Manual of Petroleum Measurement Standards
Chapter 5—Metering

Section 4—Accessory Equipment for Liquid Meters

FOURTH EDITION, SEPTEMBER 2005

ERRATA, MAY 2015

REAFFIRMED, AUGUST 2015

AMERICAN PETROLEUM INSTITUTE

Manual of Petroleum Measurement Standards Chapter 5—Metering

Section 4—Accessory Equipment for Liquid Meters

Measurement Coordination

FOURTH EDITION, SEPTEMBER 2005

ERRATA, MAY 2015

REAFFIRMED, AUGUST 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.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

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 authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications 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 5 of the API *Manual of Petroleum Measurement Standards* (API *MPMS*) provides recommendations, based on best industry practice, for the custody transfer metering of liquid hydrocarbons. The various sections of this Chapter are intended to be used in conjunction with API *MPMS* Chapter 6 to provide design criteria for custody transfer metering encountered in most aircraft, marine, pipeline, and terminal applications. The information contained in this chapter may also be applied to non-custody transfer metering.

The chapter deals with the principal types of meters currently in use: displacement meters, turbine meters and Coriolis meters. If other types of meters gain wide acceptance for the measurement of liquid hydrocarbon custody transfers, they will be included in subsequent sections of this chapter.

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.

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 publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, 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.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards 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.

Suggested revisions are invited and should be submitted to the Standards and Publications Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

CONTENTS

Page

Chapter 5—Metering

Section 4—Accessory Equipment for Liquid Meters

5.4.1 Introduction

API Chapter 5.4 of the *Manual of Petroleum Measurement Standards* is intended to be a guide for the selection and application of accessory equipment that is used with liquid hydrocarbon meters to obtain accurate measurements and optimum service life. Accessory equipment is any device that enhances the utility of a measurement system. Selecting the kinds of accessory equipment that are described in this section depends on the function, design, purpose, and manner in which a specific measurement installation is to be used.

This publication does not endorse or advocate the preferential use of any specific type of equipment or metering system, nor does it intend to restrict the development of any particular meter, instrument, or accessory equipment.

5.4.2 Scope

This section of API *MPMS* Chapter 5 describes the characteristics of accessory equipment that may be used with meters in liquid hydrocarbon service. Having a knowledge of these characteristics helps designers and operators of meter installations provide satisfactory quantity measurement results. Certain minimum requirements for devices that monitor temperature, density, and pressure are discussed in this section. Most system hardware, such as non-control valves, vents, and manifolding, is not discussed in this section.

5.4.3 Field of Application

The field of application of this section is all segments of the petroleum industry that require dynamic measurement of liquid hydrocarbons by meters.

5.4.4 Referenced Publications

The current editions of the following API *MPMS* Standards contain information applicable to this chapter:

API

Manual of Petroleum Measurement Standards

Chapter 4.2, "Pipe Provers"
Chapter 4.6, "Pulse Interpolation"
Chapter 5.2 "Measurement of Liquid Hydrocarbons by Displacement Meters"
Chapter 5.3, "Measurement of Liquid Hydrocarbons by Turbine Meters"
Chapter 5.6, "Measurement of Liquid Hydrocarbons by Coriolis Meters"
Chapter 7, "Temperature"
Chapter 9, "Density Determination"
Chapter 11, "Volume Correction Factors"
Chapter 12, "Calculation of Liquid Petroleum Quantities"

5.4.5 Selecting Accessory Equipment for Meters

Accessory devices should be selected so that trouble will not arise from the following:

a. *Environment*. Local climate extremes should be evaluated, and the installation should be protected accordingly. Electrical safety factors (including the hazardous area classification), electromagnetic and radio frequency interference, weatherproofing, fungus-proofing, and corrosion should be considered.

b. *Maintenance*. Easy access should be provided for maintenance, and spare parts that have been recommended by the manufacturer should be obtained.

c. *Compatibility*. The readout device or register must be compatible with the meter and its transmission system.

d. *Installation*. All equipment must be installed and operated according to the manufacturer's recommendations and must conform to all applicable regulations and codes.

5.4.5.1 Isolating type flow conditioners, which produce a swirl-free, uniform velocity profile, independent of upstream piping configurations, are typically more sophisticated, expensive and higher pressure drop than simple straightening element type flow conditioners. However, in certain installations, they provide a performance advantage and should be considered.

5.4.5.2 Flanges and gaskets shall be internally aligned, and gaskets shall not protrude into the liquid stream. Meters and the adjoining straightening section shall be concentrically aligned.

