Manual of Petroleum Measurement Standards Chapter 4—Proving Systems

Section 4—Tank Provers

SECOND EDITION, MAY 1998

American Petroleum Institute

Helping You Get The Job Done Right.SM

Manual of Petroleum Measurement Standards Chapter 4—Proving Systems

Section 4—Tank Provers

Measurement Coordination

SECOND EDITION, MAY 1998

American Petroleum Institute

Helping You Get The Job Done Right.SM

SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Measurement Coordination Department [telephone (202) 682-8000]. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the Measurement Coordinator, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

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 Institute of Standards and Technology (NIST). 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”
Section 8, “Operation of Proving Systems”

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

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

CONTENTS

Chapter 4—Proving Systems

Section 4—Tank Provers

1 Introduction

Throughout this chapter a prover tank shall be considered an open or closed volumetric measure that generally has a graduated top neck and may have a graduated bottom neck. The volume is established between a shut-off valve or bottom-neck graduation and an upper-neck graduation.

The requirements in this chapter are intended for crude oil and refined petroleum products. Meter proving requirements for other fluids should be appropriate for the overall custody-transfer accuracy and should be agreeable to the parties involved.

2 Scope

This chapter specifies the characteristics of stationary (fixed) or portable tank provers that are in general use and the procedures for their calibration. Guidelines are provided for the design, manufacture, calibration and use of new and/or replacement tank provers, and are not intended to make any existing tank provers obsolete.

More specific design criteria are available in NIST[1] Handbook 105-3, *Specifications and Tolerances for Graduated Neck-Type Volumetric Field Standards* (includes Provers, per Section 1.1 of NIST 105-3). Consideration must also be given to the requirements of any weights and measures authority that may be involved.

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 1 *Vocabulary*
Chapter 4 *Proving Systems*
Chapter 5 *Metering*
Chapter 7 *Temperature Determination*
Chapter 11 *Physical Properties Data*
Chapter 12 *Calculation of Petroleum Quantities*
Chapter 13 *Statistical Aspects of Measuring and Sampling*

NIST[1]

Handbook 105-3 *Specifications and Tolerances for Graduated Neck-Type Volumetric Field Standards*

[1]National Institute of Standards and Technology, Gaithersburg, Maryland 20899.

4 Equipment

4.1 GENERAL CONSIDERATIONS

All components of the tank prover installation, including connecting piping, valves, and manifolds, shall be in accordance with applicable pressure codes.

Once a closed tank prover is on stream, it becomes part of the pressure system. Provisions should be made for expansion and contraction, vibration, reaction to pressure surges, and other process conditions. Consideration should be given to the installation of valving to isolate the tank prover from line pressure when the system is not in use or during maintenance.

All closed tank provers should be equipped with vent and drain connections.

Provisions should be made for the disposal of liquids and/or vapors that are drained or vented from the tank prover. The disposal may be accomplished by pumping liquids or vapors back into the system or by diverting them to a collecting point.

Blind flanges or valve connections should be provided on either side of a double block-and-bleed valve in the tank prover piping system. These connections can serve as locations for proving portable meters or as a means of calibrating the tank prover by the master-meter or waterdraw method.

4.2 VALVES

All valves used in a tank prover system that can provide or contribute to a bypass of liquid around the tank prover or the meter or to leakage between the tank prover and the meter shall be double block-and-bleed valves, or the system shall be provided with valves and piping that are the equivalent. A method for checking leakage in the valve system is required.

4.3 WIRING AND CONTROLS

All wiring devices and controls shall conform to the applicable codes.

Electrical controls and components should be located in a convenient place for operation and maintenance.

4.4 SAFETY DEVICES

Safety relief valves, with discharge piping and leak detection facilities, shall be installed to control thermal expansion of the liquid in the tank prover and its connecting piping while they are isolated from the main stream. Automatic and remote controls should be protected with lockout switches or circuits or both between remote and local panel locations to prevent accidental remote operation while a unit is being controlled locally.

Safety devices and locks should be installed to prevent inadvertent operation of, or unauthorized tampering with, equipment. All automated or power-operated meter proving systems should have emergency manual operators for use during an accident or power failure.

Grounding devices should be provided to protect against electrical shock or static discharge in both tank prover and electrical instrumentation.

4.5 CLOSED SYSTEMS

If the liquid to be measured by meter has a high vapor pressure, a closed tank proving system should be used. Open tank provers (with or without evaporation control) or closed tank provers may be used for liquids that have low vapor pressure. The distinction between low-vapor-pressure liquid and high-vapor-pressure liquid depends on whether its equilibrium vapor pressure is less or greater than atmospheric pressure at the operating temperature.

4.6 NECKS

Tank provers may have top and bottom graduated necks (see Figures 1, 2, and 3) or a top graduated neck only (see Figures 4 and 5).

The top and bottom graduated-neck scale tank prover is a vessel that has a reduced cross-section neck so that a more accurate determination of incremental volume can be made. It may he used as either an open or closed tank prover and is suitable for most liquids. Both top and bottom necks should have graduated scales and gauge glasses or other suitable means for indicating the liquid level. Each neck may have one or more gauge scales.

The top graduated-neck tank prover is a vessel that has a reduced cross-section neck at the top only and may be either open or closed. The neck should have gauge glasses or another suitable means for indicating the liquid level. The neck may have one or more gauge scales.

4.7 COUNTERS/REGISTERS

During meter proving operations there are occasions when the meter registration, used in meter-factor calculations, is derived from an auxiliary proving counter rather than from the meter register. In such cases, steps shall be taken to ensure that all volumes indicated by the proving counter are also reflected in the meter register.

5 Design and Construction

5.1 GENERAL CONSIDERATIONS

The design of a tank proving system should include the piping, instruments, and auxiliaries as well as the tank prover.

The design and materials used in construction and the codes applicable to a closed pressure-type tank prover will depend on the maximum pressure to which the prover may be subjected and the characteristics of the liquid to be metered.

