate the wind speed sensors in the first or third measuring sections where the measured wind speed is within $\pm 5\%$ of the average, but not within 6 in. of the sides of the wind tunnel (see 10.5.1 of API MPMS Chapter 19.3 Part A, 1st edition).

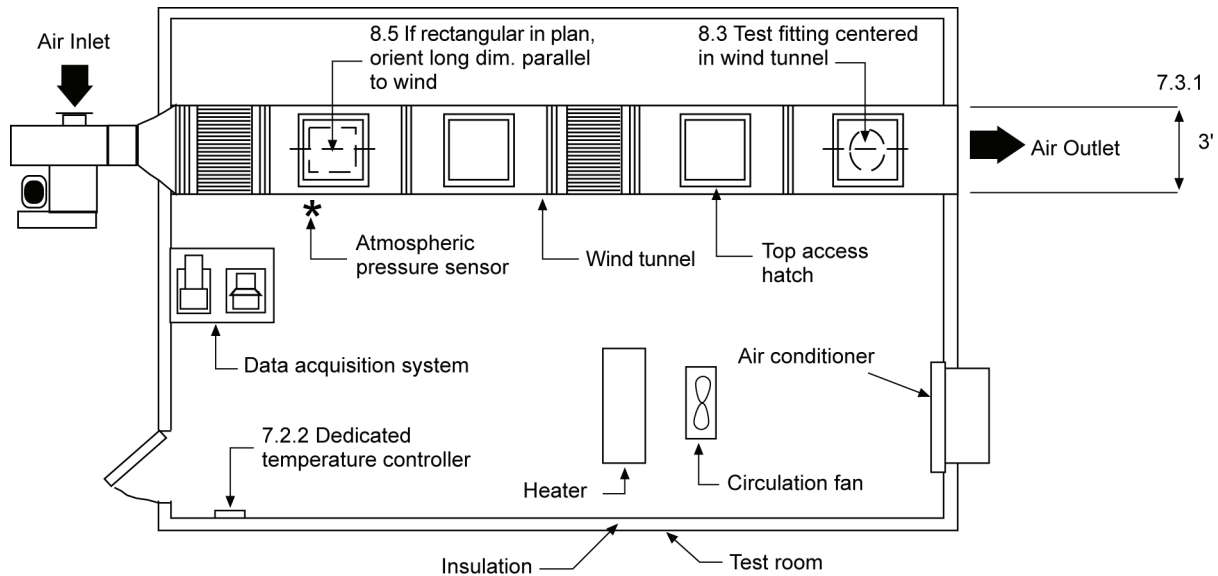
NOTE 4 Air flow straighteners shall be at least 2 ft long. The first air flow straighteners shall be located at least 6 in. downstream of the air flow distribution mechanism (see 7.3.4.2 of API MPMS Chapter 19.3 Part A, 1st edition).

NOTE 5 The 5-ft length shown for the measuring sections (measuring stations) is a minimum (see 7.3.2 of API MPMS Chapter 19.3, Part A, 1st edition).

NOTE 6 When testing is performed with test items of different sizes in the wind tunnel, larger items are to be placed downstream of smaller ones (see 8.3 of API MPMS Chapter 19.3, Part A, 1st edition).

Figure 1—Elevation View of a Typical Wind Tunnel Test Facility





NOTE Citations are to API MPMS Chapter 19.3, Part A, 1st edition.