5.4.6 Shaft-driven (Mechanical) Accessories

A variety of shaft-driven accessories are applied to displacement meters and sometimes to turbine meters. A mechanical linkage, usually a gear train, transmits force and motion from the rotating measurement element to the exterior of the meter, where the accessories are attached. Care should be exercised in selecting the number and type of accessories so that excessive torque, which can overload the meter, is avoided. This section discusses some of the accessory devices that are now being used.

5.4.6.1 ADJUSTER (CALIBRATOR)

A mechanical meter adjuster, or calibrator, changes the drive-system gear ratio between the volume-sensing portion of the meter and the primary register. The calibrator adjusts the register so that it is direct reading (that is, it provides a unity meter factor). For example, if precisely 100.0 units of volume are delivered by a meter, the register should be adjusted to indicate 100.0 units. Adjusters may be gear changing, friction driven, or clutch driven; depending on the design, the adjustment range may cover from 1 to 10 percent of throughput.

Different types of adjusters are capable of handling different torque loads. Friction-driven and clutch-driven adjusters show decreased sensitivity and repeatability when torque is increased. Increased torque reduces life in all types of adjusters. If adjustment to a unity meter factor is not required, the adjusting device should be omitted from the meter, and a direct drive shaft to the register should be installed.

5.4.6.2 REGISTER

A shaft-driven primary register is attached directly to the meter. The primary register displays the selected standard units of measurement, such as gallons, barrels, or cubic meters; the register also displays fractions of these units, if required. A primary register may be a totalizer only or a totalizer with a separate non-resettable register. A primary register is usually secured and sealed to the meter to prevent tampering (see 5.4.13).

5.4.6.3 PRINTER

A shaft-driven primary printer may accompany a primary register. The primary printer records on a measurement ticket the amount of liquid that is delivered. The ticket is printed in standard units of measurement, such as gallons, barrels, or cubic meters, and in decimal fractions of these units, if required.

Impact or pressure-roller printers are capable of printing one or more paper copies. The number of copies is limited by the type of paper and the clarity that is required. Mechanical printers usually show the lowest digit to the nearest whole number. Ticket forms are inserted, printed, and removed manually.

5.4.6.4 TEMPERATURE COMPENSATOR

A temperature compensator is a variable-ratio mechanism located in the meter’s drive train. It has a temperature sensor that works with the variable-ratio mechanism to correct the indicated volume to standard reference temperature, 60ºF, 15ºC, or 20ºC. The temperature compensator must be set for the appropriate thermal coefficient of expansion of the liquid hydrocarbon that is measured.

The location of the temperature compensator in relation to primary or other accessory readout devices depends on which of the devices are to be compensated and which are to remain uncompensated. Where practical, mechanical temperature compensators should be avoided. Temperature compensation is best achieved by approved electronic methods within the flow computer.

5.4.6.5 PULSE GENERATOR

A pulse generator provides pulses in a quantity that is directly proportional to meter throughput. Pulsing devices can have various types of output signal, including switch closures, square-wave signals, and sine-wave signals. The devices can also have various frequency outputs.

5.4.6.6 REMOTE TRANSMISSION

A remote-transmission device is used to transmit a measurement signal to a remote device, such as a driving device, that in turn can operate most meter shaft-driven accessories.

5.4.6.7 PRESET DEVICE

A preset device can be preset for any quantity of meter throughput. At the pre-selected quantity, the device will stop the flow of liquid or will perform other, desired functions automatically. It may or may not be an indicating device.

5.4.6.8 GEAR-CHANGE ADAPTER

A gear-change adapter changes the output shaft speed by a fixed ratio and is sometimes used to achieve a given output for accessory devices.

5.4.6.9 RIGID EXTENSION

A rigid extension is a convenience device used to elevate meter accessories some distance above the meter itself. The device is also used to isolate meter accessories from adverse environmental conditions at the meter.

5.4.6.10 ANALOG GENERATOR

An analog generator allows a displacement meter to generate a DC current or voltage proportional to meter speed. The generator’s analog output can be used to remotely indicate or control flow rate or related tasks. This should not be used for quantity calculations in custody transfer.

5.4.6.11 RATE-OF-FLOW INDICATOR

A rate-of-flow indicator is a mechanical device that is mounted on a meter and indicates the meter’s flow rate by driving a tachometer-type indicator.

5.4.6.12 SWIVEL ADAPTER

A swivel adapter is a convenience device that allows accessories mounted above the swivel to rotate without changing indication or registration.

5.4.6.13 ANGLE ADAPTER

An angle adapter is a convenience device that allows a counter/printer to be mounted at an angle for better accessibility and visibility.

5.4.6.14 DUAL ADAPTER

A dual adapter is used to mount two sets of shaft-driven accessories on a single meter. The device is often used with a temperature compensator on one side so that both compensated and uncompensated meter readings are available.