The construction of a tank prover shall be strong and rugged enough to prevent distortion of the vessel that would significantly influence measurement when the tank prover is full of liquid at the proving pressure. Tank provers shall be constructed to ensure complete drainage of all liquid to the lower reference level without trapping pockets of liquid or sediment. Changes of cross-sections should be gradual and sufficiently sloped so that gas bubbles will not be trapped, but will travel to the top of the tank prover. As the tank prover is emptied, the liquid will quickly drain.

The tank prover should be as self-cleaning as possible so that corrosive products, valve grease, and other foreign matter will not collect inside. Arrangements should be made for periodic internal inspection of the tank prover. Lining a tank prover to prevent rust can, in some cases, greatly extend the intervals between calibrations. Gauge glasses should be capable of being cleaned, or swabbed out, without being removed from the tank prover.

Appurtenances should be installed in locations that are convenient for quick and practical operation and precise readability.

5.2 TEMPERATURE MEASUREMENT

Temperature measurement of the test liquid in both the meter and the tank prover is essential. All temperature devices should be checked with an NIST-certified thermometer, or a precision thermometer that is traceable to a NIST-certified thermometer. Temperature devices should be checked frequently to ensure continued accurate indication (see API *MPMS* Chapter 7—*Temperature Determination*).

Temperature devices of suitable range should be graduated in fractional degrees and should be accurate within $^1/_2$°F ($^1/_4$°C) or better.

The location of temperature sensors in the tank prover is important. The use of one sensor in tank provers that hold up to 100 gallons (380 liters) is acceptable. The use of two sensors is recommended in tank provers that have a capacity of at least 100 gallons (380 liters) but not more than 500 gallons (1900 liters). Three sensors should be used in tank provers that have a capacity of 500 gallons (1900 liters) or more. If one sensor is used, it should be placed in the center of the tank prover vertical height. If two sensors are used, one should be located in the upper third of the vertical-tank height and the other in the lower third. If three sensors are used, one should be located within each third of the tank prover shell height. When more than one sensor is used, sensors should be equally spaced around the tank circumference.

Where tank prover operating pressure allows, temperature sensors should be installed directly through the tank prover shell without using a thermowell. A stem immersion depth of one third of the tank radius is recommended; however, a min-

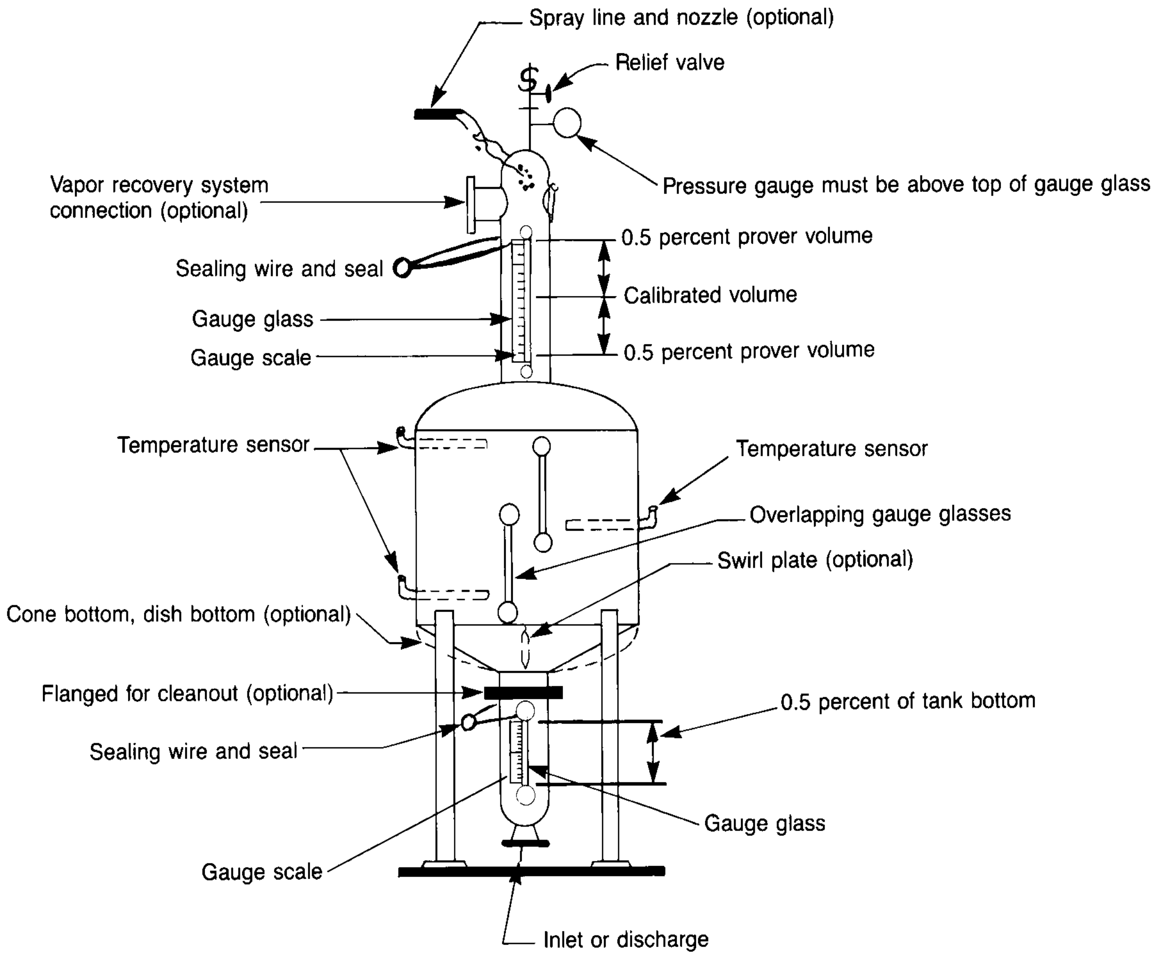

Figure 1—Closed Stationary Tank Prover

imum depth of 12 inches (30 centimeters) is desirable, provided that the sensor does not extend past the tank prover center. If temperature sensor wells must be used in a tank prover (for example, when pressure is great enough to require them), the sensor well should be constructed so that it has the smallest possible diameter and metallic section consistent with the necessary strength.

