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Measurement and sampling of cargoes on board
tank vessels using closed and restricted equipment

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Measurement and sampling of cargoes on board tank vessels using
closed and restricted equipment

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This standard is intended to provide guidelines for measurement and sampling of cargoes on board tank vessels using closed and restricted equipment. However, it is not intended to preclude the use or development of any other technologies or methods. To gain a better understanding of the methods described in this standard, the reader should review in detail the latest editions of the publications, standards and documents referenced herein.

SI units are used throughout this publication as the primary units of measure since this system is commonly used in measurement and sampling. However, US Customary (USC) units continue to be used in some applications. Therefore, both SI and USC units are shown (with USC in parentheses).

This standard is not intended to supersede any safety or operating practices recommended by organisations such as the International Maritime Organization (IMO), International Safety Guide for Oil Tankers and Terminals (ISGOTT), International Chamber of Shipping (ICS) and Oil Companies International Marine Forum (OCIMF), or individual operating companies, nor is the publication intended to supersede any other safety or environmental considerations, local regulations, or the specific provisions of any contract.

All shipboard procedures described in this standard should be performed by or in the presence of the ship's master, or their designated representatives. For reasons of safety, only approved equipment certified intrinsically safe or otherwise approved suitable for its intended use shall be used.

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Classified areas may vary depending on the location, conditions, equipment, and substances involved in any given situation. Users of this standard should consult with the appropriate authorities having jurisdiction. Users of this standard should not rely exclusively on the information contained in this publication. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

Shall: As used in a standard denotes a minimum requirement in order to conform to the requirement.

Should: As used in a standard, denotes a recommendation or that which is advised but not required in order to conform to the requirement.

This publication was produced following API/EI standardisation procedures that ensure appropriate notification and participation in the developmental process and is designated as an API/EI standard.

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Introduction

Measurement accuracy and representative sampling are essential to the sale, purchase and handling of bulk liquids. Accurate measurements and representative sampling require the use of standardized equipment and procedures.

Government and regulatory agencies worldwide are imposing safety and environmental regulations that prohibit tank vessel operations from releasing hydrocarbons into the atmosphere. This has resulted in the restriction and, in some cases, the prohibition of traditional methods of obtaining cargo measurements and samples. Consequently, methods and technologies are now being developed and used that allow cargo measurements and samples to be taken with no vapor release (closed) or with very limited vapor release (restricted).

Shipboard sampling at the load or discharge port is frequently required to test the quality of the cargo against contract and also to determine if any cargo quality degradation has occurred during the shipping process. Shipboard sampling may also be required prior to cargo acceptance and custody transfer, particularly where shipboard blending has taken place.

It should be noted that when taking vessel samples it may not be possible to obtain representative samples of non-homogenous cargos due to the inherent nature of the cargo and the sampling restrictions.

Measurement and sampling of cargoes on board tank vessels using closed and restricted equipment

1 Scope

This document provides guidance on the use, maintenance and calibration of restricted and closed measurement and sampling equipment. It also provides guidance on preferred size and positioning for gauging and sampling fittings on vessels.

2 Normative References

This document should be used in conjunction with the following referenced documents. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Manual of Petroleum Measurement Standards (MPMS) Chapter 1, Vocabulary

API MPMS Chapter 2, Tank Calibration

API MPMS Chapter 2.8B, Establishment of the Location of the Reference Gauge Point and the Gauge Height of Tanks on Marine Tank Vessels

API MPMS Chapter 3, Tank Gauging

API MPMS Chapter 3.1A-2005, Manual Gauging for Petroleum and Petroleum Products

API MPMS Chapter 7, Temperature Determination

API MPMS Chapter 8.1, Manual Sampling of Petroleum and Petroleum Products

API MPMS Chapter 17.2, Measurement of Cargos on Board Tank Vessels

API MPMS Chapter 17.4, Method of Quantification of Small Volumes on Marine Vessels (OBQ/ROB)

API MPMS Chapter 17.12/EI HM 51, Procedures for Bulk Liquid Chemical Cargo Inspection by Cargo Inspectors

API Recommended Practice 2003, Protection Against Ignitions Arising out of Static, Lightning and Stray Currents

EI HM 28, Procedures for Oil Cargo Measurement by Cargo Inspectors

EI HM 29, Procedures for Oil Product Cargo Measurements by Cargo Inspectors, Section 1, Crude Oil

ISO 3170:2004¹, Petroleum liquids—Manual sampling

¹ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva, Switzerland, www.iso.org.

3 Terms and Definitions

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

3.1

air saturated vapor pressure

ASVP

The observed pressure exerted in vacuo by air-saturated petroleum products, components and feedstocks, in the absence of undissolved water.

3.2

assay

A procedure to determine the presence, absence, or quantity of one or more components.

3.3

dead bottom sample

A sample obtained from the lowest accessible point in a tank.

3.4

decanting

To pour (a liquid) from one container into another.

3.5

density

For a quantity of a homogeneous substance, the ratio of its mass to its volume. The density varies as the temperature changes and is therefore generally expressed as the mass per unit of volume at a specified temperature.

3.6

flash point

The minimum temperature to which a product shall be heated for the vapors emitted to ignite momentarily in the presence of a flame when operating under standardized test conditions and for the flame to propagate across the liquid surface.

3.7

inert gas

Gas that does not react with the surroundings.

