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DIAPHRAGM-TYPE GAS DISPLACEMENT METERS
(Under 500 Cubic Feet Per Hour Capacity)

Secretariat

AGA American Gas Association

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PREFACE

This publication represents a basic standard for safe operation and substantial and durable construction for diaphragm-type gas displacement meters having a gas flow rating of under 500 cubic feet per hour (14.2m^3/h) at 0.5 inch water column (125 Pa) differential pressure at base conditions. This work is the result of years of experience, supplemented by extensive research. The standard is designed to ensure efficient performance and substantial construction of equipment.

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. A soft conversion from existing inch-pound values is shown. Soft conversion implies a change in nomenclature only; in this document, the alternative nomenclature (metric) is shown by using parentheses.

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: American Gas Association, ATTN: Secretariat B109, 400 North Capitol Street, NW, SUITE 450, Washington, DC 20001, U.S.A.

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HISTORY OF THE DEVELOPMENT OF STANDARDS FOR DIAPHRAGM-TYPE GAS DISPLACEMENT METERS

In response to an expressed need within the industry for standardization of diaphragm-type gas displacement meters, the American Gas Association late in 1966 requested the establishment of a project within the American National Standards Institute for development of suitable standards for such meters. At a General Conference held on January 31, 1967, at ANSI headquarters, approval of the project scope was obtained, which was subsequently endorsed by the Mechanical Standards Board of ANSI.

The organizational meeting of ANSI Committee B109 was held on November 30, 1967, at which time five subcommittees were established to develop various sections of the standard. The first draft standard was issued in June 1970 for review and comment. This was followed by three additional drafts, each incorporating modifications made in the light of comments received.

To ensure that the standard as published would have wide acceptance, the fourth draft was distributed on an industry-wide basis and to all known interested parties. Comments received on the fourth draft were reviewed by the various subcommittees and indicated revisions were made in two additional drafts. Draft Six was reviewed by Committee B109 at its May 4, 1973, meeting and the standard approved for submittal to ANSI for endorsement as an American National Standard.

Throughout all stages of development of this standard, consideration has been given to the work done by the Task Committee on Standardization of Meter Purchase Specifications of the Operating Section of the American Gas Association as published in Gas Meter Specifications (OP-58-2, 1963).

The first edition of the diaphragm-type gas displacement standard (B109.1) was endorsed as an ANSI standard by the American National Standards Institute, Inc., on November 27, 1973. An addendum (B109.1a) was published in 1980. Separate standards were also published in 1980 for larger gas displacement meters (500 cubic feet per hour capacity and over)—B109.2 and for rotary type gas displacement meters—B109.3.

In the second edition, auxiliary devices relating only to larger capacity meters were deleted from this standard and added to other appropriate standards. Soft metric conversions and informative appendices on prover bell calibration and bar coding were added to this standard. The second edition was approved by ANSI on January 9, 1987.

In the third edition, minor editorial changes and a title correction were made. The third edition was approved by ANSI on November 12, 1992.

In the fourth edition, minor editorial changes and reaffirmation of the standard was approved by ANSI on April 13, 2000. The document was reaffirmed by ANSI on April 16, 2008 without any change to the document.

During the 2018 review cycle, the standard went through a thorough review and update. The review and reaffirmation period exceeded the five year period and ANSI withdrew the standard from publication on 4/28/2018. Work on the update continued and the standard was re-introduced with extensive changes and updates. Published as the fifth edition, the B109.1 standard provides the basis for residential diaphragm meters for the natural gas industry. Additional review and documentation are planned following this publication to further update sections to reflect current trends and technological advances pertaining to meters covered by this standard. Substantive changes have been shown by a bar [|] in the margin.

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SCOPE

This standard applies to diaphragm-type gas displacement meters, designed for revenue measurement of fuel gas, having a flow rating of less than 500 cubic feet per hour (14.16m^3/h) capacity at 0.5 inch water column (125 Pa) differential pressure at base conditions.

