

Guidelines for Determining the Fullness of Pipelines between Marine Vessels and Shore Facilities

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. While this standard primarily addresses pipelines between vessels and marine terminals, it can also be applied to pipelines involved in shore-to-shore transfers. 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 parties should agree on the amount of difference that will be accepted when comparing measurements taken before and after the procedure. This agreement will be in terms of volume, expressed as a volume, percentage, or level measurement.

3.2

line fullness

The liquid fill condition of transfer lines between two measuring points (e.g., shore tank and marine vessel).

3.3

line fullness verification

The activity of verifying the fill condition of the transfer lines between two measuring points (e.g., shore tank and marine vessel) before and after a transfer.

4 Health and Safety Precautions

4.1 General

Due consideration shall be given to applicable health and safety procedures. Considerations shall include but are not limited to:

- potential electrostatic and other fire and explosion hazards;
- personnel exposure to toxic hazards;
- hazard communication, including availability of safety data sheets;
- training.

Applicable international, federal, state, and local regulations shall be observed. Safety procedures designated by the employer, vessel operator, and other concerned parties shall also be observed. The International Safety Guide for Oil Tankers and Terminals (ISGOTT), Oil Companies International Marine Forum (OCIMF), and appropriate API publications shall be consulted for additional safety information.

Caution—Petroleum vapors and associated substances, including hydrogen sulfide vapors, may also be toxic. 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 or avoided. A breathing apparatus can be required.

Refer to HM 69^[7], *Procedures for determining H₂S concentration in cargo tank head spaces.*

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. 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 to be adopted that either eliminate or minimize air/vapor spaces or allow determination of 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 preferred order):

- 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. Consider the following when selecting method(s) for line verification before the transfer begins.

- The design, equipment, cargo transfer quantity, 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, or line press method (or line pack method) may be performed prior to the start of the custody transfer or vessel arrival. 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 blow or strip their lines before and after transfers can result in their lines being in an unknown condition, as neither 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. Terminals that pig their lines may need to perform multiple pigging operations in order to fully evacuate the line.
- The high-point bleed-valve 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 that may minimize any void spaces that may be present.

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

6 Procedures

6.1 General Procedures

Terminal personnel shall designate a tank(s), pipeline systems (including meters, if used), and the method(s) that are available for line verification. 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;
- e) the location of the floating roof.

6.2.1 Measurement Tolerance Agreement

The tolerance shall be the volume on each tank opening and closing gauge represented by the measurement tolerance $1/8"$ or 3mm of the sending and receiving tanks (as stated in API *MPMS* Ch. 3.1A/HM 4 and API *MPMS* Ch. 3.1B). Unless otherwise established between commercial parties.

EXAMPLE In the case of two vessel tanks discharging to one shore tank, the tolerance would be the volume represented by $1/4"$ or 6 mm (within the gauging range) for each vessel tank plus $1/4"$ or 6 mm (within the gauging range) for the shore tank.

NOTE 1 Refer to latest version of API *MPMS* Ch. 3.1A/HM 4 for applicable measurement reading and reporting. As of 2022, API *MPMS* Ch. 3.1A, 3rd Edition/HM 4 states $1/8"$ or 3 mm.

NOTE 2 Refer to latest version of API *MPMS* Ch. 3.1B for applicable measurement reading and reporting. As of 2022, API *MPMS* Ch. 3.1B, 3rd Edition states $\frac{3}{16}$ " or 4 mm.

In the case of meters, use the accuracy stated in the manufacturer's precision statement. Refer to API *MPMS* Chapter 4^[1].

In the event that TCV volumes are used, temperature tolerance may also be taken into account. Refer to API *MPMS* Chapter 7.3.

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.

Use of the high-point bleed-valve method can involve a loss of line integrity and, for this reason, is no longer a recommended method. Facilities that employ this method shall be fully aware of the associated additional risks.

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 Procedure for High-point Bleed-valve Method

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

- 1) Before opening high-point bleed valves, ensure that lines are under positive pressure at bleed positions.
- 2) Open valves into the sewer system.

NOTE If this method is used without an appropriate sewer system, place a suitable container under each valve opening to receive liquid.

- 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.
- 4) Close the valve and proceed to the next bleed valve.
- 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, it has potential to affect custody transfer volumes when performed after transfer.