Figure 2—Plan View of a Typical Wind Tunnel Test Facility

Table 2—Instrument Requirements for API MPMS Chapter 19.3, Part A, 1st Edition

Variable To Be Measured	Instrument Type	Maximum Tolerable Error	Maximum Calibration Interval	Required Sensitivity	Reference in Part A
Weight of the test apparatus	Scale	$\pm 0.1\%$	3 months	$\pm 0.01\%$ of the test assembly wt.	10.3
Time of the observation	Clock of the DAS	$\pm 0.1\%$	6 months	1 seconds	10.2
Wind speed	Vane anemometer	$\pm 5\%$	6 months	0.1 mph	10.5
	Pitot tube	—	—	0.1 mph	10.5
Temperature of the air in the wind tunnel	Thermocouple	$\pm 0.5\text{ }^{\circ}\text{F}$	6 months	$\pm 0.2\text{ }^{\circ}\text{F}$	10.4
Average bulk temperature of the test liquid	Thermocouple	$\pm 0.5\text{ }^{\circ}\text{F}$	6 months	$\pm 0.2\text{ }^{\circ}\text{F}$	10.4
Temperature of the air in the test room	Thermocouple	$\pm 0.5\text{ }^{\circ}\text{F}$	6 months	$\pm 0.2\text{ }^{\circ}\text{F}$	10.4
Temperature of the scale or load cell	Thermocouple	$\pm 0.5\text{ }^{\circ}\text{F}$	6 months	$\pm 0.2\text{ }^{\circ}\text{F}$	10.4
Voltage delivered by the power supply	Voltmeter of the DAS	$\pm 0.1\%$	6 months	—	10.6
Atmospheric pressure	Pressure transducer	$\pm 0.05\text{ psia}$	6 months	$\pm 0.01\text{ psia}$	10.7

NOTE 1 The first four columns are from API MPMS Ch. 19.3, Part A, 1st Edition, Table 2.

NOTE 2 The accuracy of the instruments shall be demonstrated using NIST-traceable standards and shall be based on readings indicated by the DAS (API MPMS Ch. 19.3, Part A, 1st Edition, Section 10.1).

NOTE 3 The reference weights shall have certified accuracies of $\pm 0.1\%$ (API MPMS Ch. 19.3, Part A, 1st Edition, Section 10.3.2.1).

6 Preparation for Protocol Testing

6.1 General

The activities involved in the preparation for protocol testing of a particular floating-roof device are outlined in Figure A.2. The results from all tests of devices that are substantially the same in configuration, dimensions, and materials of construction shall be included in the determination of a loss factor. The combinations of configuration, dimensions, and materials to be included in the protocol testing shall be described in the test report to identify the entire range being claimed. Also determine, for the wind tunnel test method of API *MPMS* Ch. 19.3, Part A, whether any nonsymmetrical features of the device warrant testing it in multiple orientations. Annex E provides guidance for the review of preparation for protocol testing.

6.2 Physical Identification of Tested Device

The floating-roof device to be tested and the recommended installation procedure for the device shall be described in writing, including sketches and drawings, so that the test facility can properly mount the device in the test apparatus in a manner consistent with its intended use.

The description of the floating-roof device shall identify it in a manner that distinguishes it from other devices of similar type and construction, such that determination of whether a device installed in the field is substantially similar to the device tested can be ascertained by inspection of installed components in the field. All tolerances on dimensions, variations on configuration or substitution of material intended to be included in the description of the device shall be identified. These descriptions need not identify proprietary compositions of matter except in general terms or internal mechanical details that have no impact on the evaporative loss performance. The material shall be sufficiently detailed to conclusively identify the device that was tested, distinguish the device from similar devices, and permit the reconstruction of the device should retesting be necessary.

Each floating-roof device prepared for testing shall be positively and permanently marked with a unique alphanumeric identifier. The identifier shall be included in all records of testing.

Accurate mechanical drawings shall be prepared of the device to be tested and its configuration during testing. These drawings shall show all details that are relevant to reproducing an identical device should retesting be necessary.

Each tested device shall be photographed in as much detail as necessary to show clearly the important features of the tested device and to allow identification of the device tested at a later date.

Each tested device, the identifying photographs and the mechanical drawings shall be retained for a period of 5 years by the test facility.

6.3 Data Collection and Integrity

The results of any testing conducted under these protocols shall be measured and recorded as specified herein.

All time-dependent loss measurements shall be recorded through the use of an electronic data collection system. The data files created by the system shall contain in each record:

- a unique test identification code,
- a time stamp that can be reconciled against other standard time stamps, and
- the serial number of the sensor generating the signal.

