

## 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. 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 7.3, *Fixed Automatic Tank Temperature Systems*

EI HM 4 Manual Level Measurement for Hydrocarbon Liquids.

### 3 Terms and Definitions

For the purposes of this document, the following definitions apply. Terms of more general use may be found in the API MPMS Chapter 1 Online Terms and Definitions Database.

#### 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, percentage or level measurement.

### 4 Health and Safety Precautions

#### 4.1 General

Due consideration shall be given to applicable safety and health procedures. Considerations shall 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 shall be evaluated, and applicable international, federal, state, and local regulations shall be observed. Safety procedures designated by the employer, the vessel operator, and other concerned parties shall also be observed. The International Safety Guide for Oil Tankers and Terminals and appropriate Oil Companies

International Marine Forum (OCIMF) and API publications shall be consulted for additional safety information.

**Caution—Petroleum vapors and associated substances, including hydrogen sulfide vapors may also 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. Take appropriate precautions for protection against toxic vapors or oxygen deficiency. Develop procedures to provide for appropriate exposure monitoring, personal protective equipment, and emergency rescue precautions. When it is necessary, utilize suitable respiratory protection before entering the gauge site and during the gauging procedure.**

## **4.2 Physical Characteristics and Fire Considerations**

Personnel who handle petroleum-related substances (as well as other chemical materials) shall 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 shall comply with individual company safe operating practices and local, state, and federal regulations. Personnel shall be alert to avoid potential sources of ignition and shall keep containers of materials closed when not in use. Refer to the substance's Safety Data Sheet and other documents relevant to the cargo's quality.

## **5 Significance and Use**

### **5.1 General**

When petroleum liquids are transferred, the accuracy of the measurement is affected by the condition and integrity of the connecting pipelines. This requires procedures be adopted that either eliminate or determine the volume of air/vapor or liquid contained in the pipeline. The minimum requirement to conform to this standard is to perform a line verification at the start of custody transfer, by either filling or emptying the line by one of the following means in no preference:

High-point bleed-valve method (or sight-glass/mechanical sight verification method).

Internal circulation method.

Line clearing method (Pigging/Blowing/Stripping).

Line displacement involving marine vessels.

Line press method (or line pack method).

**NOTE** While it is recommended that a line verification be performed after custody transfer, operational constraints may prevent line fullness from being determined. If line fullness is not able to be determined at the end of the transfer it can have an effect on the overall custody transfer volume. In theory this could be up to the capacity of the line.

## **5.2 Considerations for Selecting a Method**

Local limitations, product characteristics, and specific designs may restrict the selection and use of a procedure and may affect the accuracy of the procedure selected. The following should be taken into consideration when selecting a method for line verification before the transfer.

The design, equipment, and operational capabilities of the vessel and/or terminal.

The “High-point bleed-valve method (or sight-glass/mechanical sight verification method), Internal circulation method and Line press method (or line pack method)” may be performed prior to the start of the custody transfer. These methods also provide an opportunity to confirm integrity of pipeline condition (e.g., misaligned valves) and to take corrective action as necessary without becoming a portion of the custody transfer volume determination.

Terminals that pig, blow or strip their lines before and after transfers, may result in their lines being in an unknown condition, as none of these methods can fully evacuate the line. When this situation occurs, it is necessary to quantify the volume of product in the line. The line can either be filled prior to the custody transfer by circulating the line, or a line displacement can be performed to determine the amount of the void in the line.

The high-point bleed-valve method (or sight-glass/mechanical sight verification method), and the internal circulation method, are intended to fill the line prior to custody transfer.

The line displacement method can either be used to prove the line is full or can be used to quantify the void in the line.

The line press method (or line pack method) pressurizes the contents of the designated pipeline system with a liquid to minimize any void spaces that may be present.

After transfer all of the above methods except for line displacement can be used.

## **6 Procedures**

### **6.1 General Procedures**

Terminal personnel shall designate a tank(s), a pipeline system (including meters, if used), and the method(s) that are available to determine line fullness. If automatic tank gauges are used, terminal personnel shall provide evidence that they are custody-transfer qualified in accordance with the provisions of API *MPMS* Ch. 3.1B and API *MPMS* Ch. 7.3

### **6.2 Loading or 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.
- b) The stated condition of the designated pipelines (full, slack, or empty).
- c) The last (or current) product in the designated pipeline(s).
- d) The temperature of cargo to be transferred.