5.3 PRESSURE MEASUREMENT

A pressure gauge is required on closed tank provers. The gauge shall be of suitable range and calibrated to an accuracy of 2 percent of full-scale reading. Gauge connections shall be above the uppermost liquid level and sloped to avoid trapping vapors or liquids.

5.4 PROVER CAPACITY

The capacity of a tank prover shall not be less than the volume delivered in 1 minute at the normal operating flow rate through the meter to be proved. The capacity will preferably be 1$^1/_2$ times the volume delivered in 1 minute.

The inside diameter of the necks on tank provers shall be such that the smallest graduation represents no more than 0.02 percent of the total volume of the tank prover.

The inside diameter of the neck shall not be less than 3$^7/_8$ inches (10 centimeters).

The capacity of the upper neck falling within the gauge-glass length shall be at least 1.0 percent of the tank prover volume, and the capacity of the lower neck falling within the gauge-glass length shall be it least 0.5 percent of the tank prover volume. When large-capacity meters are to be proved, a longer reading range (larger neck capacity) may be required to provide observation of the liquid level during the time required for manipulating the valves.

5.5 CONNECTIONS

Tank prover inlet and outlet connections will depend on the particular application involved. If a submerged fill pipe is used, it shall be permanently installed and equipped with a vapor bleed valve. The pipe shall be sized to accommodate the maximum flow rate of the meter being proved (see Figure 4) and to minimize splash and turbulence. The tank

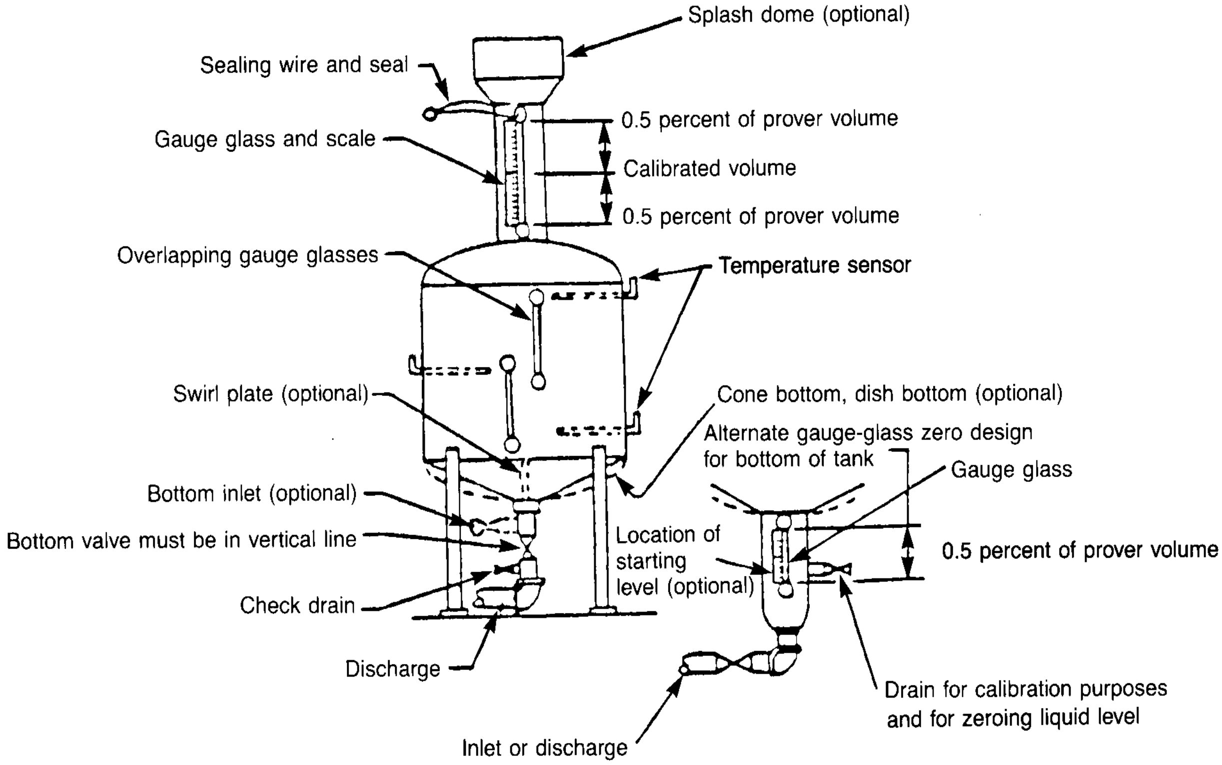

Figure 2—Open Stationary Prover Tank (Drain-to-Zero or Bottom Gauge-Glass Type)

prover outlet connections should be sized to permit rapid emptying of the tank prover, and provisions made for indicating the drawdown level. All inlet and outlet valves shall be of the double block-and-bleed type.

A vent should be provided at the highest point of the tank prover to remove any gas that may accumulate.

5.6 GAUGE GLASSES

Gauge glasses shall have a minimum inside diameter of 5⁄8 inch (16 millimeters), preferably larger. Shown in Table 1 is the capillary rise for several sizes of gauge glasses and water. Gauge glass fittings on tank provers should be installed directly into the walls of the neck or the body of the tank prover. Additional gauge glasses may be provided to cover the main body of the tank prover. The suggested maximum length for any single gauge glass is 24 inches (60 centimeters). This length minimizes errors that result from temperature differences between the liquid in the gauge glass and in the tank prover.

The gauge-glass scales shall be subdivided into the desired increments. Scales shall be securely mounted behind or immediately adjacent to the gauge glasses. They shall have provisions for vertical adjustment and scaling into a permanent position. Scales should be made of corrosion-resistant metal with a coefficient of thermal expansion similar to that of the tank prover material.

An upper gauge glass and scale shall cover at least 1.0 percent of the nominal volume of the tank prover, while a lower gauge glass and scale shall cover at least 0.5 percent.

