

Manual of Petroleum Measurement Standards Chapter 19.3—Evaporative Loss Measurement

Part C—Weight Loss Test Method for the Measurement of Rim-Seal Loss Factors for Internal Floating-roof Tanks

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FOREWORD

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

Testing programs conducted by API, which began in the mid-1970s and extended through 1982, provided the information on which the current evaporative rim-seal loss factors are based for common, generic types of external, covered, and internal floating-roof rim seals. These rim-seal loss factors are published in API Publication Chapter 19.2, "Evaporative Loss From Floating-Roof Tanks," for use in estimating the evaporative loss of petroleum stocks from external, covered, and internal floating-roof tanks. These rim-seal 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 rim-seal loss factors for proprietary designs of individual manufacturers. By publishing this test method, API is making the test method available to interested parties who wish to test particular rim seals under the auspices of API.

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

- (a) The testing shall be performed in laboratories licensed by API. The requirements to qualify for licensure are presented in API *Manual of Petroleum Measurement Standards*, Chapter 19.3, Part G, "Certified Loss Factor Testing Laboratory Registration;"
- (b) Testing and determination of test results shall be performed as specified herein; and
- (c) 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 API *Manual of Petroleum Measurement Standards*, Chapter 19.3, Part F, "Evaporative Loss Factor for Storage Tanks Certification Program."

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

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Chapter 19.3—Evaporative Loss Measurement

PART C—WEIGHT LOSS TEST METHOD FOR THE MEASUREMENT OF RIM-SEAL LOSS FACTORS FOR INTERNAL FLOATING-ROOF TANKS

0 Introduction

The purpose of this standard is to establish a uniform method for measuring evaporative rim-seal loss factors of rim seals used on internal floating-roof tanks. These rim-seal loss factors are to be determined in terms of loss rate and seal gap area 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 rim seals. Furthermore, equipment should not 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 rim-seal loss factors for rim seals used on 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 procedure, and the calculation procedures to be used. The variables that are to be measured are defined, and quality provisions are stipulated. 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 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

2.1 API NORMATIVE STANDARDS

API

Manual of Petroleum Measurement Standards, Chapter 19.2, “Evaporative Loss From Floating-Roof Tanks”

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

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

Publ 2517 *Evaporative Loss from External Floating-Roof Tanks*

Publ 2519 *Evaporation Loss from Internal Floating-Roof Tanks*

2.2 ASTM NORMATIVE STANDARDS

ASTM¹

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

E220, *Method for Calibration of Thermocouples by Comparison Techniques*

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

3 Terminology

3.1 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 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 deck seam: Certain types of internal floating roofs are constructed of deck sheets or panels that are joined by mechanical means at deck seams. Such mechanically joined seam devices have an associated deck seam loss. Other types of internal or external floating roofs are constructed of metal

¹ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428.

sheets that are joined by welding. Such seam devices do not have an associated deck seam loss.

3.1.5 evaporative loss factor: An expression used to describe the evaporative loss rate characteristics of a given floating roof device. In order to obtain the standing storage evaporative loss rate for a bulk liquid storage tank equipped with a floating roof, the evaporative loss factor for each evaporative loss contributing device 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, a vapor molecular weight, and a product factor.

3.1.6 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.

3.1.7 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 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.

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

3.1.9 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 by their use of a fixed roof to protect the internal floating roof from environmental exposure. Internal floating roofs are typically designed in accordance with Appendix H of API Standard 650, *Welded Steel Tanks for Oil Storage*.

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

3.1.11 rim seal: A flexible device that closes the annular rim space between the tank shell and the perimeter of the floating roof deck. Effective rim seals close the annular rim space, accommodate irregularities between the floating roof

and the tank shell, and help to center the floating roof, yet permit normal floating roof movement.

3.1.12 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.

3.1.13 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.

3.1.14 vapor pressure function: A dimensionless factor, used in the loss estimation procedure, that is a function of the ratio of the vapor pressure of stored liquid to the 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.

3.1.15 weight loss test method: The method of determining a loss factor by measuring the weight loss of a test assembly over time as test liquid evaporates from the test assembly.

3.2 UNITS OF MEASUREMENT

3.2.1 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, Metric Units.

3.2.2 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 °F, or the degree Rankine, designated °R. The unit of electromotive force is the volt, designated V.

3.2.3 Pressure

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

3.2.4 Rim-Seal Loss Factors

The unit of reporting rim-seal loss factors is the pound-mole per foot of tank diameter per year, designated lb-mole/ft yr.

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

A pound-mole, designated lb-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 then convert the actual pound-moles per foot of tank diameter per year to pounds per year of a given liquid product, the loss rate ($K_r P^* K_c$) is multiplied by the tank diameter, D , and the molecular weight of the liquid product in its vapor phase, M_v , with molecular weight having units of pounds per pound-mole. Additional information on this formula may be found in API Publications 2517 and 2519, and in API MPMS, Chapter 19.2.

3.3 NOMENCLATURE

Table 1 provides a description of the symbols and units.