5.4.6.15 RIGHT-ANGLE TAKEOFF

A right-angle takeoff is a device in the meter's drive train that is used to provide a rotating external output shaft for operating mechanical accessories that are mounted externally to the meter.

5.4.6.16 SHIFTER ADAPTER

A shifter adapter is used for mounting two sets of shaft-driven accessories on a single meter so that only one set of shaft-driven accessories can be driven at a time. The device is generally used in conjunction with tender changes in pipeline operation, where the total quantity of a tender must be retained while registration is in process on the alternate printer or register. The means of shifting, which may be manual or remote, transfers the meter drive train from one set of accessories to the other. The adapter can be equipped with an optional indicator to show its position.

5.4.6.17 KEY-LOCK COUNTER

A key-lock counter is usually used in conjunction with the unattended operation of a bulk-plant metering system. The equipment provides a readout for any person who has authorized access to the system. Access is gained through keys and locks that connect the appropriate readout to the meter drive train and actuates the system.

5.4.7 Pulse-Driven (Electronic) Accessories

A variety of pulse-driven accessories can be used with liquid meters covered in Chapter 5. The pulses generated by high-resolution pulse generators on meters represent discrete units of quantity and can be used to provide input signals to the equipment discussed in 5.4.7.1 through 5.4.7.15.

5.4.7.1 ELECTRONIC ADJUSTER (CALIBRATOR OR SCALER)

An electronic adjuster, also called a factoring counter, manipulates the pulse signal to achieve a unit meter factor for direct reading of quantity. The device is generally capable of being calibrated to one part in 10,000.

5.4.7.2 READOUT

An electrically driven primary readout indicates quantities in the desired standard units of measurement, such as gallons, barrels, or cubic meters; it also indicates decimal fractions of these units, if required. The accuracy of the readout depends on system resolution, which is proportional to the number of pulses per unit quantity.

Electromechanical registers are limited in speed. Their adequacy should therefore be considered before a decision is made about installation. Electronic readouts are not limited in speed, but they depend on electrical power for proper performance. During a power failure, standby power is needed to verify and retain meter registration if a mechanical means is not available.

5.4.7.3 PRINTER

Several types of electrical printers are available. The two common ones include electromechanical mechanisms in the final stages. The first type is designed so that each adjacent digit advances the next digit into position as it would in a mechanical readout. This type of printer is simple, inexpensive, and widely used, but it has limited speed and longevity.

The second type of printer includes individual digit modules that remain in a rest position until they are called on to print the throughput quantity that is stored in a memory. This type of printer has high resolution, high speed, and exceptional longevity.

5.4.7.4 FLOW COMPUTER

Many types of electronic flow computers are available that accept meter output signals, and other sensor signals, to calculate volume or mass flow quantities as required. Flow computers display, transmit, and print data that can be used for operational or custody transfer purposes. A flow computer can be designed for a single meter run or a bank of meters.

In addition to meter signals, some flow computers accept signals from pressure, temperature, and density devices that allow the calculation of gross and net flow rates and totals. The flow computer should have provisions to accurately calibrate input or output signals. Security measures should be provided to prevent unauthorized access and alteration of the flow computer memory or user configuration. Security may be hardware, such as key locks or switches, or software passwords. Also, the flow computer should have means of internal processor and circuit error checking to ensure the integrity of calculated results.

5.4.7.5 PRESET COUNTER

A preset counter is a totalizing counter that actuates a contact closure when the measured quantity equals a value that was pre-selected on a manually adjustable counter.

5.4.7.6 PROVING COUNTER

A proving counter is a high-resolution digital-pulse totalizer that provides a display of the accumulated high-frequency pulse output from the meter. An on/off gating circuit that is operated from the prover's mounted detectors starts and stops the pulse totalizer. The prover sphere detector switches identify the passing of a calibrated quantity of fluid. The totalizer may be an electromechanical counter or an electronic counter. If the counter is attached to a small volume prover, as described in API *MPMS* Chapter 4.2, the device will constitute a sophisticated electronic system that has the capability to quantify fractions of a pulse cycle, using the pulse interpolation techniques discussed in API *MPMS* Chapter 4.6.

5.4.7.7 FLOW-RATE INDICATOR

A flow-rate indicator converts an input signal to a visual display of flow rate in the desired units. The device is used for general operational information and to monitor system flow rate during meter proving.

5.4.7.8 FREQUENCY CONVERTER

A frequency converter converts an input frequency, or a pulse train, to a proportional analog signal for retransmission to other devices, such as recorders or controllers, that require analog input signals.