6 Tank Prover Calibration

6.1 GENERAL CONSIDERATIONS

Tank provers are normally calibrated at atmospheric pressure using water. When tank provers are calibrated and operated at atmospheric pressure, no pressure-volume corrections are needed; however, when a tank prover is to be operated at pressures above atmospheric, a correction must be made for the resulting increase in the tank prover volume over the volume determined in the calibration at atmospheric pressure. This correction should be experimentally determined during the calibration (see 6.7).

Table 1—Capillary Rise in Glass Tubes with Varying Water Quality

	Capillary Rise, Inches		
Tube Diameter, Inches	Pure Water	Aerated Water	Dirty Water
5/8	0.025	0.0060	0.016
3/4	0.015	0.0035	0.012
1	0.005	0.0011	0.005

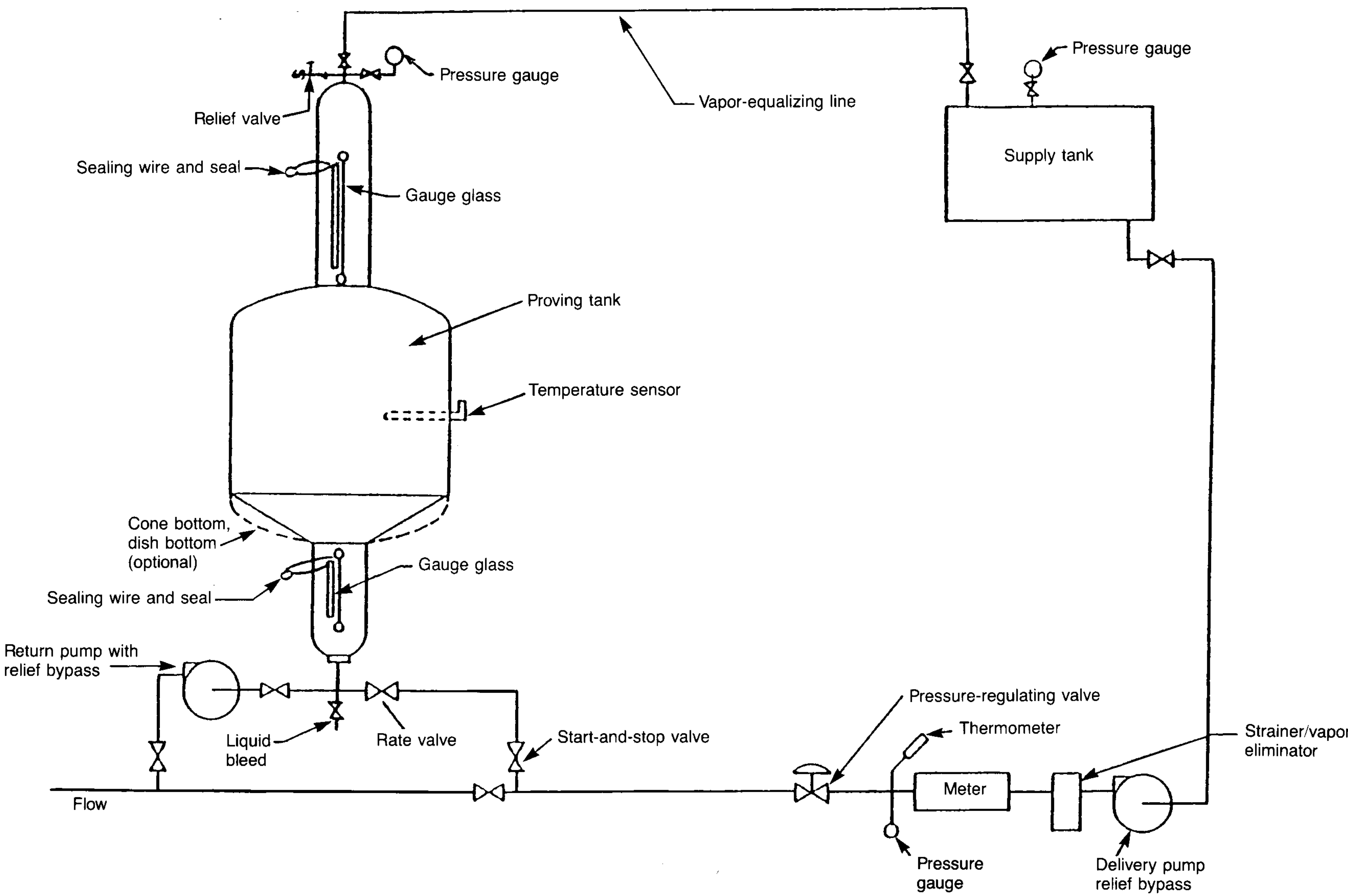

Figure 3—Schematic Operating Diagram of Volumetric Prover for Vapor Displacement

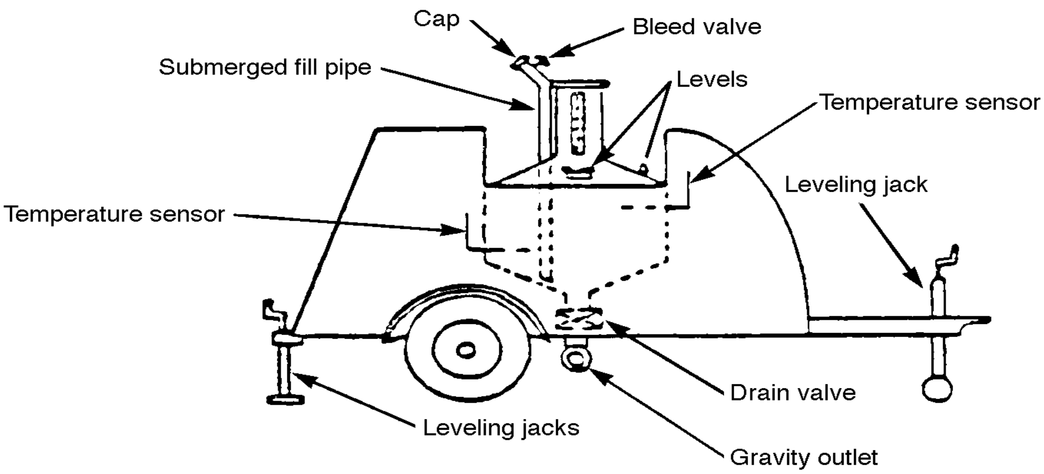

Figure 4—Portable Prover (Drain-to-Zero or Bottom Gauge-Glass Type)

Water is considered the best medium for calibration. There are two industry-accepted methods of calibrating tank provers:

a. Calibration by means of field standard test measures; or

b. Calibration by means of a master meter.