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

Part II covers the construction requirements for qualifying new-type meters in the designated flow-rate ranges.

Part III covers the performance requirements for qualifying new-type meters in the designated flow-rate ranges.

Part IV covers the "in-service" performance requirements for diaphragm-type meters in the designated flow-rate ranges.

Part V addresses installation requirements for these meters.

Part VI pertains to auxiliary devices used with gas 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 D for methods of expressing meter accuracy.)

1.2 **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.

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

1.4 **BASE CONDITIONS**. The standard or base conditions of pressure and temperature for the volumetric measurement of natural gas. As used in this standard 14.73 psi (101.56 kPa) and 60°F (15.6°C) are established as the base pressure and temperature respectively to which all volumes are commonly referred. (Also known as STANDARD CONDITIONS)

1.5 **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.

1.6 **CAPACITY, RATED**. The flow rate in cubic feet per hour of 0.6 specific gravity gas delivered through the meter at an absolute pressure of 14.73 psi (101.56 kPa) and at 60°F (15.6°C) that results in an average differential pressure across the meter connections of 0.5 inch water column (125 Pa).

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

1.8 **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.

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

1.10 **INDEX, CONSTANT PRESSURE COMPENSATING**. 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.

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

1.12 **CUBIC FOOT, STANDARD**. That quantity of gas at base conditions occupies a volume of 1 cubic foot. (See BASE CONDITION)

1.13 **CUBIC METER, STANDARD**. That quantity of gas at base conditions occupies a volume of 1 cubic meter. (See BASE CONDITION)

1.14 **DIAPHRAGM**. A semi-flexible material anchored at its periphery, serving as a barrier between the volumetric chambers.

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

1.16 **HUBS, METER**. Same as 1.10, CONNECTIONS, METER.

1.17 **INDEX, METER**. The device that displays the volume of gas that has passed through the meter.

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

1.19 **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).

1.20 **INDEX TEST DIAL**. See 1.8, CIRCLE(S), TEST.

1.21 **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.

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

1.23 **METER CAPACITY CLASS**. A capacity rated group designation for meters within different ranges of meter capacity. Rated capacity must equal or exceed the capacity class designation, but be less than the next higher meter capacity class.

1.24 **METER, 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.

1.25 **METER, GAS**. A device for measuring the volume of flowing gas.

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

1.27 **METER, NEW TYPE**. A gas meter sufficiently different in design or materials of construction (such as diaphragm material, cubic feet per tangent revolution, ratio of valve-to-diaphragm area, etc.) so affecting performance as to require qualification as a new-type meter under this standard.

1.28 **MILEAGE**. See 1.41, REGISTRATION.

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

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

1.30 **PERCENT REGISTRATION**. See 1.1, ACCURACY, METER and Appendix D. Same as 1.29 PERCENT ACCURACY.

1.31 **PRESSURE, ABSOLUTE**. Atmospheric pressure plus gauge pressure. Abbreviated as psia.

1.32 **PRESSURE, BASE**. An absolute pressure value to which measured gas volumes are corrected. If a purchase contract applies, the term is referred to as a contract base pressure. See 1.4 Base Conditions.

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

1.34 **PRESSURE, GAUGE**. Pressure measured relative to atmospheric pressure. Abbreviated as psig.

1.35 **PRESSURE, METER**. The pressure in a meter under operating conditions. (Usually considered to be the meter's inlet pressure.)

1.36 **PROVER**. Device for measuring the accuracy of gas meter registration.

1.37 **PROVER, BELL**. Device for measuring the accuracy of gas meter registration. A calibrated cylindrical bell in which a quantity of air is collected over an oil seal.

1.38 **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.

1.39 **PROVER, SONIC FLOW**. Also referred to as SONIC NOZZLE PROVER or CRITICAL FLOW PROVER. A device employing either venturi, 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 to the restriction standard time corrected for test conditions provides a measure of meter accuracy.

1.40 **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.

1.41 **REGISTRATION**. The indicated volume of gas passed through a meter.

