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Guidelines for Determining the Fullness of Pipelines Between Vessels and Shore Tanks

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Guidelines for Determining the Fullness of Pipelines Between Vessels and Shore Tanks

1 Scope

This document describes procedures for determining or confirming the fill condition of pipeline systems used for the transfer of liquid cargoes before and/or after the liquid is loaded onto or discharged from marine vessels. It includes descriptions of methods and procedures that apply to crude oil and petroleum products.

While this document includes descriptions of common line fill verification methods, it does not recommend any particular method. The responsibility for selecting a method appropriate for a given terminal, and documenting its effectiveness, rests with those responsible for operating the terminal where it is applied.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API MPMS Chapter 3.1A, *Standard Practice for Manual Gauging of Petroleum and Petroleum Products*

API MPMS Chapter 3.1B, *Standard Practice for Level Measurement of Liquid Hydrocarbons in Stationary Tanks by Automatic Tank Gauging*

API MPMS Chapter 7, *Temperature Determination*

API MPMS Chapter 17.2, *Measurement of Cargos On Board Tank Vessels*

API MPMS Chapter 17.11, *Measurement and Sampling of Cargoes On Board Tank Vessels Using Closed/Restricted Equipment*

3 Terms and Definitions

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

3.1

agreed tolerance

Before executing the line displacement method, all authorized parties should agree on the amount of difference that will be accepted when comparing measurements taken before and after the procedure. This agreement may be in terms of volume rather than level measurement. The term agreed tolerance refers to this agreed-upon span of acceptable difference.

3.2

high-point bleed-valve method

Sight-glass/mechanical sight verification method

Checking for the presence of liquid at high-point valves or sight glasses in the designated pipeline system between the shore tank and the vessel berth.

3.3

internal circulation method

Transferring a measured volume of liquid from one shore tank into the same or another shore tank through the pipeline system designated for the transfer of cargo to or from a marine vessel.

3.4

line displacement method

Measuring the amount of liquid pumped from a shore tank to a vessel (or from a vessel to a shore tank) through the pipeline system designated for cargo transfer and comparing the measured volume delivered to the measured volume received. TOV is the normal method used.

3.5

line press method

line pack method

Pressurizing the contents of the designated pipeline system with a liquid to determine if gases are present.

3.6

pigging method

Displacement of the contents of a pipeline system by a tight-fitting wiping device propelled through the line by gas or liquid, leaving the line full of the propellant.

4 Significance and Use

4.1 General

When custody of petroleum liquids is transferred to or from marine vessels, accuracy in the measurement of quantities transferred is affected by the contents and integrity of the shore and vessel pipelines and by shore and vessel tank measurements. Pipelines that contain air or vapor, when assumed to be filled with liquid, require procedures that either eliminate or determine the volume of air or vapor contained in the pipeline. This can be accomplished by one of the following means.

- 1) Displacing the air or vapor with liquid.
- 2) Displacing the entire line contents.

The following methods, listed alphabetically, are recommended for line fill determination. Local limitations, product characteristics, and specific designs may restrict the best selection and use of a procedure and may affect the accuracy of the procedure selected.

- a) High-point bleed-valve method (or sight-glass/mechanical sight verification method).
- b) Internal circulation method.
- c) Line displacement.

NOTE This method can directly affect custody transfer volumes.

- d) Line press method (or line pack method).
- e) Pigging method.

NOTE The high-point bleed-valve method (or sight-glass method), the internal circulation method, and the line displacement method are all intended to fill the designated pipeline system with liquid. The pigging method is intended to entirely displace the contents of the designated pipeline system. The line press method (or line pack method) is intended to assess the fill condition of the designated pipeline system.

4.2 Considerations for Selecting a Method

The following should be taken into consideration when selecting a method for line verification.

- a) Methods in 4.1, Items a), b), d), and e) may be performed prior to the vessel arrival. These methods also provide an opportunity to confirm integrity of pipeline condition (e.g. leaking valves) and to take corrective action as necessary without becoming a portion of the custody transfer volumes determination. TOV is the normal method used.
- b) The design, equipment, and operational capabilities of the vessel and/or terminal.

5 Health and Safety Precautions

5.1 General

Due consideration should be given to applicable safety and health procedures. Considerations should include—but are not limited to—potential electrostatic and other fire and explosion hazards; considerations regarding potential personnel exposure (such as exposure limits, hazard communication, training, and associated protective clothing and equipment requirements, and work practices); and potential explosive and toxic hazards associated with a cargo tank's atmosphere. The physical characteristics of the cargo and existing operational conditions should be evaluated, and applicable international, federal, state, and local regulations should be observed. Safety procedures designated by the employer, the vessel operator, and other concerned parties should also be observed. The International Safety Guide for Oil Tankers and Terminals and appropriate Oil Companies International Marine Forum (OCIMF) and API publications should be consulted for additional safety information.

