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ROTARY-TYPE
GAS DISPLACEMENT METERS

Secretariat

American Gas Association

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Contents

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PREFACE

This publication represents a basic standard for operation, substantial and durable construction, and acceptable performance for rotary-type gas displacement meters. This work is the result of years of experience that has been supplemented by extensive research. The standard is intended to meet the minimum design, material, performance and testing requirements for efficient use of rotary displacement meters

It is recognized that during any transition period to the metric system, sizes and dimensions need to be expressed in either the metric system or the inch-pound system or in both. In this document, both systems are used, with the inch-pound units given preference. In most cases, a soft conversion from existing inch-pound values is shown. Soft conversion implies a change in nomenclature only; in this document, the alternative nomenclatures (metric and inch-pound) are shown by using parentheses and can be used interchangeably. Hard conversion is used to express metric values in (closely equivalent) round inch-pound units. Bracketed values are not to be used interchangeably with the corresponding metric values.

Nothing in this standard is to be considered as in any way indicating a measure of quality beyond compliance with the provisions it contains. It is designed to allow the construction and performance of displacement meters that may exceed the various provisions specified in any respect. In its preparation, recognition was intended to be given to the possibility of improvement through ingenuity of design. As progress takes place, revisions may become necessary. When they are believed desirable, recommendations should be forwarded to the Chairman of ANSI B109 Committee, Operating and Engineering Section, American Gas Association, 400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, U.S.A.

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HISTORY OF THE DEVELOPMENT OF THIS STANDARD

Following approval of the Standard for Gas Displacement Meters (Under 500 Cubic Feet per Hour Capacity), ANSI B109.1, in 1973, a subcommittee was appointed to develop a standard covering rotary-type gas displacement meters.

Five drafts of the standard were prepared and reviewed by the subcommittee before a final draft was prepared and submitted to American National Standards Committee B109 for its consideration on June 20, 1979. Subsequent to adoption by the committee, the first edition of the standard for rotary-type gas displacement meters was approved as American National Standard by the American National Standards Institute, Inc., on April 14, 1980.

The second edition was approved as American National Standard by the American National Standards Institute, Inc., on January 9, 1987. Major changes included the additions of: Part VI on Auxiliary Devices for Gas Meters; Part VII on Test Methods and Equipment; and informative Appendices for bar coding of meters and auxiliary devices, and prover calibration.

In the third edition, minor editorial changes were made. The third edition was approved on November 12,1992.

In the fourth edition of standard B109.3, several additions/deletions were made to avoid any ambiguity, to make it more consistent and to improve upon some requirements. The fourth edition was approved on April 13, 2000.

This is the fifth edition of standard B109.3, in which several additions/deletions have been made to avoid any ambiguity, to provide more consistency with other B109 standards, to improve upon some requirements and to allow more leeway for future innovation and developments. Substantive changes have been shown by a bar [|] in the margin.

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ANSI B109.3 would like to recognize individuals who are not part of the ANSI B109.3 voting membership but contributed to the development of the standard -- Andre Nel, IMAC Systems, Inc; Andrew Smich, Romet; Brian Lee, Romet; Dennis Chapman Consumers Energy; Eddy Collins, ONE Gas, Inc; Fernando De Los Riscos Garcia, Gas Natural; Glen Heard, Romet; Jeff Webb, Avista; Jerre Kilroy, Honeywell (American Meter); Mark Witherspoon, IMAC Systems, Inc.; Ramesh Konduri,Baker Hughes, a GE Company; Stephen Wenford, CenterPoint Energy; Tony Miller, Ameren Illinois Company

SCOPE

This standard applies to rotary-type positive displacement meters designed for revenue measurement of fuel gas.

Part I comprises a list of definitions and terms used throughout the standard.

Part II covers the construction requirements for qualifying new-type rotary meters.

Part III covers the performance requirements for qualifying new meters and new-type rotary meters.

Part IV covers “in-service” performance requirements for rotary-type meters.

Part V addresses installation requirements for these meters.

Part VI pertains to auxiliary devices used with meters covered by this standard.

Part VII covers test methods and equipment.

PART I
DEFINITIONS

1.1 ACCURACY, METER. The degree to which a meter correctly measures the volume of gas passing through it, determined by comparing the volume registered by the meter with that registered by the prover. (See Appendix B for methods of expressing meter accuracy.)

1.2 ADAPTOR PLATE, INSTRUMENT. A specially designed plate mounted between a meter and an instrument to provide for a proper drive to the instrument.

1.3 AUTOMATIC INTEGRATORS

1.3.1 Recording Type. This type of automatic integrator is equipped with corrected and uncorrected volume counters and a chart to record the time, pressure or temperature, or combinations thereof:

1.3.2 Non-Recording Type. This type of automatic integrator is equipped with corrected and uncorrected volume counters.

1.3.3 Automatic Integrating Device for Pressure. An automatic integrating device for pressure is an auxiliary device designed to automatically correct a volume-related input to some predetermined base pressure condition.

1.3.4 Automatic Integrating Device for Temperature. Automatic integrating device for temperature is an auxiliary device designed to automatically correct a volume related input to some predetermined base temperature condition in accordance with Charles' Law.

1.3.5 Automatic Integrating Devices for Pressure and Temperature. An automatic integrator device for pressure and temperature is an auxiliary device designed to automatically correct a volume-related input to some predetermined base pressure and base temperature condition in accordance with Boyle’s Law and Charles’ Law.

1.4 AUXILIARY DEVICES. Devices used with a meter to provide an adjustment of the meter reading, to permit obtaining special information, or to transmit information to a remote location.

1.5 BADGE. A permanent plate, affixed in a conspicuous place on a meter, containing basic meter information.

1.6 BASE CONDITIONS. The standard base conditions of pressure and temperature for the volumetric measurement of natural gas, ANSI/API 2562-1969, has established 60°F (15.6°C) and 14.73 psi (101.56 kPa) as the base temperature and pressure to which all volumes are commonly referred.

1.7 BOTTLE, CUBIC FOOT. A specially constructed and calibrated bottle, usually immersion type, complete with an immersion tank containing a light oil of low vapor pressure, with the bottle suspended over the tank by means of a suitable cord and pulley so that the bottle may be immersed in the oil between two graduations, top and bottom. The bottle is constructed so that exactly 1 cubic foot of air is displaced when the bottle is immersed between the two marks. The calibration of the bottle must be traceable to the National Institute of Standards and Technology (NIST).

1.8 CAPACITY, RATED. The maximum flow rate at which a rotary meter should be operated. See 3.2.

1.9 CIRCULAR CHARTS. A circular chart is a piece of paper, or other suitable material, with graduated lines upon which a pen or stylus draws a record indicating the variables being measured.

1.10 CIRCLE(S), READING. Graduated index circles with hands that register the accumulated volume of gas passed through the meter.

1.11 CIRCLE(S), TEST. A graduated circle provided with a rotating pointer (proving hand) on the meter index, used for testing the meter and for indicating gas flow. Also referred to as index test dial or proving circle.

1.12 CONNECTIONS, METER. The integral parts of the meter designed for attachment to meter swivels, pipe or other piping components.

1.13 CONSTANT-PRESSURE-COMPENSATING INDEX. An index used in conjunction with a gas meter operated at a constant pressure, other than the contract base pressure, to indicate gas volume corrected to a contract base pressure.

1.14 CUBIC FOOT, METERED. The quantity of gas that occupies 1 cubic foot when under pressure and temperature conditions existing in the meter.

1.15 CUBIC FOOT, STANDARD. (See ANSI Z132.) That quantity of gas that under an absolute pressure of 14.73 psi (101.56 kPa) and at a temperature of 60°F (15.6°C) occupies a volume of 1 cubic foot.

1.16 CUBIC METER, STANDARD. That quantity of gas that under an absolute pressure of 101.56 kPa (14.73 lbf/in^2) and a temperature of 288.7°K (519.7°R) occupies a volume of 1 cubic meter.

1.17 FLOW RATE, PILOT. A minimum flow rate that a meter is required to register with a prescribed accuracy.

1.18 HUBS, METER. Same as 1.12, CONNECTIONS, METER.

1.19 INDEX, CONSTANT PRESSURE COMPENSATING. Same as 1.13. CONSTANT-PRESSURE-COMPENSATING INDEX.

1.20 INDEX, METER. The mechanism that displays the volume of gas that has passed through the meter.

1.21 INDEX RATE. The uncorrected flow rate calculated by dividing the registration by time.

1.22 INDEX, TEMPERATURE COMPENSATING. A meter index used to display corrected volume under flowing gas conditions to a base temperature, commonly 60°F (15.6°C).

1.23 1NDEX TEST DIAL. See 1.11, CIRCLE(S), TEST.

1.24 INDICATOR, DEMAND. A device that indicates on a scale, chart or tape the maximum volume metered during a predetermined period of time.

1.25 INDICATOR, VOLUME. A component of an auxiliary device designed to indicate on a scale or chart or both the volume of gas passing through a meter in relation to time, temperature, pressure or any combination thereof.

1.26 INSTRUMENT ADAPTOR PLATE. An instrument adapter plate is a mounting surface of suitable material mounted on and driven by a gas displacement meter. The instrument adapter plate mounts between the meter and instrument and provides the correct instrument drive rotation and speed or displaced volume per revolution with respect to the meter output drive shaft.

1.27 INSTRUMENT CHART DRIVES. Meter- or clock-driven charts.

1.28 INTEGRATING DEVICE. A mechanism designed to automatically correct a gas volume-related input to some predetermined base conditions.

1.29 LIFE TEST, ACCELERATED. A test under controlled conditions simulating long-term operation designed to determine long-term maintenance and performance characteristics within a relatively short period of time.

1.30 MAOP. Maximum Allowable Operating Pressure equivalent to manufacturer's maximum working pressure.

1.31 METER ACCURACY. See 1.1, ACCURACY, METER.

1.32 METER, DISPLACEMENT OR POSITIVE DISPLACEMENT. A meter that utilizes the principle of alternately filling and emptying compartments of known size and totals the number of times the cycle is accomplished, thereby indicating the volume of gas passing through the meter.

1.33 METER, GAS. A device for measuring a volume of flowing gas.

1.34 METER, NEW. A meter of all new materials as received from the manufacturer; never used in service.

1.35 METER, NEW TYPE. A gas meter sufficiently different in design or materials of construction (such as case, impeller or vane material, case configuration, bearings and gearing, method of lubrication, sealing of gas chamber, index drive, cubic feet per revolution) so affecting performance as to require qualification as a new-type meter under this standard.

1.36 METER, ROTARY DISPLACEMENT. A meter that utilizes the principle of filling and emptying rotating compartments of known size and totals the number of times the cycle is accomplished, thereby indicating the volume of gas passing through the meter.

1.37 MILEAGE. See 1.67, REGISTRATION.

1.38 MULTIPLIER, COMBINED PRESSURE AND TEMPERATURE. Multiplication factor for correcting the maximum combined pressure and temperature conditions back to base conditions.

$$\text{Combined Pressure and Temperature Multiplier} = \frac{520}{T_f + 460} \times \frac{P_g + P_a}{14.73}$$

where:

T_f = Flowing Gas Temperature, °F
P_g = Meter Gauge Pressure, psig or lbf/in^2 (gauge)
P_a =Atmospheric Pressure at the Meter Site, psia or lbf/in^2 (absolute)

1.39 PERCENT ACCURACY. The volume indicated by the meter (V_m) divided by the volume indicated by the standard (V_s), taken as a percentage.

1.40 PERCENT REGISTRATION. See 1.1, ACCURACY, METER and Appendix B. Same as percent accuracy.

1.41 PIPELINE QUALITY GAS. A gas that: a) can be accepted by a pipeline without causing unacceptable operational problems for the pipeline, and b) can be blended or commingled with other pipeline gas such that the levels of individual components, including contaminants, render the overall gas stream suitable for most combustion and feedstock applications – all as spelled out in a pipeline tariff or contract.

1.42 PRESSURE, ABSOLUTE. Atmospheric pressure plus gauge pressure. Abbreviated as psia; symbol lbf/in^2 (gauge).

1.43 PRESSURE, ATMOSPHERIC. The pressure due to the weight of the atmosphere (air and water vapor) on the Earth's surface. The average absolute atmospheric pressure at sea level has been defined as 14.696 pounds force per square inch (101.33 kPa).

1.44 PRESSURE, BASE. An absolute pressure value to which measured gas volumes are corrected. A contract or contractual understanding normally exists any time there is an exchange of gas whether it is wholesale or retail sales or purchase.

1.45 PRESSURE DIFFERENTIAL. The difference in pressure between two points in a flowing gas system.

1.46 PRESSURE DROP. The loss in pressure between two points in a fluid flow system.

1.47 PRESSURE, GAUGE. Measured pressure relative to atmospheric pressure taken as zero. Common abbreviation

psig; symbol lbf/in^2 (gauge).

1.48 PRESSURE, METER. The pressure in a meter under operating conditions.

1.49 PROVER. Device for measuring the accuracy of gas meter registration.

1.50 PROVER, BELL. A calibrated cylindrical bell in which a quantity of air is collected over an oil seal.

1.51 PROVER, LOW PRESSURE FLOW. An apparatus utilizing an orifice for testing meters at low pressures by passing gas or air through both the orifice and meter and finally discharging it to the atmosphere. The time for a given quantity of gas to pass through the meter compared to the orifice standard time corrected for test conditions provides a measure of meter accuracy.

1.52 PROVER PISTON. A mechanically sealed device that is calibrated to measure the volume of gas delivered to a meter.

1.53 PROVER, CRITICAL FLOW. See 1.70, SONIC FLOW NOZZLE.

1.54 PROVER, TRANSFER. A device for determining the accuracy of a meter under test by comparing its reading against the reading obtained from a calibrated reference meter connected in series with the meter under test.

1.55 PROVING CIRCLE. A graduated circle provided with a movable pointer (proving hand) on the meter index used for testing the meter and for indicating gas flow.

1.56 READING CIRCLES. Those circles that indicate the volume of gas passed through the meter and are commonly used for billing purposes. See also 1.10, CIRCLE(S), READING

1.57 RECORDER, DEMAND. An instrument that records gas flow rate as a function of time.

1.58 RECORDER, PRESSURE, CLOCK-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations of pressure relative to time by means of a clock-driven circular chart.

1.59 RECORDER, PRESSURE AND TEMPERATURE, CLOCK-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations in pressure and temperature relative to time by means of a clock-driven circular chart.

1.60 RECORDER, PRESSURE, TEMPERATURE AND VOLUME, CLOCK-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations in pressure and temperature and units of volume relative to time by means of a clock-driven circular chart.

1.61 RECORDER, PRESSURE, TEMPERATURE AND VOLUME, METER-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations in pressure and temperature relative to volume by means of a circular chart driven by the meter.

1.62 RECORDER, PRESSURE and VOLUME, CLOCK-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations in pressure and units of volume relative to time by means of a clock-driven circular chart.

1.63 RECORDER, PRESSURE and VOLUME, METER-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations in pressure relative to volume by means of a circular chart driven by the meter. The area under the pressure recording is related to the volume corrected for pressure.