1.42 **REMOTE METER READING DEVICE**. A device for a gas meter 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.

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

1.44 **STANDARD CONDITIONS**. See 1.4, BASE CONDITIONS.

1.45 **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.

1.46 **COMPRESSIBILITY**. Deviation of a real gas from the ideal gas laws relative to changes in pressure and temperature.

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

1.48 **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.

1.49 **TEMPERATURE, BASE**. A reference temperature to which measured gas volumes are corrected. See 1.4 BASE CONDITIONS

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

1.51 **TEMPERATURE, METERING**. The temperature of the gas in a meter at operating conditions. (Defined as the meter's outlet temperature.)

PART II
CONSTRUCTION REQUIREMENTS
FOR QUALIFYING NEW-TYPE METERS

2.1 **SCOPE**

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

2.2 **CONNECTION DIMENSIONS**

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

2.2.1 **Meter Capacity Class Connections.** Standard, top mount, meter capacity class connections are listed in Table I. Dimensions for connections listed below as standard, and other commonly used connections, are defined in Appendix A and Appendix B.

TABLE I

METER CAPACITY CLASS CONNECTIONS

Meter Capacity Class	Connection Designation	Center-to-Center Dimensions	
		Imperial	Metric
50	5Lt	6"	152.4 mm
175	20Lt	6"	152.4 mm
250	20Lt	6"	152.4 mm
400	30Lt	8¼"	209.6 mm

2.2.2 **Top-Mounted Connections**.

Meters with top-mounted connections shall conform to the dimensions and specifications illustrated in Figure 1.

2.2.2.1 The tolerance limits on dimension "A" (center-to-center) of the connections are specified in Table II

TABLE II

CENTER-TO-CENTER CONNECTION TOLERANCE

Dimension "A", Figure 1		Tolerance	
Imperial	Metric	Imperial	Metric
6" and less	152.4 mm and less	± 1/32"	0.8 mm
> 6" up to 12"	>152.4 mm up to 304.8 mm	± 1/16"	1.6 mm
>12"	>304.8 mm	± 3/32"	2.4 mm