### 6.2.1 Measurement Tolerance Agreement

For line displacement and line circulation methods, a measurement tolerance shall be established between the commercial parties. However, in the absence of such, the tolerance shall be the volume represented by twice the measurement accuracy, as stated in API *MPMS* Ch. 3.1A/HM 4 and API *MPMS* Ch. 3.1B, of the sending and receiving tanks.

NOTE 1      Currently, the measurement accuracy stated in in API *MPMS* Ch. 3.1A /HM 4 is  $\frac{1}{8}$ " or 3 mm.

NOTE 2      Currently, the measurement accuracy stated in in API *MPMS* Ch. 3.1B is  $\frac{3}{16}$ " or 4 mm.

In the case of meters, the manufacturers stated precision statement shall be used.

In the event that TCV volumes are used then temperature tolerance may also be taken into account.

NOTE 3      Currently, the temperature resolution stated in API *MPMS* Ch. 7.2<sup>(1)</sup> and API *MPMS* Ch. 7.3 is 0.1 °F or 0.1 °C

## 7 Procedures and Application

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

#### 7.1.1 General

This method can be used both before and after transfer and will not affect custody transfer volumes.

#### 7.1.2 Requirements

High-point valves shall be located 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 shall be installed into the pipe at the highest point on the pipe's circumference; otherwise, this procedure shall not be used.

Sight-glass connections shall be at the top and bottom of the pipeline circumference and 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 shall be selected.

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

Appropriate action shall 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 shall be performed by terminal personnel and shall be witnessed by authorized parties interested in the custody-transfer measurement.

### **7.1.3 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.

## **7.2 Procedure for Internal Circulation Method**

### **7.2.1 General**

This method can be used both before and after transfer and will not affect custody transfer volumes when performed before transfer, however, has potential to affect custody transfer volumes when performed after transfer.

### **7.2.2 Requirements**

Terminal personnel shall circulate product through the designated pipeline system via the dock manifold. If circulation cannot pass through the designated dock manifold, then an evaluation shall be made of the validity and accuracy of using this method.

Shore tanks designated to receive internal circulation volumes shall not be in the bottom (nonlinear) or critical zones as indicated on the strapping chart.

The circulation method is generally used on pipelines already considered to be full. This method can also be used after custody transfer.

### **7.2.3 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, using either automatic or manual measurement equipment.
- STEP 2 Circulate product to displace the volume of the pipeline.
- STEP 3 Close tank valves and re-gauge tank(s) using the same method as that used for opening gauges.

## **7.3 Procedure for Line Displacement Method**

### **7.3.1 General**

This method is only practical at the beginning of the transfer and an alternative method would have to be used after the transfer. This method can have an effect on custody transfer volumes when line voids are detected.

### **7.3.2 Requirements**

Where possible the vessel shall be on an even keel with no list. Otherwise, a trim or list correction shall be applied and noted on the report. If a wedge calculation is necessary, refer to API *MPMS* Ch. 17.4<sup>[4]</sup>.

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.

The number of vessel tanks used for line displacement shall 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, which shall be a minimum of 100 % of the combined capacity of all designated vessel and shore transfer lines.

Shore tanks designated to receive or deliver line displacement volumes shall not be in the bottom (nonlinear) or critical zones as indicated on the strapping chart.

### **7.3.3 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. Measurements may be taken using either automatic measurement equipment or manual measurement equipment. If meters are utilized, then record meter reading.  |
| 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.   |
| STEP 3 | Repeat Step 1 using the same types of equipment and technique that were used for the opening measurements.  |
| STEP 4 | Using tank calibration tables or meters, as appropriate, convert the measurements taken before and after line displacement to volumes. Normally, TOV is used to quantify volumes transferred; however, TCV can be used 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 delivered and received volumes. The designated pipeline system may be considered full if the difference between measured volume delivered and received is within the agreed tolerance. No further line fullness determination is required, and cargo transfer may proceed.

If vessel and shore volumes differ by more than the agreed tolerance, the following steps to be performed.

- a) Check all calculations for accuracy.
- b) Verify all measurements are accurate and confirm vessel lines are in same fullness condition as before the transfer.
- c) If difference still exceeds tolerance, refer to customer instructions on line displacement difference exceeding agreed tolerance. In the event no instructions have been given then contact all parties involved to establish agreement on how to proceed further.
- d) If customers cannot be contacted for further instructions, it is recommended to perform a second line displacement if the terminal will allow it.