1.64 RECORDER, TEMPERATURE, CLOCK-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations of temperature relative to time by means of a clock-driven circular chart.

1.65 RECORDER, TEMPERATURE and VOLUME, CLOCK-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations in temperature and units of volume relative to time by means of a clock-driven circular chart.

1.66 RECORDER, TEMPERATURE and VOLUME, METER-DRIVEN CIRCULAR CHART. An auxiliary device designed to record variations of temperature relative to volume by means of a circular chart driven by the meter. The area under the temperature recording is related to the volume corrected for temperature.

1.67 REGISTRATION. The indicated volume of gas passed through a meter.

1.68 REMOTE METER READING DEVICE. A mechanical or electrical device that provides or reproduces a reading of the meter index at a point remote from the meter. The reading may be displayed for visual observation, recorded in a portable device or transmitted to a distant point.

1.69 SEAL. A device designed to give evidence of tampering with a meter.

1.70 SONIC FLOW NOZZLE. Also referred to as SONIC FLOW PROVER or CRITICAL FLOW PROVER. A device employing either venturis, orifices or sonic nozzles as restrictions that is used for testing meters, usually at elevated pressures, by passing gas or air through both the meter and restriction and finally discharging it at a lower pressure that maintains sonic velocity (critical flow) through the restriction. The time for a given quantity of gas or air to pass through the meter compared with the restriction standard time corrected for test conditions provides a measure of meter accuracy.

1.71 STANDARD STILLMAN. A portable, 1-cubic-foot, liquid-sealed, bell-type transfer device used in the calibration of bell provers.

1.72 STRAPPING. A method of checking a bell prover by determining the relationship between displaced volume and linear movement of a bell prover by means of measuring scale length, bell circumference and displacement of the sealing liquid.

1.73 SUPERCOMPRESSIBILITY. Deviation of a gas from the ideal gas laws.

1.74 TAPE, STRAPPING. A metal tape calibrated to give a direct reading of diameter when applied to the circumference of a circular surface.

1.75 TEMPERATURE, ABSOLUTE. That temperature obtained in degrees Rankine by adding 459.67 degrees to a reading of a Fahrenheit thermometer or in degrees Kelvin by adding 273.15 degrees to that of a Celsius thermometer reading.

1.76 TEMPERATURE, BASE. A reference temperature to which measured gas volumes are corrected.

1.77 TEMPERATURE, FLOWING. The temperature of the gas at flowing conditions.

1.78 TEMPERATURE, METERING. The temperature of the gas in a meter at operating conditions.

1.79 TEMPERATURE SYSTEM. A temperature system is one that indicates the relative hotness or coldness of the working medium. A temperature differential device measures relative temperature differences within a temperature system or between two temperature systems.

1.80 TEST, ACCELERATED LIFE. Same as 1.29, LIFE TEST, ACCELERATED.

1.81 VOLUME INDICATOR. A volume indicator is a component of an auxiliary device designed to indicate on a scale or chart, or both, the volume of gas that has passed through a meter in relation to time, temperature or pressure, or any combination thereof.

PART II
CONSTRUCTION REQUIREMENTS FOR QUALIFYING NEW-TYPE METERS

2.1 SCOPE

This part establishes the construction requirements for the qualification of a new-type rotary meter.

2.2 DIMENSIONS

The following standard specifications are included to provide for practical mounting and connecting interchangeability, consistent with accepted manufacturing procedures.

2.2.1 Meter Piping Connection. Meter piping connections shall conform dimensionally with the flange class specifications in the “Standard for Cast Iron Pipe Flanges and Flanged Fittings,” ANSI/ASME B16.1, or “Standard for Steel Pipe Flanges and Flanged Fittings,” ANSI/ASME B16.5, or threaded connection specifications in the “Standard for Pipe Threads (Except Dryseal), General Purpose (Inch),” ANSI/ASME B1.20.1, for gas transmission and piping systems.

2.2.2 Connection Tolerances. Meter connections shall conform to the face-to-face tolerance limits specified (Dimension A, Figure 1; Dimensions A and B, Figure 2). The axis of the inlet and outlet connections shall be concentric within 1/16 inch (1.6 mm). (Datum C, Figures 1 and 2.)

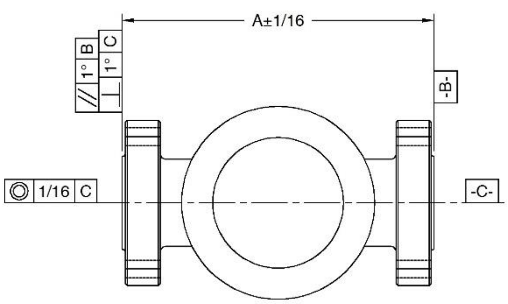


Figure 1. Flange connections.

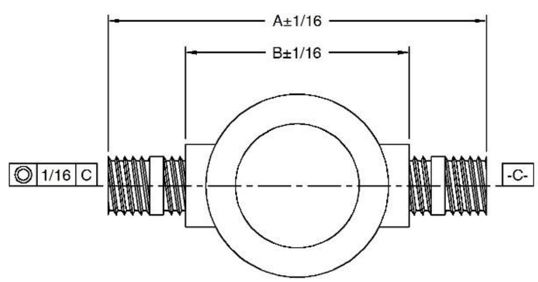


Figure 2. Threaded connections.

2.2.2.1 Flange Connections. The flange faces shall be parallel with each other and perpendicular to an axis through the center of each, to within 1 degree (0.017 rad). (Dimension B, Figure 1.)

2.2.2.2 Threaded Connections. Meters with threaded connections (pipe nipples or threaded) shall be checked for concentricity with pipe nipples, installed as illustrated in Figure 2.

2.2.2.3 For meters utilizing a Top in / Top out configuration in resemblance to a diaphragm-type gas displacement meter, refer to ANSI B109.1 (Under 500 Cubic Feet Per Hour Capacity) or ANSI B109.2 (500 Cubic Feet Per Hour Capacity and Over) as appropriate for the proper dimensional and interconnectivity guidelines.

2.3 MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP)

The MAOP shall be the maximum working pressure as determined by the manufacturer using the guidelines set forth in Section VIII of the *ASME Boiler and Pressure Vessel Code*. The pressure rating of the meter shall not exceed the MAOP of the meter or the flange connection, whichever is less.

2.4 STRENGTH OF METER CONNECTIONS

The meter connections shall be constructed to provide adequate strength in connecting the meter to related piping systems.

Method of Test:

Tests for determining the strength of meter connections shall be performed with a device constructed to provide (1) a rigid lever arm to which a force can be applied in a perpendicular plane for performing torsional and bending moment tests, (2) a pressure tight connection at meter connections, and (3) a pressure tap for connecting a manometer or pressure gauge.

Tests shall be applied in the following sequence:

a. The meter shall be tested for accuracy at 20 percent of its rated capacity near atmospheric pressure.
b. A torsional moment shall be applied as shown in Figure 3 and according to Table I and the pressure raised to 5% of the MAOP and held at this pressure for a minimum of one minute. The pressure will then be raised to 100% of the MAOP and held at this pressure for a minimum of one minute. There shall be no leakage under either of these conditions of stress and pressure.
c. A vertical bending moment shall be applied as shown in Figure 4 and according to Table I and the pressure raised to 5% of the MAOP and held at this pressure for a minimum of one minute. The pressure will then be raised to 100% of the MAOP and held at this pressure for a minimum of one minute. There shall be no leakage under either of these conditions of stress and pressure.
d. A horizontal bending moment shall be applied as shown in Figure 5 and according to Table I and the pressure raised to 5% of the MAOP and held at this pressure for a minimum of one minute. The pressure will then be raised to 100% of the MAOP and held at this pressure for a minimum of one minute. There shall be no leakage under either of these conditions of stress and pressure.
e. The meter shall then be retested for accuracy as in "a" above while subjected to the same torsional or bending moment. The two accuracy measurements shall not differ by more than 0.25%.

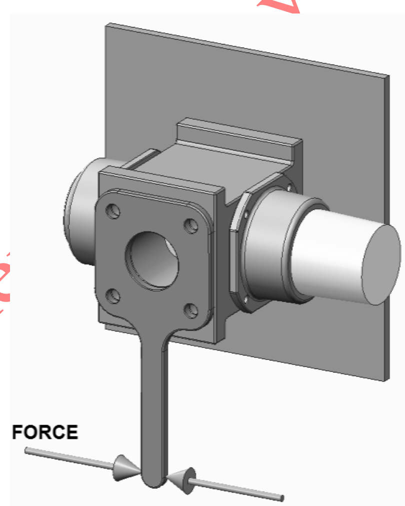


Figure 3. Torsional Loading.

TABLE I
LOADING RERQUIREMENTS FOR ROTARY METER CONNECTIONS

Nominal Pipe Size		Loading Moment	
(Inch)	(mm)	(lbf-ft)	(N.m)
¾	20	180	244.0
1	25	215	291.5
1¼	32	250	339.0
1½	40	290	393.2
2	50	325	440.6
3	75	560	759.3
4	100	900	1220.2
6	150	2000	2711.6
8	200	3300	4474.2
10	250	5200	7050.3

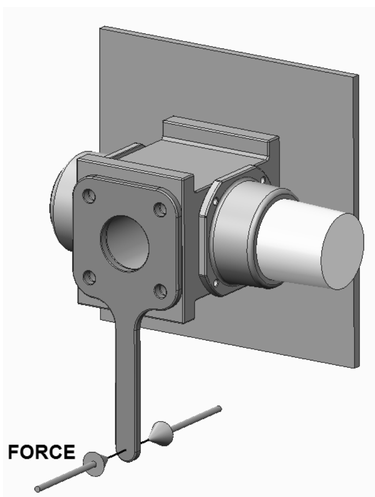


Figure 4. Bending in the Vertical Plane

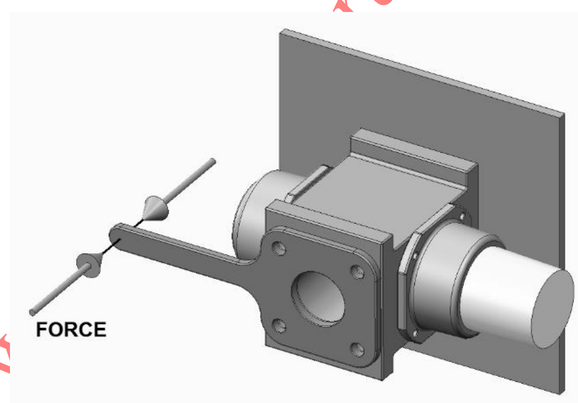


Figure 5. Bending in the Horizontal Plane.

For meters utilizing a Top in / Top out configuration in resemblance to a diaphragm-type gas displacement meter, refer to ANSI B109.1 (Under 500 Cubic Feet Per Hour Capacity) or ANSI B109.2 (500 Cubic Feet Per Hour Capacity and Over) as appropriate for the proper strength of meter connections.

2.5 METER INDEX WINDOW IMPACT RESISTANCE TESTS

A plastic index window shall be made of material having an Izod impact resistance of not less than 0.3 foot-pound per inch (16 J/m) at 73°F (23°C). (Reference the "Standard Methods of Test for Impact Resistance of Plastic and Electrical Insulating Materials," ANSI/ASTM D256.)

A glass index window shall withstand an impact to the glass equivalent to a 0.25 inch (6.4 mm) steel ball traveling at 104 mph (46.5 m/s) without a glass or housing failure. (Reference "Eye and face protectors", CSA Z94.3)

2.6 DESIGN SAFETY FACTOR

A new-type meter shall be designed and tested in accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code*. Under these design recommendations, the minimum burst pressure shall be equal to or greater than the maximum operating pressure (MAOP) multiplied by a safety factor as determined by the code. In no case shall this factor be less than 4.0.

2.7 DIFFERENTIAL PRESSURE TAPS

Differential pressure taps shall be provided in the inlet and outlet chambers of the meter for test purposes and shall be located on the top when the meter is installed in a horizontal position. These taps shall be 1/4 inch NPT, or be adaptable to 1/4 inch NPT, in size and located at the same positions on each meter of the same model.

2.8 METER IDENTIFICATION

Identifying badges shall be installed on all meters and placed where they are easily readable.

2.8.1 Manufacturer's Identification. The manufacturer's product shall contain identification information in a permanent and legible form which requires the information to remain affixed to or incorporated into the meter housing for the service life of the meter with the meter information recoverable by mechanical means through layers of paint, other forms of protective coatings, and corrosion. The information shall be readable from the same general position as the index and positioned in a manner to minimize damage during handling. Numbers shall be of the type shown in Figure 6. The meter serial number shall be at 0.125 inch (3.2 mm) high and shall be visible within an angle of 45 degrees from the perpendicular to the plane of the badge. Acceptable methods of markings can be embossing, etching; stamping and other competing technologies. The following information shall be contained on the badge:

a. Meter Model.
b. Manufacturer's name or trademark.
c. Meter serial number.
d. Year of manufacture.
e. Maximum Allowable Operating Pressure (MAOP) rating.
f. Rated capacity.

1234567890

1234567890

Figure 6. Suggested styles of numbers and characters on meter badge should follow fonts similar to Century Gothic (top) or Times New Roman (bottom). The intent is to maintain the openness of characters such as"3", "6" and "9" to prevent confusion with other characters.

2.8.2 Compensating Meter Body. For meter bodies which compensate internal to the meter body and exclusive of a correction from the meter index, the manufacturer's identification badge or marking shall be of a durable red color and shall state the compensated factors, such as temperature or pressure**.**

2.8.3 Purchaser's Badge. Space shall be provided on the meter for the attachment of a purchaser's badge and shall be of sufficient size to include the purchaser's meter identification information.

2.8.4 Optional Identification. If additional meter identification is used (example: bar code, RFID, QR code, etc.), ensure the type and format are amenable to the purchaser. Refer to Appendix C for the preferred bar code standard for meters and auxiliary devices.

2.9 FLOW DIRECTION IDENTIFICATION

The direction of flow through the meter shall be clearly indicated. For meter bodies capable of integrating bi-directional mechanical indexes or electronic correctors with forward and reverse flow capabilities, the meter body shall clearly indicate the direction of "Forward" flow.

2.10 METER OUTPUT REGISTRATION IDENTIFICATION

The meter shall be permanently marked identifying the volume (cu. ft., cu. meters, etc.) per revolution of each output shaft that drives auxiliary instrumentation. The output shaft rotation shall be clockwise.

2.11 PROTECTION OF METERS

2.11.1 Functional Protection. The inlet and outlet connections as well as any pressure and/or temperature taps, mechanical output drive connections and electrical connections shall be sufficiently protected to prevent the entrance of foreign material and to prevent damage during shipment and storage.

2.11.2 – Metrological Protection. At any point of the meter providing access to components or mechanisms which may impact the metrological function of the meter, provisions shall be made for a seal which would provide obvious and permanent visible evidence of tampering.