7.2.2 Requirements

Agree on the quantity to be displaced, which shall be a minimum of 100 % of the combined capacity of all designated transfer lines (110-120 % is preferable if terminal conditions allow).

Terminal personnel shall circulate product through the designated pipeline system via the dock manifold. If circulation cannot pass through the designated dock manifold, parties will agree on an alternate 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 Procedure for Internal Circulation Method

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

- 1) Gauge the delivering and receiving tanks before line circulation, using either automatic or manual measurement equipment.
- 2) Circulate product to displace the volume of the pipeline.
- 3) Close tank valves and re-gauge tank(s) using the same method as that used for opening gauges.
- 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 difference persists, the integrity of the system should be investigated.

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. Corrections shall be applied to any volumetric differences in line condition and will therefore affect custody transfer volumes.

7.3.2 Requirements

Where possible, the vessel should 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^[5].

The vessel's line condition can affect the accuracy of the line displacement volumes between vessel and shore. Vessel personnel shall provide the tank capacity tables and 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.

Vessel and shore will 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. 110-120 % is preferable if terminal conditions allow.

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 for Line Displacement Method

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

- 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, record the meter reading.
- 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.
- 3) Repeat Step 1), using the same types of equipment and technique that were used for the opening measurements.
- 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.
- 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, perform the following steps.

- a) Check all calculations for accuracy.
- b) Verify that all measurements from Step 3) are accurate and confirm that vessel lines are in the same fullness condition as before the transfer.
- c) After correcting any errors found, if the difference still exceeds tolerance, refer to customer instructions on line displacement difference exceeding agreed tolerance. In the event that no instructions have been given, 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. If losses above tolerance continue, vessel and shore personnel should verify line integrity.

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. Corrections shall be applied to any volumetric differences in line condition and will therefore affect custody transfer volumes.

NOTE Refer to local terminal procedures on steps to perform line clearing methods.

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. If pigs are lost or damaged, the cause for this should be resolved before the operation is repeated.

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.

- 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 measurement equipment or manual measurement equipment. If automatic equipment will be used, terminal personnel shall provide evidence that they are custody transfer qualified in accordance with the provisions of API *MPMS* Ch. 3.1B.
- 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.
- 3) Isolate the pipeline to prevent backflow and stop the pump.
- 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.
- 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 $3/16$ in. (4 mm) for automatic measurement equipment, no correction is necessary.
- 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, 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 deemed to be full and no further correction is necessary.
- 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 should 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. This 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, 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 outturn 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 outturn figure.

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Annex A (Informative)

Procedure for Line Displacement Method Not Involving Marine Vessels

A.1 Recommendations

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.

Contracted parties should 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.

A.1.1 Procedure

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

- 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, record the meter reading.
- 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.
- 3) Repeat Step 1) using the same types of equipment and technique that were used for the opening measurements.
- 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.
- 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 the transfer may proceed. If volumes differ by more than the agreed tolerance, the following steps should be performed.
 - a) Check all calculations for accuracy.
 - b) Verify that all measurements are accurate and confirm that 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 that no instructions have been given, 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 Lines¹

- 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 that the gasket is in good condition (a new gasket should be used every time) and correctly aligned. Close the end closure and seal using a "full head of bolts."
- 7) Ensure that 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 that the receiving end is ready to receive the pig and should 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 they are expecting to receive the pig into and their location on the site.
- 13) Before giving permission for the pig to be launched, the duty operator at the receiving end of the line will confirm that all valves are correctly set. In particular, they 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.

¹ The following is an example for illustration purposes only. [Each company should develop its own approach.] It is not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

- e) Slowly open the air/nitrogen supply to the launcher.
 - f) Relay the following message to 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. They 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. They 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), then close the pig receiver valve.
 - 20) The receiving operator should 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 residue 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 4 (all sections), *Proving Systems*
- [2] API MPMS Chapter 7.2, *Portable Electronic Thermometers*
- [3] API MPMS Chapter 17.1, *Guidelines for Marine Inspection*
- [4] API MPMS Chapter 17.2, *Measurement of Cargoes On Board Tank Vessels*
- [5] API MPMS Chapter 17.4, *Method for Quantification of Small Volumes on Marine Vessels (OBQ/ROB)*
- [6] API MPMS Chapter 17.11/HM 52, *Measurement and Sampling of Cargoes On Board Tank Vessels Using Closed and Restricted Equipment*
- [7] EI HM 69, *Procedures for determining H₂S concentration in cargo tank head spaces*
- [8] OCIMF¹ ISGOTT: *International Safety Guide for Oil Tankers and Terminals*

¹ Oil Companies International Marine Forum, 27 Queen Anne's Gate, London SW1H 9BU, UK, www.ocimf.com

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Caution—Petroleum vapors and associated substances, including hydrogen sulfide vapors, may also be toxic. 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 or avoided. A breathing apparatus can be required.