Caution—Petroleum vapors and associated substances, including hydrogen sulfide vapors from “sour” crude, also may involve potential toxicity. Petroleum vapors with high concentrations of hydrogen sulfide may cause unconsciousness or death. During and after the opening of the gauge hatch, stand so that vapor inhalation is minimized.

Caution—Harmful vapors or oxygen deficiency cannot be detected safely by smell, visual inspection, or judgment. Appropriate precautions should be used for protection against toxic vapors or oxygen deficiency. Procedures should be developed to provide for appropriate exposure monitoring, personal protective equipment, and emergency rescue precautions. When it is necessary, personnel should have suitable respiratory protection before entering the gauge site and during the gauging procedure.

5.2 Physical Characteristics and Fire Considerations

Warning—Personnel who handle petroleum-related substances (as well as other chemical materials) should be familiar with their physical and chemical characteristics—including potential for fire, explosion, and reactivity—and with potential toxicity and health hazards and emergency procedures. They should comply with individual company safe operating practices and local, state, and federal regulations. Personnel should be alert to avoid potential sources of ignition and should keep containers of materials closed when not in use.

6 Terminal Requirements

6.1 General

Nothing in this document should be construed as overriding safe operating procedures or applicable environmental regulations.

6.2 Requirements

The following terminal requirements should be taken into consideration.

- a) Terminal personnel should designate a tank, a pipeline system (including meters, if used), and the method that will allow the most accurate determination of the quantity received or delivered. If automatic tank gauges are used, terminal personnel should provide evidence that they are custody-transfer qualified in accordance with the provisions of API MPMS Ch. 3.1B.
- b) The selected line fill verification procedure should be performed immediately before and/or after custody transfer.
- c) Empty shore tanks should not be designated to receive line displacement or internal circulation volumes.
- d) A floating roof should not be in the critical zone.
- e) If the high-point bleed-valve method (or sight-glass method) is selected to determine if a designated pipeline system is full, the valve or sight-glass locations designated for this purpose should be identified.
- f) Data showing the results of the method selected should be available.

7 Vessel Requirements

The vessel's line condition can affect the accuracy of the line displacement volumes between vessel and shore. Vessel personnel shall provide the capacity of the designated lines, indicate their fullness condition, and offer every assistance to accurately verify this condition.

8 Procedures

8.1 General Procedures

8.1.1 General

In the cases where operational constraints exist such as: different grades in line, different custody of existing cargo in line, line capacity requires multiple shore tanks, or 120 % line capacity exceeds the custody transfer volume, then 100 % of the combined capacity, in lieu of 120 %, of all designated vessel and shore transfer lines may be used.

8.1.2 Loading and Discharging

Before loading or discharging marine cargoes, the following information should be obtained, recorded, and agreed upon to ensure that procedures to determine the fullness condition are as thorough as possible.

- a) The capacity of all designated pipelines ship and shore.
- b) The stated condition of the designated pipelines (full, slack, or empty).
- c) The date and time of last cargo movement through the designated pipeline(s).
- d) The last (or current) product in the designated pipeline(s).
- e) The temperature of cargo to be loaded or discharged.

The sources of all the above information.

8.1.3 Pipeline Fullness

Agree on the method of pipeline fullness verification to be used and on the extent—if any—of corrective actions that may be required.

8.1.4 Automatic Equipment

If automatic equipment is used to record measurements, it shall meet the precision requirements described in API *MPMS* Ch. 3.1B and API *MPMS* Ch. 7.

8.1.5 Accuracy

Review measurement accuracy limits outlined in API *MPMS* Ch. 3.1A, and agree on the tolerance to be met for the method selected (see Section 9).

8.1.6 Measuring Equipment

The procedures described in API *MPMS* Ch. 3.1A, API *MPMS* Ch. 17.2, and API *MPMS* Ch. 17.11 for selecting, calibrating, and using measurement equipment should be strictly followed.

8.2 Procedure for Internal Circulation Method

8.2.1 General

Terminal personnel should circulate product through the designated pipeline system after the system has been isolated. Circulation should pass through the designated dock manifold and be performed immediately before and/or after custody transfer. If circulation cannot pass through the designated dock manifold, then an evaluation should be made of the validity and accuracy of using this method.

8.2.2 Internal Circulation Method Steps

To apply the internal circulation method, perform the following steps consecutively.

STEP 1 Gauge the delivering and receiving tanks before line circulation. Measurements should be taken using reliable automatic gauging equipment or manual measurement equipment. If automatic tank gauges will be used, terminal personnel should provide evidence that they are custody-transfer qualified in accordance with the provisions of API *MPMS* Ch. 3.1B.