Note: See Section 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 is suspended from load cells and is fitted with a test rim seal. Spacers are placed between the test rim seal and the simulated tank shell of the test assembly to create a specified rim-seal gap area. The area below the test rim seal is filled to an appropriate height with a volatile hydrocarbon test liquid of known properties, such as normal-hexane or isohexane. The weight loss of the test assembly over time is measured. The test data is corrected for variations in temperature and atmospheric pressure during the period of the test, and a loss rate is determined. The loss rate is then factored for the properties of the test liquid and the length of the test rim seal in order to determine an evaporative rim-seal loss factor for the test rim seal at that seal gap area.

5 Significance and Use

This test method establishes a procedure for measuring the evaporative rim-seal loss factor of rim seals that are used on internal floating-roof tanks. The testing is to be performed in a laboratory that has been approved by the API for this purpose in accordance with the API MPMS, Chapter 19.3, Part G, “Cer-

Table 1—Description of the Symbols and Units

Symbol	Description	Units
A_g	Rim-seal gap area	in ²
A_p	Constant in the vapor pressure equation	dimensionless
B_p	Constant in the vapor pressure equation	° R
D	Tank diameter	ft
F_g	Rim-seal gap area factor	in ² /ft
K_c	Product factor	dimensionless
K_r	Rim-seal loss factor	lb-mole/ft yr
L	Rim-seal loss rate	lb/hr
L_c	Length of the test assembly shell plate	ft
L_r	Rim-seal loss rate	lb/yr
L_s	Length of test rim seal	ft
M_v	Molecular weight of test liquid vapor	lb/lb-mole
P	Vapor pressure of the test liquid	psia
P_a	Atmospheric pressure	psia
P^*	Vapor pressure function	dimensionless
t	Time	hr
T	Stock liquid temperature	°R or °F
W	Weight loss of the test rim seal	lb

tified Loss Factor Testing Laboratory Registration.” The values determined by this method are to be evaluated in accordance with the API *MPMS*, Chapter 19.3, Part F, “Evaporative Loss Factor for Storage Tanks Certification Program,” to assign API-certified loss factors to the particular rim seal tested. The laboratory approval procedure, the test method, and the evaluation method together constitute a procedure by which manufacturers of floating roof rim seals may obtain API-certified loss factors for rim seals of their proprietary design.

6 Limitations to 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 API *MPMS* Chapter 19.3, Part F.

6.2 LOW LOSS RATES

This test method is not valid for rim seals 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.

If it is determined that the loss rate of the test rim seal is less than the detection limit of the instrumentation or the drift rate of the load cells, the report of test results shall state a de minimis value for the rim-seal loss factor that is based on the instrumentation detection limit and the drift rate of the load cells.

7 Test Apparatus

7.1 TEST APPARATUS SCHEMATIC

Figures 1, 2, and 3 are schematics of the test apparatus that is to be used to obtain the measurements necessary for developing a certified evaporative rim-seal loss factor for a test rim seal 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 Section 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 test 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 test 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 to about two air changes per hour so as to not create a condition significantly different than that inside the vapor space above an internal floating roof.

7.2.4 Access Doors

The test room shall be equipped with an equipment access door that is 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 suspended from load cells that are attached to the support frame.

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 ASSEMBLY

A rim seal to be tested shall be mounted on the test assembly which shall have at least three suspension points so that it may be suspended from load cells.

7.3.1 Test Assembly Construction

Figure 3 is a schematic of a test assembly. The test assembly simulates a portion of the rim of an internal floating roof and includes a bottom plate, rim plate, shell plate and end plates. A stiffener plate may be used to help maintain the proper contour of the shell plate. The shell plate shall be curved to simulate the shell of a tank with a 50-foot radius. The test assembly may be constructed of aluminum to reduce its weight. The length of the test assembly shall be sufficient to permit mounting a section of the test rim seal that has an arc length of at least 10 feet.

The test assembly shall be fitted with a thermocouple to measure the temperature of the test liquid within 3 inches below the test liquid surface.

The test liquid is contained in the simulated rim space that is between the shell plate and rim plate.

The height of the rim plate shall be sufficient to allow the level of the test liquid surface to be at a distance below the top of the rim plate that is within ± 1 inch of a specified level, which shall be that which is typical of industry practice for the rim seal being tested.

The test assembly shall have at least 3 support points so that it may be suspended from load cells and its orientation adjusted to permit it to be in a horizontal position during the test period.

Test rim seals 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 rim seals with greater loss rates. This requirement may result in the use of load cells with reduced load capacity, thereby limiting the weight of the test assembly.

7.3.2 Rim Seals

The rim seal to be tested shall be mounted on the simulated floating roof rim using the assembly and installation procedures normally used for the rim seal, as specified by the rim seal manufacturer. The only exception to this use of normal procedures involves the sealing method for the ends of the test rim seal. At each end of the section of test rim seal, the test rim seal must be joined and sealed to the end plate of the test assembly to eliminate emission end effects. Sealing details for these end joints shall be documented in the report of test results and should be installed in a manner so as to not affect the emission characteristics of the test rim seal.

The surfaces of the test rim seal and the test assembly shell plate shall be clean and free from oil or other material that may affect the rim-seal loss factor test results.