5.4.7.9 STEPPER DRIVE

A stepper drive converts a frequency input to an acceptable form for driving a stepper motor. The stepper motor then rotates at a speed that is proportional to the input frequency. The device can be used to drive various mechanical devices that require a rotary input (for example, counters, ticket printers, and compensators).

5.4.7.10 TEMPERATURE COMPENSATOR

A temperature compensator combines an input signal from a meter and an input from a temperature sensor to provide a corrected output to standard reference temperature, 60ºF, 15ºC, or 20ºC.

5.4.7.11 COMBINATOR

A combinator accepts two or more simultaneous input frequencies and displays their total.

5.4.7.12 PERFORMANCE COMPENSATOR

A performance compensator is generally used on multi-viscosity turbine meters to compensate for the effect of viscosity on the meter performance curve. This devise is microprocessor-based and uses meter factor vs. velocity/viscosity curve to compensate for viscosity change. Each meter has a unique meter factor vs. velocity/viscosity curve plotted over a specific flow and viscosity range. Product viscosity must be input for each product metered. Security measures should be provided to prevent unauthorized access and alteration of the flow computer memory or user configuration. Security may be hardware, such as key locks or switches, or software passwords.

5.4.7.13 PULSE RESOLUTION ENHANCER

A pulse resolution enhancer may be used on relatively low K-factor turbine meters (e.g., dual helical type turbine meters) to enhance the resolution of the output pulse train. The device precisely measures the time period of each input pulse from the turbine meter. One such commonly used device assumes that the next incoming pulse will have the same time period as the average time period of the two previous incoming pulses. It then generates (with an insignificant time delay) the programmed number of additional pulses (e.g., 10), equally spaced over the projected time period of the next pulse. By doing this for each pulse produced by the turbine meter, it legitimately increases the resolution (i.e., frequency) of the turbine meter pulse train. Security measures should be provided to prevent unauthorized access and alteration of the computer memory or user configuration. Security may be hardware, such as key locks or switches, or software passwords.

5.4.7.14 DUAL CHRONOMETRY PULSE INTERPOLATOR

This device can be used to obtain the proving resolution needed when the number of meter pulses per proving run is less the 10,000. It has two precise digital timers. One measures the precise duration of the proving run (i.e., time between detector switches). The other measures the time from the first meter pulse after the first detector switch signal to the first pulse after the second detector switch signal. The ratio of these two times allows calculation of the fraction of a meter pulse to be added to the number of whole meter pulses measured between detector switches.

5.4.7.15 SMART PRE-AMP

A smart pre-amp is used on some turbine meters. Smart pre-amps perform the same signal preamplification function as typical preamplifiers, with some additional capability for diagnostic analysis. This device is microprocessor-based and its primary function is to perform real-time diagnostics of a turbine meter's performance by precisely measuring the time period of each pulse and then monitoring the consistency of the pulse train "signature". Security measures should be provided to prevent unauthorized access and alteration of the computer memory or user configuration. Security may be hardware, such as key locks or switches, or software passwords.

5.4.8 Interface Connections to Pulse-Driven Accessories

Interface connections, as described in this section, are the connections between the meter and its driven equipment.

5.4.8.1 SHIELDED CABLE

The signal from a meter in a measurement system is in the form of a pulse train. The accuracy of the measurement system depends on the security with which the signals are transmitted and received.

Noise is an unwanted distortion in the meter pulse signal that may be induced either electrically or magnetically into the pulse carrying cable or the receiving equipment. It can be picked up electrically through capacitance coupling to other conductors. It can be picked up magnetically through induction. The amount of noise and the cost of removing it depend on the type of equipment, the length of the transmission line, and the proximity of the source.

Acceptable pulse transmission can usually be maintained when meters are located within 1000 feet of the electronic receiver and if a signal of ample strength (≥100 millivolts peak to peak) is transmitted. The cables should be routed so that proximity to sources of electrical interference is avoided. Shielding shall be grounded at the receiving end only to prevent ground-loop effects. In addition, if the signal goes to more than one instrument, each instrument ground shall then be tied to a common instrument ground.

5.4.8.2 PREAMPLIFIER

A preamplifier may be used to shape the meter output pulse and increase the signal to noise ratio. If a pulse carrying cable equal to or greater than the maximum distance recommended by the manufacturer of the pulse generator or receiver is required, a preamplifier should be used. The preamplifier should always be located at the meter (the source of the signal) so that the original low-level signals will be amplified and increased to a satisfactory level. Pulse duration and frequency should be considered when matching the preamp and the receiver. When used in conjunction with shielded cable, the pre-amp can mitigate the effects of noise.