2.12 MECHANICAL METER INDEX

2.12.1 General

2.12.1.1 A mechanical index face and markings shall be of contrasting colors to provide for ease of reading. All markings on a mechanical index shall be permanent. The index of a mechanically temperature-compensated meter shall indicate in red lettering on a white or silver background both meter temperature compensation and base temperature. Electronic indexes shall indicate whether the displayed reading is temperature compensated or non-compensated.

2.12.1.2 Index and markings shall not be adversely affected by environmental conditions, such as ultraviolet or infrared radiation, or ambient temperatures from –40 °F (–40°C) to 140°F (60°C).

2.12.1.3 All indexes shall be identified to aid in the installation of the correct index on a meter.

2.12.1.4 The index and mating parts shall have adequate markings to clearly indicate proper usage.

2.12.1.5 An indication of the volume unit being measured shall appear in a prominent place on the index face (for example: cubic feet, cubic meters).

2.12.2 Pointer-Type Circular Dial Reading Indexes.

2.12.2.1 Each reading circle shall be divided into 10 equal parts with division marks numbered from “0” to “9.” The “0” division mark shall be located at the top of the circle. The reading circle shall be a minimum of 0.6 inch (15 mm) in diameter.

2.12.2.2 The index gearing shall provide for adjacent reading hands to rotate in opposite relative directions in a 10-to-1 ratio.

2.12.2.3 The fastest moving reading hand shall be located to the right of the index when viewed from the front of the index.

2.12.2.4 The fastest moving reading hand shall rotate in a clockwise direction and have a value per revolution of 1,000 cu. ft. (28.3 m^3) when installed on a 10 cu. ft. (0.28 m^3) per revolution meter, 1,000 cu. ft. (28.3 m^3) when installed on a 100 cu. ft. (2.8 m^3) per revolution meter, and 10,000 cu. ft. (283.2 m^3) when installed on a 1,000 cu. ft. (28.3 m^3) per revolution meter.

2.12.2.5 Each reading circle shall be appropriately marked to indicate the number of volume units measured per complete revolution of the reading hand and shall be provided with an arrow indicating the direction of rotation of the reading hand.

2.12.2.6 On non-reading circles with a “proving hand” or “test hands,” the volume per revolution shall be clearly indicated. The circle shall have 10 equally spaced divisions, and a directional arrow shall be provided to show the direction of rotation. No numbers shall appear on the subdivisions.

2.12.3 Direct Reading Indexes (Digital or Counter Type).

2.12.3.1 The digits of the counter shall be arranged to appear in a horizontal straight line that can be viewed through a cutout in the index face or counter mask.

2.12.3.2 A permanent decimal point, zeroes or multiplying factor shall appear on the index face to clearly indicate total volume units appearing on the counter. Example: Last digit on right side of counter indicates hundreds of volume units. Two permanent zeroes (“00”) or a multiplier of “× 100” will be shown in line with and to the right of the last digit to indicate total units.

2.12.3.3 An appropriate test hand or unit shall be provided for proving. It shall be suitable for scanning by photoelectric or other mechanical or electronic means.

2.13 CORROSION AND CHEMICAL RESISTANCE OF INTERNAL PARTS

Internal parts and surfaces of the meter shall be resistant to corrosion or chemical attack that would adversely affect the operation of the meter when used to measure pipeline quality gas.

2.14 CORROSION AND CHEMICAL RESISTANCE OF EXTERNAL PARTS

The meter case and external parts shall be made of or protected by materials that are resistant to attack by the weather (sunlight, humidity and temperature changes) and common meter cleaning agents over the expected life of the meter. The meter case and exterior parts shall be capable of meeting or exceeding the requirements of the following tests.

2.14.1 Accelerated Weathering Test. Samples of the meter case or other specific external parts of the meter that are to be tested shall be prepared and protected using the same methods and materials employed in manufacturing the meter. Samples shall be exposed to the following weathering tests, with reference to ASTM D822, ASTM D6695 (Daylight Filter) or ASTM D4587 (UVA-340) for 2,000 hours. The exposure cycle shall consist of the periods of ultraviolet light radiation and fresh water spray shown in Table II. Following this 2,000 hour test, there shall be no appreciable progressive corrosion, electrolytic action, or any appreciable discoloration or deleterious reaction.

TABLE II
EXPOSURE CYCLE

Portion of Exposure Cycle	Time Period
Direct Ultraviolet Radiation (Light Only)	102 min.
Fresh Water Spray (Light and Spray)	18 min.
Total Exposure Cycle	120 min.

2.14.2 Salt Spray Test. Samples, as in Section 2.14.1, shall be mounted in the salt-spray chamber in their normal operating position. They shall be subjected to a 1,000-hour salt-spray test in accordance with ASTM Method B-117, "Salt Spray (Fog) Testing." At the conclusion of the test, the coating will meet or exceed the following acceptance criteria:

a) Ferrous-based materials shall be evaluated using ASTM D-610 and have a score of Grade 4 or greater.

b) In general, non-ferrous metal materials shall be evaluated using ASTM D-714 and exhibit blister size No. 4 or greater with no more than a Medium density. For surface areas susceptible to galvanic corrosion due to adjacencies with dissimilar materials (such as bolts, washers, recessed head pipe plugs and sight gauges), materials shall be evaluated using ASTM D-714 and exhibit blister size No. 2 or greater with no more than a Medium Dense density.

2.15 TEMPERATURE RESISTANCE TEST

A meter shall be capable of operating within ambient temperature and flowing gas temperature limits of 140°F (60°C) and -40°F (-40°C). It shall comply with the accuracy and pressure tests specified in Part III.

2.15.1 High Temperature Resistance. The meter case only shall not be structurally impaired by exposure to 360°F (182°C) for a period of 1 hour. The meter case shall not leak by an exposure to 200°F (93°C) for a period of 1 hour. Both tests shall be conducted while the meter is pressurized at its MAOP.

2.15.2 Thermal Shock Resistance. The assembled meter shall be subjected to the following thermal shock test with no subsequent effect on the meter's accuracy. The test shall be conducted while the meter is pressurized at 1.5 times its MAOP, and no leaks shall be detected.

Method of Test

The assembled meter shall be heated in a 140°F (60°C) water bath for 1 hour and then plunged into water at 40°F (4.5°C). The assembled meter shall then be cooled to 20°F (–6.7°C) for 1 hour and then plunged into water at a temperature of 120°F (49°C).

PART III
PERFORMANCE REQUIREMENTS FOR QUALIFYING NEW METERS AND NEW-TYPE METERS

3.1 SCOPE

This part establishes the performance requirements for qualification of new meters and new-type rotary meters.

3.2 RATED CAPACITY

The rated capacity is the maximum flow rate at which a rotary meter should be operated and is determined by the dynamic loads acting on the rotating parts of the meter. These loads are primarily related to meter RPM, and secondarily to the metering pressure. With few exceptions, the standard volume capacity of a rotary meter increases directly with changes in absolute line pressure and inversely with changes in absolute line temperature.

3.3 ACCURACY

A meter shall measure and register gas accurately within the range of flow rates for which it was designed.

3.3.1 Initial Accuracy. The initial accuracy of each meter is to be 100 ±1% accuracy for flow rates for approximately 10% to 100% of the meter's rated capacity. In the absence of other customer supplied test accuracy criteria, the manufacturer shall provide accuracy test data for each meter at 10% to 100% of the meter's rated capacity.

Method of Test:

The accuracy of a meter under test will be determined as follows. The meter will be connected in series with a proving standard having sufficient capacity.

The test flow accuracy will be determined by comparing the registered volume of the proving standard with the registered volume of the meter under test. Correction for pressure and temperature differentials must be made when applicable.

3.3.2 Accelerated Life Test for New-Type Meters. To determine the ability of a rotary meter to measure gas accurately for relatively long service periods, it shall be subjected to an accelerated life test. To comply with this provision, the meter must continue to operate and register for the entire period of the accelerated test.

Method of Test:

Meters shall be leak-tested and calibrated with the initial accuracy as specified in 3.3.1 before placing on test.

Meters shall be tested with air or with the type of gas for which the meter is intended. The flow rate through the meter shall be maintained at not less than 100% of the meter's rated capacity and at a minimum of 50 psig (344.7 kPa) working pressure (but not in excess of the MAOP). After a total of 4,000 hours of operation or its equivalent in total meter revolutions, the accuracy of the meter shall remain within 0.5% of the meter's Initial Accuracy as determined in 3.3.1.

3.3.3 Sustained Accuracy for New Type-Meters. After being subjected to the accelerated life test described in 3.3.2, the meter accuracy shall remain within the initial accuracy tolerance of 100 ±1% for flow rates for approximately 10% to 100% of the meter's rated capacity.

3.4 NOISE AND VIBRATION

All new meters shall be essentially free of noise and vibration.

3.5 STARTING RATE TEST FOR NEW-TYPE METERS

To ensure minimum internal friction and clearances, each new-type rotary meter shall start to run and continue to run at less than or equal to 0.5% of its rated capacity.

Method of Test

A proving standard or test meter of appropriate capacity shall be connected in series with the meter under test. A small valve shall be slowly opened until the meter under test starts to rotate. As soon as the meter starts to turn, and continues to turn for 30 seconds, the rate of flow shall be determined and recorded. A minimum of five tests shall be performed and all flow rates recorded shall be less than or equal to 0.5% of the meter's rated capacity.

3.6 PRESSURE AND LEAK TEST CONDITIONS FOR NEW METERS

3.6.1 Each new meter shall be tested to establish that it is able to withstand an internal pressure in excess of that to which it may be subjected in actual service. A shell (or case) pressure test shall be performed at 1.5 times the MAOP for cast steel, cast aluminum and wrought aluminum shells, and at 2.0 times the MAOP for cast and ductile iron shells. (Reference Section VIII, ASME Boiler and Pressure Vessel Code.)

3.6.2 Each new meter shall be given a pressure leak test while submerged in water, or a test equivalent in sensitivity, to determine that it is free from leakage. During the test, the meter shall be slowly pressurized (not exceeding 5 psig per second) with a gas from zero psig to at least 1.25 times the MAOP.

Method of Test:

The meter shall be sealed and submerged in water or a test equivalent in sensitivity prior to the pressurization. During the pressurization and for a period of at least 1 minute after having reached the maximum pressure, there shall be no leakage.

3.7 DIFFERENTIAL PRESSURE TEST CONDITIONS

The pressure loss across a rotary meter at a specified index rate, gas specific gravity and metering pressure is indicative of the meter's condition.

3.7.1 Starting Differential Pressure for New-Type Meters. The differential pressure shall be measured by means of a differential pressure gauge connected to the inlet and outlet of the meter. A device or valve controlling an air source connected to the meter inlet should be slowly opened to a point where the meter starts to rotate. The reading at this point is the starting differential. The rotating parts of the meter should be started in six different positions (approximately 60° increments), and the starting differential shall not exceed 0.10 inch water column (24.9 Pa) when tested with air at atmospheric conditions. If excessive differential pressure is required to start the meter turning, a bind or drag is indicated.

(Note: "Jetting" air into the meter to start it may cause false starting differentials. For example, a high-pressure hose should not be used.)

3.7.2 Running Differential Pressure for New Meters. A differential pressure test with the meter running at speeds of at least 10% of the meter's rated capacity, sometimes referred to as a differential rate test, is indicative of the operating condition of the meter. The manufacturer shall provide differential test data for each meter at 10% and 100% of the meter's rated capacity. A discussion and description of the use of these test data can be found in Appendix A.

PART IV
IN-SERVICE PERFORMANCE

4.1 SCOPE

This part establishes in-service performance standards for rotary meters.

4.2 TEST CONDITIONS

4.2.1 Test of In-Service or Repaired Meters. Meters shall be inspected and tested in a meter shop, or other test facility, or in the field with approved equipment and procedures. Appropriate action shall be taken to ensure that the meters conform to the limits set forth in 4.2.3.

4.2.2 Test Flow Rate (Where Applicable). Meters shall be tested at one or more rates of flow to ascertain their accuracy. When one rate of flow is used, it shall be 10% to 30% of the rated capacity. When two rates are used, one of the flow rates shall be the same as the single rate test. The high flow rate shall be 60% to 100% of the rated capacity. If this is not attainable, then it shall be the maximum capacity of the proving equipment. If an intermediate flow rate is used, it should be approximately midway between the low and high rates.

After the initial accuracy tests have been made by the manufacturer or user, differential tests may be used to confirm the continued accuracy of in-service rotary meters (see Appendix A).

4.2.3 Meter Accuracy. Meter accuracy shall be 100 ±1% from approximately 20% to 100% of the meter's rated capacity.

4.3 IN-SERVICE PERFORMANCE PROGRAMS

4.3.1 Objectives. The primary purpose of an in-service performance evaluation of rotary meters is to provide an optimum scheduling of testing and maintenance. Scheduling of testing and inspections should be made at intervals frequent enough to preclude excessive mechanical damage or inaccuracies, but not more frequently than is actually necessary. Any program established should be periodically reviewed.

4.3.2 Differential Pressure Testing. The differential pressure in a rotary meter is the resulting difference in pressure from the inlet to the outlet, taken under operating conditions. Pressure taps used for these tests are provided by the manufacturer at identical locations in the body of each meter of a given model. The differential pressure is predictable for a given model and flow rate when the specific gravity and pressure of the gas being measured are known. This test should be carried out at flow rates in excess of 10% of rated capacity of the meter.

The test is based on the principle that, as the rotating resistance of the meter increases, more energy is absorbed from the flowing gas, resulting in an increase in differential pressure. Increased differential pressure may be indicative of debris in the measuring chamber, worn bearings or other problems requiring maintenance. As a general rule, when the differential pressure of a rotary meter increases over 50% under the same operating conditions, corrective action should be taken to return the meter to the normal differential pressure or it should be removed from service. (See Appendix A.)

4.3.3 Records. A record should be maintained of at least the last differential pressure test of each rotary meter. The record should include such items as model, size, location and company number, along with the pressure, rate of flow and date of the test. This record is required in order to schedule field tests at intervals necessary for adequate maintenance surveillance. A lubrication record should also be maintained.

PART V
METER INSTALLATION

5.1 SCOPE

This part establishes installation requirements for rotary meters.

5.2 GENERAL

The customer or his agent should confer with the supplier of gas service as one of the first steps in planning a new gas installation or a major alteration to an existing one. Normally, the supplier shall determine the location, type and size of metering equipment to be installed.

The supplier of gas service shall have available for customers, architects and contractors copies of the supplier's rules, specifications and requirements pertaining to meter installations. Meter installations shall conform to the safety requirements of the supplier and applicable codes.

5.3 LOCATION

a. Gas meters shall be located in ventilated spaces readily accessible for examination, reading, replacement or necessary maintenance.
b. Gas meters shall not be located where they will be subjected to damage, such as adjacent to a driveway, under a fire escape, in public passages, halls, coal bins, or where they will be subjected to excessive corrosion or vibration. Electrical separation shall be maintained between cathodic-protected and noncathodic-protected piping.
c. Gas meters shall be located at least 3 feet from known sources of ignition or air intakes.
d. Gas meters shall not be located where they will be subjected to extreme temperatures or sudden changes in temperature. Meter manufacturers shall furnish information regarding safe temperature limits.