The preferred method, using field standard test measures, involves either the determination of the volume of water withdrawn from the full tank prover into field standard test measures; or the determination of the volume of water taken from field standard test measures to fill the tank prover. The recommendation of this standard is that it is preferable to calibrate a tank prover by withdrawing water into test measures, however, in certain installations it may be expedient to reverse the procedure. In either case, the appropriate water-volume corrections shall be applied, to compensate for the temperature differences between the water in the tank prover and the water in the field standard test measures.

The second calibrating method involves using a master meter, previously proved by a Master Prover, where tank provers are large enough that the use of field standard test measures is impractical, or when circumstances, such as those found in the desert or the arctic, are not physically compatible with water calibration using test measures. With this method, water or a stable low viscosity petroleum liquid may be metered into or out of the tank prover, and correction factors applied as necessary.

The following general procedures apply to the calibration of both permanently installed and portable tank provers:

a. The tank prover shall be internally cleaned and shall be plumb and level.

b. All devices and instruments that affect the internal volume of the prover, such as spray lines, temperature sensors, and gauge glasses, shall be in place.

c. Tank provers, including all valves, fittings, and blinds that hold the test liquid, shall be checked for leaks.

d. Provisions should be made for convenient filling and withdrawal of the test liquid.

6.2 PROCEDURAL UNCERTAINTY IN PROVER CALIBRATION

MPMS Chapter 13 contains procedures to estimate the standard deviation and uncertainty of meter prover calibration procedures. Range limits of 0.02% between high and low runs are normally used to prescribe tank prover calibration acceptance requirements. The estimated standard deviation of the average of the two to five calibration runs that agree within a range of 0.02% are shown in Table 2.

The uncertainty of the average at the 95% confidence level of two to five calibration runs that agree within a range of 0.02% are shown in Table 3.

Table 2—Estimated Standard Deviation of Average Tank Prover Calibration Sets

Number of Cal. Runs	Estimated Standard Deviation (Percent)
2	0.018
3	0.012
4	0.010
5	0.009

Table 3—Uncertainty of the Average at the 95% Confidence Level of Prover Calibration Sets

Number of Cal. Runs	Uncertainty
2	±0.159
3	±0.029
4	±0.016
5	±0.011

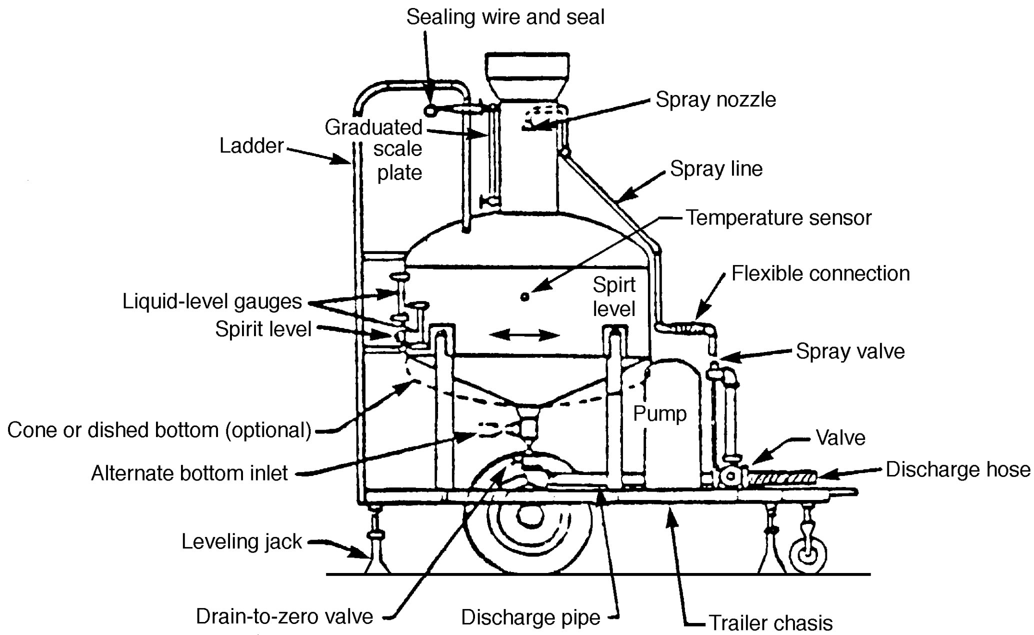

Figure 5—Open Portable Prover Tank With Pump Assembly

6.3 TEMPERATURE STABILITY

The calibration of tank provers may be simplified, when possible, by placing the tank prover, field standard test measures, and the liquid in a constant temperature enclosure for enough time to allow the equipment and test liquid to reach an equilibrium temperature. The calibration should preferably be conducted under these conditions to minimize the temperature changes of the equipment and test liquid during the calibration. Correction factors for the effects of temperature on water and steel must be applied (see 6.6 and *MPMS* Chapter 12—*Calculation of Petroleum Quantities*).

To prevent accumulation of air bubbles on the inside of the tank prover walls, the tank prover should not be allowed to stand full of water any longer than necessary to stabilize the temperature before the calibration is started.

6.4 CALIBRATION BY THE WATERDRAW METHOD

6.4.1 Tank Provers With Top and Bottom Necks

In tank provers that have top and bottom necks, either of two methods may be used to calibrate the lower and upper necks. The first method, described in this section, consists of determining and marking the actual capacity of the tank prover on the scale. The second method consists of installing previously marked scales and preparing tank tables in appropriate units of measurement. Each method has both advantages and disadvantages, and either method may be used if agreeable to all the parties concerned.