The shielded conductor shall be grounded at the receiving end only to prevent ground-loop effects. In addition, if the signal goes to more than one instrument, each instrument ground shall then be tied to a common instrument ground.

5.4.9 Instructions and Guidance for Installing Pulse-Driven Accessories

5.4.9.1 A system that transmits data consists of at least three components: a meter (pulse producer), a transmission line (pulse carrier), and a receiver/readout device (pulse counter and display). These three components must be compatible, and each component must meet the specifications recommended by the manufacturers of the meter and accessory equipment.

5.4.9.2 Electrical noise is a troublesome element in systems that have low-level signal outputs. Even in high-level output systems, noise and spurious electrical signals must be eliminated. Noise signals are superimposed on meter signals by electromagnetic induction, electrostatic or capacitive coupling, or electrical conduction.

5.4.9.3 Great care should be exercised in effectively isolating the meter system from external electrical influences. To minimize unwanted noise, all instrument grounding should be connected and separate from other, non-instrument grounding networks. Shielding the transmission cables of meter and prover detectors is essential.

5.4.9.4 Every meter system must meet two requirements to operate properly: first, the readout device shall be sensitive enough to respond to every pulse produced by the meter throughout its operating range; second, the signal-to-noise ratio shall be high enough to prevent spurious electrical signals from influencing the readout device.

5.4.9.5 A meter's output signal may be viewed as a train of electrical pulses. If preamps or photoelectric sensors are used any of the methods generate a signal that represents a discrete quantity of liquid passing through the meter. One approach to producing electrical pulses is to use magnetic induction to directly translate the rotational motion of the meter into electrical energy. Another approach is to supply external electrical power to a proximity or photo-sensing device.

With the first approach, both pulse frequency and amplitude are generally proportional to flow rate. With the second approach, only pulse frequency is proportional to flow rate since the amplitude of the output voltage is nearly constant.

5.4.9.6 Most electronic readout devices condition a wave form to count each pulse or to measure the frequency of meter output so that flow rate can be indicated. Since signals may have a relatively low power level, installation conditions shall be suitable for low power level signals. The recommendations described in this section do not apply to all meters; they are related only to systems that have low power level signals.

5.4.9.7 The following pulse characteristics influence proper operation of the meter system:

a. *Amplitude*. Any receiving device that is connected to a pulse producer, or meter, shall be sensitive enough to operate when the pulse amplitudes are generated over the rated flow range.

b. *Frequency*. The receiving device shall be able to cope with the maximum output frequency of the pulse producer, or meter, when it reaches its highest expected flow rate.

c. *Width*. After shaping, the duration of every pulse generated by the pulse producer, or meter, shall be long enough to be detected and counted by the receiving device.

d. *Shape*. A sine-wave output shall not be used, without preamplification and shaping, to operate a receiving device that requires a square-wave input.

5.4.9.8 In signal transmission, great care should be exercised to maintain the signal amplitude at the highest level possible and to reduce the magnitude of noise. The following steps should be taken to maintain the optimum signal level:

a. Minimize the length of the signal transmission cable (s).

b. Avoid coiling excess signal transmission cable to minimize impedance.

c. Use the most technically compatible signal transmission cable that is available, as recommended by the equipment manufacturer(s).

d. If dictated by the transmission distance or the manufacturer's requirements, introduce a preamplifier into the meter's signal transmission system.

e. Ensure that voltages supplied to preamplifiers and constant-amplitude pulse-generating systems are of proper magnitude and do not exceed the maximum noise level or ripple requirements specified by the equipment manufacturer(s).

f. Ensure that all pickup coils are securely mounted and properly located.

g. Periodically inspect and clean all terminals and connectors.

h. Minimize the number of terminations or connections.

i. Replace components that give a weakened signal as a result of deterioration.

5.4.10 Protection/Control Equipment Conditioners

Protection/control equipment is used with meters to ensure the most accurate and reliable performance. This includes, but is not limited to, flow control, pressure control, and removal of unwanted foreign material, such as dirt, water, or gas.

5.4.10.1 STRAINERS

Foreign material, such as rust, scale, welding beads, slag, sand, and gravel, may damage a meter system or may adversely affect its performance. A strainer is usually installed upstream of the meter as a protective device. It includes a basket or barrier (usually made of perforated sheet, metal cloth, or screen) that stops and collects foreign material before it enters the meter. The strainer design and mesh size should be designed according to the needs of the meter system and the overall system on which meter is installed. Meter and strainer manufacturers should be consulted regarding design criteria.