5.4 INSTALLATION

Manufacturer's recommendations shall be considered when a meter is installed.

5.4.1 Piping. The manufacturer's recommendation for piping configurations, fittings and connections should be followed, including size and lengths of straight piping, the location of valves, filters and thermometer wells.

5.4.2 Level. The meter shall be installed level within the tolerances recommended by the manufacturer.

5.4.3 Bypass Piping. It may be desirable to install a secured valve bypass around the meter. This arrangement will allow meter maintenance as required without a shutdown. The installation of a blow-down valve on the meter piping may further facilitate meter removal or maintenance.

5.4.4 Filters and Strainers. Foreign material should be removed from the piping before installing the meter. Where foreign particles such as sand, mill scale, rust and welding beads may be entrained in the gas, a filter or strainer should be installed upstream to protect the meter. The device used should be sized to permit adequate flow through the meter.

5.4.5 Pressure Taps. Pressure taps should be fitted with valves or test plugs when differential testing is used. These taps are particularly useful as an aid in determining the operating condition of rotary meters. A gauge or manometer may be mounted permanently near the meter to determine the differential across the meter for this purpose.

5.4.6 Over-Speed Protection. Where a meter may be subjected to an over-speed condition because of an on-off, unknown or varying load condition creating a sudden drop in downstream pressure, a properly sized restricting orifice or flow nozzle should be installed downstream of the meter in accordance with the manufacturer's recommendation. The orifice or nozzle should be sized to restrict the gas flow to the extent that the meter cannot exceed 120% to 150% of rated capacity under the given conditions. The use of a venturi flow nozzle instead of an orifice will substantially reduce the overall pressure in the system. Other methods may also be applicable.

5.4.7 Instrumentation Where instrumentation is to be installed to bring metered gas volumes to base conditions, temperature wells, pressure taps and other auxiliary connections should be installed in accordance with the manufacturer's recommendations.

5.4.8 Lubrication. At the time of installation, consideration should be given to the lubrication of the meter where recommended by the manufacturer. The grade of lubricants used should be equal to or exceed the specification recommended by the manufacturer for the intended service conditions. The meter shall be oriented in a position recommended by the manufacturer to provide proper lubrication.

5.4.9 Pressurizing and Depressurizing the System. The system should be pressurized and depressurized slowly to avoid damage to rotating parts from excessive acceleration. Generally the pressure gradient should not exceed 5 psi (34.5 kPa) per second. Pressurization may be accomplished by the installation of a small needle valve installed on a bypass around the main shut-off valve.

5.5 METER SHUT OFF

A means shall be provided between the main and the meter to shut off the gas.

5.6 METER SUPPORT

Meters shall be secured in a proper position and installed in such a manner as to avoid undue stress upon the connecting piping or the meters (see 2.4).

5.6.1 Piping Support. Where meters are designed to be installed in and supported by the pipe, the piping should be aligned and supported so as to prevent undue strain on the meter and piping.

5.6.2 Other Support. Where meters are designed to rest on a permanent base such as a concrete pad or metal stand, the base should be designed to carry the weight without settlement. The piping should also be aligned and supported to prevent undue strain on the meter and piping.

5.7 METER SIZING

Meters shall be sized to measure the expected load. The diversity of the total connected load, the range of operating pressures and the rated capacity should be considered (see 3.2).

5.8 SPACING OF METERS

When two or more meters are grouped, they should be spaced so that installation, maintenance, testing and removal of an individual meter can be accomplished without disturbing the adjacent meter(s).

5.9 IDENTIFICATION

When two or more meters are installed at one building, the piping, other than the meters, shall at all times be legibly marked to indicate the customer or facility being metered.

5.10 ON-SITE INSPECTION

A general inspection of the metering facility serving the customer shall be made when a meter is installed, removed or tested.

5.11 SPECIAL SERVICE

Before a customer installs equipment or facilities, which require service at other than the supplier's standard conditions, the customer shall provide the supplier with all necessary information for consideration of the application. Attention should be given to conditions such as pulsations, surges, other pressure fluctuations and temperature variations that might affect metering and control equipment. Some provisions for maintaining continuity of supply (such as the use of a meter bypass, etc.) should be considered where a planned interruption would cause undue hardship to the customer or supplier.

5.12 DUAL METER INSTALLATIONS

When two or more rotary meters are installed in parallel, they should be of similar size or with similar differentials as compared with the percent of flow rate to ensure that one meter does not exceed its dial or flow rate.

PART VI
AUXILIARY DEVICES FOR GAS METERS

6.1 SCOPE

This part includes the standard requirements, approval tests and test methods for mechanical auxiliary devices that are commonly used with gas displacement meters. Included in this section are:

a. Temperature, pressure and volume recording devices
b. Temperature, pressure and volume integrating devices
c. Load demand devices
d. Remote reading units including any associated actuating device
e. Other miscellaneous associated equipment

The primary objectives are to:

a. Provide a workable and realistic standard and acceptance criteria for new types of auxiliary devices.
b. Provide guidelines for inspection and testing as well as establish performance standards for new devices.
c. Provide guidelines for inspection, testing and maintenance as well as establish performance standards for in-service devices.
d. Specify realistic test standards.

6.1.1 Acceptable Auxiliary Devices. Auxiliary devices, in order to be recognized as an acceptable type, shall conform to requirements specified below that are intended to determine their reliability and acceptable accuracy.

6.1.2 Adequacy of Test Equipment. Where applicable and feasible, tests for determining the acceptability of the types of auxiliary devices under these specifications should be made using reference standards or instruments of an order of accuracy at least three times greater than specified for the device being tested. The tests shall be conducted or directed by personnel who have a thorough, practical and theoretical knowledge of meters, instruments and related auxiliary devices.

6.1.3 Inspection and Testing.

6.1.3.1 New Devices. New auxiliary devices should be inspected and tested in a shop or laboratory before being placed in service. The tests should be performed using test equipment as prescribed in 6.1.2.

6.1.3.2 In-Service Devices. The inspection and testing frequency of in-service auxiliary devices, unless otherwise stated, should coincide with the programs established in Section 6.12, Inspection and Testing. Requirements to comply with manufacturers' warranties should also be considered.

6.1.3.3 Inspection. An inspection for general condition of the metering installation shall be made before and after an auxiliary device is installed, removed or tested.

6.1.4 Auxiliary Device Identification. Each auxiliary device shall provide identification, which shall include, at a minimum, the following information:

a. Manufacturer's name or trademark, serial number and type
b. Additional data as specified in the requirements for each auxiliary device

6.1.5 Construction Requirements

6.1.5.1 Case Specifications. The cases of auxiliary devices shall be of a sturdy design to provide physical protection for the operational elements. They shall be fabricated of a durable rust-resistant, moisture-proof material suitable for outdoor service in ambient temperatures of –40°F (–40°C) to 160°F (71°C), and shall be fitted with a cover or door of suitable material. All auxiliary devices shall be gasketed between the case and door. Provision for a seal or lock, or both, should be provided.

6.1.5.2 Case Style. Various case styles are considered acceptable for the direct- and remote-mounting of auxiliary devices.

6.1.5.3 Pressure Connection. Each element for sensing pressure shall be supplied with a threaded connection within or extending from the case. The recommended thread size shall be 1/4" (6 mm) NPT (internal or external thread).

6.1.5.4 Chart Plates. Those auxiliary devices requiring circular charts shall be equipped with a chart plate. This chart plate shall be designed to provide proper support for the recording chart.

6.1.6 Installation

6.1.6.1 Direct-Mounting Devices. Those devices mounted directly to the meter should have positive attachment by means of latch, bolt or some other method.

6.1.6.2 Remote-Mounting Devices. Those devices remotely located from the meter but activated by the meter shall be rigidly supported. The connection from the meter to the remote device shall be firmly attached at both the meter and auxiliary device and the entire assembly shall be suitably protected. Provisions shall be made for the independent removal of the meter or auxiliary device.

6.1.6.3 Location of Sensing Probes. When the meter installation requires the use of a pressure-sensing line, the manufacturer's reference pressure tap should be utilized. Where such location is impractical, the pressure tap should be located as close as practicable to the inlet connection of the meter.

The temperature sensing probe should be located in the meter or within 5 pipe diameters downstream of the meter. If another location is necessary or desirable, the temperature difference between the meter and the temperature probe should not exceed 3°F (1.7°C).

6.1.7 Acceptance Standards

6.1.7.1 Auxiliary Device Driving Torque. Manufacturers shall publish maximum torques for all devices. Consideration should be given to the effect the torque will have on basic meter performance.

6.1.7.2 Accuracy—Laboratory Conditions. When this standard refers to the accuracy of an auxiliary instrument, the term shall be defined as a number or quantity that defines the limit of error under reference operating conditions. Unless otherwise specified, accuracy is defined as that in effect under reference operating conditions. Accuracy is the combined or joint effects of method, observer, apparatus and environment. Unless stated otherwise, all accuracy statements in this standard refer to percent of maximum scale reading.

NOTE: Reference operating conditions referred to in this standard would be "laboratory condition" (i.e., 75°F ±5°F (24°C ±2.8°C), normal atmospheric pressure, clean gas).

6.1.7.2.1 Accuracy of pressure elements should be ±0.5% of full scale.

6.1.7.2.2 Accuracy of temperature elements should be ±1.5°F (±0.83°C).

6.1.7.2.3 Accuracy of pressure recording devices should be ±0.75% of full scale.

6.1.7.2.4 Accuracy of temperature recording devices should be ±2.5°F (±1.39°C).

6.1.7.2.5 Accuracy of Integrating Devices. In addition to the basic accuracy of the pressure element and temperature element, an additional tolerance for each separate integrating function is required. These tolerances are included in the following:

6.1.7.2.5.1 Accuracy of pressure-integrating devices shall be ±0.75% of the maximum pressure multiplier over a pressure range of 10% to 100% of maximum gauge pressure when the maximum gauge pressure is 150 psig (1091 kPa) or less. On higher pressure ranges, the above specified accuracy shall cover a range of 20% to 100% of the maximum gauge pressure.

6.1.7.2.5.2 Accuracy of temperature-integrating devices shall be ±0.75% of the maximum temperature multiplier over the full temperature range.

6.1.7.2.5.3 Accuracy of pressure- and temperature-integrating devices shall be ±1% of the maximum combined pressure and temperature multiplier over the full temperature range, and a pressure range of 10% to 100% of the maximum gauge pressure when the maximum gauge pressure is 150 psi (1091 kPa) or less. On higher pressure ranges, the specified accuracy shall cover a range of 20% to 100% of the maximum gauge pressure.

6.1.7.3 Accuracy—Field Conditions. It should be recognized that accuracy figures stated for laboratory conditions may need to be expanded to apply to field-type tests. This is necessary because the reference operating conditions can vary widely depending upon the prevailing ambient conditions.

6.2 PRESSURE SYSTEM

6.2.1 Definition. A pressure system is one that measures pressures above or below atmospheric pressure at any point in a closed system. A pressure-differential device will measure pressure differences within a pressure system or between two pressure systems.

6.2.2 Accuracy. Accuracy of basic pressure elements should be as specified in 6.1.7.2.

6.2.3 Types

a. Bourdon tube
b. Metal diaphragm or bellows
c. Manometer

6.2.4 Basic Pressure Ranges—Gauge (lbf/in2)

psig	psig
0-5	0-150
0-15	0-300
0-30	0-600
0-60	0-1000
0-100	0-1500

0-30 inches of mercury vacuum
Note: For metric conversion lbf/in^2 × 6.8948 = kPa

6.2.5 Pressure Elements. It is recommended that the manufacturer provide interchangeability for the normal pressure ranges of specific types defined in 6.2.3.

6.2.6 Pressure Systems. Pressure systems shall be considered the same when such systems have the same:

a. Accuracy rating
b. Design rating
c. Performance rating
d. Range

6.3 TEMPERATURE SYSTEM

6.3.1 Definition. A temperature system is one that indicates the relative hotness or coldness of the working media. A temperature-differential device measures relative temperature differences within a temperature system or between two temperature systems.

6.3.2 Types

a. Filled System
    (1) Case Compensated
    (2) Fully Compensated
b. Bi-Metallic System
    (1) Case Compensated
    (2) Fully Compensated

6.3.2.1. Case Compensated Temperature System. With the bulb placed in an agitated 70°F ±5°F (21.1°C ±2.8°C) temperature bath, there shall be no more than 2°F (1.1°C) change in the indicated temperature of the temperature system when the case containing the calibrated temperature element is subjected to ambient temperatures between -20°F to 120°F (–6.7°C to 48.9°C).

6.3.2.2 Fully Compensated Temperature System. With the bulb placed in an agitated 70°F ±5°F (21.1°C ±2.8°C) temperature bath there shall be no more than 3°F (1.67°C) change in the indicated temperature of the temperature system when the case and all but 5 feet (1.5 meters) of the capillary tubing are subjected to ambient temperature changes between -20°F to 120°F (-6.7°C to 48.9°C).

6.3.3 Temperature Range

(1) Filled System: 150°F (83.3°C) temperature span
(2) Bi-Metallic System: 150°F (83.3°C) temperature span

6.3.4 Capillary Lengths

Case Compensated	Fully Compensated
Feet	Feet
5	15
10	25
15	50
20	75
	100

Note: For metric conversion ft. × .3048 = meters

6.3.5 Sensing Bulb

a. The material used for sensing bulbs shall be of the type that will not absorb or permit the escape of the sensing material.
b. Outer diameter: Should not exceed a diameter of 0.620 inches (15.7 mm).

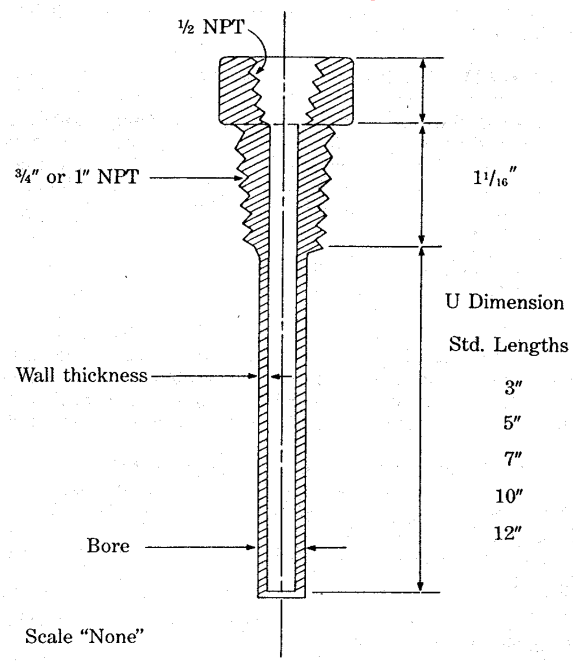
6.3.6 Temperature Wells

6.3.6.1 Well Materials. Well materials should be selected to suit the application. Some of the common materials are:

a. Brass
b. Low carbon steel
c. 316 SS
d. 304 SS
e. Nickel
f. Monel

6.3.6.2 Well Dimensions

a. External thread size: 3/4" (19 mm) N.P.T or 1" (25.4 mm) N.P.T.
b. Internal thread size: 1/2" (12.7 mm) N.P.T.
c. Bore: Maximum allowable bore to be 0.630



Note: for metric conversion 1 inch=2.54 cm or 25.4 mm

Figure 4. Temperature well dimensions.