The sensors shall not be recalibrated, respanned, or the signals adjusted during a test without clear documentation of the change made and the time stamp associated with the change.

The facility shall calibrate the equipment used for testing under this standard using the means specified in the appropriate test protocols. Equipment may be calibrated more often than the maximum time interval specified.

The mass and temperature calibration standards shall be traceable to the National Institute of Standards and Technology or a national standards agency.

6.4 Testing of Standard Devices

As part of the preparation of a testing laboratory for the testing of floating-roof devices, the facility shall perform testing of specific standard devices as specified in D.3 for calibration of the test facility.

The facility will rerun the testing of the specified standard devices, following modifications to the test facility, for the purpose of assuring that the modifications did not have an adverse impact on the quality of data produced by the test apparatus. If the results of the rerun tests are not comparable to historical results, the facility shall resolve the differences.

Furthermore, one standard device shall be included within each group of 20 test runs as specified in D.4. Wind tunnel tests at different wind speeds shall individually count as one run each.

For example, in a four-test-position wind tunnel, it is expected that at least one standard device will be tested for every five times a wind tunnel test is performed.

7 Performing Protocol Testing

The activities involved in the protocol testing of a particular floating-roof device are outlined in Figure A.3. The test methods for this loss factor development program are published as separate standards as part of the API *MPMS* Ch. 19.3 series, as referenced previously. The application of these test methods is illustrated in this standard by reviewing the requirements for the wind tunnel test method in API *MPMS* Ch. 19.3, Part A, 1st Edition.

Each demonstration of compliance with any requirement of the loss factor development program shall be documented in a quantified manner (i.e. by stating the value of each measurement or observation and by stating the reference value or range to which it compares).

Each test report shall include documentation of compliance with the requirements of the test method itself, as well as documentation that demonstrates compliance with all other conditions of the loss factor development program. These other conditions include documentation that the testing laboratory was properly prepared to perform that particular test method, documentation of the required tests of standard devices, documentation that all instrument calibrations were current, and documentation of the properties of the test liquid. When n-hexane, technical grade or better, is used as the test liquid, the requirement of API *MPMS* Ch. 19.3, Part A, 1st Edition, Section 7.6.2 is satisfied by monthly testing of the Reid vapor pressure in accordance with either ASTM D323 or ASTM D5191. The stated concern with respect to preferential evaporation of the lighter components is not relevant to a high-purity, single-component liquid. When multicomponent test liquids are used, however, the Reid vapor pressure shall be measured before and after each test.

API *MPMS* Ch. 19.3, Part A, 1st Edition, Sections 9.3 and 11.3 indicate that deck fittings having a relatively high rate of evaporative loss may initially experience unstable conditions during testing due to the effect of evaporative cooling on the surface of the test liquid. A procedure for determining when steady-state conditions have been achieved is presented in Annex F.