A maintenance program should be followed for inspection/cleaning strainer baskets. The purpose of the strainer is defeated if the screen/basket becomes loaded to the point of rupturing. A differential pressure gauge or upstream and downstream pressure gauges should be used to indicate the differential pressure across the strainer. The differential pressure will be in proportion to the amount of foreign material that has accumulated. Based on this information, major problems caused by foreign materials can be avoided.

If the flow cannot be stopped for strainer maintenance, dual strainers should be used. Strainers are also available that are cleaned through periodic back washing to a sump or other disposal facility.

5.4.10.2 AIR OR VAPOR ELIMINATORS

Air or vapor in a flowing stream will be measured as liquid and will result in an error in the indicated quantity. Large quantities of air or vapor, such as may exist in an empty piping system, can result in overspeeding and damage to a rotating meter.

Lines to and from tanks are normally kept full of liquid; however, if the same line is used to pump liquid into and out of a tank, air may enter after a delivery from the tank is completed. Likewise, operating at unusually low tank levels may allow air or vapor to be drawn into the system. Under these conditions, air or vapor elimination equipment is required; additional shutdowns and alarms may also be required.

High vapor pressure liquids, such as liquefied petroleum gas, are handled under pressure conditions that are intended to maintain the product in the liquid phase. If adequate pressure is not maintained, the liquids may flash or vaporize. In such cases, a vapor separator or condensing tank must be installed in the system if the problem cannot be corrected by another means.

Air eliminators are normally not required on pipeline installations where flow does not originate from nearby tanks; however, a means of manual venting should be provided at strategic locations to release air or vapor during startup and after maintenance.

Selecting the size and type of air or vapor eliminator for an installation requires that careful consideration be given to piping and other equipment and to the operating details of the system. These details should include the maximum possible quantity of air or vapor, the type of liquid being handled (with particular reference to its viscosity and foaming characteristics), the size and length of piping, the type and location of the pumps, and the rate of flow. The piping downstream of the eliminator must remain filled with liquid to prevent air or vapor from being measured along with the liquid. This may require the installation of a control valve downstream of the meter that will automatically throttle or stop the liquid flow when air/vapor is being vended.

5.4.10.3 CONTROL OF FLOW

Most installations include a manually or power-operated valve for starting, controlling, and stopping the flow of liquid. In general, power-operated valves should open and close slowly to prevent flow and pressure surges.

To avoid over-speeding a meter, it may be necessary to include a control that will limit the maximum rate of flow to the rated maximum of the meter. In multi-meter installations, a control valve is normally used downstream of each meter to balance flow when one or more meters are taken off line or when proving takes place. If it is necessary to prevent the flow of liquid from reversing direction, a valve that allows flow in only one direction should be used.

A minimum back pressure must be maintained to prevent liquid from vaporizing or flashing (see API *MPMS* Chapters 5.2 and 5.3). This may require the use of a back-pressure controller and a control valve that can maintain the required back pressure under any line pressure.

If a meter is equipped with a counter that can be preset for delivering a particular quantity, the on/off valve is usually controlled by the counter so that the flow can be stopped at the proper time. The preset counter may be linked to the valve by mechanical, electrical, or other means.

Pressure-reducing valves are commonly employed in pipelines to reduce pressure to a level that is suitable to meter or station manifolding. Care must be exercised to ensure that pressure is not reduced enough for vaporization to occur. It is not good practice to throttle immediately upstream of a flow meter since this may create flow disturbances and cause measurement error.

5.4.11 Fluid Property Monitoring Instrumentation

Some conditions and properties of liquid hydrocarbons have a greater effect on measurement accuracy than do others; monitors may therefore be desirable to assess the temperature, pressure, density, and viscosity of the flowing liquid. For example, a 1ºC change in gasoline temperature can produce a quantity change of 0.12 percent (a 1ºF change can produce a quantity change of 0.07 percent), and a change in pressure of 7 kilopascals (1 pound per square inch) in the same product affects quantity by only 0.0008 percent. In this case, the equivalency relationship between pressure and temperature is 960 kilopascals to 1ºC (80 pounds per square inch to 1ºF).

When the temperature of a metered stream is determined for correcting the thermal effects on the stream or meter, obtaining the stream temperature inside the meter body is most desirable. Some meters provide for a temperature-measuring device installed in the meter body; however, this is impractical with many meters because of the way they are constructed or the type of temperature-measuring device that is selected.

If it is impractical to mount the temperature-measuring device in the meter, the device should be installed either downstream or upstream of the meter as shown in schematics included elsewhere in Chapter 5. In liquid turbine meters, the temperature-measuring device should be located immediately downstream of the downstream flow-conditioning tube. Where several meters are manifolded in parallel, one temperature sensor located in the total liquid stream is acceptable if the temperatures at each meter and at the temperature-sensor location are in accordance with Table 1 in API *MPMS* Chapter 7.

