

Manual of Petroleum Measurement Standards Chapter 4.9.1

Introduction to the Determination of the Volume of Displacement and Tank Provers

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Introduction

Provers are precise, volumetric standards that are used to verify the accuracy of liquid flow meters. Both displacement and tank provers are used to prove a meter to obtain its meter factor. The base volume of a displacement or tank prover, determined by calibration, is an essential requirement in the determination of these meter factors. The accuracy of a meter factor is limited by several considerations, as shown below.

- equipment performance;
- observation errors;
- prover volume calibration errors;
- calculation errors.

Prover volumes used to calibrate meters are determined by calibration and not by theoretical calculation. Volumetric provers shall have an exact reference volume determined by a recognized method of calibration. Techniques for the determination of this reference volume include the waterdraw, master meter, and gravimetric methods of calibration. API *MPMS* Chapters 4.9.2, 4.9.3, and 4.9.4 are used to accurately determine the calibrated volume of meter provers.

U.S. Customary and Metric (SI) Units

This standard presents U.S. Customary (USC) units. Where International System (SI) are not presented, they can be referenced in Annex D. Implementation of either system of units in a calibration can be limited by a method's individual standard. The system of units to be used is typically determined by contract or regulatory requirements.

National Metrology Institutes

Throughout this document, issues of traceability are addressed by references to the National Institute of Standards and Technology (NIST). However, other appropriate national metrology institutes can be referenced.

Safety Considerations

There is no intent to cover safety aspects of conducting the work described in this standard, and it is the duty of the user to be familiar with all applicable safe work practices.

Introduction to the Determination of the Volume of Displacement and Tank Provers

1 Scope

Chapter 4, Section 9 covers all the procedures required to determine the field data necessary to calculate a base prover volume (BPV) of either displacement provers or volumetric tank provers. It will enable the user to perform all the activities necessary to prepare the prover, conduct calibration runs, and record all the required data necessary to calculate the base volumes of displacement and tank provers. Evaluation of the results and troubleshooting of many calibration problems are also discussed.

This component, Chapter 4, Section 9, Part 1, is the introduction, and contains all those relevant aspects that are general in nature, yet essential and applicable to all the different methods of calibration. Therefore, each subsequent part, which describes a specific method of prover calibration, shall be used with Part 1. Together, the two parts contain all the information that is essential to complete the required method of calibration.

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 4.2, *Displacement Provers*

API MPMS Chapter 4.7, *Field Standard Test Measures*

API MPMS Chapter 4.8, *Operation of Proving Systems*

API MPMS Chapter 4.9, *Methods of Calibration for Displacement and Volumetric Tank Provers Part 2—Determination of the Volume of Displacement and Tank Provers by the Waterdraw Method of Calibration*

API MPMS Chapter 4.9, *Methods of Calibration for Displacement and Volumetric Tank Provers Part 3—Determination of the Volume of Displacement Provers by the Master Meter Method of Calibration*

API MPMS Chapter 4.9, *Methods of Calibration for Displacement and Volumetric Tank Provers Part 4—Determination of the Volume of Displacement and Tank Provers by the Gravimetric Method of Calibration*

API MPMS Chapter 5 (all sections), *Metering*

API MPMS Chapter 12.2.4, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors, Part 4—Calculation of Base Prover Volumes by Waterdraw Method*

3 Terms and Definitions

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

3.1

base prover volume

BPV

The volume of the prover at base conditions as shown on the prover calibration certificate.

3.2

block and bleed valve

A high integrity valve with double seals and provision for determining if either seal leaks.

3.3

calibration certificate

A report documenting the calibration of a measurement device, such as a meter prover, thermometer, or pressure instrument, and its traceability to a national metrological institute (e.g., National Institute of Standards and Technology for the U.S.).

3.4

calibration run

One run conducted during the calibration of a displacement or tank meter prover.

3.5

designated reference device

A single reference device to which other reference or working devices are verified.

3.6

pass

A single movement of the displacer in a displacement prover that activates the start-stop detectors.

3.7

prover calibration certificate

A document package stating the base prover volume (BPV) that includes the physical and run data used to calculate the BPV, calibration certificates, and instrumentation verification documents.

3.8

round trip

The combination of a single pass of the displacer in one direction (e.g., forward) followed by a single pass of the displacer in the opposite direction (e.g., back) in a bidirectional displacement prover.

3.9

reference device

A certified and traceable measurement device to which other similar devices are verified or calibrated.

3.10

working device

A certified or non-certified measurement device used for operational measurements. These devices are routinely verified or calibrated to a reference device.

3.11

verification certificate

A document indicating the results of a comparison of instrumentation of the same type used in the calibration method.

4 Applications

A prover calibration is initially performed at the manufacturing plant where the prover is built. A prover shipped and installed with the measuring section intact may not require a field calibration. After the initial calibration, the frequency shall be determined according to API *MPMS* Chapter 4.8. The frequencies normally range from one to a maximum of five years, or could be as short as a few months based upon the calculation required by API *MPMS* Chapter 4.8.

Consideration of the following items will help to establish the possible loss exposure and measurement risk, and will help to determine a required frequency of calibration for all provers:

- the total yearly value of each product metered;
- volume through the metering system associated with the prover between prover calibrations;
- number of meters regularly proved by the prover and their frequency of proving;
- service conditions and properties of products being metered and proved;
- whether the prover is portable or stationary;
- the different types of products being metered;
- the range of properties of liquids being metered;
- the required yearly maintenance and repair;
- the overall condition of the prover, including detectors and sphere displacer.

5 Types of Meter Provers

5.1 General

The following describes the most common types of provers. See other sections of API *MPMS* Chapter 4^[1] for additional detail on prover design.

5.2 Displacement Type Unidirectional Provers with Free Displacers

These types of unidirectional provers may be subdivided into the following two categories depending on the manner in which the displacer is handled:

- unidirectional sphere provers with electromechanical detectors and manual return;
- unidirectional sphere provers with electromechanical detectors and circulating return.

The manual-return unidirectional prover, sometimes referred to as the measured distance, is an elementary form of an in-line prover that uses a section of pipeline as the prover section. Prover detector switches that define the calibrated volume of the prover section are placed at selected points along the pipeline. A displacer-launching device is placed upstream from the prover section, and receiving facilities are installed at some point downstream from the prover section. Conventional launching and receiving scraper traps are usually used for this purpose. To make a proving run, a displacer is launched and allowed to displace the reference volume before being received downstream and manually transported back to the launching site. This type of prover is no longer in common use.

The circulating-return unidirectional type prover has evolved from the prover described above. In a unidirectional ball displacer type prover design, the piping is arranged so that the downstream end of the loop crosses over and above the upstream end of the looped section. The interchange is the means by which the displacer is transferred from the downstream to the upstream end of the loop without being removed from the prover. The displacer detectors are located inside the looped portion at a suitable distance from the interchange. Unidirectional prover loops may be automated or manually operated.

5.3 Displacement Type Bidirectional Provers with Free Displacers

- bidirectional sphere provers with electromechanical detectors;
- bidirectional piston provers with electromagnetic detectors and check valves;