The following procedure describes a method of calibrating a tank prover with top and bottom necks at standard conditions and at atmospheric pressure using water as a calibrating liquid:

a. To remove any floating debris, the tank prover should be filled to overflowing with water and allowed to stand for several minutes; then the debris should be flushed off the top. All drain valves should be checked for leaks. The withdrawal line must be free from air. After filling, the water source shall be disconnected at the inlet valve.

b. The upper neck shall be calibrated. The water drawoff shall be opened slightly until the water level appears at the extreme top of the upper gauge glass; the valve shall then be closed. This point should be temporarily marked on the gauge scale, and the water withdrawals should be started. Decrements should be marked on the gauge scale as the water is withdrawn one test measure at a time from the tank prover into the chosen test measure. When the level approaches the midpoint of the upper gauge glass at the completion of a whole decrement, a mark should be made on the scale and identified as the assumed upper reference level. Withdrawals should be continued, and the scale should be marked, as before, as long as the liquid level remains in sight in the upper gauge glass. These measured divisions may be subdivided as desired to complete the calibration of the upper neck. The upper and lower necks may be calibrated as a separate exercise.

c. Withdrawal of the water from the main body of the tank prover should be continued, one test measure at a time, using a conveniently sized field standard test measure until the water level is approximately at the top of the lower gauge glass.

Withdrawals should be continued from this point with the test measure used in the upper-scale operation, and the lower gauge scale should be marked in the same decrements. The lower reference level for the uncorrected nominal volume of the tank prover should be set on a whole decrement mark midpoint on the lower gauge scale. The volumes withdrawn between the upper and lower reference levels should be corrected for any water temperature variations that may have occurred during the calibration run, as described in 6.6. This corrected total should be recorded as the corrected volume for the run.

d. Finally, the lower neck below the lower reference level should be calibrated. Withdrawal should be continued one field standard test measure at a time below the lower reference level until the liquid level reaches the lower end of the gauge scale, which is marked at each measured interval.

This calibration should be repeated until two or more consecutive runs, after correction, agree within a range of 0.02 percent. The average of the consecutive tank prover volumes shall be used as the calibrated volume of the tank prover.

The final operation is to permanently mark the upper and lower reference levels, and all graduations, on both the upper and lower scales, and to attach the scales securely and permanently to the tank prover necks, sealing them to prevent unattended or unauthorized movement.

6.4.2 Tank Provers With Top Neck and Bottom Drain Valve

The following procedure describes the method of performing a "to-deliver" calibration of a tank prover with a top neck and a bottom drain valve as the lower reference level at standard conditions, using water as the calibrating liquid:

a. Water should be withdrawn into the test measure by one of the following methods:

1. *Gravity method.* The piping should first be disconnected below the bottom valve. Water shall be withdrawn through the bottom valve of the tank prover into test measures using a hose or pipe sloped for free and complete drainage. The bottom valve and any other drain valves should be closed to perform a leak check. Tests for leaks shall be made by pouring a small volume of water into the tank prover. After the leak check is made, the bottom valve shall be opened to drain the water through the drain hose. The prover and drain hose must be emptied, but the hose should be left wet. The bottom valve shall then be closed, and the tank prover filled with water to the extreme top of the upper gauge glass. This liquid level should be temporarily marked on the scale.

2. *Pump method.* If elevating the tank prover above the test measures is not practical, a pump may be used. If a pump is used, the hoses and pump should be purged of air, and with this pump running (pumping against a blocked valve at the test measure filling line), the bottom valve on the tank prover shall be closed. The liquid level should then be temporarily marked on the scale.

b. The upper neck shall be calibrated. Withdrawals should be made using a suitable test measure. Decrements should be marked on the gauge scale as the water is withdrawn. Withdrawals should be continued one at a time as long as the liquid level remains in sight in the upper gauge glass.

c. The body of the tank prover shall be calibrated using one of the following methods:

1. *Gravity method.* Withdrawals shall be made through the bottom valve with a conveniently sized test measure until all the water has been withdrawn. The last withdrawal may be a partial test measure volume, which must be determined to the nearest 1 cubic inch (10 cubic centimeters). This partial volume should be converted into linear inches (centimeters) of the upper neck. A temporary upper reference level should be established near the center of the scale, to bring the volume of the tank prover, below the upper reference level, to a whole unit of volume. The gauge scale should be marked at this temporary upper reference level. Throughout this operation, temperature corrections should be made as described in 6.6.

2. *Pump method.* If a pump is used, the bottom valve must be closed when the liquid level nears the bottom "zero" before the pump is turned off. The pump and hoses may then be disconnected, and a final withdrawal should be made directly into a small test measure or transfer container.

d. The calibration should be repeated, starting with the tank prover, filled to the new temporary reference level, until two or more consecutive runs, after correction, agree within a range of 0.02 percent. The average of the tank prover volumes shall be used as the calibrated volume. The upper reference level should be temporarily marked on the gauge glass or on a part of the tank prover, immediately adjacent to the scale, so that the scale may be removed for permanent marking.

e. All required graduations shall be permanently marked on the upper gauge-glass scale and adjusted to the corrected upper reference level; the scale shall be securely and permanently attached to the prover neck and sealed to prevent unintended or unauthorized movement.

6.4.3 Small Tank Provers With Top Neck and Closed Bottom

Small tank provers with top necks and closed bottoms are used to prove small meters and calibrate provers. The best practice is to send small provers to the NIST, or another approved competent laboratory, for calibration. It is possible and permissible to calibrate small tank provers by using field standard test measures and suitable glass graduates. If drying the prover after each emptying is convenient, the prover may be calibrated to contain; when the prover is calibrated and used in this manner, it will be most accurate for measuring liquid hydrocarbons. If the prover is intended to calibrate large provers using water, then calibrating the prover to deliver is more suitable.