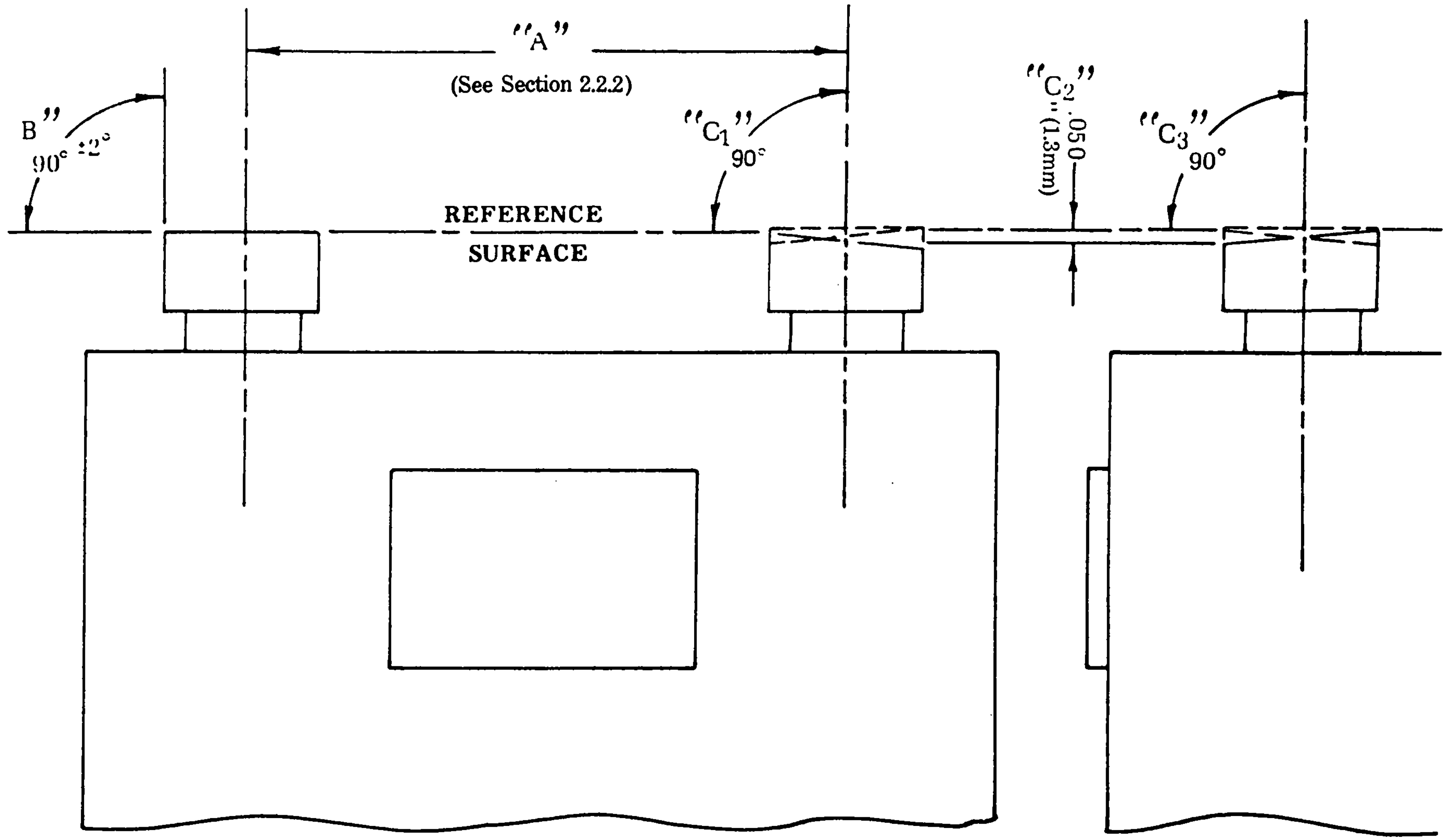


Figure 1. Top-mounted hub tolerances.

2.2.2.2 The axis of the threads on the connections shall be perpendicular to the gasket face within 2 degrees (Dimension “B”)

2.2.2.3 The gasket surfaces of top-connected meters must be aligned and constructed to meet the following guideline:

a) shall not permit a gap exceeding 0.050 inch (1.3 mm) from a plane formed by a flat plate resting on both connections (dimension “C_2”), and
b) the nominal axis of the connections must be perpendicular (90º ±1º) to the plane (Dimensions “C_1” and “C_3”.

2.2.2.4 The performance of the gasket and seal between the connections and mating swivel is dependent on the alignment and dimensional tolerances of the meter connections.

2.3 **METER IDENTIFICATION**

2.3.1 Identifying badges shall be readable from the same general position as the index.

2.3.2 **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 2. The meter serial number shall be at 0.25 inch (6.35 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 Capacity Class.
b) Manufacturer's name or trademark.
c) Meter serial number.
d) Year of manufacture.
e) Maximum Allowable Operating Pressure (MAOP) rating.
f) If the gas meter is a temperature-compensating model, the badge shall be a durable red color and shall state that the meter is “temperature compensating.” The use of a badge of red color shall be limited to temperature-compensated meters.
g) Meter capacity at a 0.5-inch (125 Pa) water column pressure differential.

1234567890

1234567890

Figure 2. 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.

2.3.3 **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.

2.3.4 **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 F for the preferred bar code standard for meters and auxiliary devices.

2.4 **DIAPHRAGM IDENTIFICATION**

The diaphragm manufacturer's name or trademark, their designation of the type of material and the year of manufacture shall be visible on the diaphragm assembly.

2.5 **INLET IDENTIFICATION**

The inlet connection shall be clearly and permanently identified.