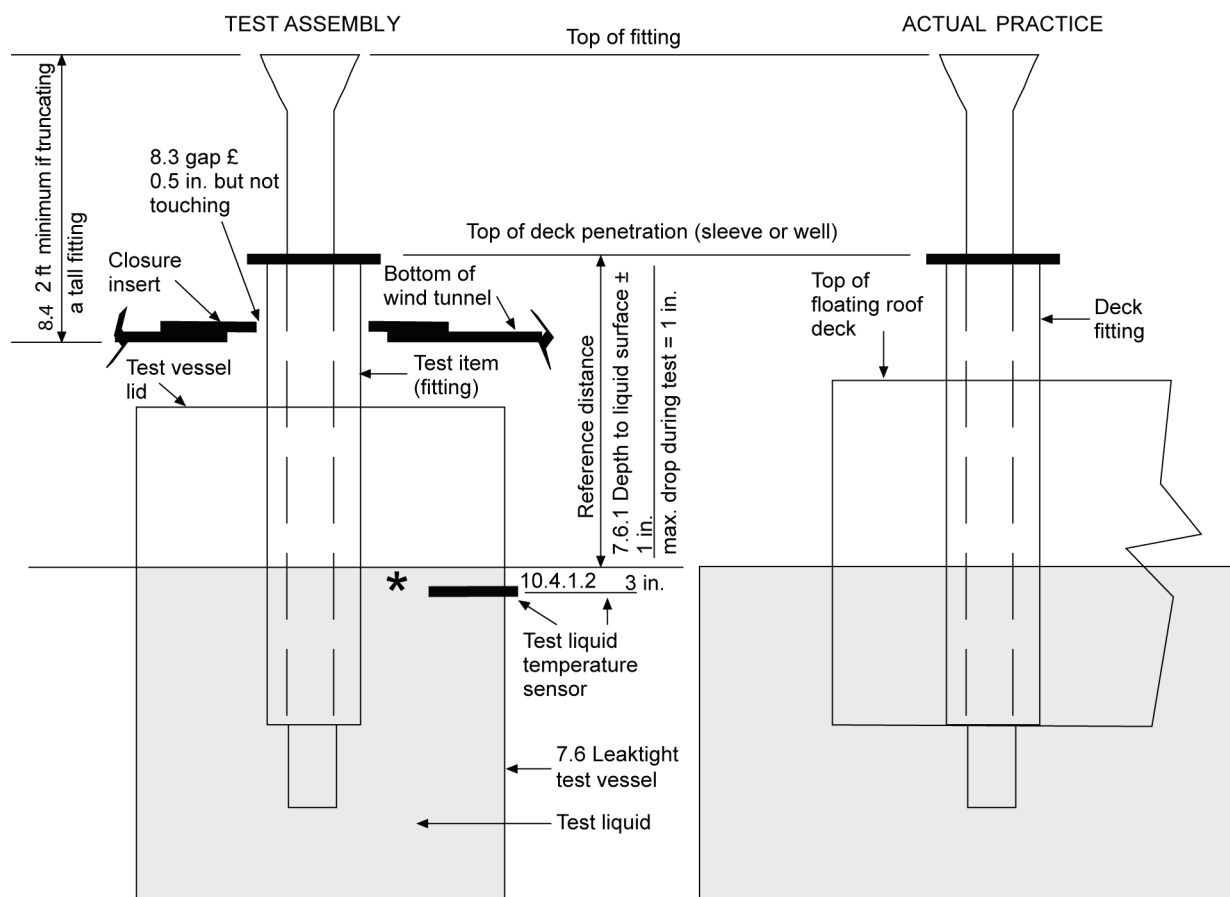
Numerous statistical calculations are required in the determination of test results. These are summarized in Annex B for the wind tunnel test method in API *MPMS* Ch. 19.3, Part A, 1st Edition and include the requirement of B.3.7 concerning limits on the variability of the test results.

When evaluating loss factors to be obtained from the wind tunnel test method, the loss factor coefficients shall be determined as specified in API *MPMS* Ch. 19.3, Part A, 1st Edition, Appendix C.

8 Reporting of Protocol Testing

Reports of protocol testing shall document that each step of the loss factor development program specified herein has been followed. The procedure for review of the loss factor development steps is outlined in Figure A.4. This includes reviewing the test preparation and reviewing that all documentations, calibrations, and testing of standard devices were current and satisfactory.

Documentation of how the test assembly was installed in the test facility is compared with the installation drawings and procedure to confirm compliance with the reference dimensions specified in the test methods. The test method drawing of the test assembly shall show the proper placement of the test assembly in the test facility. Figure 3 illustrates the requirements of the wind tunnel test method specified in API *MPMS* Ch. 19.3, Part A, 1st Edition for installing a deck-fitting test assembly.



NOTE Citations are to API *MPMS* Chapter 19.3, Part A, 1st edition.