3.8

inerting

A procedure used to reduce the oxygen content of a vessel's cargo spaces by introducing an inert gas such as nitrogen or carbon dioxide or a mixture of gases such as processed flue gas.

3.9

portable manual sampling unit

PSU

Intrinsically-safe device used in conjunction with a vapor control valve to obtain required cargo samples under closed or restricted system conditions.

3.10

portable measurement unit

PMU

Intrinsically-safe device used in conjunction with a vapor control valve to obtain required liquid level and/or temperatures under closed or restricted system conditions.

3.11

remaining on board

ROB

Material remaining in a vessel's cargo tanks, void spaces, and/or pipelines after the cargo is discharged. ROB includes any combination of water, oil, slops, oil residue, oil water emulsions, sludge, and sediment.

3.12**stand pipe**

A vertical section of pipe extending from the top of a marine vessel tank through which measurements and samples of tank contents can be obtained.

NOTE Stand pipes are frequently fitted with vapor control valves to allow closed or restricted operation. The pipe should extend to the floor of the tank with the internal part (also called “stilling well” or “still pipe”) slotted to allow free flow of tank contents while providing guidance for gauging and sampling equipment.

3.13**static accumulator oils**

Oils having a conductivity of less than 50 pS/m; these oils relax (dissipate charge) slowly.

3.14**UTI**

Ullage, temperature and interface

3.15**vapor control valve****VCV**

Valve fitted on a stand pipe, expansion trunk or the deck that permits use of the portable hand-held gauging instruments while restricting the release of vapors into the atmosphere.

3.16**vapor pressure****RVP, TVP**

Reid vapor pressure (RVP): The vapor pressure of a liquid at 100 °F (37.8 °C, 311 °K) as determined by ASTM D323.

True vapor pressure (TVP): The pressure at which the fluid is in equilibrium between its liquid and gas state.

3.17**volatile organic compounds****VOCs**

Organic chemicals that have a high vapor pressure and easily form vapors at normal temperature and pressure.

3.18**washing, crude oil****COW**

Use of a high pressure stream of the crude oil cargo to dislodge or dissolve clingage and sediment from the bulkheads, bottom, and internal tank structures of a vessel during the discharge operation.

4 Health and Safety Precautions

4.1 General

Personnel involved with the gauging and sampling of petroleum and petroleum-related substances should be familiar with their physical and chemical characteristics, including potential for fire, explosion, and reactivity, and with the appropriate emergency procedures as well as potential toxicity and health hazards.

Personnel should comply with the individual company safe operating practices and with local, state, federal and national regulations, including the use of proper protective clothing and equipment.

Personnel involved in inspection, measurement, and/or sampling on board a vessel using equipment via a vapor control valve (VCV), shall at all times be accompanied by a designated ship's representative.

4.2 Static Electricity Hazards

If the tank is in a non-inert condition, specific precautions will be required with regard to safe measurement and sampling procedures when handling static accumulator oils. These are generally as follows.

During loading, and for 30 minutes after the completion of loading, metallic equipment for dipping (gauging), ullaging or sampling shall not be introduced into or remain in the tank. Examples of equipment include manual steel ullage tapes, portable gauging devices mounted on deck stand pipes, metal sampling apparatus and metal sounding rods. Non-conducting equipment with no metal parts may, in general, be used at any time. However, ropes or tapes used to lower equipment into tanks shall not be made from synthetic materials.

After the 30-minute waiting period, metallic equipment may also be used for dipping (gauging), ullaging and sampling but it is essential that it is effectively bonded and securely earthed to the structure of the ship before it is introduced into the tank and that it remains earthed until after it has been removed.

Operations carried out through stand pipes are permissible at any time because it is not possible for any significant charge to accumulate on the surface of the liquid within a correctly designed and installed stand pipe. A stand pipe should extend the full depth of the tank and be effectively bonded and earthed to the tank structure.

4.3 Health Hazards

Petroleum vapor dilutes oxygen in the air and may also be toxic. Hydrogen sulfide vapors are particularly hazardous. Petroleum vapors with relatively low concentrations of hydrogen sulfide may cause unconsciousness or death. During and after the opening of a VCV, personnel should position themselves to avoid any gas which may be released. Harmful vapors or oxygen deficiency cannot always be detected by smell, visual inspection, or judgment. Appropriate precautions should be used for the protection against toxic vapors or oxygen deficiency. It is recommended that users always wear gas monitors that, as a minimum, measure gas concentrations of H₂S.

Procedures should be developed to provide for the following:

- a) exposure monitoring,
- b) need for personal protective equipment, and
- c) emergency rescue precautions.

When necessary, suitable fresh air breathing equipment should be worn prior to entering the gauge site and during the gauging and sampling procedure.

This discussion on safety issues is not exhaustive and the appropriate API or Energy Institute publications, together with the *International Safety Guide for Oil Tankers and Terminals (ISGOTT)*, *Safety of Life at Sea (SOLAS)*, and Oil Companies International Marine Forum (OCIMF) publications should be consulted for applicable safety precautions.

5 Types of Equipment

5.1 General

Ship-owner, charterer or terminal safety or environmental regulations may restrict tank gauging and sampling operations which result in the release of inert gas, hydrocarbons or other volatile organic compounds (VOCs) into the atmosphere. In these circumstances, traditional open gauging and sampling procedures will not be permitted.

The decision to use either restricted or closed equipment will be based on many factors including, but not limited to:

- hazardous nature of the cargo,
- local regulations and restrictions,
- vessel regulations and restrictions,
- tank pressure.