2.6 **PROTECTION OF METERS**

The meter inlet and outlet shall be protected to prevent entrance of foreign materials and to protect the threads during shipment or storage meeting an IP 53 level of protection per IEC 60529, IP Code.

2.7 **SEALING**

For any part of the meter providing access to the meter interior or index, there shall be provision for sealing.

2.8 **METER INDEX**

2.8.1 An indication of the volume unit being used shall appear in a prominent place on the index face. For example, cubic feet, cubic meters, etc.

2.8.2 **Pointer-Type Circular Dial Reading Indexes.**

2.8.2.1 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 (15.2 mm) in diameter.

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

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

2.8.2.4 The fastest moving reading hand shall rotate in a clockwise direction and have a value per revolution of 1,000 cubic feet (or metric equivalent).

2.8.2.5 Indexes with multiple reading circles: The centers of the reading circles shall lie on a straight line or on the arc of a circle or ellipse. Non reading circles (such as "proving hands" or "test hands") shall not be in the same geometric line as the reading circles.

2.8.2.6 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.

2.8.2.7 On non-reading circles with "proving hands" 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.

2.8.2.8 The index face and markings shall be of contrasting colors to provide for ease of reading. All markings shall be permanent.

2.8.2.9 All indexes shall have an identifying mark on the index face to ensure installation of the correct index on a meter.

2.8.3 **Direct Reading Indexes (Digital Type)**

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

2.8.3.2 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.

2.8.3.3 An appropriate test hand or unit wheel shall be provided for proving a meter with a direct reading index and should meet the general requirements of 2.7.2.7.

2.8.3.4 The index face and markings shall be of contrasting colors to provide for ease of reading. All markings shall be permanent.

2.8.3.5 Index and markings shall not be adversely affected by environmental conditions.

2.8.3.6 All indexes shall have an identifying mark on the index face to ensure installation of the correct index on a meter.

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

2.9 **CORROSION AND CHEMICAL RESISTANCE OF INTERNAL PARTS**

All materials of the meter and component parts shall be suitable for the intended use and shall be chemically resistant to constituents normally found in natural, manufactured and liquefied petroleum (LP) gases.

2.10 **CORROSION AND CHEMICAL RESISTANCE OF EXTERNAL PARTS OF GAS METERS**

The meter case and external components shall be made of or protected by materials resistant to attack by the atmosphere, weather or sunlight and agents used in meter cleaning and repair. Meter exteriors shall be capable of meeting or exceeding the following tests:

2.10.1 **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 exactly the same methods and material employed in manufacturing the meters. 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 III. Following this 2,000 hour test, there shall be no appreciable progressive corrosion, or electrolytic action, or any appreciable discoloration or deleterious reaction.

TABLE III
EXPOSURE CYCLE

Portion of Exposure Cycle	Time Period
Direct ultraviolet radiation Light Only:	102 minutes
Fresh water spray Light and spray:	18 minutes
Total Length of Each Exposure Cycle	120 minutes

2.10.2 **Salt spray test:**

Samples, as in Section 2.10.1, 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) 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.

2.10.3 **Chemical Resistance Test (for meter index window).**

The meter index window shall demonstrate resistance to chemicals recommended by the manufacturers and used in cleaning meters.

Method of Test

The window shall be immersed in the cleaning agent for 30 minutes, without showing any discoloration or harmful effects.

2.11 **METER INDEX WINDOW IMPACT TEST**

The index window shall resist impact.

Method of Test

With the index assembled on the meter, the window shall withstand a perpendicular impact of a 0.875-inch (22 mm) solid steel ball dropped from a height of 15 inches (381 mm).

2.12 **METER INDEX WINDOW CLEARNESS TEST**

Under normal installation conditions, there shall be no appreciable distortion or loss of clarity of the index markings caused by the window material.

2.13 **TEMPERATURE AND THERMAL SHOCK RESISTANCE**

Meters shall be capable of operating within ambient temperature and flowing gas temperature of –30°F and 120°F (-34.4°C and 49°C) and, following the conduct of the test specified in 2.13.2, the meters shall comply with the requirements of initial accuracy specified in 3.3.1 and sustained accuracy specified in 3.3.2, and the pressure test requirements specified in 3.4.