Figure 3—Test Assembly

The test results are then reviewed for validity and consistency of the data, including checks of the statistical calculations summarized in Annex B. If no errors are found in the data or the statistical calculations and the variability of the test results is within the limits of B.3.7, then review the determination of the loss factor coefficients. Test results showing very low loss rates shall be evaluated to determine whether they exceed the *de minimis* criteria of Annex G. Finally, evaluate the uncertainty in the loss factors as outlined in Annex H.

All tests of the device shall be reported. However, tests that were conducted for product development, at conditions not permitted by the test protocols or on objectively different devices, should not be included in the report. It is the intent of this standard that the loss factors be based on the widest available pool of information.

The report shall include the loss factors for use in API evaporative loss calculation methods, the 95 % confidence limits for the factors, and a physical description of the device. The report shall include copies of all test measurements, drawings, specifications, and reports required by the test protocols used, as well as any additional data material to the evaluation of the loss factor.

The testing laboratory shall assure that all statements, representations, data, and reports provided are accurate and complete to the best of their knowledge.

9 Specifications for Protocol Testing

9.1 General

This section specifies test conditions and number of tests to develop a loss factor for each type of device.

9.2 Deck Fittings

Deck fittings for use only with internal or covered floating roofs shall be tested at the nominal zero mph wind speed, in accordance with the test method of either Part A or Part E of API *MPMS* Ch. 19.3. A minimum of three tests shall be performed.

The minimum test requirements for deck fittings for use with external floating roofs are summarized in Table 3. Deck fittings that are orientation-dependent shall be tested with the prominent feature oriented at 0°, 45°, and 90° to the direction of wind, for each of the nonzero wind speeds. That is, for orientation-dependent deck fittings, the number of tests shown in Table 3 at wind speeds other than zero shall be performed at each of the specified orientations.

Wind speeds of 4.3 mph, 8.5 mph, and 11.9 mph are specified to allow comparison to the test results for generic deck fittings that were tested at these wind speeds by API as described in API *MPMS* Ch. 19.2, 3rd Edition, D.2. Since these are actual wind speeds at the deck fitting, they correspond to ambient wind speeds at the tank site of ~6 mph, 12 mph, and 17 mph, after applying the fitting wind-speed correction factor of 0.7 (as specified in API *MPMS* Ch. 19.2, 3rd Edition, 4.2.2.3).

Table 3—Minimum Number of Tests for Deck Fittings

Wind Speed	0 ^a (mph)	4.3 ^b (mph)	8.5 ^{b,c} (mph)	11.9 ^b (mph)
Number of tests	3	1	3	1
Test method (API <i>MPMS</i> Ch. 19.3)	Part A or Part E	Part A	Part A	Part A
^a The nominal 0 mph condition is any level of wind speed less than 0.5 mph. ^b The number of tests shown shall be performed at each orientation, for orientation-dependent deck fittings. The specified orientations are 0°, 45°, and 90°. ^c The nominal 10 mph wind speed shall be taken as a wind tunnel wind speed of 8.5 mph for consistency with previous API testing as described in API <i>MPMS</i> Ch. 19.2, 3 rd Edition, Section D.2.				

The determination of acceptable variability of the test results, as specified in Annex B, shall be performed at zero mph for all deck fittings and additionally at 8.5 mph for deck fittings to be used with external floating roofs. The limits specified in Table B.2 shall apply for both wind speed conditions.

9.3 Rim Seals

The rim-seal test method described in API *MPMS* Ch. 19.3, Part B, 1st Edition, Section 11.2 specifies that the wind speed levels to be used for testing the evaporative loss rates for rim seals shall be 0 mph, 5 mph, 10 mph, and 15 mph. Rim seals to be used only with internal or covered floating roofs shall be tested at the nominal zero mph wind speed in accordance with the test method of either Part B or Part C of API *MPMS* Ch. 19.3. A minimum of three tests shall be performed.

The minimum test requirements for rim seals to be used with external floating roofs are summarized in Table 4.