5.2 Gauging Equipment

5.2.1 Restricted Gauging

Restricted equipment is designed to substantially reduce or minimize the amount of vapor losses that would occur during open gauging or sampling, but may still allow some quantity of vapor to escape because the equipment is not completely gas tight. This vapor release will be increased if the cargo tank is blanketed with either inert gas or nitrogen under positive pressure.

Portable measurement units (PMUs) are designed to measure bulk liquid levels, water levels and/or temperatures of a cargo in a tank. The units may be designed to perform one, two or all three of these functions. Multi-function units are sometimes referred to as ullage, temperature and interface (UTIs). PMUs use an electronic sensing device integrated into a measuring tape.

The PMU comprises an electronic head and tape fitted to an extension tube. This tube houses the tape bob/sensor probe when it is withdrawn from the tank.

The PMU is fitted with a means to provide a tight seal onto the VCV. However, the tape is open and a simple wiper seal reduces vapor loss as the tape is raised and lowered. The extension tube fills with vapor when the VCV is opened and this vapor escapes when the PMU is removed from the VCV after completion of the measurement operation.

Generally, PMUs and VCVs made by the same manufacturer are designed to be used together. However, equipment made by different manufactures may be used together with appropriate adapters that either do not require measurement correction or have a known fixed correction.

The manufacturer's instructions should be carefully reviewed and followed. In addition, the manufacturer's maintenance schedule should be followed and a log kept of all maintenance and verifications performed on each device. PMUs shall be verified and records kept in accordance with API *MPMS* Ch. 3 and API *MPMS* Ch. 7.

When measurement equipment is first put into service, it shall be carefully inspected for any signs of damage or construction flaws. The measurement tapes of all PMUs should be compared against a certified master tape to be certain the linear markings on the tape are correct and in accordance with API *MPMS* Ch. 3.1A. All equipment and fittings should be checked for proper size, operation, seating, and any signs of wear before each use.

5.2.2 Closed Gauging

Closed gauging equipment does not permit the release of any tank contents to the atmosphere during gauging. Equipment is similar to that described above for restricted gauging except that the tape housing is completely enclosed and gas tight and provision should be made for purging the contents of the tape housing and tube before it is removed from the VCV.

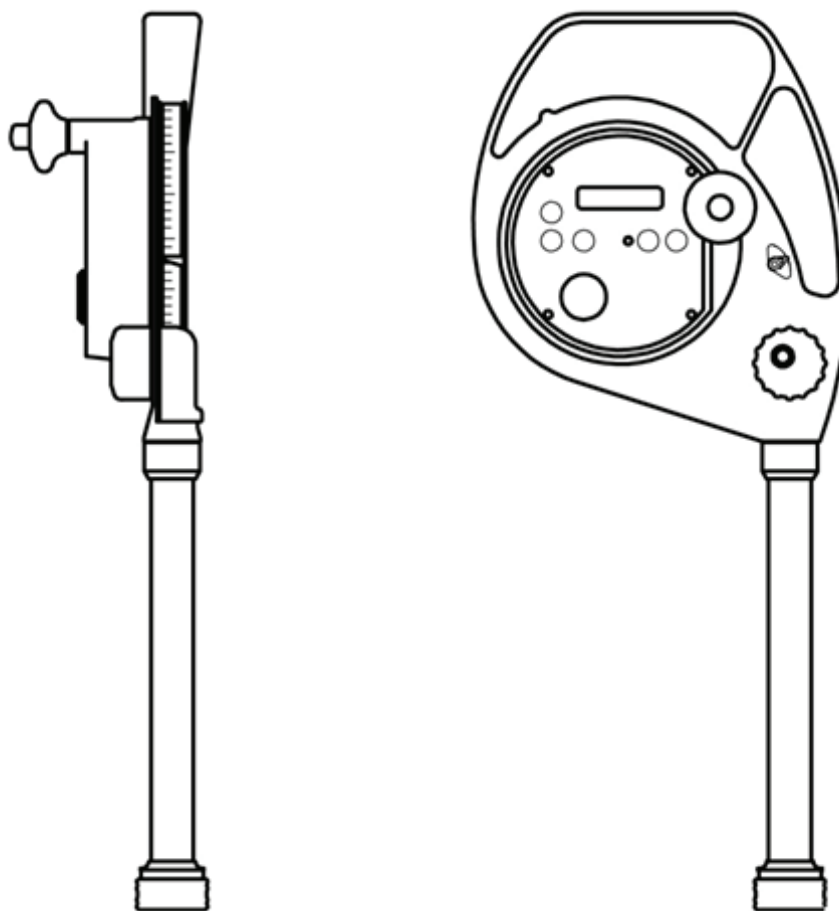


Figure 1—Restricted Gauging Equipment

5.3 Sampling Equipment

5.3.1 Restricted Sampling

Portable sampling units (PSUs) designed to obtain samples under restricted conditions operate via VCVs fitted to the vessel and are very similar to the restricted gauging PMUs described in 5.2.1 except that the electronic head, sensor and tape is replaced with a simple tape system.

Samplers (sample containers) of various types (see 5.3.4) can be placed inside the extension tube, lowered to the desired level in the tank and then retrieved. The VCV can then be closed and the sampler removed with a limited loss of vapor.

