

# **Manual of Petroleum Measurement Standards Chapter 4—Proving Systems**

## **Section 3—Small Volume Provers**

FIRST EDITION, JULY 1988  
REAFFIRMED, MARCH 2002





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**Measurement Coordination Department**

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## FOREWORD

Chapter 4 of the *Manual of Petroleum Measurement Standards* was prepared as a guide for the design, installation, calibration, and operation of meter proving systems commonly used by the majority of petroleum operators. The devices and practices covered in this chapter may not be applicable to all liquid hydrocarbons under all operating conditions. Other types of proving devices that are not covered in this chapter may be appropriate for use if agreed upon by the parties involved.

The information contained in this edition of Chapter 4 supersedes the information contained in the previous edition (First Edition, May 1978), which is no longer in print. It also supersedes the information on proving systems contained in API Standard 1101, *Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter* (First Edition, 1960); API Standard 2531, *Mechanical Displacement Meter Provers*; API Standard 2533, *Metering Viscous Hydrocarbons*; and API Standard 2534, *Measurement of Liquid Hydrocarbons by Turbine-Meter Systems*, which are no longer in print.

This publication is primarily intended for use in the United States and is related to the standards, specifications, and procedures of the National Bureau of Standards (NBS). When the information provided herein is used in other countries, the specifications and procedures of the appropriate national standards organizations may apply. Where appropriate, other test codes and procedures for checking pressure and electrical equipment may be used.

For the purposes of business transactions, limits on error or measurement tolerance are usually set by law, regulation, or mutual agreement between contracting parties. This publication is not intended to set tolerances for such purposes; it is intended only to describe methods by which acceptable approaches to any desired accuracy can be achieved.

Chapter 4 now contains the following sections:

- Section 1, "Introduction"
- Section 2, "Conventional Pipe Provers"
- Section 3, "Small Volume Provers"
- Section 4, "Tank Provers"
- Section 5, "Master-Meter Provers"
- Section 6, "Pulse Interpolation"
- Section 7, "Field-Standard Test Measures"

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Suggested revisions are invited and should be submitted to the director of the Measurement Coordination Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.



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## Chapter 4—Proving Systems

### SECTION 3—SMALL VOLUME PROVERS

#### 4.3.1 Introduction

The use of small volume provers has been made possible by the availability of high-precision displacement detectors used in conjunction with pulse-interpolation techniques (see Chapter 4.6). The small volume prover normally has a smaller base volume than that of conventional pipe provers (see Chapter 4.2) and is usually capable of fast proving passes over a wide range of flow rates.

Small volume provers have a volume between detectors that does not permit a minimum accumulation of 10,000 direct (unaltered) pulses from the meter. Small volume provers require meter pulse discrimination using a pulse-interpolation counter or another technique that increases the resolution (see Chapter 4.6). This may include using provers with both large and small base volumes, depending on the pulse rates of the meters to be proved.

The small volume prover may be used in many applications in which pipe provers or tank provers are commonly used. Small volume provers may be stationary or portable.

The volume required of a small volume prover can be less than that of a conventional pipe prover when high-precision detectors are used in conjunction with pulse-interpolation techniques. Pulse-interpolation methods of counting a series of pulses to fractional parts of a pulse are used to achieve high resolution without counting 10,000 whole meter pulses for a single pass of the displacer between detectors (see Chapter 4.6.)

To achieve the required proving accuracy and repeatability, the minimum volume between detector switches depends on the discrimination of a combination of pulse-interpolation electronics, detectors, and uniform meter pulses, as well as flow rate, pressure, temperature, and meter characteristics.

##### 4.3.1.1 SCOPE

This chapter outlines the essential elements of a small volume prover and provides descriptions of and operating details for the various types of small volume provers that meet acceptable standards of repeatability and accuracy.

##### 4.3.1.2 DEFINITION OF TERMS

Terms used in this chapter are defined in 4.3.1.2.1 through 4.3.1.2.6.

**4.3.1.2.1** *Interpulse spacing* refers to variations in the meter pulse width or space, normally expressed in percent.

**4.3.1.2.2** *Meter proof* refers to the multiple passes or round trips of the displacer in a prover for purposes of determining a meter factor.

**4.3.1.2.3** A *meter prover* is an open or closed vessel of known volume utilized as a volumetric reference standard for the calibration of meters in liquid petroleum service. Such provers are designed, fabricated, and operated within the recommendations of Chapter 4.