STEP 2 Circulate product to displace the agreed volume. Close tank valves and re-gauge tank(s) using the same method as that used for opening gauges.

STEP 3 Using the tank calibration table; convert the measurements taken before and after internal circulation to volumes.

STEP 4 Compare measured volume delivered to measured volume received to determine whether their difference exceeds the agreed tolerance. If the difference exceeds agreed tolerance, repeat line circulation and the measurements. If the excessive difference persists, the integrity of the system should be investigated.

STEP 5 For purposes of line fill determination, the designated pipeline system may be considered full if the difference between measured volume delivered and measured volume received is within the agreed tolerance.

NOTE This does not necessarily ensure that voids do not exist in the line.

8.3 Procedure for Line Displacement Method

8.3.1 General

The vessel should be on an even keel with no list. Otherwise, a trim or list correction should be applied and noted on the report. If a wedge calculation is necessary, refer to API MPMS Ch. 17.4.

NOTE Even-keel measurements are preferred because of the precision limitations involved in trim, list, and wedge calculations.

8.3.2 Requirements

The vessel quantity survey should be conducted prior to line displacement.

The number of vessel tanks used for line displacement should be minimized, and their location should be selected to minimize changes in trim or list.

The shore lines and the vessel lines including deck lines and bottom lines should remain in the same fullness condition, prior to and after the line displacement. However, if vessel line conditions change, corrections to volumes shall be applied.

Agree on the quantity to be displaced. Product displaced should be at least 120 % of the combined capacity of all designated vessel and shore transfer lines unless the conditions referred to in 8.1. apply, then 100 % of line capacity will suffice.

Agree on the cargo flow rate.

8.3.3 Line Displacement Method Procedure

To apply the line displacement method, perform the following steps consecutively.

STEP 1 Measure the liquid level and temperature of delivering and receiving tanks before line displacement. Measurements may be taken using either automatic measurement equipment or manual measurement equipment.

STEP 2 Transfer the agreed volume for displacement between vessel and shore. Immediately after the transfer is complete, close the vessel manifold valve and the shore tank valve to prevent continued product flow between the vessel and the shore tank and vice versa.

STEP 3 Re-gauge the vessel's tanks utilized and re-gauge shore tanks using the same types of equipment and technique that were used for the opening measurements.

STEP 4 Using shore and vessel tank calibration tables, convert the measurements taken before and after line displacement to volumes. TOV should be used to quantify volumes transferred.

NOTE TCV may be considered if it has been historically demonstrated to be appropriate for the pipeline size, distance between vessel and shore, and/or temperature difference between vessel, pipelines and tanks, or by commercial agreement.

STEP 5 Compare measured volumes of delivering and receiving tank(s) to determine whether their difference exceeds the agreed tolerance. If vessel and shore volumes differ by more than the agreed tolerance, any or all of the following options may be exercised until all parties agree that line fullness has been determined to their satisfaction.

- a) Check all calculations for accuracy.
- b) Re-gauge shore tank and re-gauge designated vessel tank(s).
- c) Re-gauge all vessel tanks and reconfirm vessel lines are in same fullness condition as before the transfer.

- d) Repeat the line displacement procedure.
- e) Proceed with cargo transfer and determine after transfer whether the line fill difference has had any unacceptable effect on the cargo transfer volume.

STEP 6 For purposes of line fill determination, the designated pipeline system may be considered full if the difference between measured volume delivered and measured volume received is within the agreed tolerance.

NOTE Measurements obtained from vessels and /or shore tanks with non-slotted standpipes shall not be used for the line displacement method (refer to API *MPMS* Ch. 3.1A). Another line fullness verification method is required.

8.4 Procedures for High-point Bleed-valve Method (or Sight-glass/Mechanical Sight Verification Method)

8.4.1 General

High-point bleed valves should be installed for the purpose of line fill verification only. Other valves on a pipeline should not be used for this purpose. High-point valves or sight glasses should be located beginning at a point near the vessel and at those points along the pipeline where the line's elevation is the highest, such as road crossings or other elevated sections. High-point valves should be tapped into the pipe at the highest point on the pipe's circumference; otherwise this procedure should not be used.

NOTE 1 This method may not be applicable to pipeline systems with horizontal sections since gases may remain in these sections.

NOTE 2 Should the high-point bleed-valve method be selected, valves designated for this operation should be identified.

NOTE 3 Product flowing through a pipeline system while valves are being bled may cause existing air pockets to move past the bleed point.

8.4.2 Requirements

Sight-glass connections should be at the top and bottom of the pipeline circumference and should permit convenient visual observation. If sight-glass systems do not enable bleeding to evacuate gases seen in the sight glass, one of the alternate verification methods should be selected.

All appropriate valves between the designated shore tank and the vessel berth should be open and under sufficient positive pressure to permit the line to be filled with liquid.