Floating-roof rim seals in actual practice sometimes have gaps between the rim seal and the shell of the tank. The cumulative area of all such gaps (rim-seal gap area) for an individual tank is expressed as the ratio of the total area of gaps divided by the diameter of the tank (in²/ft). Each rim-seal test result shall be determined as the weighted average of evaporative loss-rate measurements for various rim-seal gap areas, on the basis of an assumed distribution of rim-seal gap areas among the actual tank population for each type of rim seal. The rim-seal gap areas to be tested for the determination of rim-seal loss factors are summarized in Table 5, as well as the assumed distribution to be used in calculating a weighted-average test result.

Table 4—Minimum Number of Tests for Rim Seals

Wind Speed	0 ^a (mph)	5 (mph)	10 (mph)	15 (mph)
Number of Tests ^b	3	1	3	1
Test Method (API MPMS Ch. 19.3)	Part B or Part C	Part B	Part B	Part B
^a The nominal zero mph condition is any level of wind speed less than or equal to 0.5 mph. ^b Each test result shall be determined as the weighted average of evaporative loss-rate measurements for various rim-seal gap areas, as shown in Table 5.				

The determination of acceptable variability of the test results, as specified in B.3.7, shall be performed at 0 mph for all rim seals, and additionally at 10 mph for rim seals to be used with external floating roofs. The limits specified in Table B.2 shall apply for both wind speed conditions.

Table 5—Rim-seal Gap Areas^a and Distributions for Average-fitting Rim Seals

Type of Primary Rim Seal	Primary Rim-seal Gap Area (in ² /ft)	Secondary Seal (if present) Gap Area (in ² /ft)	Distribution for Weighted Average (%)
Mechanical shoe-seal, welded tank shell ^b	0	0	10
	2.8	0	80
	9.4	1.0	10
Mechanical shoe-seal, riveted tank shell ^c	0	0	5
	2.8	0	60
	9.4	1.0	35
Liquid-mounted seal ^b	0	0	65
	1.3	0	25
	2.6	1.0	10
Vapor-mounted seal ^b	0	0	65
	1.0	0	25
	1.0	1.0	10
^a A method for the determination of rim-seal gap areas is specified in API MPMS Ch. 19.3, Part B, 1 st Edition, Section 11. The measured rim-seal gap area for a given test shall be within ± 10 % of the nominal value selected from this table, except for the zero rim-seal gap area, which shall be as described in API MPMS Ch. 19.3, Part B, 1 st Edition, Section 11.1.4. ^b Loss factors for tight-fitting rim seals, as described in API MPMS Ch. 19.2, 3 rd Edition, Section 4.2.2.2, shall be based on only the 0 in ² /ft rim-seal gap area. ^c The potential for rivet heads to hold the metallic shoe of a mechanical-shoe seal away from a riveted tank shell results in an assumption of larger gaps for this combination of primary-seal type and tank construction.			

9.4 Deck Seams

The deck-seam test method described in API MPMS Ch. 19.3, Part D, 1st Edition, Section 11.1 specifies that the pressure differences to be used for testing the evaporative loss rates for deck seams shall be 0.02, 0.04, 0.06,

0.08, and 0.10 in. of water column for each test. A minimum of three tests shall be performed for each deck-seam loss factor to be determined, with each test involving measurements at each of the specified pressure differences.

Floating-roof deck seams in actual practice sometimes have to accommodate gaps between adjoining sections of the floating-roof deck. At least one of the tests for the determination of a deck-seam loss factor shall be performed on a deck seam constructed with an intentional gap in the fit-up of the deck seam. This gap shall be described in the test report to document the maximum gap between adjoining sections for which the reported deck-seam loss factor is applicable.

Testing for the determination of a deck-seam loss factor shall include at least three deck joints representative of where the deck seams intersect each other and at least three deck joints representative of where deck seams intersect the rim of the floating roof. The deck joint configurations tested shall represent the full range of angles at which the deck seam may intersect the rim of the floating roof. The range of angles tested shall be described in the test report to document the full range for which the reported deck-seam loss factor is applicable.