5.4.11.1 THERMOMETERS

The accuracy and resolution of a thermometer used in a measurement system should be appropriate for the meter's needs and scale of operation. Since metering requires the highest accuracy possible, the equipment should allow for precise reading and should be checked or calibrated frequently.

API *MPMS* Chapter 7 discusses in greater detail the requirements for temperature measurements associated with meters.

5.4.11.2 TEMPERATURE/PRESSURE-AVERAGING INSTRUMENTS

Temperature/pressure-averaging instruments determine the temperature and pressure of a metered quantity on a quantity or time-paced basis. The devices also accurately determine average conditions if instantaneous line conditions are changing.

5.4.11.3 TEMPERATURE TRANSMITTERS & RTDs

Temperature transmitters or RTDs provide an electronic form of the fluid temperature measurement equivalent to that obtained by thermometers. The accuracy and resolution of the electronic temperature sensing device used in a measurement system should be appropriate for the meter's needs and scale of operation. Temperature measurement with an accurate, repeatable electronic device provides the best method of determining the temperature required for the quantity correction calculations described in API *MPMS* Chapter 12.2. Because of the need for accuracy, calibration against a standard is required at appropriate intervals.

5.4.11.4 TEMPERATURE RECORDERS

Recording liquid temperatures on a chart facilitates the averaging of temperatures over a period of time. The accuracy of the recorded temperatures cannot be greater than that of the temperature-sensing device. Recorded temperatures are often less accurate. The sensing, recording, and chart-integration parts of a temperature recorder should be calibrated periodically.

5.4.11.5 PRESSURE GAUGES

Pressure gauges must be selected to suit the range of expected operating pressures. They should be checked frequently against a master gauge or a deadweight tester, and necessary adjustments should be made.

5.4.11.6 PRESSURE TRANSMITTERS

Pressure transmitters provide an electronic form of the fluid pressure measurement obtained by pressures gauges. The accuracy and resolution of the pressure transmitter used in a measurement system should be appropriate for the meter's needs and scale of operation. Pressure measurement with an accurate, repeatable electronic device provides the best method of determining the pressure required for the quantity correction calculations described in API *MPMS* Chapter 12.2. Because of the need for accuracy, calibration against a standard is required at appropriate intervals as described in API *MPMS* Chapter 21.2, Section 11.3.2, "Verification and Calibration Frequency".

5.4.11.7 PRESSURE RECORDERS

The range of a pressure recorder should be suited to the expected range of the metering operation and should not be wider than required. The instrument's indicator and its sensing device should be checked frequently with a master gauge or a deadweight tester, and necessary adjustments should be made.

5.4.11.8 HYDROMETERS

Floating bulb-type hydrometers are used to determine the relative density, density or API gravity required for the quantity correction calculations described in API *MPMS* Chapter 12.2. Refer to API *MPMS* Chapters 9 and 11 for instructions to be followed and tables to be used in converting readings to standard reference conditions.

5.4.11.9 DENSITOMETERS (GRAVITOMETERS)

Densitometers provide an electronic form of the relative density, density or API gravity. The accuracy and resolution of the densitometer used in a measurement system should be appropriate for the meter's needs and scale of operation. Density measurement with an accurate, repeatable electronic device provides the best method of determining the density required for the quantity correction calculations described in API *MPMS* Chapter 12.2. Because of the need for accuracy, calibration against a standard is required at appropriate intervals.

5.4.12 Security

Consideration should be given to sealing the meter systems to prevent or identify unauthorized attempts at tampering with or manipulating system components. The accuracy, usefulness, and output of a measurement system can be compromised in many ways, resulting in the loss of credit for hydrocarbon liquids that pass through the meter. Meter systems are often equipped with security seals made of wire, plastic, or paste that when broken or disturbed indicate possible tampering. Electronic systems can also be secured with key locks, access codes, and so forth. Each system should be reviewed to define its exposure risk and to identify appropriate seal locations and techniques.

5.4.12.1 SECURITY FOR DISPLACEMENT METERS

Common seal points for displacement meter installations are meter cover and accessory stack flange bolts, meter counter mounting bolts, calibrator and compensator adjustments, right angle drive covers, and covers for electrical conduits and control boxes.

5.4.12.2 SECURITY FOR TURBINE METERS

Common seal points for turbine meter installations are the mechanical counter enclosures, pickup mounting fittings, preamplifier housings, electrical conduit covers, and control box covers. Sealing electrically operated systems that have many accessories, power supplies, and readouts becomes burdensome; the equipment is often housed in a building or enclosure that can be locked or sealed to meet the system's needs.