6.3.6.3 Well Construction

6.3.6.3.1 The part of the well projecting beyond the container must be as small as possible so as to eliminate heat transfer to or from surroundings.

6.3.6.3.2 The thermometer well shall be so constructed just inside the wall of the pipe that it has the smallest possible metallic section consistent with the necessary strength. This will tend to reduce the heat flow along the well with a given temperature difference and accordingly, will tend to maintain the maximum possible difference of temperature between opposite ends of the well.

6.3.6.4 Well Installation

6.3.6.4.1 The thermometer well shall be so selected and placed that the bulb's sensitive portion will be exposed to the flowing gas stream. The thermometer well shall be placed so as not to materially restrict the gas flow.

6.3.6.4.2 When metal-to-metal contact is not made between the bulb and its separable well, the placing of heat conducting liquids in the well reduces time lag in the sensing of changing temperatures.

6.3.6.5 Thermometer Installation. When installing thermometers that are not compensated for ambient temperatures, the shortest possible standard length of capillary tubing shall be used.

6.4 VOLUME INDICATOR

6.4.1 Definition. A volume indicator is a component of an auxiliary device designed to indicate on a scale or chart, or both, the volume of gas that has passed through a meter in relation to time, temperature or pressure, or any combination thereof.

6.4.2 Types

a. Chart, Clock-Driven
b. Chart, Meter-Driven
c. Demand Indicator

6.4.3 Clock-Driven Chart. A clock-driven chart shall record the volume in relation to time. Additional information on pressure or temperature, or both, may also be recorded on the chart. The volume per pen cycle should be clearly indicated.

6.4.4 Meter-Driven Chart. A meter-driven chart shall record the amount of volume by chart rotation. Additional information on pressure or temperature, or both, may also be recorded on the chart. The volume as recorded on the chart and that shown by the index shall not differ by more than ±0.5%.

Volume indicators shall have the volume per chart revolutions clearly indicated.

6.4.5 Demand Indicator. A demand indicator indicates on a scale, chart or tape the maximum volume metered during a predetermined period of time.

6.4.6 Time Indicator. In addition to recording pressure or temperature, or both, a volume recorder may be equipped with a time-driven pen to record time cycles on the chart.

6.5 INSTRUMENT CHART DRIVES

6.5.1 Definition. An instrument chart drive or clock is a timing device used to provide a time base for auxiliary devices.

6.5.2 Classification. Instrument chart drives shall be classified in categories, which indicate their initial drive force and time cycle.

6.5.3 Types

a. Mechanical
b. Pneumatic
c. Battery
d. Synchronous
   (1) Standard Case
   (2) Explosion Proof Case

6.5.4 Specifications for Construction and Identification. Each drive in its category shall be designated by type, time cycle and rewind period, where applicable. The direction of rotation shall be indicated, and the serial number, time cycle and manufacturer's name prominently displayed on the clock or chart drive.

6.5.5 Construction and Workmanship. Each clock shall be constructed of acceptable material to attain repeatability of performance. Each clock shall be constructed in a manner that it can be used with universal adapters to fit various types of instrument cases. All clocks and turrets used as chart drives shall be constructed with arbors of 0.499 to 0.502 inch (12.67 to 12.75 mm) diameter. Automatic chart changer arbors need not conform to these dimensions.

6.5.6 Basis of Acceptable Performance. Clocks shall be considered acceptable when the timing element is not in error by more than ±4 minutes in 24 hours, tested under laboratory conditions as set forth in 6.1.7.2. In the application of the clock, consideration should be given to the ambient operating conditions.

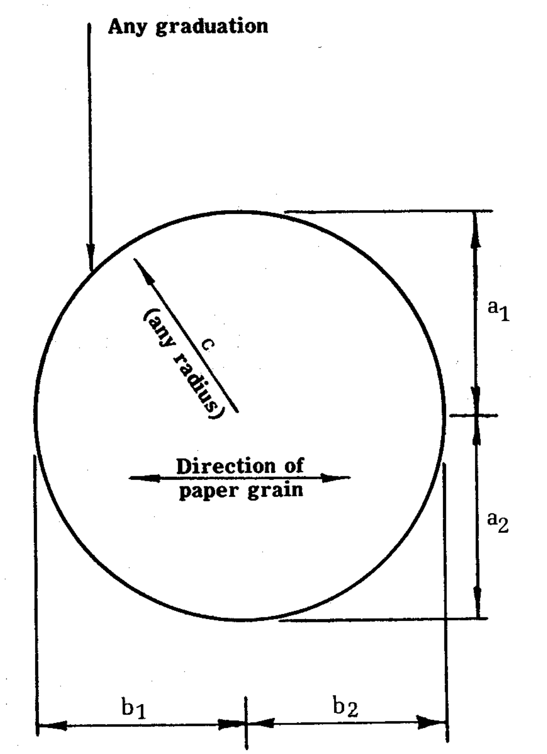


Figure 5. Circular chart dimension diagram.

6.6 CIRCULAR CHARTS

6.6.1 Definition. A circular chart is a piece of paper, or other suitable material, with graduated lines upon which a pen or stylus draws a record indicating the variables being measured.

6.6.2 Material

6.6.2.1 Paper charts made from seven-point paper shall have a tolerance of 7.0 to 7.5 mils. The paper shall have a density of at least 51 lbs. per cubic foot or .82 grams per cubic centimeter, and should have a surface smoothness and surface hardness designed to resist drag by the pen or stylus and to properly absorb the ink.

6.6.2.2 Charts made from materials other than paper should conform to the dimensional specifications set forth below.

6.6.3 Dimensions

6.6.3.1 Measurement. Dimensions of the printed image shall be based on Figure 5. The “a” dimension shall be the radius of any graduation taken across the grain of the paper. The “b” dimension shall be radius of any graduation. Radial dimensions shall be taken from the center of the graduation. All measurements shall be made after the paper has been conditioned for 24 hours at standard conditions of 73.4°F ±6.3°F (23°C ±3.5°C) and relative humidity of 50% ±2%.

6.6.3.2 Mean Radius. The mean radius shall be calculated from the expression:

$$\frac{a_1 + a_2 + b_1 + b_2}{4}$$

The mean radius of the zero and full-range graduations shall be within ±2 mils of the calculated or correct value. The mean radius of all other major graduations shall be within ±3 mils of the calculated or correct value.

6.6.3.3 Size.

6.6.3.3.1 All charts shall have a center hole, cut clean without any burrs or fuzz, and 0.500 to 0.503 inch (12.70 to 12.78 mm) in diameter.

6.6.3.3.2 The outside diameter of charts shall be as recommended by the original equipment manufacturer and shall have a tolerance of +.000 to –3/32 inch (+000 to –2.381 mm).

6.6.3.4 Eccentricity. Eccentricity and roundness shall be measured by determining the maximum and minimum radii (C_{max} minus C_{min}). The value shall be calculated from the expression C_{max} minus C_{min}. The eccentricity shall not exceed 3 mils in the inner portion of the chart. Beyond a 3-inch radius, eccentricity shall not exceed 1.5 mils per inch (25.4 mm) radius.

6.6.3.5 Major Graduations. The charts shall contain major graduations representing some regular function of the full chart range. One of these graduation lines shall represent 0% of full scale range and one shall represent 100% of full scale range. Line widths shall be 11 mils ±2 mils. When specified by the user, the zero graduation may be in accordance with specifications for minor graduations or intermediate graduation.

6.6.3.6 Minor Graduations. The charts shall have minor graduations between the major graduations. It is recommended that the number of these minor graduations be one, five or ten. Line widths shall be 3 mils ±1.5 mils.

6.6.3.7 Sub-Major Graduations. A sub-major graduation may be used between graduations to better delineate minor graduations. The line widths of sub-major graduations shall be 7 mils ±2 mils.

6.6.3.8 Time Arc. Time arc lines are nominally radial across the face of the chart from zero to full scale and shall follow the arc of the pen of the instrument for which the chart is intended. The time arc lines shall not deviate from the design radius of the pen arm by more than ±5 mils. The spacing between the time arc lines, referred to as the midpoints of the arc lines, shall not deviate at any point on the line from the correct angle ±0.50 when measured from a zero reference line such as 12 noon. Major arcs such as hours or days shall have widths the same as major graduations.

Where the chart is graduated uniformly, it shall be graduated along the arc.

6.6.4 Identification. All charts shall be marked to show the name or trademark of the chart manufacturer, and an identifying code number established by the manufacturer or the instrument number and the range of the identification number indicating the plate from which the chart was printed.

6.6.5 Specifications.

6.6.5.1 Dimensional Stability—Humidity. The chart shall be made of a material that will withstand a relative humidity variation of ±30% relative humidity from base conditions of 50% relative humidity with a total dimensional deviation of less than 1% when measured across the grain. Measurements shall be made on two samples with one being raised to 80% relative humidity and the other being lowered to 20% relative humidity. The material shall have sufficient memory across the grain to return to within ±0.3% of the original dimensions after undergoing a 30% change in relative humidity and being restored to original conditions. Refer to 6.6.3.1 for dimensional measurements.

6.6.5.2 Strength. Paper shall have sufficient strength so as not to tear during normal operation of the instrument.

6.6.5.3 Inking Qualities. When used with the ink recommended by the manufacturer or supplier, the charts shall produce a clear, legible, unblurred record, without blotting or running. (See 6.6.5.6.) Tests shall be made using clean, standard pens mounted to simulate the actual recording method.

6.6.5.4 Smoothness. The chart surface shall produce minimum resistance to the motion of the pen. The surface shall be free from particles that might tend to clog the pen point. Watermarks shall not be permitted.

6.6.5.5 Finish. Charts shall be printed on paper having an image face finish of 75 BEKK ±25%, or a Sheffield finish between 60 and 120 prior to printing.

6.6.5.6 Recording Inks and Pens. The proper application of inks and pens depends on various factors. Among those factors to be considered are humidity, ambient temperature, type of pen design and capillary system.

6.6.5.7 Chart Changers. Chart changers for recording instruments shall be designed so that the resulting chart record is not adversely affected.

6.7 RECORDERS

Recorders may be used to record the variables of time, pressure, temperature or volume, or combinations thereof. These recorders shall conform to the construction and acceptance standards of 6.1.5 and 6.1.7.

All recorders shall be installed in conformance to 6.1.6. The components of these recorders shall conform to sections 6.2, 6.3, 6.4, 6.5 and 6.6, where applicable.

6.7.1 Pressure Recorders—Circular Charts

6.7.1.1 Definition. A pressure recorder is an auxiliary device designed to record variations of pressure relative to time by means of a clock-driven circular chart.

6.7.1.2 Identification. All pressure recorders shall have permanent identification of pressure range and chart, in addition to the requirements of 6.1.4.

6.7.2 Temperature Recorders—Circular Charts

6.7.2.1 Definition. A temperature recorder is a auxiliary device designed to record variations of temperature relative to time by means of clock-driven circular charts.

6.7.2.2 Identification. All temperature recorders shall have permanent identification of temperature range and chart, in addition to the requirements of 6.1.4.

6.7.3 Pressure and Temperature Recorders—Circular Charts

6.7.3.1 Definition. A pressure and temperature recorder is an auxiliary device designed to record variations in pressure and temperature relative to time by means of a clock-driven circular chart.

6.7.3.2 Identification. All pressure and temperature recorders shall have permanent identification of pressure range, temperature range and chart, in addition to the requirements of 6.1.4.

6.7.4 Pressure and Volume Recorders with Meter-Driven Circular Chart

6.7.4.1 Definition. A pressure-volume recorder is an auxiliary device designed to record variations in pressure relative to volume by means of a circular chart driven by the meter. The area under the pressure recording is related to the volume corrected for pressure.

6.7.4.2 Identification. All pressure-volume recorders shall have permanent identification of the pressure range, chart and rotational information, in addition to the requirements of 6.1.4.

6.7.5 Temperature and Volume Recorders with Meter-Driven Circular Chart

6.7.5.1 Definitions. A temperature-volume recorder is an auxiliary device designed to record variations of temperature relative to volume by means of a circular chart driven by the meter. The area under the temperature recording is related to the volume corrected for temperature.

6.7.5.2 Identification. All temperature volume recorders shall have permanent identification of temperature range and rotational information, in addition to the requirements of 6.1.4.

6.7.6 Pressure, Temperature and Volume Recorder with Meter-Driven Circular Chart

6.7.6.1 Definition. A pressure-temperature-volume recorder is an auxiliary device designed to record variations in pressure and temperature relative to volume by means of a circular chart driven by the meter.

6.7.6.2 Identification. All pressure-temperature-volume recorders shall have permanent identification of pressure range, temperature range and rotational information, in addition to the requirements of 6.1.4.

6.7.7 Pressure and Volume Recorder with Clock-Driven Circular Chart

6.7.7.1 Definition. A pressure and volume recorder are an auxiliary device designed to record variations of pressure and units of volume relative to time by means of a clock-driven circular chart.

6.7.7.2 Identification. A pressure and volume recorder shall have permanent identification of the pressure range, and chart and rotational information, in addition to the requirements of 6.1.4.

6.7.8 Temperature and Volume Recorder with Clock-Driven Circular Chart

6.7.8.1 Definition. A temperature and volume recorder are an auxiliary device designed to record variations in temperature and units of volume relative to time by means of a clock-driven circular chart.

6.7.8.2 Identification. All temperature and volume recorders shall have permanent identification of temperature range, and chart and rotational information, in addition to the requirements of 6.1.4.

6.7.9 Pressure, Temperature and Volume Recorder with Clock-Driven Circular Chart

6.7.9.1 Definition. A pressure, temperature and volume recorder are an auxiliary device designed to record variations in pressure and temperature and units of volume relative to time by means of a clock-driven circular chart.

6.7.9.2 Identification. A pressure, temperature and volume recorder shall have permanent identification of the pressure range, the temperature range, and chart and rotational information, in addition to the requirements of 6.1.4.

6.7.10 Demand Recorder. A demand recorder records on a chart or tape the corrected or uncorrected volume metered during a recurring predetermined period of time. Demand recorders perform their function by means of a time-based chart, printout or tape.

6.8 AUTOMATIC INTEGRATORS

Automatic integrators automatically apply correction factors to a volume-related input. These correction factors can be the function of either single variables or multiple variables.

6.8.1 Recording Type. This type of automatic integrator is equipped with corrected and uncorrected volume counters and a chart to record the time, pressure, temperature or volume, or combination thereof.

6.8.2 Non-Recording Type. This type of automatic integrator is equipped with corrected and uncorrected volume counters.

6.8.3 Automatic Integrating Device for Pressure

6.8.3.1 Definition. An automatic integrating device for pressure is an auxiliary device designed to automatically correct a volume-related input to some predetermined base pressure condition.