5.3.2 Closed Sampling

Closed system equipment is designed to be completely gas-tight during sampling to prevent release of vapor to the atmosphere. Similar to the closed system PMUs, the tape housing is hermetically sealed and the design should allow sample transfer to secondary (transportation) receivers with minimal vapor loss.

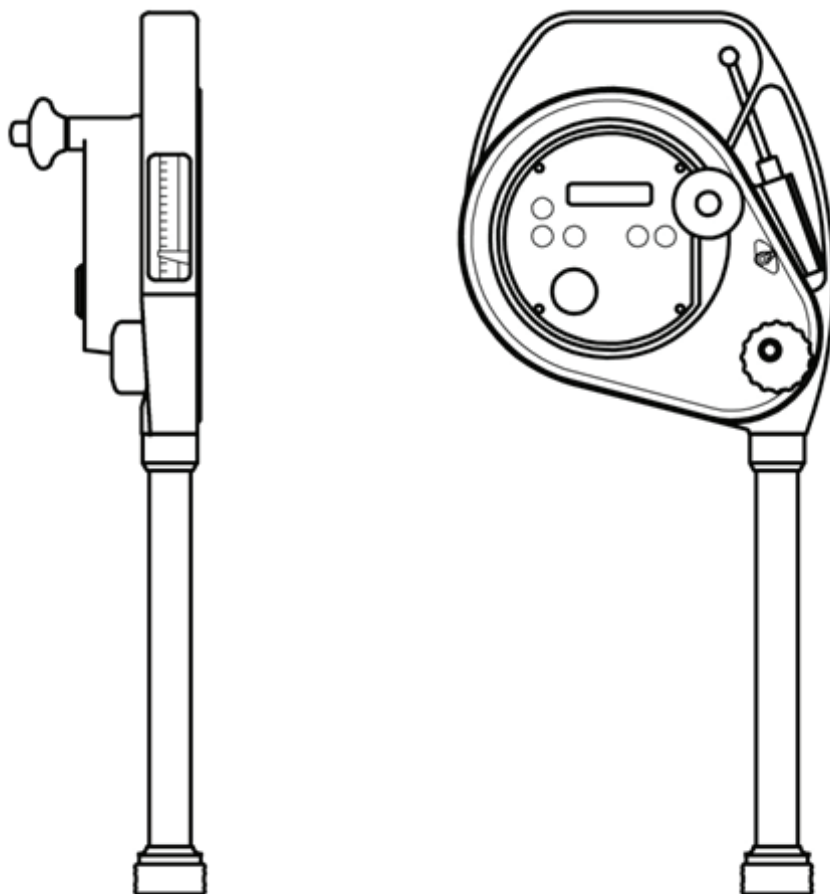


Figure 2—Closed Gauging Equipment

Additional options include:

- use of multiple, sealed primary samplers to avoid sample transfer,
- vapors held up within the housing to be displaced back to the tank or to an absorbent canister, or
- the system to be purged with inert gas.

Refer to API *MPMS* Ch. 8.1.

5.4 Sampler Types

5.4.1 General

Closed and restricted sampling equipment can be used to perform several different types of sampling operations similar to those which are performed using open manual sampling e.g. zone, spot, running, all levels, bottom and dead bottom samples. This is achieved by using different designs of sampler with the PSU.

5.4.2 Zone Samplers/Flow-through Sampler

Most zone samplers operate on the basis of an open ended tube with a ball valve at the bottom. When the tube is introduced into the tank, liquid flows through the sampler while it descends through the liquid. When the sampler is

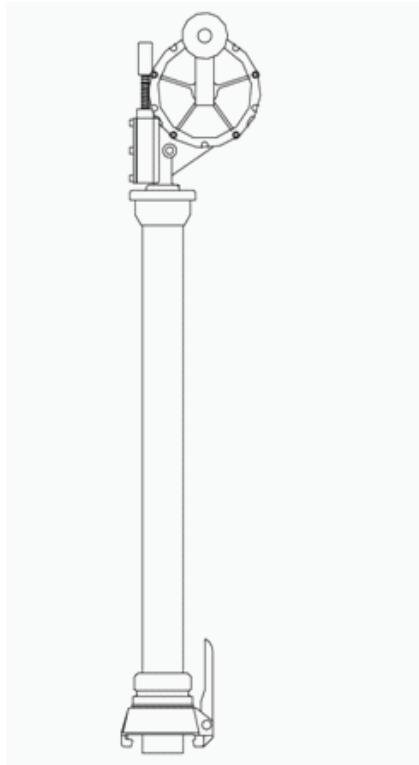


Figure 3—Small Volume PSU (2 in.)

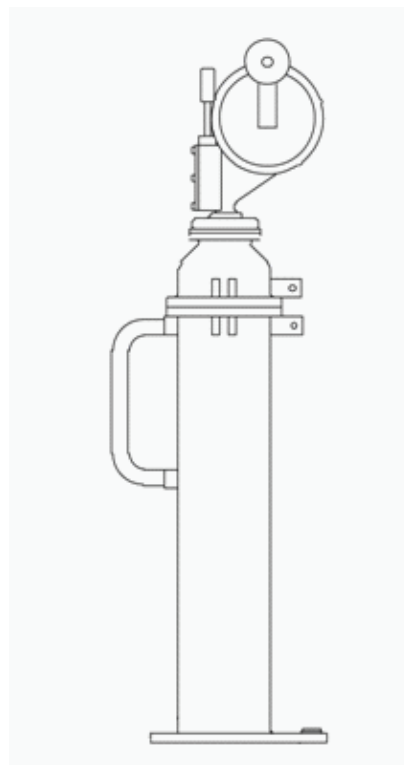


Figure 4—Large Volume PSU (4 in.)

stopped, the ball valve closes and the sampler should retain the sample from that level in the cargo. The quality of this type of sample depends largely on operator ability and on how well the ball valve opens and closes in the liquid medium. Since this type of sampler has a top that is open at all times, the sample is unlikely to be 100 % representative of the liquid at the desired level.