The following procedure should be used to calibrate small tank provers as described in this section:

a. The inside of the prover should be thoroughly dried if the prover is to be calibrated to contain. To calibrate the tank prover "to deliver," it must first be filled with water and then emptied, allowing the water to drain for the prescribed draining time.

b. The tank prover should be placed in a level position and checked with a leveling instrument.

c. Water should be poured into the tank prover, one test measure at a time, from certified field standard test measures. The temperature of the water in each test measure should be recorded. The tank prover should be filled to a whole unit volume level near the center of the neck. This level should he marked on the gauge glass or tank prover shell as the temporary reference level. The temperature of the water in the tank prover should now be determined; after any necessary temperature corrections are made, the corrected volume should be recorded for the run.

d. The calibration shall be repeated until two or more consecutive runs, after correction, agree within a range of 0.02 percent. The average of the volume shall be used as the calibrated volume.

e. Having started with the tank prover filled to the established reference level, the upper neck, above and below the established reference level, should be calibrated by adding or extracting water and measuring it in a glass graduate. This may be done conveniently by using a syringe. The tank prover reference level and scale graduations should be permanently marked on the gauge scale, and the scale should be fastened and sealed.

6.5 CALIBRATION BY THE MASTER-METER METHOD

In calibrating some tank provers, particularly large ones, using a master meter may be more expedient than filling individual field standard test measures.

The following general procedure shall be used for master-meter calibration:

a. A non-temperature compensated direct-drive master meter shall be proved, and its meter factor shall be determined at the intended flow rate, pressure, and temperature, using a calibrated master prover or field standard test measure, and the same liquid with which the master meter is intended to calibrate the tank prover. The preferred test liquid is water; however, a stable, low viscosity petroleum liquid may be used, if the necessary temperature and pressure corrections are available and accepted by all parties.

b. The tank prover shall be calibrated in accordance with the appropriate method, except that volumes should be indicated by the master meter rather than by counting test measures. If the tank prover being calibrated is equipped with a neck or necks, it is often more practical to calibrate the neck or necks using test measures, and the body of the tank prover calibrated using the master meter.

c. Sufficient temperature readings shall betaken to compute the average temperature of the metered liquid. Volume corrections necessitated by temperature differences between the metered liquid and the liquid in the filled tank prover must be made.

The following procedure describes the use of a master meter in a "to-deliver" calibration of the body of a tank prover, with top and bottom necks, using water, at standard conditions:

a. The top and bottom necks shall be calibrated using field standard test measures.

b. The master meter shall be connected so that water may be removed from the tank prover through the meter at the required rate of flow. A pump may be required. The tank prover should then be filled with water to the reference mark in the upper neck, and the master meter should be sufficiently purged during the filling operation to ensure that the master meter and all the piping are full of water.

c. The tank prover body should be calibrated by withdrawing water from the tank prover through the master meter. The master meter reading, and water temperature, shall be recorded. Water should be withdrawn until the level appears at the top of the lower gauge-glass scale. During this withdrawal the master meter must be operated at the rate at which it was proved. The meter factor should be applied to the observed meter volume, and temperature corrections should be made to bring the metered volume to reference conditions. A temperature correction for the steel in the tank prover must also be made to the volume metered to determine the calibrated volume of the tank prover at standard conditions. See *MPMS* Chapter 12—*Calculation of Petroleum Quantities*. If the master meter is stopped when water reaches the top of the lower gauge-glass scale, the volume from there, to the lower reference, must be determined from the calibration in Item (a) to obtain total tank prover volume to the lower reference level.

d. The calibration shall be repeated until two or more consecutive runs, after correction, agree within a range of 0.02 percent. The average of the tank prover volumes shall be used as the calibrated volume.

e. The required graduations shall be marked on the gauge-glass scales, which shall then be attached and sealed.

6.6 TEMPERATURE CORRECTIONS

Correction factors for the effects of temperature on water and steel must be applied (see *MPMS* Chapter 12—*Calculation of Petroleum Quantities*). The following procedure is for the withdrawal of water from a tank prover into test measures. If the tank prover is filled from the test measures, appropriate changes in the procedure must be made.

The following is the volume correction procedure, for a change in the water temperature, during the calibration of a prover:

a. The starting tank prover temperature shall be recorded. If there is more than one thermometer in the tank prover, then the average temperature shall be determined and recorded, as the starting tank prover temperature.
b. The volume of each test measure withdrawal shall be recorded.
c. The temperature of the water in each test measure withdrawn shall be recorded. The temperature shall be measured immediately after the volume is filled and read.
d. The difference between the water temperature in each test measure withdrawal and the average starting temperature in the full tank prover shall be recorded as a temperature rise, or a temperature drop, with respect to the average tank prover starting temperature.
e. The temperature-correction factor for each test measure volume shall be determined (see *MPMS* Chapter 11—*Physical Properties Data*), and multiplied by the volume of the test measure. The sum of these corrected volumes is the tank prover volume at reference conditions for this run (see *MPMS* Chapter 12—*Calculation of Petroleum Quantities*).

6.7 DETERMINING A TANK PROVER VOLUME UNDER PRESSURE

If a tank prover is to be used at a pressure above atmospheric, a correction must be made for the resulting increase in the tank prover volume over the volume that was determined in calibrating the tank prover at atmospheric pressure. This correction shall be experimentally determined, for each tank prover, during the calibration procedure, and after the tank prover has been calibrated at atmospheric pressure.

For a tank prover that is used at a single operating pressure, a correction factor should be determined at that pressure. If the tank prover is used at varying pressures, correction factors shall be determined throughout the range of operating pressures. A table or graph of pressure-correction factors should be prepared to provide the necessary correction data during operation of the tank prover.

Facilities are required to pressurize the tank prover to its maximum operating pressure.

Tank provers that have top gauge glasses must first be filled with water, to a mark near the top of the upper gauge glass. This gauged volume of the water in the tank prover at atmospheric pressure shall be recorded. While the water temperature is kept as constant as possible, gas or air should be introduced into the top of the tank prover, in pressure increments, until the maximum operating pressure has been reached. With each increment of pressure, the indicated volumes of water at the pressure shall be recorded.