2.13.1 **Temperature Resistance**.

The meter case only shall withstand the following high temperature test.

Method of Test

The meter case shall be exposed to 360°F (182°C) for a period of one hour. After the test the meter casing shall be allowed to return to room temperature, and shall comply with the pressure requirements specified in 3.4.

2.13.2 **Thermal Shock Resistance.**

The assembled meter shall withstand the following thermal shock test.

Method of Test

The assembled meter shall be heated in 140°F (60°C) water for one hour and then plunged into water at a temperature of 40°F (4.4°C). The assembled meter shall then be cooled to 20°F (–6.7°C) for one hour and then plunged into water at a temperature of 120°F (49°C).

2.14 **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:

a) Provide a lever arm of predetermined length to which a force can be applied in a perpendicular plane for performing torsional and bending moment tests;
b) Provide a pressure-tight connection at the meter connection;
c) Provide a pressure tap for connecting a manometer or pressure gauge.

With the meter subjected to an internal pressure of 1.5 times the MAOP or 10 psig (69 kPa) whichever is greater, the inlet and outlet connection shall be individually subjected to the bending moments and the torsion shown in Table IV for a period of one minute. There shall be no leakage and meter accuracy shall not be adversely affected by these tests (per Sections 3.4.1 and 3.4.2).

TABLE IV
BENDING MOMENTS AND TORSION REQUIREMENTS

Meter Connection	Bending Moment		Torsion	
Size, Inches	Pound-feet	Newton-meters	Pound-feet	Newton-meters
3/4 and smaller	60	81	200	270
1	60	81	200	270
1¼	80	108	250	340
1½	125	170	250	340

PART III
PERFORMANCE REQUIREMENTS FOR QUALIFYING NEW-TYPE METERS

3.1 SCOPE

This part establishes performance requirement qualification of a new-type meter.

3.2 METER CAPACITY CLASS

Meter capacity class designates a base or nominal grouping reference for meters within defined rated capacity ranges. Table V establishes the meter capacity class designations and related capacities covered by this standard.

TABLE V
METER CAPACITY CLASS by RATED CAPACITY (ft^3/h)

Meter Capacity Class	Minimum Capacity		Maximum Capacity	
	(ft^3/h)	(m^3/h)	(ft^3/h)	(m^3/h)
50	50	1.4	174	4.93
175	175	5.0	249	7.05
250	250	7.1	399	11.29
400	400	11.3	499	14.13

3.2.1 Determination of Meter Capacity.

The capacity obtained by rounding to the nearest multiple of 5 cfh. The average readings of 10 randomly chosen production-type meters representing a particular meter model.

3.2.1.1 Test Conditions

a) Bell prover operating on air at a minimum of 1.5 inch water column (375 Pa) gauge.
b) Integral connections on meters on test for qualification:

Meter Capacity Class	Connection Size
50	5 Lt
175	20 Lt
250	20 Lt
400	30 Lt

c) The error of the meter on test shall be less than 0.5 percent at flows of 20% to 35% and 100% of its rated capacity; it shall be capable of passing a pilot flow rate test (as defined in Table VI) for leakage and binds.
d) The pressure differential shall be measured between a point 1.5 diameters straight upstream of the integral connection on the meter inlet and at a point 8 diameters straight downstream of the meter outlet. (See Figure 3.) Any differential pressure caused solely by the test piping at the flow rate being investigated must be compensated for so that a 0.5 inch water column (125 Pa) differential is available at the meter connections to drive the meter.