## **7.4 Procedures for Line Clearing Methods**

### **7.4.1 General**

The three common methods for line clearing are pigging, blowing, and stripping. All three have the objective of evacuating the line; however, the receiving tank shall be measured before and after to determine the amount of product displaced from the line. These methods can be used both before and after transfer, and corrections shall be applied to any volumetric differences in line condition and will therefore affect custody transfer volumes.

### **7.4.2 Pigging Method**

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

In the pigging method, a 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 displaced by the liquid, gas, or air used to propel the pig through the line.

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

### **7.4.3 Line Blowing Method**

This method entails blowing the line with either compressed air, nitrogen, or other gas.

### **7.4.4 Line Stripping Method**

This method involves using stripping pumps to remove product from the pipelines involved.

## **7.5 Procedure for Line Press Method (or Line Pack Method)**

### **7.5.1 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 pressure gauge. This procedure is invalid with any pipeline system that does not meet this tightness recommendation.

This method will not have an effect on custody transfer volumes.

### **7.5.2 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 automatic gauging equipment or manual measurement equipment. If automatic tank gauges will be used, terminal personnel shall provide evidence that they are custody- transfer qualified in accordance with the provisions of API <i>MPMS</i> 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 shall 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 1/8 in. (3 mm) of one another for manual measurement, or 3/16" (4mm) for automatic tank gauges, 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 the above tolerance relieve the line pressure into the tank and then repeat the test. If the tank product levels before and after the second line press differ from one another by less the tolerance above 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 the tolerance, the line fill condition may be corrected by one of the alternate methods listed under 5.1.  |



## **8 Procedure for partially empty/full line condition**

Some facilities blow or strip their lines, leaving them partially empty. These can lead to differences in fill condition between the start and completion of custody transfer that will need to be taken into account.

If the line is unable to be filled prior to transfer, then it is recommended to perform a line displacement and correct for the void detected in the line. After transfer is complete, the shore tanks shall be gauged off while the line is still full and before any line stripping or blowing commences. This will complete the custody transfer.

Any stripping or blowing of lines after this point has no effect on custody volumes and will only affect inventory volumes between the terminal and its customer.

**NOTE** For discharge operations in the event of an unexplained out turn gain the line condition upon completion of discharge should be verified when possible. As the line could potentially be only partially full resulting in an overstated out turn figure.

## **Annex A (Informative)**

### **Procedure for Line Displacement Method – not involving marine vessels**

#### **A1.0 Requirements**

Shore tanks should be static and not in the bottom (nonlinear) critical zone or floating roof critical zone.

Terminal personnel should provide the capacity of the designated lines, indicate their fullness condition, and offer every assistance to accurately verify this condition.

Agree on the quantity to be displaced, which should be a minimum of 100 % of the combined capacity of all designated transfer lines.

**NOTE** This method can have an effect on custody transfer volumes when line voids are detected.

#### **A1.1 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. Measurements may be taken using either automatic measurement equipment or manual measurement equipment. If meters are utilized, then record meter reading.
- STEP 2** Transfer the agreed volume for displacement between tanks. Immediately after the transfer is complete, close the shore tank valves to prevent continued product flow between the tanks.
- STEP 3** Repeat Step 1 using the same types of equipment and technique that were used for the opening measurements.
- STEP 4** Using tank calibration tables or meters, as appropriate, convert the measurements taken before and after line displacement to volumes. Normally, TOV is used to quantify volumes transferred; however, TCV can be used if it has been historically demonstrated to be appropriate for the pipeline size, distance between shore facilities, and/or temperature difference between shore pipelines and tanks, or by commercial agreement.
- STEP 5** Compare delivered and received volumes. The designated pipeline system may be considered full if the difference between measured volume delivered and measured volume received is within the agreed tolerance. No further line fullness determination is required, and transfer may proceed.

If volumes differ by more than the agreed tolerance, the following steps to be performed.

- a) Check all calculations for accuracy.
- b) Verify all measurements are accurate and confirm all lines are in same fullness condition as before the transfer.
- c) If difference still exceeds tolerance, refer to customer instructions on line displacement difference exceeding agreed tolerance. In the event no instructions have been given then contact all parties involved to establish agreement on how to proceed further.
- d) If customers cannot be contacted for further instructions, it is recommended to perform a second line displacement if the terminal will allow it.