5.4.3 Spot Samplers

Spot type samplers are available that can be used to take samples at chosen tank levels [e.g. at upper, middle and lower (UML) or at the tank bottom]. These samplers require manual opening to fill when they have been lowered to the required level, and are primarily used to verify the absence of stratification within the tank. It is also possible to use this type of sampler to take multiple spot samples, one above another, to get close to a “running” type of sample. This is not common since it is normally extremely time consuming.

Another type of spot sampler is available specifically to collect dead bottom samples. This sampler is tripped when it reaches the tank bottom, and fills from the bottom.

5.4.4 Running Average Samplers

Running average samplers are equipped with fixed or adjustable restricted openings that are designed to take “running average” samples. The sample is obtained continuously as the sampler moves down through the oil column and back up to the surface. Care should be taken to ensure that the sample container is between 70 % and 85 % full when sampling is completed. If the sample container is full it is not possible to ensure that a representative sample was collected throughout the lowering and raising operation over the complete liquid column and it therefore cannot be considered to be a true running average sample.

5.4.5 All Level Sampler

All level samplers fill in one direction. The filling rate shall be steady and on completion of sampling, the sampler should be 70 % to 85 % full to ensure that all levels in the oil column have been sampled.

NOTE Refer to API MPMS Ch. 8.1 for full definitions of sample types.

5.5 Accessories

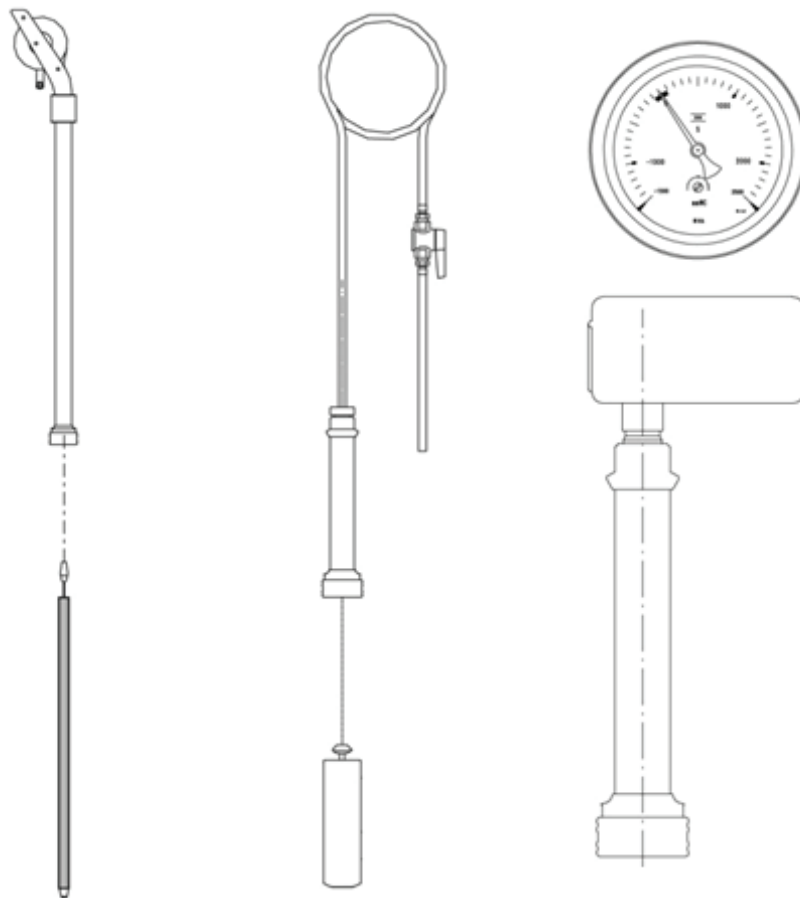


Figure 5—ROB/OBQ Figure 6—Gas Monitoring Figure 7—Tank Pressure

When working under restricted or closed conditions, accessories/adapters may be required to complete certain tasks. These include equipment for remaining on board (ROB) and on board quantity (OBQ) measurements, tank pressure monitoring, or for oxygen/gas testing.

6 Stand pipes

API MPMS Ch. 3.1A specifically *prohibits* the use of unslotted stand pipes for tank gauging.

Tank gauging and sampling shall not be carried out from unslotted stand pipes, since the measurements, of level and temperature, obtained inside an unslotted stand pipe are usually not the same as for bulk cargo outside the stand pipe. The slots are designed to allow the free flow of liquid into and out of the stand pipe.

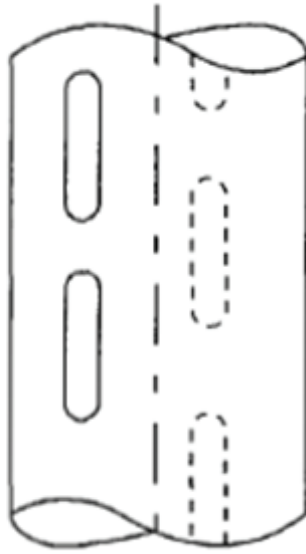


Figure 8—Slotted Stand pipe

For similar reasons, samples obtained from an unslotted stand pipe may not be representative of the tank contents.