Any use of elastomers such as gaskets or caulk in the deck seams or the deck joints shall be photographed and described in sufficient detail such that it can be ascertained as to whether the details in actual construction are reasonably similar to the details that were tested.

The deck-seam loss factor shall be determined from the average values of the results from each test at a pressure difference of 0.05 in. of water column. If the test assemblies include representative types and quantities of deck joints, then the deck-seam loss factor shall be calculated as follows:

$$K_d = \left(\frac{\pi}{4}\right) \left(\frac{\sum_{i=1}^n K_{d_{0.05}}}{n}\right)$$

where

K_d	is the deck-seam loss factor to be used in API <i>MPMS</i> Ch. 19.2,
$K_{d_{0.05}}$	is the deck-seam loss factor determined from the test method in API <i>MPMS</i> Ch. 19.3, Part D, 1 st Edition, for an individual test, i , at a pressure difference of 0.05 in. of water column;
n	is the number of tests.

If the quantities of deck joints in the test assemblies are not representative of the frequency of deck joints per foot of deck seam in actual construction, then the loss rate shall be determined for the deck joints separately from determining the loss rate for the deck seams, and the overall deck-seam loss factor shall be calculated as follows:

$$K_d = \left(\frac{\pi}{4}\right) \left[\left(\frac{\sum_{i=1}^n K_{d_{0.05}}}{n}\right) + \left(\frac{K_{J_{tee}}}{L_{tee}}\right) + \left(\frac{K_{J_{rim}}}{L_{rim}}\right) \right]$$

where

K_d	is the deck-seam loss factor to be used in API <i>MPMS</i> Ch. 19.2;
$K_{d_{0.05}}$	is the deck-seam loss factor determined from the test method in API <i>MPMS</i> Ch. 19.3, Part D, 1 st Edition, for an individual test, i , at a pressure difference of 0.05 in. of water column;
n	is the number of tests;
$K_{J_{tee}}$	is the average loss rate for deck joints where the deck seams intersect each other, at a pressure difference of 0.05 in. of water column;

L_{tee}	is the typical length of deck seams per joint where the deck seams intersect each other;
K_{jrim}	is the average loss rate for deck joints where the deck seams intersect the rim of the floating roof, at a pressure difference of 0.05 in. of water column;
L_{rim}	is the typical length of deck seams per joint where the deck seams intersect the rim of the floating roof. A tank diameter of 90 ft may be assumed for purposes of determining L_{rim} .

Testing conducted for the development of the test method in API *MPMS* Ch. 19.3, Part D, 1st Edition, demonstrated that significant variability can occur in the observed loss rate for a given type of deck seam, particularly in the event of an imperfection in the fit-up of the deck seam or deck joint in the test assembly. Because fit-up can also be an issue during construction of the floating-roof deck in an actual tank, imperfections in the fit-up of the deck seam or deck joint or imperfections in the installation of caulk or gasketing in the test assembly shall not be a basis for rejecting the results of a test.

Given the expected variability of the test results, there is no limit on the acceptable variability of the test results for deck-seam testing; that is, three tests shall be deemed acceptable for determination of a deck-seam loss factor, regardless of the variability of the test results, as long as the three tests include representative deck joints and at least one test accommodates the maximum gap for which the reported deck-seam loss factor is to be applicable.

Annex A

(informative)

Flow Diagram of the Loss Factor Development Program

This annex provides flow diagrams illustrating the steps of the loss factor development program for the wind tunnel test method of API *MPMS* Ch. 19.3, Part A. Figure A.1 presents the procedure by which a testing laboratory develops a loss factor for a given device. The responsibilities involved in preparing to perform protocol testing are listed in Figure A.2. Figure A.3 outlines the procedure for actually performing the test method, and Figure A.4 is a checklist of the steps involved in the review of the testing program. Citations are to this document (API *MPMS* Ch. 19.3, Part H), unless another part is indicated.