**4.3.1.2.4** A *prover pass* is one movement of the displacer between the detectors in a prover.

**4.3.1.2.5** A *prover round trip* is the result of the forward and reverse passes in a bidirectional prover.

**4.3.1.2.6** A *proving timer/counter* is a high-speed counter used in double chronometry to measure time with a pulsed signal of known frequency.

#### 4.3.1.3 REFERENCED PUBLICATIONS

The current editions of the following standards, codes, and specifications are cited in this chapter:

##### API

###### *Manual of Petroleum Measurement Standards*

Chapter 4, "Proving Systems," Section 2, "Conventional Pipe Provers," Section 6, "Pulse Interpolation," and Section 7, "Field-Standard Test Measures"

Chapter 5, "Metering," Section 2, "Measurement of Liquid Hydrocarbons by Displacement Meters," Section 3, "Measurement of Liquid Hydrocarbons by Turbine Meters," and Section 4, "Accessory Equipment for Liquid Meters"

Chapter 7.2, "Dynamic Temperature Determination"

Chapter 12.2, "Calculation of Liquid Petroleum Quantities Measured by Turbine or Displacement Meters"

##### NFPA<sup>1</sup>

###### *70 National Electrical Code*

<sup>1</sup> National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.

### 4.3.2 Small Volume Prover Systems

The small volume prover is available in several different configurations that allow a continuous and uniform rate of flow. All types operate on the common principle of the repeatable displacement of a known volume of liquid in the calibrated section of a pipe or tube. A displacer travels through a calibrated section with its limits defined by one or more highly repeatable detectors. The corresponding metered volume simultaneously passes through the meter, and the whole number of pulses is counted. Precise calculations are made using a pulse-interpolation technique (see Chapter 4.6).

The two types of continuous-flow small volume provers are unidirectional and bidirectional. The unidirectional prover allows the displacer to travel and measure in only one direction through the proving section and has a means of returning the displacer to its starting position. The bidirectional prover allows the displacer to travel and measure first in one direction and then in the other and is capable of reversing the flow through the prover section.

Both unidirectional and bidirectional small volume provers must be constructed so that the full flow of the stream passing through the meter being proved will pass through the prover.

### 4.3.3 Equipment

The small volume prover must be suitable for the intended fluids, pressures, temperatures, and type of installation. The materials used must be compatible with the fluid stream and the location where the prover will be installed.

A small volume prover will normally consist of the following elements:

- a. A precision cylinder.
- b. A displacer piston, spheroid, or other fluid-separation device.
- c. A means of positioning and launching the displacer upstream of the calibrated section.
- d. A displacer detector or detectors.
- e. A valve arrangement that allows fluid flow while the displacer is traveling from one position to the opposite position.
- f. Pressure-measurement devices.
- g. Temperature-measurement devices.
- h. Instrumentation with timers, counters, and pulse-interpolation capability.

#### 4.3.3.1 MATERIALS AND FABRICATION

The materials selected for a prover shall conform to applicable codes, pressure ratings, corrosion resistance, and area classifications.

The calibrated volume-measurement section of the prover, located between the displacer-position sensors, must be designed to exclude any appurtenances such as vents or drains.

Flanges or other provisions should be included for access to the inside surfaces of the calibrated and prerun sections. Care should be exercised to ensure and maintain proper alignment and concentricity of pipe joints.

Internally coating the prover section with a coating or plating material that will provide a hard, smooth, long-lasting finish will reduce corrosion and prolong the life of the displacer or displacer seals and the prover.

#### 4.3.3.2 TEMPERATURE STABILITY

Temperature stability is necessary to achieve acceptable proving results. Temperature stabilization is normally achieved by continuously circulating liquid through the prover section, with or without insulation. When provers are installed aboveground, the application of thermal insulation will contribute to better temperature stabilization.

#### 4.3.3.3 TEMPERATURE MEASUREMENT

Temperature-measurement sensors should be of suitable range and accuracy and should be graduated by temperature discrimination in fractional degrees to at least 0.5°F (0.25°C). See Chapters 7.2 and 12.2. Temperature-measurement devices shall be installed at appropriate locations to measure temperature at the meter and the prover. Caution must be exercised to ensure that the temperature sensors are located in a position in which they will not be shut off from the liquid path.

#### 4.3.3.4 PRESSURE MEASUREMENT

Pressure-measurement devices of suitable range and accuracy, calibrated to an accuracy of 2 percent full scale or better, shall be installed at appropriate locations to measure pressure at the meter and the prover. (See Figures 1–4 and Chapter 12.2 for further information).