Tanks with *unslotted* stand pipes should be treated as would “active tanks” for reporting and calculation purposes. Appropriate protests should be made and all concerned parties notified before proceeding.

- a) Slotted stand pipes should be of sufficient diameter to allow for proper gauging and sampling procedures with both restricted and closed equipment.
- b) The stand pipe shall have two rows of slots, or two rows of holes (i.e. perforations) located on the opposite sides of the pipe, which start at the lower end of the pipe and continue to above the maximum liquid level. Typical sizes of the slots are 2.5 cm (1 in.) in width and 26 cm (10 in.) in length. Typical diameter of the perforations is 5 cm (2 in.).
- c) The maximum spacing between perforations or slots if not overlapping shall be 30 cm (12 in.).

7 Procedures

7.1 Gauging

Care shall be taken to determine an accurate trim and list, and apply the required corrections, before any calculation of quantities is attempted.

The preferred condition of the vessel is to be on an even keel (i.e. with zero trim and list), which eliminates the need for any trim or list corrections to be applied to the gauge readings.

7.1.1 General

When vessels are fitted with vapor control valves, PMUs can be used to measure bulk liquid and free water levels, and also temperature.

The use of the independent inspection company's equipment is preferred for custody transfer. Prior to boarding a vessel equipped with VCVs, the manufacturer and size of the VCVs should be determined so that compatible equipment or adapters can be taken on board.

It shall also be determined whether restricted or closed equipment should be used. Verify that the equipment to be used for gauging is fit for purpose by carrying out the checks specified in 5.2.1. In addition, before gauging, verify the following.

- a) Tank capacity tables correspond to the VCV locations and to the gauging equipment being used. If discrepancies are identified, notify the appropriate parties and document in the gauging report (see API *MPMS* Ch. 2 and API *MPMS* Ch. 3.1A).
- b) All cargo operations have been stopped, and no cargo is being transferred.
- c) When applicable, the inert gas system (IGS) to the cargo tank is isolated. Refer to *ISGOTT* ^[1] for further guidance.
- d) The gauging equipment has been calibrated and the calibration/verification log reviewed.
- e) Verify that equipment is adequately grounded as per manufacturer's instructions.
- f) The equipment is free of breaks, kinks, and signs of wear which might affect measurement accuracy or its intrinsic integrity.
- g) The equipment is suitably clean for the product to be measured and the numbers and graduations on the tape are legible.
- h) The batteries are charged.
- i) For greater accuracy, trim and list should be eliminated. If this cannot be done, the trim and list shall be recorded and appropriate corrections made to measurements and/or volumes.

7.1.2 Use of Vessel's Equipment

In some circumstances it may be necessary to use a vessel's PMU. In those instances, the unit should be verified as follows.

- a) The tape function is visually verified against a manual steel tape that has been calibrated in accordance with API *MPMS* Ch. 3.1A.
- b) The temperature thermometer function is verified by comparing the reading against a thermometer traceable to a national standard in liquid as per API *MPMS* Ch. 7.
- c) The sensor function has been checked as per manufacturer's instructions and API *MPMS* Ch. 3.1A.
- d) The appropriate parties are notified and it is duly noted on the gauging report. This notation shall include the serial number of the PMU.

7.1.3 Liquid Level and Free Water Measurement Using PMUs

- a) Verify tank capacity tables correspond to the VCV locations and to the gauging equipment being used. If discrepancies are identified, notify the appropriate parties and document in the gauging report (see API *MPMS* Ch. 2 and API *MPMS* Ch. 3.1A).
- b) Record the reference gauge height indicated for each vessel's tank on the vessel's capacity tables.

NOTE Any corrections for individual stand pipes and/or adapters and calculate the actual reference height for the reference gauge point used.

- c) Due to the design of the probe used, the tip of the probe may not be the zero point of the gauge tape. In this case, an adjustment to the reading shall be made to convert the observed reference height to the corrected reference height. This adjustment should be found on the certificate of verification or in the manufacturer's instructions.
- d) Prior to gauging, verify with vessel's officer that no cargo is being transferred.
- e) When applicable, verify that the IGS to the cargo tank is isolated.
- f) Water finding paste may be added to the probe.
- g) Place the PMU gauging tape assembly onto the vapor control valve and screw it down tightly (or lock firmly, if quick-release type).
- h) To measure the cargo level, open the vapor control valve and slowly unwind the tape until the oil indicating tone is heard. When the sensor on the probe indicates an oil level according to the manufacturer's operating instructions, read the tape at the reference gauge point to the nearest tape graduation. Manual gauging shall be carried out in accordance with the requirements of API MPMS Ch. 3.1A.
- i) Persistent variance between measurements can indicate movement of the tank contents. If cargo movement in a tank is unavoidable, at least five measurements shall be obtained in minimal time, recorded, and then averaged.
- j) When using an interface detecting PMU, water-finding paste may be placed on the outside of the probe before lowering it to the tank bottom. When a clean strike of the tank bottom is felt, allow the probe to remain in the tank a sufficient amount of time for any water present to react with the paste. Normally 30 to 60 seconds will be required but more time might be necessary for heavier oils. After the required reaction time, retrieve the probe without hesitation and measure the cut on the probe using a calibrated tape. This is the innage of the water in the tank being measured.
- k) Record the measurement at which the bottom of the tank is found to the nearest tape graduation, 1 mm ($1/8$ in. for tapes with customary units). This is the observed reference height of the tank. The difference between the ullage of the free-water interface and the observed reference height may be the free water innage or an approximation to it, depending on the formation of any emulsions. Separate verification may be made with a water finding rule and water finding paste. Refer to API MPMS Ch. 3.1A-2005, subsection 11.2.3, for guidance when the observed or published reference height as stated on the tank capacity table is either exceeded or not reached. Heavy bottom sludge (sediments) may make the tank bottom difficult to feel, necessitating the use of a specially designed weighted attachment. Also, the probe end of the PMU can become blocked by the sediment, which may affect the sensitivity of the probe (see API MPMS Ch. 3.1A).
- l) Raise/lower the probe into the cargo to recheck the interface level. Once the interface level is verified, record the free water ullage reading to the nearest tape graduation, 1 mm ($1/8$ in.) for customary unit tapes at the reference gauge point.
- m) When all measurements are complete, wind the tape until the bob is fully retrieved above the valve. Then close the vapor control valve and disconnect the gauging equipment from the valve.