Refer to HM 69^[7], *Procedures for determining H₂S concentration in cargo tank head spaces.*

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.

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- internal circulation method;
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- line displacement involving marine vessels;
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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. Consider the following when selecting method(s) for line verification before the transfer begins.

- The design, equipment, cargo transfer quantity, 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, or line press method (or line pack method) may be performed prior to the start of the custody transfer or vessel arrival. 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 blow or strip their lines before and after transfers can result in their lines being in an unknown condition, as neither 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. Terminals that pig their lines may need to perform multiple pigging operations in order to fully evacuate the line.
- The high-point bleed-valve 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 that may minimize any void spaces that may be present.

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

6 Procedures

6.1 General Procedures

Terminal personnel shall designate a tank(s), pipeline systems (including meters, if used), and the method(s) that are available for line verification. 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;
- e) the location of the floating roof.

6.2.1 Measurement Tolerance Agreement

~~For line displacement and line circulation methods, a measurement tolerance should be established between the commercial parties. The tolerance shall be the volume on each tank opening and closing gauge represented by the measurement tolerance 1/8" or 3mm of the sending and receiving tanks (as stated in API *MPMS* Ch 3.1A/HM 4 and API *MPMS* Ch. 3.1B). Unless otherwise established between commercial parties.~~

~~However, in the absence of such, the tolerance shall be the total volume represented by twice the measurement range of the sending and receiving tanks (as stated in API *MPMS* Ch 3.1A/HM 4 and API *MPMS* Ch. 3.1B).~~

~~EXAMPLE In the case of two vessel tanks discharging to one shore tank, the tolerance would be the volume represented by $\frac{1}{8}$ " or 3 mm for each vessel tank plus $\frac{1}{8}$ " or 3 mm for the shore tank. EXAMPLE In the case of two vessel tanks discharging to one shore tank, the tolerance would be the volume represented by $\frac{1}{4}$ " or 6 mm (within the gauging range) for each vessel tank plus $\frac{1}{4}$ " or 6 mm (within the gauging range) for the shore tank.~~

NOTE 1 Refer to latest version of API *MPMS* Ch. 3.1A/HM 4 for applicable measurement reading and reporting. As of 2022, API *MPMS* Ch. 3.1A, 3rd Edition/HM 4 states $\frac{1}{8}$ " or 3 mm.

NOTE 2 Refer to latest version of API *MPMS* Ch. 3.1B for applicable measurement reading and reporting. As of 2022, API *MPMS* Ch. 3.1B, 3rd Edition states $\frac{3}{16}$ " or 4 mm.

In the case of meters, use the accuracy stated in the manufacturer's precision statement. Refer to API *MPMS* Chapter 4^[1].

In the event that TCV volumes are used, temperature tolerance may also be taken into account. Refer to API *MPMS* Chapter 7.3.

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.

Use of the high-point bleed-valve method can involve a loss of line integrity and, for this reason, is no longer a recommended method. Facilities that employ this method shall be fully aware of the associated additional risks.

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 Procedure for High-point Bleed-valve Method

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

- 1) Before opening high-point bleed valves, ensure that lines are under positive pressure at bleed positions.
- 2) Open valves into the sewer system.

NOTE If this method is used without an appropriate sewer system, place a suitable container under each valve opening to receive liquid.

- 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.

- 4) Close the valve and proceed to the next bleed valve.
- 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, it has potential to affect custody transfer volumes when performed after transfer.

7.2.2 Requirements

Agree on the quantity to be displaced, which shall be a minimum of 100 % of the combined capacity of all designated transfer lines (110-120 % is preferable if terminal conditions allow).