#### 4.3.3.5 DISPLACING DEVICES

One type of displacer is a piston, with seals, connected to a central shaft. A second type of displacer is a free piston that uses seals between the precision cylinder and the piston. A third type is the elastomer sphere filled with liquid under pressure. To provide a seal without excessive friction, the sphere is expanded to a diameter greater than the prover pipe's inside diameter, which is normally 2–4 percent. Insufficient expansion of the sphere can lead to leakage past the sphere and

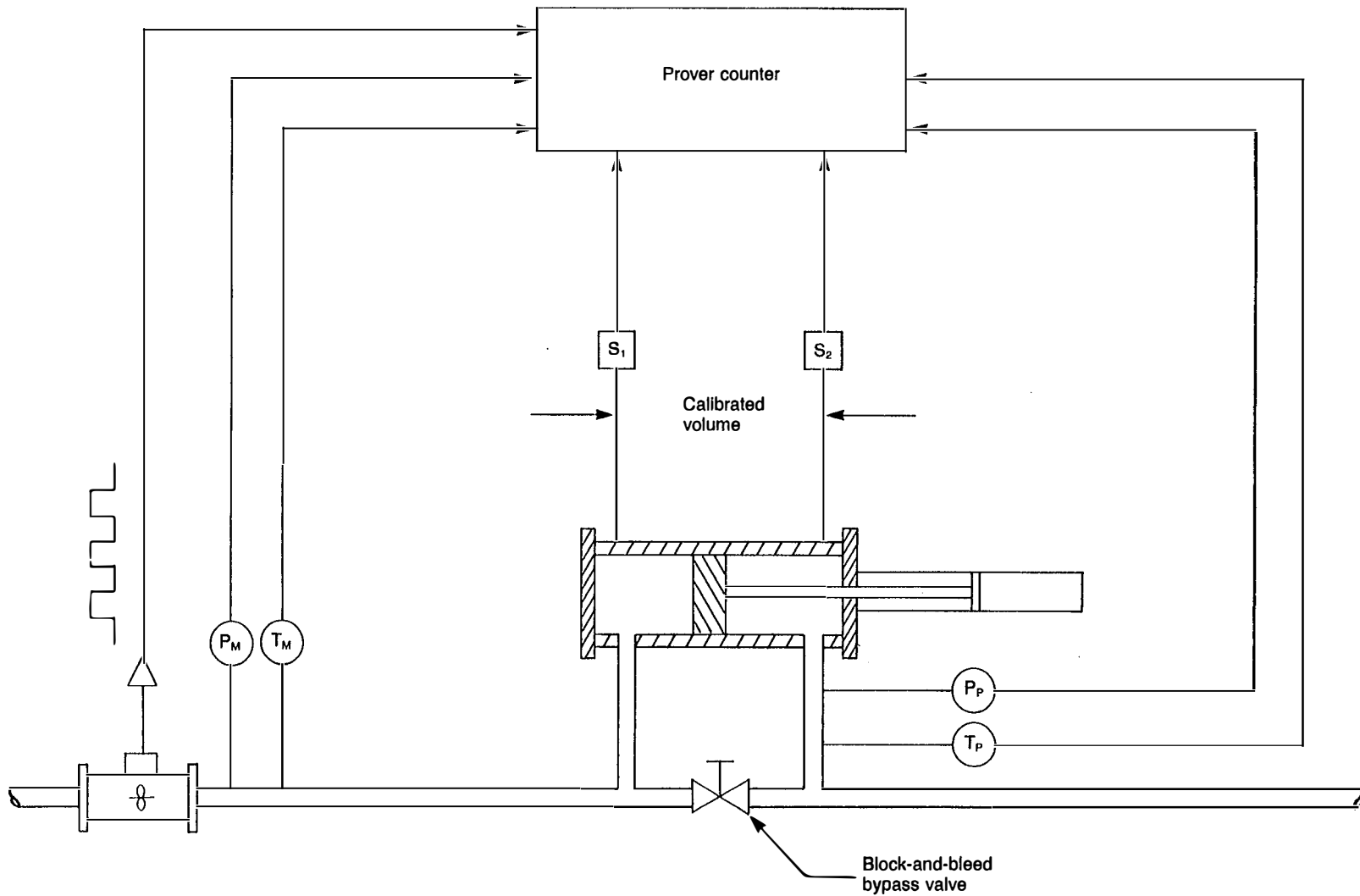


Figure 1—Generalized System Overview