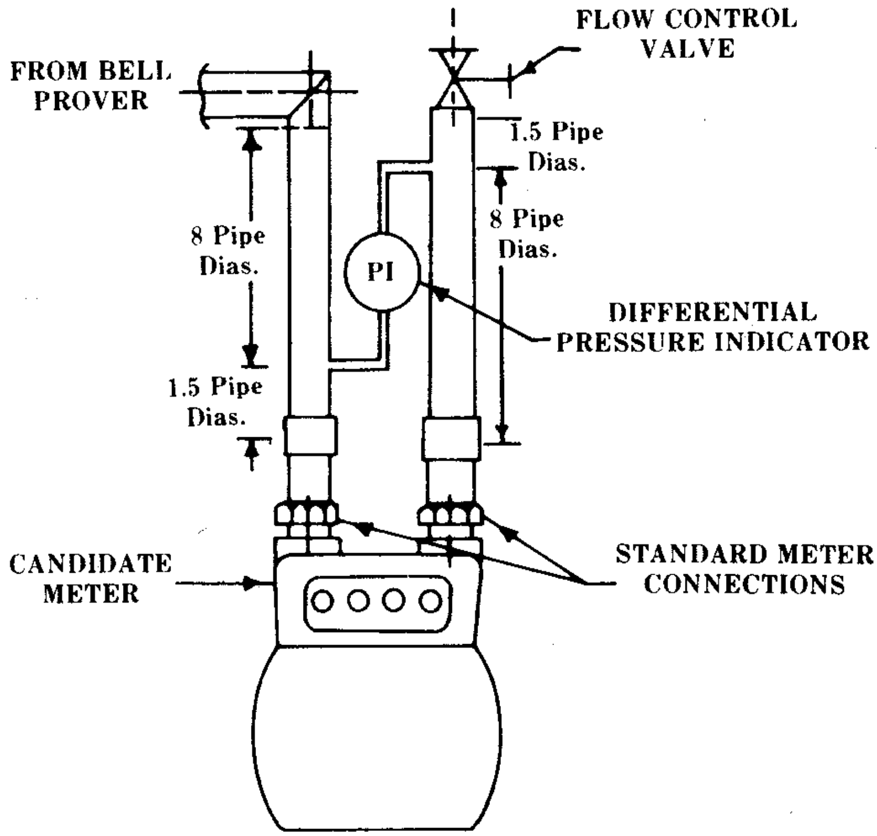


Figure 3. Test apparatus and arrangement for determining the meter capacity class.

e) The volume passed during the test interval is defined by the corrected volume indication from a prover:

$$\text{Corrected volume } v = V_p \times \frac{P_p}{P_m} \times \frac{T_m}{T_p}$$

(See Appendix D for definition of symbols.)

f) The timing measurement shall be accurate to 0.25 percent.
g) The pressure measurement shall be accurate to 0.004 inch water column (one Pascal). The gauge may be pulsation-dampened to improve readability.

3.2.1.2 **Meter Capacity Class Test**.
With the meter connected to the test system and with the bell prover supplying test air, the control valve shall be adjusted until exactly 0.5 inch water column (125 Pa) differential is available at the meter connection [any small fluctuations should be averaged into the 0.5 inch water column (125 Pa) reading].

With a stop watch, the bell shall be timed for a unit volume displacement as indicated by the prover scale to determine the observed air flow rate through the meter. The proving bell temperature and the barometric pressure shall be noted at the time of the test.

3.2.1.3 **Meter Capacity Class Calculations**.
From the time interval and the volume measured, the hourly rate shall be calculated. This will be the observed air capacity of the meter.

$$C_o = \frac{3600(v)}{t}$$

where

v = corrected volume
t = time interval, seconds
C_o = observed air capacity of the meter

$$\text{and } v = V_{prover} \times \frac{P_{prover}}{P_{meter}} \times \frac{T_{meter}}{T_{prover}}$$

Corrections for barometric pressure, temperature and specific gravity shall be made as follows:

$$C_g = C_o \left(\frac{1}{0.60} \times \frac{P_m}{14.73} \times \frac{520}{T_m} \right)^{0.5}$$

where

P_m = meter inlet pressure absolute, (psia)
C_g = gas capacity corrected for pressure, temperature and 0.60 specific gravity gas
T_m = meter outlet air temperature, absolute, (°R)

Observations should be made on a statistically reliable sample of a given type of meter to average manufacturing variations to determine minimum gas capacity (C_g) and ensure proper capacity class designation.