Terminal personnel shall circulate product through the designated pipeline system via the dock manifold. If circulation cannot pass through the designated dock manifold, parties will agree on an alternate 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 Procedure for Internal Circulation Method

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

- 1) Gauge the delivering and receiving tanks before line circulation, using either automatic or manual measurement equipment.
- 2) Circulate product to displace the volume of the pipeline.
- 3) Close tank valves and re-gauge tank(s) using the same method as that used for opening gauges.
- 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 difference persists, the integrity of the system should be investigated.

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. Corrections shall be applied to any volumetric differences in line condition and will therefore affect custody transfer volumes.

7.3.2 Requirements

Where possible, the vessel should 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^[5].

The vessel's line condition can affect the accuracy of the line displacement volumes between vessel and shore. Vessel personnel shall provide the tank capacity tables and 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.

Vessel and shore will 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. 110-120 % is preferable if terminal conditions allow.

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 for Line Displacement Method

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

- 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, record the meter reading.
- 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.
- 3) Repeat Step 1), using the same types of equipment and technique that were used for the opening measurements.
- 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.
- 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, perform the following steps.

- a) Check all calculations for accuracy.
- b) Verify that all measurements from Step 3) are accurate and confirm that vessel lines are in the same fullness condition as before the transfer.
- c) After correcting any errors found, if the difference still exceeds tolerance, refer to customer instructions on line displacement difference exceeding agreed tolerance. In the event that no instructions have been given, 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. If losses above tolerance continue, vessel and shore personnel should verify line integrity.

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. Corrections shall be applied to any volumetric differences in line condition and will therefore affect custody transfer volumes.

NOTE Refer to local terminal procedures on steps to perform line clearing methods.

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. If pigs are lost or damaged, the cause for this should be resolved before the operation is repeated.

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.

- 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 measurement equipment or manual measurement equipment. If automatic equipment will be used, terminal personnel shall provide evidence that they are custody transfer qualified in accordance with the provisions of API *MPMS* Ch. 3.1B.
- 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.
- 3) Isolate the pipeline to prevent backflow and stop the pump.
- 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.
- 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 $3/16$ in. (4 mm) for automatic measurement equipment, no correction is necessary.
- 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, 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 deemed to be full and no further correction is necessary.
- 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 should 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. This 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, 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 outturn 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 outturn figure.

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Annex A (Informative)

Procedure for Line Displacement Method Not Involving Marine Vessels

A.1 Recommendations

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.

Contracted parties should 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.

A.1.1 Procedure

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

- 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, record the meter reading.
- 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.
- 3) Repeat Step 1) using the same types of equipment and technique that were used for the opening measurements.
- 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.
- 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 the transfer may proceed. If volumes differ by more than the agreed tolerance, the following steps should be performed.
 - a) Check all calculations for accuracy.
 - b) Verify that all measurements are accurate and confirm that 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 that no instructions have been given, 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 Lines¹

- 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 that the gasket is in good condition (a new gasket should be used every time) and correctly aligned. Close the end closure and seal using a "full head of bolts."
- 7) Ensure that 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 that the receiving end is ready to receive the pig and should 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 they are expecting to receive the pig into and their location on the site.
- 13) Before giving permission for the pig to be launched, the duty operator at the receiving end of the line will confirm that all valves are correctly set. In particular, they 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.

¹ The following is an example for illustration purposes only. [Each company should develop its own approach.] It is not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

- e) Slowly open the air/nitrogen supply to the launcher.
 - f) Relay the following message to 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. They 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. They 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), then close the pig receiver valve.
 - 20) The receiving operator should 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 residue 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 4 (all sections), *Proving Systems*
- [2] API MPMS Chapter 7.2, *Portable Electronic Thermometers*
- [3] API MPMS Chapter 17.1, *Guidelines for Marine Inspection*
- [4] API MPMS Chapter 17.2, *Measurement of Cargoes On Board Tank Vessels*
- [5] API MPMS Chapter 17.4, *Method for Quantification of Small Volumes on Marine Vessels (OBQ/ROB)*
- [6] API MPMS Chapter 17.11/HM 52, *Measurement and Sampling of Cargoes On Board Tank Vessels Using Closed and Restricted Equipment*
- [7] EI HM 69, *Procedures for determining H₂S concentration in cargo tank head spaces*
- [8] OCIMF¹ ISGOTT: *International Safety Guide for Oil Tankers and Terminals*

¹ Oil Companies International Marine Forum, 27 Queen Anne's Gate, London SW1H 9BU, UK, www.ocimf.com