

Manual of Petroleum Measurement Standards Chapter 4—Proving Systems

Section 4—Tank Provers

SECOND EDITION, MAY 1998

REAFFIRMED, MAY 2015



AMERICAN PETROLEUM INSTITUTE

Manual of Petroleum Measurement Standards Chapter 4—Proving Systems

Section 4—Tank Provers

Measurement Coordination

SECOND EDITION, MAY 1998

REAFFIRMED, MAY 2015



AMERICAN PETROLEUM INSTITUTE

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Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years.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.

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 1220 L Street, N.W., Washington, D.C. 20005.

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

	Page
1 INTRODUCTION	1
2 SCOPE	1
3 REFERENCED PUBLICATIONS	1
4 EQUIPMENT	1
4.1 General Considerations	1
4.2 Valves	1
4.3 Wiring and Controls	1
4.4 Safety Devices	1
4.5 Closed Systems	2
4.6 Necks	2
4.7 Counters/Registers	2
5 DESIGN AND CONSTRUCTION	2
5.1 General Considerations	2
5.2 Temperature Measurement	2
5.3 Pressure Measurement	3
5.4 Prover Capacity	3
5.5 Connections	3
5.6 Gauge Glasses	4
6 TANK PROVER CALIBRATION	4
6.1 General Considerations	4
6.2 Procedural Uncertainty in Prover Calibration	6
6.3 Temperature Stability	7
6.4 Calibration by the Waterdraw Method	7
6.5 Calibration by the Master-Meter Method	9
6.6 Temperature Corrections	9
6.7 Determining a Tank Prover Volume Under Pressure	10

Figures

1 Closed Stationary Tank Prover	3
2 Open Stationary Prover Tank (Drain-to-Zero or Bottom Gauge-Glass Type)	4
3 Schematic Operating Diagram of Volumetric Prover for Vapor Displacement	5
4 Portable Prover (Drain-to-Zero or Bottom Gauge-Glass Type)	6
5 Open Portable Prover Tank With Pump Assembly	7

Tables

1 Capillary Rise in Glass Tubes with Varying Water Quality	4
2 Estimated Standard Deviation of Average Tank Prover Calibration Sets	6
3 Uncertainty of the Average at the 95% Confidence Level of Prover Calibration Sets	6

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 NIST¹ 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*

NIST¹

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

¹National 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 be 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 $1/2^{\circ}\text{F}$ ($1/4^{\circ}\text{C}$) 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-