The next step is to reduce the pressure, in the same increments as above, until atmospheric pressure is reached. The volume change in the water, between each increment of pressure, shall be measured and recorded, along with the pressure increment.

The average that results from the first and second steps, for each pressure increment, is used to calculate the pressure-correction factor.

From the above data, a table or graph of volume-correction factors versus pressure is prepared for the tank prover operating range. The formula for finding the factor is given as follows:

$$\text{Factor} = 1 + \frac{\begin{array}{c}\text{observed increase in}\\ \text{tank volume caused}\\ \text{by increase in pressure}\end{array} - \begin{array}{c}\text{decrease in liquid}\\ \text{volume caused by}\\ \text{increase in pressure}\end{array}}{\text{beginning tank volume}}$$

$$1 + \frac{(V_a + Q) - (V_p + Q) - [(V_a + Q)(P)(F)]}{V_a + Q}$$

$$= 2 - (P)(F) - \frac{(V_p + Q)}{(V_a + Q)}$$

where

P = observed pressure, in pounds per square inch gauge (kilopascals).

V_a = observed volume in the prover at 0 pounds per square inch gauge (atmospheric pressure).

V_p = observed volume in the prover at pressure increment.

Q = calculated or measured volume of water between the bottom reference mark and the drain valve used to control withdrawal (if applicable).

F = compressibility factor for water, 0.0000032 per pound per square inch gauge (0.00000047 kPa) above atmospheric pressure.

API Related Publications Order Form

Date: ____________________ *(Month, Day, Year)*

❑ API Member *(Check if Yes)*

Invoice To – ❑ Check here if same as "Ship To"

Company:

Name/Dept.:

Address:

City: State/Province:

Zip: Country:

Customer Daytime Telephone No.:

Fax No.:

Ship To – (UPS will not deliver to a P.O. Box)

Company:

Name/Dept.:

Address:

City: State/Province:

Zip: Country:

Customer Daytime Telephone No.:

Fax No.:

(Essential for Foreign Orders)

❑ Payment Enclosed $ ____________________

❑ Payment By Charge Account:

❑ MasterCard ❑ Visa ❑ American Express

Account No.:

Name (As It Appears on Card):

Expiration Date:

Signature:

❑ Please Bill Me

P.O. No.:

Customer Account No.:

State Sales Tax – The American Petroleum Institute is required to collect sales tax on publications mailed to the following states: AL, AR, CT, DC, FL, GA, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MO, NE, NJ, NY, NC, ND, OH, PA, RI, SC, TN, TX, VT, VA, WV, and WI. Prepayment of orders shipped to these states should include applicable sales tax unless a purchaser is exempt. If exempt, please print your state exemption number and enclose a copy of the current exemption certificate.

Exemption Number: State:

Quantity	Order Number	Title	SO*	Unit Price	Total
	H30081	MPMS Ch. 4.1, *Introduction*		$30.00	
	H30082	MPMS Ch. 4.2, *Conventional Pipe Provers*		$40.00	
	H30083	MPMS Ch. 4.3, *Small Volume Provers*		$40.00	
	H30085	MPMS Ch. 4.5, *Master—Meter Provers*		$30.00	
	H30086	MPMS Ch. 4.6, *Pulse Interpolation*		$30.00	
	H04081	MPMS Ch. 4.8, *Operation of Proving Systems*		$60.00	

Shipping and Handling – All orders are shipped via UPS or First Class Mail in the U.S. and Canada. Orders to all other countries will be sent by Airmail. U.S. and Canada, $5 per order handling fee, plus actual shipping costs. All other countries, for Airmail (standard service) add 25% of order value. All other countries, for UPS Next Day, add an additional 10% of order value.

Rush Shipping Charge – FedEx, $10 in addition to customer providing FedEx account number: ____________________. UPS Next Day, $10 plus the actual shipping costs (1-9 items). UPS Second Day, add $10 plus the actual shipping costs (1-9 items).

Rush Bulk Orders – 1-9 items, $10. Over 9 items, add $1 each for every additional item.

NOTE: Shipping on foreign orders cannot be rushed without FedEx account number.

Subtotal	
State Sales Tax *(see above)*	
Rush Shipping Charge *(see left)*	
Shipping and Handling *(see left)*	
Total *(in U.S. Dollars)*	

***** *To be placed on Standing Order for future editions of this publication, place a check mark in the space provided. Pricing and availability subject to change without notice.*

Mail Orders: American Petroleum Institute, Order Desk, 1220 L Street, N.W., Washington, DC 20005-4070

Fax Orders: (202) 962-4776

Phone Orders: (202) 682-8375

To better serve you, please refer to this code when ordering: H M 4 3 5 9 0 5 9 8

The American Petroleum Institute provides additional resources and programs to industry which are based on API Standards. For more information, contact:

• Training/Workshops	Ph:	202-682-8490
	Fax:	202-682-8222
• Inspector Certification Programs	Ph:	202-682-8161
	Fax:	202-962-4739
• American Petroleum Institute Quality Registrar	Ph:	202-682-8130
	Fax:	202-682-8070
• Monogram Program	Ph:	202-962-4791
	Fax:	202-682-8070
• Engine Oil Licensing and Certification System	Ph:	202-682-8233
	Fax:	202-962-4739
• Petroleum Test Laboratory Accreditation Program	Ph:	202-682-8129
	Fax:	202-682-8070

In addition, petroleum industry technical, patent, and business information is available online through API EnCompass™. Call 1-888-604-1880 (toll-free) or 212-366-4040, or fax 212-366-4298 to discover more.

To obtain a free copy of the API Publications, Programs, and Services Catalog, call 202-682-8375 or fax your request to 202-962-4776. Or see the online interactive version of the catalog on our web site at www.api.org/cat.

American Petroleum Institute

Helping You Get The Job Done Right.℠

5/98—5C

Additional copies available from API Publications and Distribution:
(202) 682-8375

Information about API Publications, Programs and Services is available on the World Wide Web at: http://www.api.org

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005-4070
202-682-8000

Order No. H04042