## **Annex B (Informative)**

### Example of procedure to pig lines

1. Reference to the product Safety Data Sheet should be made before pigging any product, and safety precautions including Personal Protective Equipment (PPE) should be observed.
2. The correct propellant for the pigging operation should be selected, appropriate to the product
3. Before opening the pig launcher the Operator will ensure the main line isolation valve is closed and the launcher's vent/drain valve is open.
4. While standing to one side of the line to be pigged, open end closure.
5. Insert the suitably sized pig and position it in the pig trap/launcher (utilizing the metal launcher cage if necessary)
6. Check the gasket is in good condition, (new gasket should be used every time) and correctly aligned. Close the end closure and seal using a "full head of bolts".
7. Ensure all vent and drain lines are closed.
8. Connect air/nitrogen hose (as appropriate for product to be pigged) to the launcher.
9. All pigging operations should be undertaken with both ends of the pipeline to be pigged attended by Operators liaising directly by phone or radio.
10. Only one pigging operation should be completed at once, this helps to confirm the routing of the pipeline.
11. The Duty Operator at the launching end should ensure the receiving end is ready to receive the pig and get the Receivers authority to launch prior to firing the pig.
12. The Operator launching the pig should announce which line the pig is being sent down, the receiving Operator should also state which line he is expecting to receive the pig into and his location on the site.
13. The Duty Operator at the receipt end of the line will, before giving permission for the pig to be launched, confirm that all valves are correctly set. In particular he will check and confirm the following:
  - (a) The drain valve is closed
  - (b) The main line valve is open (inlet)
  - (c) The tank side valve is open (outlet)
  - (d) The end closure is tight and secure (full head of bolts)

14. After receiving clearance, the Duty Operator at the launching end of the pipework will now proceed as follows: -
    - (a) Slowly open the air/nitrogen supply to the launcher.
    - (b) Check the pipework for leaks.
    - (c) If there are no leaks vent pressure from the launcher via the vent/drain valve.
    - (d) Close the vent/drain valve and slowly open the main pipework line valve.
    - (e) Slowly open the air/nitrogen supply to the launcher.
    - (f) Advise the receiving Operator "pig launched".
  15. The receiving Operator will confirm that this message has been received. If confirmation is not forthcoming the operation will be shut down immediately.
  16. Control of the pig's speed will be the responsibility of the receiving Operator. He should monitor the pressure on the pipeline by listening to the speed of the liquid being released through the gagged valve on the outlet of the pig receiver. Adjustments should be made if required by opening or closing the outlet valve on the pig receiver.
  17. When the pig is received the receiving Operator will advise the launching Operator to close the air/nitrogen supply.
  18. On receipt of advice that the pig has been received the launching Operator will close the air/nitrogen valve and the main line isolation valve. He will then inform the receiver that this action has been carried out.
  19. On confirmation that the air/nitrogen supply has been isolated and the main line valve is closed, the receiving Operator will allow as much pressure through the line into the receiving tank as possible (when pigging liquid into the tank) and then close the pig receiver valve.
  20. The receiving operator shall isolate all valves to the pig receiver and check the pressure gauge within the pig receiver. All pressure should be released to a safe area before attempting to remove the pig receiver door.
  21. Once the pig is removed it should be washed out and squeezed dry before being placed in the appropriate pig skip.
  22. The Duty Operators will then agree who will be releasing the remaining pressure in the line. The line will still contain residues of the product so an assessment should be made to ensure the pressure is released into a safe area away from the Operators place of work.
  23. Having decided how the excess line pressure will be handled, it will be done so in a controlled manner. Any drain points or vent lines used will be closed and capped after use.
- NOTE The attending Inspector should rely on the information provided by the terminal in relation to prior cargo(es) and any washing/cleaning performed on the shore line prior to pigging.

## Bibliography

- [1] API MPMS Chapter 7.2, *Portable Electronic Thermometers*
- [2] API MPMS Chapter 17.1, *Guidelines for Marine Inspection*
- [3] API MPMS Chapter 17.2, *Measurement of Cargoes On Board Tank Vessels*
- [4] API MPMS Chapter 17.4, *Method for Quantification of Small Volumes on Marine Vessels (OBQ/ROB)*
- [5] API MPMS Chapter 17.11/HM 52, *Measurement and Sampling of Cargoes On Board Tank Vessels Using Closed and Restricted Equipment*
- [6] EI HM 69, *Procedures for determining H<sub>2</sub>S concentration in cargo tank head spaces*
- [7] OCIMF<sup>1</sup> ISGOTT: *International Safety Guide for Oil Tankers and Terminals*

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<sup>1</sup> Oil Companies International Marine Forum, 27 Queen Anne's Gate, London SW1H 9BU, United Kingdom, [www.ocimf.com](http://www.ocimf.com)