Appropriate action should be taken to ensure that any venting of vapors or release of liquids during bleeding operations is controlled and contained in accordance with applicable safety and environmental regulations.

The operation of high-point valves or sight glasses should be performed by terminal personnel and should be witnessed by authorized parties interested in custody-transfer measurements.

8.4.3 High-point Bleed-valve Method Procedure

To apply the high-point bleed-valve method (or the sight-glass method), perform the following steps consecutively.

STEP 1 Before opening high-point bleed valves; ensure that lines are under positive pressure at bleed positions.

STEP 2 Place an appropriate container under each valve opening to receive liquid.

STEP 3 Slowly open the valve and allow it to remain open until liquid appears in a steady stream. Allow adequate time between the bleedings of any two valves for gas to collect at the bleed points.

STEP 4 Close the valve and proceed to the next bleed valve.

STEP 5 Bleed each valve in the same manner until all valves are bled.

8.5 Procedures for Pigging Method

8.5.1 General

The pigging method is an acceptable method only when the terminal is fitted with the launching and retrieving systems designed for this purpose.

8.5.2 Requirements

In the pigging method, a tight-fitting wiping device (or “pig”) is placed in a launching system and then pushed through the designated pipeline system with liquid, gas, or air. The original contents of the pipeline system are therefore completely displaced by the air, gas, or liquid used to propel the pig through the line.

All pigs should be accounted for after use. The operation should be repeated when pigs are lost or damaged in pipelines.

The pigging method may be executed before, after, or both before and after a cargo transfer. If the pigging method is selected, appropriate corrections for full and empty line conditions shall be applied.

8.6 Procedure for Line Press Method (or Line Pack Method)

8.6.1 General

This procedure assumes that the designated pipeline system is tight and able to withstand pressures applied during line press operations without loss of line pressure as determined by pressure readings from a calibrated pressure gauge. This procedure is invalid with any pipeline system that does not meet this tightness recommendation.

8.6.2 Line Pack Method Procedure

To apply the line press method (or the line pack method), perform the following steps consecutively.

STEP 1 Close the valve at the dock manifold. Open the shore tank and pump valves, and gauge the tank before line press. Measurements may be taken using either reliable automatic gauging equipment or manual measurement equipment. If automatic tank gauges will be used, terminal personnel should provide evidence that they are custody-transfer qualified in accordance with the provisions of API MPMS Ch. 3.1B.

STEP 2 Start the pump and run it until the discharge pressure stabilizes and/or reaches a predetermined pressure. The predetermined pressure should be higher than the maximum static pressure available on the system.

STEP 3 Isolate the pipeline to prevent backflow and stop the pump.

STEP 4 Once the pump has been shut down, record the pressure and re-gauge the tank using the same gauging method as that used for the opening measurements. Record the tank product level.

STEP 5 If the tank product levels before and after the line press are within $\frac{1}{8}$ in. (3 mm) of one another, pipelines may be considered liquid-full and no correction is necessary.

STEP 6 If the tank liquid levels before and after the line press differ from one another by more than $\frac{1}{8}$ in. (3 mm), relieve the line pressure into the tank until the pressure at the highest elevation is slightly above product vapor pressure and then repeat the test. If the tank product levels before and after the second line press differ from one

another by less than $\frac{1}{8}$ in. (3 mm), pipelines are now full of liquid because condensable vapors have been re-liquefied and no further correction is necessary.

STEP 7 If the tank liquid levels before and after the second line press differ from one another by more than $\frac{1}{8}$ in. (3 mm), the line fill condition may be corrected by one of the alternate methods listed under 4.1.

STEP 8 For purposes of line fill verification, the designated pipeline system may be considered full if the difference between the volume gauged before line press and the volume gauged after line press is within measurement precision.

NOTE This does not ensure that voids equal to compressed gas volumes less than measurement precision do not exist in the line.

8.7 Line Verification After Cargo Transfer

After cargo has been transferred, the fullness condition of shore pipelines can be determined by the application of any method outlined in 8.2 to 8.6.

9 Establishing Agreed Tolerance

The precision of the liquid level measurement for each tank—regardless of whether it's a vessel tank or a shore tank is stated in API *MPMS* Ch. 3.1A and Ch. 3.1B depending on whether it is manual or automatic gauging.

To agree on tolerances when comparing volumes using line displacement, both the measurement precision limits above and historical experiences should be considered. The factors listed under "General Procedures" (8.1) should also be considered as possible influences on measurement tolerances. Special situations such as those involving temperature variations between line contents and tanks, the effect of volumetric shrinkage, and product quality differences should also be considered.

It should also be recognized that all measurements shall be recorded to API *MPMS* standards. Rounding of gauges is not a recommended practice.

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