A leak-tightness test may be performed on the test rim seal to ensure that there are no leak paths through the two end joints. An example of such a leak-tightness test consists of applying a slight gas pressure in the vapor space under the rim seal. A leak detection liquid (typically a soap-like liquid that will form bubbles at vapor leaks) may then be applied at the end joints. If no bubbles are detected, it can be assumed that no significant end joint emission leaks are present.

7.3.3 Test Liquid

The test liquid shall be maintained at a level relative to the test rim seal that corresponds to that which is typical of industry practice for the rim seal being tested.

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. Samples of the test liquid

shall be taken both before and after the test period and tested to determine the Reid vapor pressure of the mixture in accordance with ASTM D323.

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 surface of the water 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.

Test rim seals that normally extend into the liquid product on a storage tank shall be mounted in the test assembly in a manner that permits free flow of the test liquid to all rim space areas below the test rim seal. For example, when testing a mechanical-shoe primary seal, the layer of test liquid that is floating on water must extend below the bottom of the shoe.

7.3.4 Emptying and Filling

All penetrations of or attachments to the test assembly, including those for emptying and filling, must be leak-tight. A method of indicating the liquid level in the test assembly 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 or window, 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 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.



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8 Test Item

8.1 TEST ITEM CONSTRUCTION

The test items to be tested according to this test method are rim seals for internal floating-roof tanks. Items to be tested shall be full-scale samples of the rim seals. These shall be constructed according to the manufacturer's standard practice and shall include all features typical to actual use.

8.2 TEST RIM SEAL ATTACHMENT

The rim seal to be tested shall be attached to the test assembly in a manner similar to its attachment to a floating-roof rim in practice. Test rim seals that normally extend into the liquid product on a floating roof shall be mounted in a similar manner on the test assembly.

8.3 TEST RIM SEAL END CONNECTIONS

The ends of the test rim seal shall be sealed to the end plates of the test assembly. A suitable sealant or caulk may be used for this purpose.

9 Preparation of Apparatus

9.1 TEST ASSEMBLY PLACEMENT

Install the test rim seal on the test assembly, as described in 7.3.2 and 8.2. Suspend the test assembly from the load cells. Fill the test assembly with test liquid to the proper level, as described in 7.3.4. Insert rim-seal gap spacers between the test rim seal and the shell plate to create the required rim-seal gap area, as described in 11.1.

9.2 TEST ROOM AIR TEMPERATURE CONTROL

Start the test room air temperature control system and adjust the test room temperature to the required level.

9.3 DATA ACQUISITION ROOM AIR TEMPERATURE CONTROL

Start the data acquisition room air temperature control system and adjust the data acquisition room air temperature to the required level.

9.4 STEADY STATE OPERATION

Start the data acquisition system and record the test assembly weight loss over a period of time until a steady rate of weight loss versus time is achieved. Following this initial start-up period during which the evaporation rate stabilizes, the subsequent test data recorded by the data acquisition system, as described in 11.3, shall constitute the record of test data that is to be used in calculating the evaporative loss factor.

10 Instrumentation and Calibration

10.1 ACCURACY

Each parameter to be measured requires a sensor, an indicator, and a method of recording the data. The specifications that follow describe the required instruments, the methods to be employed in the measurement process, and the accuracy requirements. Calibration procedures are specified to minimize systematic error, or bias, in the instruments. The instrument requirements are summarized in Table 2.

Procedures are also specified for certain steps of the measurement process which have been identified as likely potential sources of random error, so as to limit the imprecision associated with these steps. One such step is the method of indicating observed values and recording them. The process of receiving signals from the sensors, determining the values corresponding to the signals, and recording the results may be collectively referred to as data acquisition. Data acquisition is to be accomplished with a programmable electronic data acquisition system so that the frequency and precision of observations can be controlled within specified tolerances.

The demonstrated accuracy of the sensors shall be based on the readings indicated by the data acquisition system, thereby providing verification of the indicator as well as the sensor. Calibration standards shall be traceable to national measurement reference standards maintained by NIST.

10.2 DATA ACQUISITION SYSTEM

The data acquisition system shall be capable of recording all of the data transmitted by the sensors. The data acquisition system shall include a chronometer that indicates time in intervals not greater than one second with a demonstrated accuracy of ± 0.1 percent. The data acquisition system shall be capable of being programmed to record individual sensor readings at a specified frequency. The data acquisition system shall have the capability to record sensor readings multiple times within a specified time period, and then determine the mean and the standard deviation of these values. The data acquisition system should be capable of real-time display of the observed values, so that any out-of-specification conditions can be detected and corrected as soon as possible. The software of the system shall be verified by using the data acquisition system as the indicator when calibrating the sensors.

10.3 WEIGHT MEASUREMENT

The weight of the test assembly shall be sensed with high-precision load cells, and the signals indicating the load cell weight measurements shall be transmitted to the data acquisition system. The load cells shall be capable of sensing weight changes of ± 0.01 percent of the weight of the test assembly. Rim seals that exhibit relatively low rates of evaporative loss may require the use of load cells that are capable of sensing even smaller weight changes, or the length of a test period