6.8.3.2 Identification. All automatic integrators for pressure shall have permanent identification of the pressure range, multipliers for counters, designated atmospheric pressure, contract base pressure and rotational information of the instrument drive, in addition to the requirements of 6.1.4. Information regarding the volume per revolution of the instrument drive should be affixed to the instrument. Where the automatic integrator is supplied in combination with a recorder, additional identification is required in conformance with the applicable portions of Section 6.7.

6.8.4 Automatic Integrating Device for Temperature

6.8.4.1 Definition. An automatic integrating device for temperature is an auxiliary device designed to automatically correct a volume-related input to some predetermined gas temperature condition in accordance with Charles' Law.

6.8.4.2 Identification. All automatic temperature integrating devices shall have permanent identification of temperature range, multipliers for counters, base temperature, rotational information and volume per revolution of instrument drive in addition to the requirements of 6.1.4. Where the automatic integrator is supplied with a recorder, additional identification is required in conformance with the applicable portions of Section 6.7.

6.8.5 Automatic Integrating Devices for Pressure and Temperature

6.8.5.1 Definition. An automatic integrating device for pressure and temperature is an auxiliary device designed to automatically correct a volume-related input to some predetermined base pressure and base temperature condition in accordance with Boyle’s Law and Charles’ Law.

6.8.5.2 Identification. All automatic integrating devices shall have permanent identification for pressure and temperature ranges, multipliers for counters, atmospheric pressure, contract base pressure, base temperatures, rotational information and volume per revolution of instrument drive, in addition to the requirements of 6.1.4. Where the automatic integrator is supplied with a recorder, additional identification is required in conformance with the applicable portion of 6.7.

6.9 CONSTANT-PRESSURE-COMPENSATING INDEX

6.9.1 Definition. A constant-pressure-compensating index is an index used to indicate a gas volume converted to a contract base pressure when used in conjunction with a gas meter operated at a constant pressure other than the contract base pressure. See also 1.13.

6.9.2 Construction

6.9.2.1 Test Dials. All compensating indexes shall be equipped with a prover test dial designed to indicate the uncorrected volume being delivered through a gas displacement meter.

6.9.2.2 Gear Ratios. The gear train between the prover test dial and the 1,000-cubic-foot hand shall be designed to have a gear ratio, as near as practical, not to exceed ±0.75% to the theoretical ratio required to correct the indicated volume in accordance with Boyle’s Law. This theoretical gear ratio shall be based on a designated atmospheric pressure, a contract base pressure and the pressure delivered through the meter.

6.9.2.3 Identification. Standard constant-pressure-compensating indexes shall be constructed with a red color dial face. Other colors may be used for dial circle background to improve readability. All markings and all lettering must be of contrasting color. The index face shall be permanently marked with the actual gear ratio in fractional form.

6.9.3 Standard Ratings. Standard constant-pressure indexes shall be manufactured to compensate, as nearly as practical, for the following conditions:

a. 14.4 psia atmospheric pressure
b. 14.73 psia contract base pressure
c. 2, 5, 10, 15, 20, 30 or 50 psig metering pressure

Note: For metric conversion 1 lbf/in^2 = 6.8948 kPa

6.9.4 Non-Standard Conditions. Each manufacturer should provide a set of adjusted gas delivered pressure tables for each of their indexes, taking into account the following factors:

a. The difference between the theoretical and actual gear ratio.
b. Average atmospheric pressure in a minimum of 500 feet increments for the elevations from 0 to 5,000 feet above sea level.
c. Base pressures of 14.65 psia, 14.73 psia, 4 ounces above atmospheric and 8 ounces above atmospheric, respectively.

Note: For metric conversion 1 lbf/in^2 = 6.8948 kPa

6.9.5 Application. A small indicated gas volume error is sometimes introduced by the use of pressure-compensating indexes as it is not always practical to exactly match the required theoretical gear ratio since the average atmospheric pressure or the contract base pressure, or both, may be at variance with the standard design pressures. Methods of compensating for these errors and for proper use of the compensating indexes for other than the standard design atmospheric pressure and base pressure shall be considered.

6.10 REMOTE METER READING DEVICES

6.10.1 Definition.

A remote reading device for a gas meter continuously provides or reproduces a reading of the meter index, at a point remote from the meter. The reading may be displayed for visual observation, recorded in a portable device or transmitted to a distant point.

6.10.1.1 Continuous Monitoring. A continuous monitor is a device that transmits the volume reading to the remote register during the consumption period. Several of these types are:

a. Self-generating electrical pulsing device
b. Externally powered electrical pulsing device
c. Pneumatic pulsing device
d. Direct drive

6.10.1.2 Periodic Interrogation. A periodic interrogator is a device that transmits the volume reading to the remote location on a request basis or predetermined time basis. Several of these types are:

a. Encoder-register with electromechanical switching
b. Encoder-register with electro-optical switching

6.10.2 General System Requirements

6.10.2.1 Compatibility. The encoder-register component of a remote reading system shall be compatible with a maximum number of different gas meters in order to enhance its installation in an established gas distribution system. The encoder-register component shall not cause accelerated wear or shorten the useful life of the gas meter and shall comply with applicable safety standards.

6.10.2.2 Accuracy. The remote reading system shall reproduce the meter index reading within ±1 count. The addition of the system shall not be detrimental to the measurement accuracy of the meter itself.

6.10.2.3 Readability. The remote reading read-out shall have the same readability as required for the standard displacement meter index as detailed in section 2.7 B109.1 and B109.2. If the remote reading system has an electrically illuminated display, it shall be readable under all conditions of lighting, including direct sunlight.

6.10.2.4 System Compatibility. If the system is of the recording type (punch card, magnetic tape, etc.), the recording system should provide data convertible to conventional data-processing equipment in current use.

6.10.2.5 Installation. The installation of the remote reading system shall be made in accordance with the manufacturer's specifications, including distance limitations between the gas meter and the remote station and use of properly sized electrical conductors. All materials used in making the installation shall be rust- and corrosion-resistant and shall not discolor the customer's property. The entrance of the conductor or conduit into the customer's home shall be made in such a manner as to prevent the entrance of water or vermin. Electrical wiring shall comply with all codes where applicable.

6.10.2.6 In-Service Performance. Reliability of the remote system shall be demonstrated by its continued ability to provide remote readings that reproduce the meter index. Local and remote components and the interconnecting conductors shall retain their structural integrity and be securely fastened in place.

6.10.3 Encoder Specification. The encoding register, which is to be attached to the gas meter, shall be identified with the following information, in addition to the requirements of section 6.1.4:

a. Meter size and make
b. Units of measurement (e.g., cubic feet × 100)

6.10.4 Remote Register Specification. The remote read-out unit shall provide for positive identification of the customer to prevent billing errors. Units of measure shall be made in the design to permit the resetting of the remote register.

6.11 INSTRUMENT ADAPTOR PLATES

6.11.1 Definition. An instrument adaptor plate is a mounting surface of suitable material mounted on and driven by a gas displacement meter. The instrument adaptor plate mounts between the meter and instrument and provides the correct instrument drive rotation and speed or displaced volume per revolution with respect to the meter output drive shaft.

6.11.2 Instrument Adaptor Plate Identification. All adaptor plates shall have a badge containing the following information:

a. Rotational information
b. Internal gear ratio
c. Position of adaptor plate relative to meter and instrument

6.12 INSPECTION AND TESTING CLASSIFICATION

6.12.1 Classification of Inspection and Testing To Be Performed on Auxiliary Devices.

6.12.1.1 Inspection should be made on all auxiliary devices for:

a. Physical damage
b. Mechanical defects
c. Conformance to standards as set forth herein

6.12.1.2 The complexity of the test and the number of test points should be a function of the desired operational data required and the economics involved. The test classification shall be designated as Type I, Type II and Type III.

6.12.1.2.1 Type I Tests. One or more points for the pressure system or the temperature system or both. It is recommended that one of the test points for each system be at nominal operating conditions.

6.12.1.2.2 Type II Tests. Three test points on the pressure system at approximately 10%, 50%, and 90% of the fall range. Two test points on the temperature system spanning a minimum range of 30°F (16.7°C).

6.12.1.2.3 Type III Tests. Five test points on the pressure system at approximately 10%, 30%, 50%, 70% and 90% of the full range. Three points on the temperature system at approximately 0°F, 60°F and 120°F (–17.8°C, 15.6°C and 48.9°C).

6.12.2 Test Equipment. Test equipment should conform to the requirements of 6.1.2.

6.12.3 Auxiliary Devices Classification

6.12.3.1 Definition of New Types. This classification includes all newly designed auxiliary devices. These devices shall be tested for acceptance at the applicable Type III test points and shall meet all applicable standards included in Part VII.

6.12.3.1.1 Pressure Recorders. These recorders shall not exhibit hysteresis errors greater than 0.50 percent of full scale and shall conform to the accuracy requirements of 6.1.7.2.3. All such tests shall be made using charts or scales certified by the manufacturer.

6.12.3.1.1.1 The procedure for testing pressure recorders shall be as follows:

a. Apply pressure proceeding up scale to each test point
b. Apply full-scale pressure and proceed down scale to each test point
c. Check the pen arc and chart trace

6.12.3.1.2 Temperature Recorders. These recorders shall conform to the accuracy requirement of 6.1.7.2.4. All such tests shall be made using charts or scales certified by the manufacturer.

6.12.3.1.2.1 The procedure for testing temperature recorders shall be as follows:

a. With the probe in an agitated liquid bath at approximately 60°F (15.6°C), the temperature indicator should be set to coincide with the bath temperature after stabilization.
b. Check the calibration at approximately 0°F (–17.8°C).
c. Check the calibration at approximately 120°F (48.9°C).

6.12.3.1.3 Volume Recorders. Volume recorder should be checked by rotating the input shaft the required number of revolutions to obtain one complete cycle of the volume indicator.

6.12.3.1.4 Clocks. Clocks shall conform to the requirements of 6.5.

6.12.3.1.5 Automatic Pressure-Integrating Devices. These devices shall be capable of adjustment so that all of the applicable specified test points in Section 6.12.1.2.3 conform to the accuracy limits of 6.1.7.2.5.1. These devices should be capable of being cycled up and down the scale at any of the specified test points.

6.12.3.1.6 Automatic Temperature-Integrating Devices. These devices should be capable of adjustment so that all of the applicable specified test points in Section 6.12.1.2.3 conform to the accuracy limits of Section 6.1.7.2.5.2.

6.12.3.1.7 Automatic Pressure- and Temperature-Integrating Devices. Accuracy, calibration and cycling test of these devices shall conform to sections 6.12.3.1.5 or 6.12.3.1.6, respectively, when each function is calibrated and tested individually. In all cases, the overall accuracy shall be within the limits specified in Section 6.1.7.2.5.3 when tested in combination at any of the specified pressure and temperature test points.

6.12.3.1.8 Combination Recording or Integrating Devices or Both. Auxiliary devices, which include any combination of the devices, covered by Section 6.12.3 shall conform to the specified requirement for the individual component. Only those components that are of new design shall be subject to the requirement of Section 6.12.3.1.

6.12.3.2 Definition of Newly Purchased Types. Newly purchased auxiliary devices are devices that have been previously approved under the requirements of 6.12.3.1 (New Types) and have never been in service. These devices should be inspected to ensure freedom from damage and mechanical defects and to ensure conformance with the standards set forth. This may be accomplished by 100 percent inspection or by an acceptable statistical sampling plan.

6.12.3.2.1 Recording and Integrating Devices. These devices shall be tested for acceptance at the applicable Type I or Type II test points. The intended application of the auxiliary device should determine the type test points to be used. They should also meet all applicable portions of sections 6.7 and 6.8.

6.12.3.2.2 Pressure-Compensating Indexes. These devices should conform to section 6.9. They should be tested by checking the gear ratio between the input shaft and the first reading circle.

6.12.3.3 In-Service Types. In-service auxiliary devices are devices that are, or have been, in service.

6.12.3.3.1 Recording or integrating in-service auxiliary devices shall be either field- or shop-tested in conformance with the applicable Type I test points as specified in 6.12.1.2.1. Where these devices are found to be outside the limits of point accuracy of 98 percent to 101 percent, they shall be adjusted to a point accuracy within 98 percent to 101 percent.

6.12.3.3.1.1 Tests on recording and integrating devices should coincide, where practical, with the periodic meter test. However, the period between tests on the auxiliary devices may be altered if a surveillance system is in effect.

PART VII
TEST METHODS AND EQUIPMENT

7.1 SCOPE

This part establishes identification of measurement standards, test equipment and test methods for gas displacement meters and related measurement devices.

7.2 MEASUREMENT REFERENCE BASE

The final authority for all standards of measurement in the United States is the National Institute of Standards and Technology (NIST), U.S. Department of Commerce, whose function includes the following assigned by Public Law 619 of the 81st Congress (64 Stat. 371, 5USC 271-286): “The custody, maintenance and development of national standards of measurements, and the provision of means and methods for making measurements consistent with these standards.”

7.3 UNITS OF MEASURE

The legal values of measure are those represented by, or derived from, the national standard. Within the scope and purpose of this standard, all units of measure that are necessary in the testing of gas displacement meters, meter testing devices and associated apparatus shall conform to those legal values.

7.4 BASE CONDITIONS

For the purpose of defining a volumetric unit for measure of gas, a base pressure and temperature must be established, because of the behavior of gases when subjected to changes of pressure or temperature.

Boyle’s Law states that the volume occupied by a given mass of gas varies inversely with the absolute pressure if the temperature remains constant.

Charles’ Law states that the volume occupied by a given mass of gas varies directly with the absolute temperature if the pressure remains constant.

By combination of these two laws, the relationship of PV/T = Constant is derived.

These laws are exactly applicable as stated only to perfect gases—which do not exist. Actual gases at elevated pressure deviate from these laws.

At an absolute pressure close to one atmosphere, the deviation is negligible so that a volume measured at an observed pressure and temperature other than the established base pressure and temperature may be corrected to base conditions by the formula:

$$V_b = V_f \times \frac{P_f}{P_b} \times \frac{T_b}{T_f}$$

where

V_b = volume at base conditions
V_f = volume registered by meter at flowing conditions
P_f = flowing pressure metered, absolute
P_b = base pressure, absolute
T_f = flowing temperature, absolute
T_b = base temperature, absolute

In testing a gas meter for accuracy, it is not necessary that the gas be at base conditions; however, the reference volume and the compared metered volume must be referred to the same conditions. When the two are not at the same conditions, one must be corrected to the condition of the other by use of the above formula.

When the pressure difference between the reference volume and the metered volume is greater than one atmosphere, the effect of deviation from the perfect or ideal gas laws should be considered through the use of the following formulae or appropriate tables, see the “Manual for the Determination of Supercompressibility Factors (F_{pv}) for Natural Gas,” PAR Research Project NX-19, or “Compressibility and Supercompressibility for Natural Gas and Other Hydrocarbon Gases,” AGA/TMC Report No. 8.