7.1.4 Measurement of Small Quantities

Measurement of small quantities on board marine tank vessels, including ROB and OBQ, is performed in the same manner as the measurement of bulk liquid levels. However, unless gauge points (as stated on the calibration tables) are properly located on the cargo tanks, small quantities may not be detectable under all conditions of trim and list. To handle varying trim conditions, gauge points should be located as close to the aft (and sometimes the forward) bulkheads as possible. On vessels where only a single trim condition (aft or forward) is experienced, the vessel should have a gauge point located in the direction of the normal operational trim of the vessel. In placing the gauge

points, care shall be given to assure their location will not cause the measurement equipment to touch the tank bulkhead when in use.

Although not a requirement for all vessels, the provision of more than a single gauge point on a tank allows for more accurate determination of OBQ/ROB quantity composition (by sampling) and distribution. All additional gauge points should be installed with vapor control valves that allow the effectiveness of tank stripping to be safely determined using either restricted or closed techniques. For more information on gauge point location, see API *MPMS* Ch. 2.8B and API *MPMS* Ch. 3.1A and Section 8 and Section 9 of this document.

Procedures outlined in API *MPMS* Ch. 17.4 should be followed for quantifying small quantities on board vessels.

NOTE When performing OBQ/ROB inspections with a PMU, a graduated bob (i.e. on a sampling unit) may be preferred for the PMU to prevent sensor damage.

7.2 Temperature Measurement

PMUs may be of the single function type or integrated into a multifunction measurement unit. As such temperatures are to be obtained in conjunction with the measurement of liquid levels in the tank. Refer to API *MPMS* Ch. 7.

- a) Assure electrical connection between the unit and VCV has been established (see Section 4).
- b) Verify the condition of the battery before and after each use.
- c) Lower the sensing probe to the predetermined level.
- d) Raise and lower the probe 0.3 m (1 ft) above and below the predetermined level to allow rapid stabilization as stated by API *MPMS* Ch. 7, if the readout varies by not more than 0.1 °C (0.2 °F) for 30 seconds.
- e) After the temperature has stabilized, read and record the temperature at the depth measured.
- f) Repeat Steps c, d, and e at each level if multiple temperatures are required.
- g) Determine the average temperature.
- h) Round off the average temperature and report the temperature to the nearest 0.1 °C or 0.1 °F.

Inaccurate temperature measurement can create the largest apparent difference between actual and measured quantities. It is essential that liquid cargo temperatures are made as accurately as possible.

7.3 Sampling

7.3.1 General

Sampling shall be carried out in accordance with procedures described in API *MPMS* Ch. 8.1 using equipment described under 5.3 and 5.4.

7.3.2 Issues that Can Affect the Reliability of Samples Obtained with Restricted and Closed Sampling Equipment

7.3.2.1 Equipment Cleanliness

To avoid contamination, samplers, fittings, etc. shall be properly cleaned prior to use and between grades. This may or may not require partial disassembly of the unit.

The traditional method of rinsing the primary sampling container with the cargo to be sampled may not be permitted when handling hazardous cargo under closed or restricted conditions. However, if this method is used care should be given to the handling, containment and safe disposal of such rinse liquids.

7.3.2.2 Sample Transfer Contamination (and Loss of Light Ends)

When performing restricted or closed sampling it is not normally possible to retain the sample in the primary sampling container (i.e. the container that is used to obtain the sample), and the sample is transferred into another container. This transfer process may affect the samples obtained in the following ways.

a) Light ends may be lost from the sample which may affect test results, including but not limited to:

- vapor pressure (RVP, TVP, ASVP, flash point, etc.);
- density;
- assay, distillation;
- H₂S.

b) Clingage may take place in the primary sampling container resulting in a non-representative transfer to the secondary (decanted) sample container.

c) It should be noted that similar problems may also be encountered with traditional open sampling systems that require the transfer of the primary sample to a secondary receiver for any reason (e.g. the traditional “beaker” sampler). ISO 3170:2004 provides generic guidance that “if it is necessary to transfer a sample from a primary sampler to a secondary sample container, appropriate precautions shall be taken to preserve the integrity of the sample,...the sampling method shall, whenever practical, avoid sample transfer by permitting the sample to be transported to the laboratory in the container it was originally obtained in (the primary sample receiver).”