5.4.12.3 SECURITY FOR CORIOLIS METERS

Common seal points for Coriolis meter installations are the electrical conduit covers and transmitter housing. Access to the transmitter software program is often protected by password security. Sealing electrically operated systems that have many accessories, power supplies, and readouts become burdensome; the equipment is often housed in a building or enclosure that can be locked or sealed to meet the system's needs.

API®

American Petroleum Institute

2005 Publications Order Form

Effective January 1, 2005.
API Members receive a 30% discount where applicable.
The member discount does not apply to purchases made for the purpose of resale or for incorporation into commercial products, training courses, workshops, or other commercial enterprises.

Available through Global Engineering Documents:
Phone Orders: **1-800-854-7179** (Toll-free in the U.S. and Canada)
303-397-7956 (Local and International)
Fax Orders: **303-397-2740**
Online Orders: **www.global.ihs.com**

Date: ______________________

❑ **API Member** (Check if Yes)

Invoice To (❑ Check here if same as "Ship To")

Name:
Title:
Company:
Department:
Address:

City: State/Province:
Zip/Postal Code: Country:
Telephone:
Fax:
E-Mail:

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

Name:
Title:
Company:
Department:
Address:

City: State/Province:
Zip/Postal Code: Country:
Telephone:
Fax:
E-Mail:

Quantity	Product Number	Title	SO★	Unit Price	Total
	H05014	MPMS 5.1, General Considerations for Measurement by Meters		$75.00	
	H05023	MPMS 5.2, Measurement of Liquid Hydrocarbons by Displacement Meters		$70.00	
	H05035	MPMS 5.3, Measurement of Liquid Hydrocarbons by Turbine Meters		$85.00	
	H05052	MPMS 5.5, Fidelity and Security of Flow Measurement Pulsed-data Transmission		$55.00	

❑ **Payment Enclosed** ❑ **P.O. No.** (Enclose Copy) ______________

❑ **Charge My Global Account No.** ______________

❑ **VISA** ❑ **MasterCard** ❑ **American Express** ❑ **Diners Club** ❑ **Discover**

Credit Card No.:

Print Name (As It Appears on Card):

Expiration Date:

Signature:

Subtotal	
Applicable Sales Tax *(see below)*	
Rush Shipping Fee *(see below)*	
Shipping and Handling *(see below)*	
Total *(in U.S. Dollars)*	

★ ***To be placed on Standing Order for future editions of this publication, place a check mark in the SO column and sign here:***

Pricing and availability subject to change without notice.

Mail Orders – Payment by check or money order in U.S. dollars is required except for established accounts. State and local taxes, $10 processing fee*, and 5% shipping must be added. Send mail orders to: **API Publications, Global Engineering Documents, 15 Inverness Way East, M/S C303B, Englewood, CO 80112-5776, USA.**
Purchase Orders – Purchase orders are accepted from established accounts. Invoice will include actual freight cost, a $10 processing fee*, plus state and local taxes.
Telephone Orders – If ordering by telephone, a $10 processing fee* and actual freight costs will be added to the order.
Sales Tax – All U.S. purchases must include applicable state and local sales tax. Customers claiming tax-exempt status must provide Global with a copy of their exemption certificate.
Shipping (U.S. Orders) – Orders shipped within the U.S. are sent via traceable means. Most orders are shipped the same day. Subscription updates are sent by First-Class Mail. Other options, including next-day service, air service, and fax transmission are available at additional cost. Call 1-800-854-7179 for more information.
Shipping (International Orders) – Standard international shipping is by air express courier service. Subscription updates are sent by World Mail. Normal delivery is 3-4 days from shipping date.
Rush Shipping Fee – Next Day Delivery orders charge is $20 in addition to the carrier charges. Next Day Delivery orders must be placed by 2:00 p.m. MST to ensure overnight delivery.
Returns – All returns must be pre-approved by calling Global's Customer Service Department at 1-800-624-3974 for information and assistance. There may be a 15% restocking fee. Special order items, electronic documents, and age-dated materials are non-returnable.
***Minimum Order –** There is a $50 minimum for all orders containing hardcopy documents. The $50 minimum applies to the order subtotal including the $10 processing fee, excluding any applicable taxes and freight charges. If the total cost of the documents on the order plus the $10 processing fee is less than $50, the processing fee will be increased to bring the order amount up to the $50 minimum. This processing fee will be applied before any applicable deposit account, quantity or member discounts have been applied. There is no minimum for orders containing only electronically delivered documents.

Additional copies are available through Global Engineering Documents at (800) 854-7179 or (303) 397-7956

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

API
American Petroleum Institute

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

Product No. H05044