The formula using compressibility factors is as follows:

$$V_b = V_f \times \frac{P_f}{P_b} \times \frac{T_b}{T_f} \times \frac{Z_b}{Z_f} \quad \text{when} \quad Z_b = \frac{1}{\left(F_{pv}\right)_b^2} \quad \text{and} \quad Z_f = \frac{1}{\left(F_{pv}\right)_f^2}$$

Substituting in the above equation:

$$V_b = V_f \times \frac{P_f}{P_b} \times \frac{T_b}{T_f} \times \frac{\left(F_{pv}\right)_f^2}{\left(F_{pv}\right)_b^2}$$

where

$(F_{pv})_f$ = supercompressibility factor at flowing conditions
$(F_{pv})_b$ = supercompressibility factor at base conditions
Z_f = compressibility factor at flowing conditions
Z_b = compressibility factor at base conditions

7.5 METER TESTING SYSTEMS

7.5.1 General. This section describes the systems, test equipment and methods that are currently available and accepted for testing the accuracy of meters.

7.5.2 Test Requirement. The necessary requirements in an acceptable system of testing are the ability to perform suitable tests with adequate accuracy.

7.5.3 Accuracy. The highest reasonable accuracy should be obtained in testing. The accuracy of any method of testing is dependent on many factors, which include:

a. Accuracy of Test Standards. The accuracy of a device or meter used as a standard for testing displacement gas meters is the accuracy obtainable with reasonable skill in practical use. The accuracy varies with the type of device and is affected by many factors including ambient temperature variations, pressure variations, length of scale, accuracy of scale markings, friction, torque and seal viscosity.
b. Uncertainties of Observation. Errors of observation may be due to estimation of fractions of scale divisions, improper averaging of instrument readings during fluctuating flow, parallax, start and stop errors of standard gasometer, meter or timing device.
c. Uncertainties in Method of Test. Errors in method of testing are due to improper use of standards, improper calculations of measurements or improper connections of test unit to standard.

7.5.4 Suitability of Test System. Test systems should, under normal conditions, be designed for use with various types of meters. In-service test systems should involve minimum size and weight and be designed for convenient use with the meter installation normally found.

7.5.5 Bell, Piston, and Transfer Provers.

7.5.5.1 Description. The bell prover is a positive or negative low-pressure, liquid-sealed, counter-balanced gasometer that is calibrated for use as a device to measure the volume of gas delivered to or received from a meter.

The piston prover is a positive low-pressure, mechanically sealed, hydraulically balanced gasometer that is calibrated for use as a device to measure the volume of gas delivered to a meter.

The transfer prover is a reference meter of known accuracy with associated equipment required for its operation as a calibration system.

Each of these provers may be equipped to operate manually or semi-automatically.

7.5.5.2 Method of Testing. The meter to be calibrated should be connected to a prover of adequate volume to permit the duration of any test to provide both an integral number of cycles of the meter mechanism and an integral number of revolutions of a displaced volume indicator.

If these conditions are not obtainable, the test should be based on a sufficient volume to cause the effect of partial revolutions of the meter mechanism, and metered volume indicator, to be less than ±0.1%.

The volume registered by the meter indicator is compared with the volume indicated by the prover both corrected to the same pressure and temperature, as an indication of the accuracy of the meter.

7.5.5.3 Pressure and Temperature Control. A correction for pressure difference between a prover and meter should be applied whenever the pressure differential at any flow exceeds 0.4 inch water column (100 Pa).

The pressure variation within the prover bell should not exceed 0.05 inch water column (12 Pa) throughout the travel of the bell.

Meters may be tested at any convenient temperature provided the following conditions are considered:

a. If meter, prover and proving environment are within 0.5°F (0.3°C) of the same temperature, no temperature correction is needed.
b. If meter, prover and proving environment are at temperatures differing more than 0.5°F (0.30°C), temperature correction shall be applied.
c. If the temperature of the proving environment is changing by more than 1°F (0.6°C) in an hour, testing is not recommended.

Test flow rates shall be in accordance with 4.2.2.

7.5.5.4 Meter Accuracy. For equivalent results in testing meters under pressure or vacuum proving:

$$\text{Percent Accuracy} = \frac{V_m}{V_p} \times \frac{P_m}{P_p} \times \frac{T_p}{T_m} \times 100$$

where

V_m = metered volume registered
V_p = prover volume displaced
P_m = meter inlet pressure, absolute
P_p = prover pressure, absolute
T_m = meter inlet air temperature, absolute
T_p = prover air temperature, absolute

For pressure proving, P_m and P_p will have values above atmospheric pressure; however, for vacuum-proving P_m will equal atmospheric and P_p will be below atmospheric pressure.

"Percent Accuracy" is recommended for use as a standard for comparing meter accuracy statistics. Formulae listed in Appendix D are some of the other methods used to determine meter test results.

7.5.6 Low-Pressure Orifice Flow Provers and Critical Flow Orifice Provers. In addition to the volume displacement devices used for meter proving, such as bell provers and portable transfer provers, there are other provers. These devices can be used for determining the accuracy of displacement meters at their in-service locations.

7.5.6.1 Low-Pressure Flow Orifice Prover. Two types of low-pressure orifice flow provers are currently available. On one type of prover, the differential pressure is measured across a pipe tap located one pipe diameter upstream of the orifice disc and a second pipe tap located approximately eight pipe diameters downstream of the orifice disc. The pressure eight pipe diameters downstream is normally equal to the atmospheric pressure. This being the case, only the upstream pressure is sensed to obtain differential pressure. This prover, construction-wise, resembles a pipe tap orifice meter. On the other type prover, the differential pressure is measured across flange taps provided in the upstream and downstream orifice disc flanges. The prover is essentially a flange tap orifice meter. Complete instructions for use of low-pressure flow orifice provers can be found in the following publications:

AGA Gas Measurement Committee Report No. 6, Methods of Testing Large Capacity Displacement Meters, "Part I—Low Pressure Flow Orifice Provers (Pipe Tap)," "Part II—Low Pressure Flow Orifice Provers (Flange Tap)"

The low-pressure orifice flow prover resembles a pipe tap orifice meter and consists of two sections of pipe held together by specially designed orifice flanges equipped with fast connecting bolts. Each prover is equipped with provisions for measuring pressure and temperature as required. The orifice discs are individually calibrated against a bell prover and the time required to pass 1 cubic foot (0.0283 m^3) of air at standard conditions is stamped on the downstream side of the disc. Air, the source of which may be a portable blower, is normally the test medium. Where it may be safely exhausted into the atmosphere, natural gas may be used as a test medium.

7.5.6.2 Use of the Low-Pressure Orifice Flow Prover. The various parameters are read out on gauges associated with the flow prover, and convenient tables for use with these readings are referenced to calculate the instantaneous flow rate. It is necessary, therefore, that the pressure and gas flowing temperature between meter and prover remain constant during the course of a test run. The average of several readings taken during a run may give accurate results if fluctuations are sufficiently small.

If a blower is used to provide air flow for pressure testing, there is the possibility that the flowing temperature will change so rapidly that accurate averaging will be difficult. To overcome this condition, it may become necessary to change from pressure-proving to vacuum-proving. In vacuum-proving, the inlet of the blower is installed on the outlet of the meter being calibrated and ambient air is caused to move through both the flow prover and the meter under test. Similar tables may be used for vacuum-proving as in pressure-proving; however, since the relation of the meter and the prover are different, the pressure and temperature adjustments for the difference between meter and prover may be different.

7.5.6.3 Critical Flow Orifice and Sonic Flow Nozzles. The critical flow orifice and sonic flow nozzle provers are devices that can be used to test displacement meters at elevated pressures. Gas or air is passed through the meter and the prover, then discharged into the atmosphere. Its components are a short piece of pipe with a high-pressure orifice holder on the end, a calibrated orifice or nozzle, and taps for measuring upstream pressure and temperature.

To perform a test, the prover is connected directly to the meter outlet. To ensure critical flow has been reached in the prover, it is necessary that the ratio of absolute inlet pressure to absolute outlet pressure be at least 2-to-1 for critical orifice discs and 1.25-to-1 for sonic nozzles. The prover nozzle or orifice is calibrated in terms of "Standard Time" for a known flow. This is compared with a "Test Time" derived by timing the proper number of revolutions of the proving hand on the meter under test. This timing is usually done with a hand-held stopwatch, and the test interval should be at least 3 minutes to minimize errors. Critical flow-proving requires considerably more gas than proving with a low-pressure prover for the same index registration. This increase is approximately equal to:

$$\text{Increase} = \frac{\text{Flowing Pressure, Absolute}}{\text{Atmospheric Pressure}}$$

Flow tests run with a critical flow prover will cause noise levels considerably higher than those resulting from other proving methods. Additional information on the use of critical flow provers can be found in the following publications:

a. *AGA Gas Measurement Committee Report No. 6, Methods of Testing Large Capacity Displacement Meters* "Part IV—Critical Flow Prover"
b. *AGA Gas Measurement Manual Part No. 12*, "Meter Proving"

7.6 CALIBRATION OF METER TESTING SYSTEMS

7.6.1 General. Calibration of meter testing systems shall be conducted under known and controlled conditions, wherein the accuracy of volumetric containers, tapes, scales and other state-of-the-art measurement devices are traceable to the National Institute of Standards and Technology (NIST).

Meter testing systems shall be calibrated when first installed and following alterations, damage or repairs that might effect accuracy. To ensure that the accuracy of the meter testing systems is maintained on a continuous basis, a daily leakage test shall be made and a periodic accuracy indication with a test meter of known accuracy shall be made. If the test results differ by more than ±0.5% from the test meter accuracy, the cause of error shall be determined and necessary corrections made prior to reuse of the system.

7.6.2 Calibration of Bell- and Piston-Type Provers. Bell- and piston-type gas meter provers or gasometers shall be calibrated with an immersion-type cubic-foot bottle or cubic-foot standard or by dimensional measurement using state-of-the-art techniques.

All provers shall be calibrated for the entire length of the prover scale. Provers used for testing meters at less than rated prover volume shall also be calibrated at scale reference points used in the meter tests.

7.6.2.1 Calibration by Volumetric Comparison. Volumetric calibrations may be established by the transfer of a gaseous volume from a cubic-foot bottle or standard into a prover bell or from a prover bell into a cubic-foot bottle or standard. Calibration shall be conducted under stable temperature conditions where temperature differences of all equipment and ambient air do not exceed 0.5°F (0.3°C) unless proper correction is applied. Sealing fluid for use in the bell prover and the cubic foot bottle or standard shall be an oil or other medium of low vapor pressure and low viscosity corresponding to the typical specifications in Table III.

TABLE III
SPECIFICATION, PROVER SEALING FLUID

Viscosity at 100°F (37.8°C)	55-75 seconds Saybolt (11×10^{-6} to $14.5 \times 10^{-6} m^2/s$)
Vapor Pressure at 200°F (93.3°C)	Less than 0.60 mm mercury (80 Pa)
Specific Gravity at 60°F (15.6°C)	0.848 to 0.878 (water, 1.0)
Pour point	Not more than 25°F (-4°C)
Flash point	Not lower than 300°F (149°C)

Fire point	Not lower than 310°F (154°C)

7.6.2.2 Calibration by Dimensional Measurement. Calibration of bell and piston provers may be more consistently achieved by physical measurements than by volumetric comparisons because temperature and pressure variations have no appreciable effect on measurement. The capacity of a prover bell or its internal volume discharged between any two points of travel will be equal to the cylinder volume above the sealing liquid at the first position, minus the cylinder volume above the liquid at the second position, plus the volume of metal in scale and other appurtenances that become immersed in the liquid, and minus the volume of seal fluid that rises between the outside of the bell and the main tank. To ensure accurate results, the prover bell and counterweights must be adjusted to provide the same pressure within the bell at any bell position, and a minimum of 3 minutes must be allowed for sealing liquid drainage prior to measurements.

Volume of air (Q) displaced by the bell is expressed by the formula:

$$Q = 0.7854\,[A^2L - (R^2 - A^2)I + G^2FH] + CDE + J$$

where

A = Average prover bell outside diameter
C = Scale length immersed in seal
D = Scale width
E = Scale thickness
F = Scale button length
G = Scale button diameter
H = Number of scale buttons immersed in seal
I = Rise in seal level
J = Volume of appurtenances immersed in seal
K = Average distance between tank and bell
L = Length of prover scale between zero and point in question
R = Inside diameter of tank (A + 2K)

Details of the test procedure are covered in Appendix D.

The piston prover, usually a large-volume gasometer, is readily calibrated by dimensional measurement, where the effective diameter of the cylinder may be determined with an inside micrometer with extension rods. The stroke of the piston may be defined using a pin bar that actuates an electronic counter, or other instruments of comparable accuracy. The accuracy of these measurement devices shall be traceable to the National Institute of Standards and Technology (NIST). Displaced volume (Q) may be expressed by the formula:

$$Q = 0.7854\,(A^2 - B^2)\,C$$

where

A = Cylinder inside diameter
B = Piston rod diameter
C = Piston stroke

7.6.3 Calibration of Transfer Provers. Transfer provers shall be calibrated under controlled temperature, pressure and flowing conditions and the accuracy of the prover determined at a sufficient number of points to enable a reliable flow rate versus accuracy curve to be drawn over the full range of its intended use. Calibration tests shall be performed using a reference standard of known accuracy such as a bell- or piston-type prover of adequate capacity. Pressure and temperature differences between the reference standard and the transfer prover shall be recorded at each flow rate and the volume appropriately corrected. The transfer prover sensing and timing equipment, temperature sensor and read-out, pressure sensor and read-out, and timing indicators shall be checked and calibrated against recognized standards of known accuracy.

APPENDIX A
DIFFERENTIAL TESTING

(This Appendix is informative and not a part of the standard.)

The rotary meter is constructed in such a way that the displacement volume by which it measures cannot change, but a build-up of dirt on the rotor or in the bearings can increase the friction in the meter and cause an increase in the differential pressure required to operate the meter. The need for meter maintenance, therefore, can be found by a simple differential test in the field.

At the time of installation, a differential test should be made on the meter and recorded and plotted on a graph. Then in future tests of the meter, a change in the differential will show the need of cleaning and repair of the meter.

The differential across the meter is also a function of the density of the gas. Therefore, when differential tests made at different meter operating pressures are to be compared, a correction factor must be used. This factor would be obtained from the manufacturer's data on the meter.

Equipment

The equipment needed for a differential test is a pressure gauge, stopwatch and a sensitive differential gauge with a high enough working pressure to use on the operating meter. The gauge should be equipped with a bypass manifold so it can be attached to the meter and put in service without blowing the liquid, or damaging the gauge when connecting it to an operating meter under pressure.

Differential Test Procedure

Rotary meters are all equipped with inlet and outlet pressure test connections. These connections should be fitted with valves or test plugs so as to simplify the attaching of a differential test gauge. The differential test is conducted by attaching the differential test gauge to the inlet and outlet pressure connection of the field meter. The gauge bypass valve is opened, then each of the pressure valves is opened. Then the bypass valve is closed and the differential across the meter can be read on the gauge. The index of the meter should be timed with a stopwatch, and the rate of flow obtained. The operating pressure of the meter should also be obtained and these three factors of pressure, differential and rate of flow recorded.