7.3.2.3 Equipment Related Contamination

Samples taken from stand pipes whether manually or by PSU are subject to potential contamination from rust or other foreign matter that could be displaced from the top section of the stand pipe into the sample. This can be a particular problem when obtaining samples from jet fuel for particulate matter testing. Stand pipes, VCVs and other fittings may also have been used for introducing additives to the tank either for the current or previous cargo and this can result in contaminated/unrepresentative samples.

Condensation can build up in the stand pipe allowing water to enter into the sample as it returns to the housing. This is a particular problem with heated cargoes

7.3.2.4 Stratification and Nature of Cargo

Stratification, especially in heavier cargoes, can complicate the sampling process significantly. The nature of the cargo and the way it is transported (i.e. heating, mixing, etc.) can make obtaining representative samples difficult.

Additionally, on heavy viscous cargoes the weight of the sampler may be insufficient to penetrate readily through the liquid. If this should be the case, the operator may think that the sampler has reached the desired depth when in fact the tape has merely stopped running with the sampler suspended at some other intermediate level.

It should be noted that when taking vessel samples it may not be possible to obtain representative samples of non-homogenous cargoes due to the inherent nature of the cargo and the sampling restrictions. In such cases, the taking of additional samples (e.g. multiple spot or comparative shore tank samples, etc.) and use of alternative sampling methods should be considered. If there is disparity in related analysis results, it is recommended that all associated

results obtained be reviewed, and considered, particularly when those results are to be used for custody transfer purposes.

Refer to API MPMS Ch. 8.1 for further clarification.

8 Vapor Control Valves (Recommended Size and Type)

The size and location of the VCVs used for closed and restricted system measurement and sampling is critical. A VCV of the proper size, located correctly, will allow more accurate measurements and more representative samples to be taken than those from VCVs that are improperly located and/or of insufficient size.

Vessel owners and operators are strongly encouraged to adopt standard fittings of the recommended size and in appropriate locations in order to reduce the possibility of delays and to promote industry uniformity. The type and size of fitting can sometimes vary depending on the global location and type of trade that the vessel is engaged in. It is important that information regarding the type and location of VCVs is readily available.

Persons involved in the chartering of vessels should make the verification of size and type of VCVs an important factor to be recorded and considered when chartering any vessel. This information, when passed on to the inspection company, will assist in avoiding potential delays.

The recommended size of vapor control valves is 100 mm (4 in.) nominal diameter. A 100 mm (4 in.) valve will allow access for the various types of sampling equipment which may be required depending on the cargo and sample type required. Vapor control valves smaller than 100 mm (4 in.) in diameter are suitable for gauging but can severely limit the type of sampling equipment that can be used and, ultimately, the quality of the sample obtained. Importantly, the use of 100 mm (4 in.) VCVs will also significantly reduce the amount of time required to obtain samples, and thereby reduce personnel and environmental exposures.

When working through a 48 mm (2 in.) VCV, closed and restricted samplers can normally only take samples in a quantity of approximately 400 ml to 500 ml. To obtain the larger quantities that are often required for accurate quality determination and for sample retention, multiple samples have to be taken. Time can become a significant consideration in such instances.

9 Gauge Points

9.1 General

The PMU gauge points should be located as close to the geometric center of the tank as possible in order to minimize the effects of trim and list. If a vessel is fitted with stand pipes below deck, these shall be slotted to allow for equalization of the liquid level and vapor pressure in the ullage space.

9.2 Additional Gauging Points

Any vessel that is certified to perform crude oil washing (COW) is required by the IMO (International Maritime Organization) to have four gauging points on each tank, with one position being at the aftermost portion of the tank.

The provision of additional gauging points is not a current requirement on product tankers or barges. *However, it is strongly recommended that there should be at least two calibrated gauging positions on each tank.*

- If the vessel generally trims by the stern, one of the gauge points should be in the aft portion of the tank.
- If the vessel normally operates trimmed by the head, one of the gauge points should be in the forward portion of the tank.
- The central gauging position should be one of the two calibrated gauging points recommended.

Any gauging point should be placed to ensure that there are no obstructions beneath the gauging position with the vessel upright or in extreme trim or list conditions. With the vessel at any stage of trim or list, each point should allow the gauging equipment to reach the tank bottom without interference.

9.3 Strapping/Calibration Table Changes

If the PMU gauge point has been modified or repositioned, it may be necessary to apply corrections to the measurements in order to obtain the correct volume from the vessel's calibration tables. Ideally a new set of official tank calibration tables should be prepared, or at minimum details of any additional or alternative corrections required should be endorsed and recorded by an appropriate independent third party (see 10.1).

9.4 Gauge Point Identification

The designated gauge points should be clearly indicated and permanently marked with the reference gauge height, coinciding with the calibration tables.

10 Vessel Calibration

10.1 Certification of Calibration and Wedge Tables

Calibration and wedge tables used to determine cargo volumes should be certified by the shipbuilder, classification society, independent inspection company, or other approved competent third party for accuracy of use on board the particular vessel for which they are issued.

10.2 Missing Calibration Tables

All parties involved, including the vessel's owners, should be notified immediately and a letter of protest issued when the vessels calibration tables cannot be located.

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