APPENDIX B – METER ACCURACY

This Appendix is informative and is not part of the standard)

Meter accuracy can be expressed in numerous different manners. The following information provides a resource for terminology and mathematical representation.

Percent Accuracy, or **Percent Registration** expresses the registration of volume by the meter relative to a known standard or reference, and expressed as a percentage. Results less than 100% indicate the meter is 'slow' as compared to the standard, and values above 100% indicate the meter is 'fast' as compared to the standard.

$$= \frac{V_m}{V_s} \times 100$$

Other methods of reporting meter accuracy may also be expressed as:

Percent Deviation, or **Percent Error** expresses the difference in the meter registration and the standard relative to the standard and expressed as a percentage. The result indicates the percent either fast or slow relative to the standard. A negative value indicates the metered volume is slow by the calculated percent.

$$= \frac{V_m - V_s}{V_s} \times 100$$

Percent Proof is the reciprocal of Percent Accuracy and expresses the volume of the standard relative to the metered volume expressed as a percentage. May be used as a multiplier times a metered volume to state the correct volume relative to the standard.

$$= \frac{V_s}{V_m} \times 100$$

Percent Correction expresses the difference in the meter registration and the standard relative to the metered volume and expressed as a percentage. When applied as a factor to a metered volume, the result will indicate the volume difference of the metered volume from the standard. A negative value indicates the meter is slower or has under reported the volume.

$$= \frac{V_m - V_s}{V_m} \times 100$$

Percent Error in Delivery expresses the difference in the standard and meter registration relative to the metered volume and expressed as a percentage. When applied as a factor to a metered volume, the result will indicate the unmeasured volume difference of the metered volume from the standard. A negative value indicates the meter is faster or has over reported the volume.

$$= \frac{V_s - V_m}{V_m} \times 100$$

Correction Factor expresses the ratio of the standard to meter registration. Similar to Percent Proof, but not expressed as percentage.

$$= \frac{V_s}{V_m}$$

Where:

V_m = Volume indicated by meter

V_s = Volume indicated by standard (Corrected prover Volume)

For non-temperature compensated meters.

$$V_s = V_p \left(\frac{P_p}{P_m}\right)\left(\frac{T_m}{T_p}\right)$$

For temperature compensated meters.

$$V_s = V_p \left(\frac{P_p}{P_m}\right)\left(\frac{T_b}{T_p}\right)$$

Where:

V_p = Prover volume displaced

P_p = Prover pressure absolute

P_m = Meter inlet pressure absolute

T_p = Prover air temperature absolute

T_m = Meter outlet air temperature absolute

T_b = Base temperature on index dial

APPENDIX B

METER ACCURACY

(This Appendix is informative and is not part of the standard.)

Percent Accuracy, $= \dfrac{V_m}{V_s} \times 100$

Percent Registration,

May also be expressed as:

Percent Deviation, or $= \dfrac{V_m - V_s}{V_s} \times 100$

Percent Error,
Percent Proof, $= \dfrac{V_s}{V_m} \times 100$

Percent Correction, $= \dfrac{V_m - V_s}{V_m} \times 100$

Percent Error in Delivery $= \dfrac{V_s - V_m}{V_m} \times 100$

Correction Factor, $= \dfrac{V_s}{V_m}$

where

$V_m =$ Volume indicated by meter

$V_s =$ Volume indicated by standard (Corrected prover volume)

For non-temperature compensated meters.

$$V_s = V_p (P_p / P_m)\ (T_m / T_p)$$

For temperature compensated meters.

$$V_s = V_p (P_p / P_m)\ (T_b / T_p)$$

where

$V_p =$ Prover volume displaced

$P_p =$ Prover pressure absolute

$P_m =$ Meter inlet pressure absolute

$T_p =$ Prover air temperature absolute

$T_m =$ Meter outlet air temperature absolute

$T_b =$ Base temperature on index dial

APPENDIX C

APPENDIX C

BAR CODE FOR METERS AND AUXILIARY DEVICES

(This Appendix is informative and is not part of the standard.)

TYPICAL FORMAT–GENERAL

Introduction: While there are several bar coding symbols available, this Appendix describes one that has been adopted by the National Electric Manufacturers Association (NEMA) for submission to the ANSI C-12 Committee.

Code:
Bar Code 39, using the 43 character ASCII set

Size and Type of Label:
2.3 inches long, 0.5 inches high

Printing Dimension and Format:
Code 39 bar code printed 9.4 characters per inch.
Bar 0.20 inch high.
Free Field Line 0.20 inch high
Interpretation Line 0.1 inch high

Number of Characters:
18 characters total, which are composed of 16 data characters and two start-stop asterisks.

Number of lines on label: Three (3)
Line 1: Free text, specified by buyer's purchase order
Line 2: Meter Information Line printed in Bar Code 39
Line 3: Bar Code Interpretation Line

Format of Meter Information:
See accompanying layout.

BAR CODE FOR METERS AND AUXILIARY DEVICES
TYPICAL FORMAT OF INTERPRETATION LINE

I. Overall layout

STANDARD SECTION						UNIQUE CODE	METER NUMBER								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

II. Layout of the standard section

Position	#of Char.	Description
1–3	3	Code–size, type (hard case, tin case, rotary or turbine)
4–6	3	Manufacturer

III. Layout of the unique code
Position 7–Unique code is a randomly generated alpha character that ensures the uniqueness of the meter number.

IV. Layout of the meter number.

Position	#of Char.	Description
8–16	9	Meter number–The meter number can either be the manufacturer's number or a Company assigned number.

APPENDIX D - PROVER BELL CALIBRATION BY PHYSICAL MEASUREMENT

(This Appendix is informative and not a part of the standard)

THEORY:

By inspection of Figure E-1:

(1) $Q = B + W$

(2) $B = V - M$

(3) $M + S = T + W$ or $W = M + S - T$

Substituting (2) in (1):

(4) $Q = V - M + W$

Substituting (3) in (4):

(5) $Q = V - M + M + S - T$

Therefore:

(6) $Q = V + S - T$

where

Q = Volume of air displaced by bell being lowered from point 0 to point in question

W = Volume displaced by the liquid that rises between the inner tank and the interior of the bell

B = Interior volume of the bell between point 0 to point in question

V = Volume of the outside of the bell

M =Volume of the metal of the bell

S = Volume of the scale

T = Volume displaced by the liquid that rises between the outside of the bell and the main tank

MEASURING INSTRUMENTS

Strapping Tape—A metal tape calibrated to convert circumferential measurements to diameter measurements, including a correction for its own thickness. If other than a strapping tape is used, then the apparent circumference measurement must be reduced by 3.14 times the tape thickness.

Depth Micrometer—0" to 4" [0-100 mm]

Vernier Caliper—0" to 6" [0-150 mm]

Steel Scale—Divided into 1/100 inches [0.25 mm]

Measurements Required—(All measurements in same units)

A = Average prover bell outside diameter

C = Length of prover scale moving in and out of the liquid seal

D = Width of prover scale

E = Thickness of prover scale

F = Scale button length

G = Scale button diameter

H = Number of buttons moving in and out of the liquid seal

I = Rise in liquid seal for bell travel between 0 and point in question

J =Volume of other appurtenances moving in and out of the liquid seal

K = Average distance between outer surface of bell and inner surface of outer prover tank

L = Length of prover scale between 0 and point in question

Q =Volume of bell

R = Inside diameter of tank

MEASURING PROCEDURES:

Determination of A:

Scale may be removed, otherwise the strapping tape must be around the bell, but not the scale. Measure the outside diameter of the bell with the strapping tape in five equal divisions of that portion of the bell that moves in and out of the seal. Apply approximately 2 pounds (10 N) of force in tension. While measuring, care must be taken that the tape lies flat on the bell and that it is positioned perpendicularly to the axis of the bell. Record and calculate the average diameter.

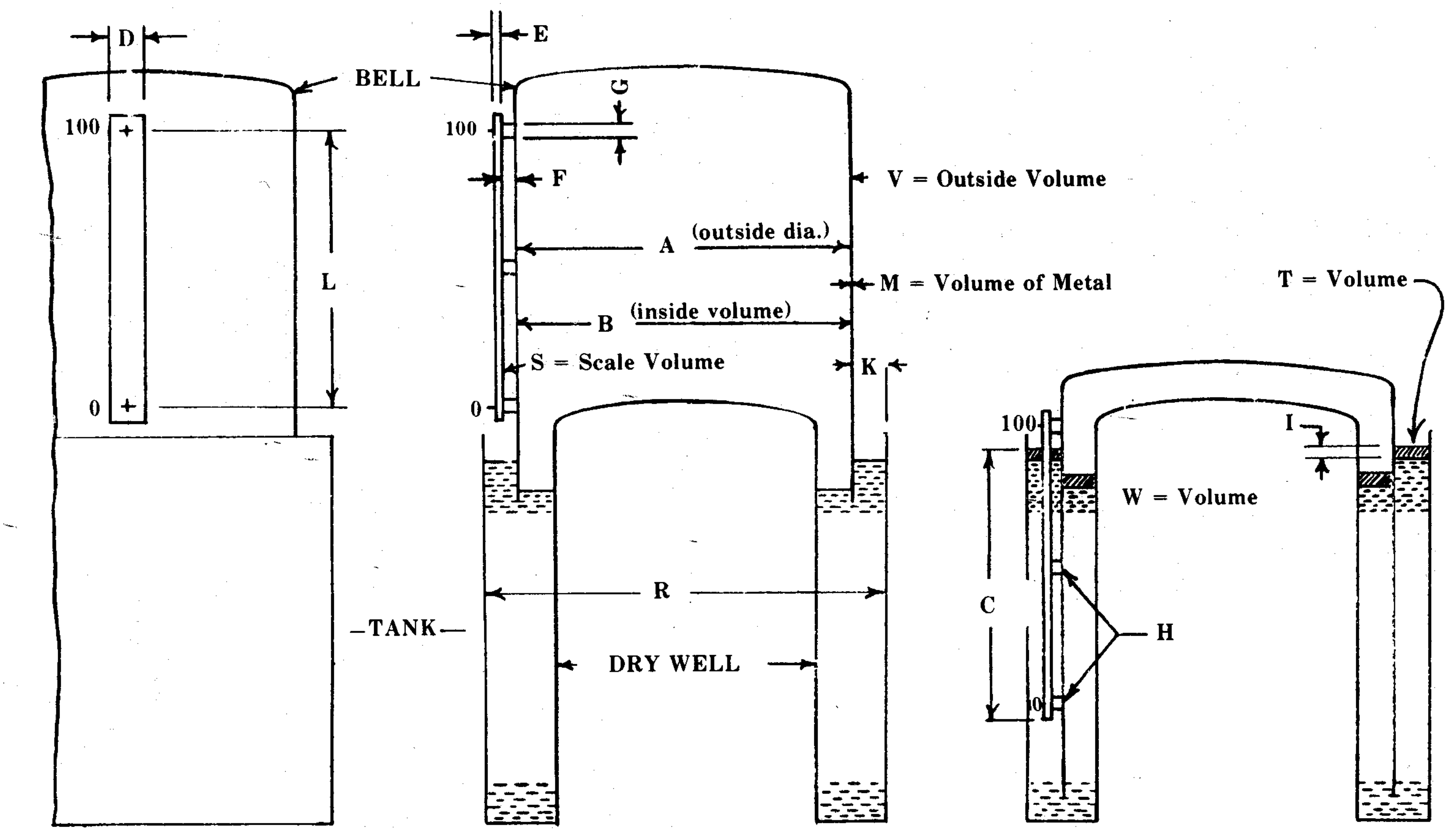


Figure D–1. Power Bell Calibration.

Determination of C, D and E

Scale must be left on the bell in order to determine the length moving in and out of the liquid seal from zero to the point in question (when the scale leaves seal completely during course of prover operation).

Determination of F, G and H

Measure scale button length and diameter and determine the number moving in and out of seal from zero to the point in question.

Determination of I

a. With the bell set at scale zero (bell up for pressure proving), the seal level should be approximately 1/4 inch above the lower extremity of the machined tank flange. Regardless of the position of the bell, the seal should always remain within the constant diameter section of the well. Accurately measure the seal level from a stable reference point with depth micrometers. Generally this can be accomplished by resting the micrometer on the top of the machined tank flange.

b. Lower the bell to the desired scale length and re-measure the seal level.

c. Dimension "I" is the difference between the two readings.

d. Repeat as often as necessary to ensure repetitive results.

NOTE: Seal level measurement must be obtained at a constant bell pressure.

Determination of J

Measure and calculate volume of any other appurtenances that move in and out of seal between zero and the point in question.

Determination of K

With strapping tape, measure the I.D. of the tank at the machined section of the cast flange, keeping the tape flat and level. Subtract the thickness of the strapping tape. Subtract "A" from this measurement and divide by 2.

$$K = \frac{(\text{I.D. of Tank} - A)}{2}$$

An alternative method would be to use an inside micrometer appropriate to the distance between the outside of the bell and the inside of the tank. Secure bell so that it cannot move and take four to six measurements of this distance at positions approximately equidistant around the circumference. Average these readings and add twice the result to the average diameter of the bell (see determination of "A") thus:

$$R = A + 2K$$

Determination of L

The length of the scale from zero to the point in question can be measured while on the bell using a cathetometer or by removing and measuring on a flat surface.

CALCULATIONS:

$$V = \frac{\pi A^2 L}{4} = \text{in}^3$$

$$S = (C)\,(D)\,(E) + \frac{\pi\,(F)\,(G^2)\,(H)}{4} + J = \text{in}^3$$

$$T = \frac{\pi\, I\,[(A + 2K)^2 - A^2]}{4} = \text{in}^3$$

$$Q\ \text{cubic inches} = V + S - T$$

$$Q\ \text{cubic feet} = \frac{V + S - T}{1728}$$

If necessary, the actual "L" should be corrected proportionally to "Q."

FORM FOR PROPOSALS ON ANSI B109.3

Send to: Operating & Engineering Section
American Gas Association
400 North Capitol Street, NW, 4th Floor
Washington, DC 20001
U.S.A.
Fax: (202) 824-7082

Name____

Company______________________________________

Address______________________________________

Tel. No. ____________________ **Fax No.** ____________________

Please Indicate Organization Represented (if any)

____

1. Section/Paragraph

____

2. Proposal Recommends: (check one)

☐ **new text**
☐ **revised text**
☐ **deleted text**

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted, use separate sheet if needed): (Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (<u>inserted wording</u>) and strike-through to denote wording to be deleted (~~deleted wording~~).

4. Statement of Problem and Substantiation for Proposal (use separate sheet if needed): (State the problem that will be resolved by your recommendation; give the specific reason for your proposal including copies of tests, research papers, etc.)

5. ☐ **This proposal is original material.** (Note: Original material is considered to be the submitter's own idea based on or as a result of his/her own experience, thought or research and, to the best of his/her knowledge, is not copied from another source.)

6. ☐ **This proposal is not original material; its source (if known) is as follows:**

____

Type or print legibly. If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members of reviewing committees or task forces.

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Date:

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Signature (Required)

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