3.2.1.4 Although meter capacity class designations are based on capacity measurements, service capacity limitations are neither suggested nor implied. For calculating recommended meter capacities at specific service conditions, see Appendix C.

3.3 **ACCURACY OF METERS**
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, after adjusting the meter to 100% ± 0.2% registration at approximate flow rates of 20% to 35% and 100% of its rated capacity and shall be within the accuracy requirements for the meter capacity class as specified in Table VI.

Method of Test

The accuracy of a meter under test, either for pilot flow or test flows, will be determined as follows:

a) The meter will be connected in series with a proving standard having sufficient flow rate and pressure capacity.
b) 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 where applicable.

TABLE VI
ALLOWABLE VARIANCES FROM CALIBRATED ACCURACY AT VARIOUS TEST FLOW RATES

Meter Capacity Class Designation	Approximate Flow rate (AIR)							
	Pilot Flow Rate		Test Flow Rates					
	ft^3/h	m^3/h	ft^3/h	m^3/h	ft^3/h	m^3/h	ft^3/h	m^3/h
50	0.25	0.007	5	0.14	10	0.25	40	1.13
175	0.25	0.007	15	0.42	30	0.85	150	4.20
250	0.25	0.007	20	0.57	40	1.13	200	5.70
400	1.00	0.028	30	0.85	60	1.70	300	8.50
Accuracy BEFORE accelerated life tests	±10.0%		±1.0%		±1.0%		±1.0%	
Accuracy AFTER accelerated life tests*	±10.0%		±2.0%		±2.0%		±2.0%	

* When compared with actual accuracy before accelerated life tests.

Pilot flow accuracy can be determined as described above for the operating flows or by the use of a calibrated orifice having the required flow rate with a constant pressure input. The orifice will be connected in series with the meter and the air or gas supplied at a constant pressure. Timing of a registered volume through the meter and comparing this flow rate with the calibrated orifice's flow rate will determine the pilot flow accuracy. Prior to initiation of accuracy tests, the meter shall be tested for case tightness and all leaks eliminated.

3.3.2 **Sustained Accuracy.**

After being subjected to the accelerated life test described in 3.3.3, the meter accuracy shall be within:

a) 10 percentage points of its initial accuracy at pilot flow rate as shown in Table VI.
b) 2 percentage points of its initial accuracy at test flow rates as shown in Table VI.

Method of Test

The accuracy of a meter under test, either for pilot flow or test flows, will be determined as described in 3.3.1.

3.3.3 **Accelerated Life Test.**

To determine the ability of a displacement 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.

NOTE: After the accelerated life test, the meter shall be tested and shall comply with the sustained accuracy requirements outlined in Section 3.3.2.

Method of Test

Meter shall be leak and pilot flow tested and calibrated before placing on test rack. Meters shall be calibrated to an accuracy of 100% ± 0.2% in accordance with 7.5.5.4.

Meters shall be installed on test rack using type of gas for which meter is intended. Flow rate through meters shall be maintained between 80% and 120% of the meter's rated capacity. After total meter index registration is equal to 4,000 times the capacity class flow rate per hour, the accuracy of the meter shall be within the limits specified in Table VI.

3.4 PRESSURE AND LEAK TESTS

This test requirement shall also apply to all newly manufactured meters.

3.4.1 Each new-type 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 on all meters to a minimum pressure of 10 psig or at 1.5 times the MAOP, whichever is greater, for cast steel, cast aluminum and wrought aluminum shells, and at 2.0 times MAOP for cast and ductile iron shells. (Reference Section VIII, ASME *Boiler and Pressure Vessel Code.*)

3.4.2 Each new-type 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 psi (34 kPa) per second] with a gas, from 0 psi gauge pressure to at least 1.25 times the MAOP.

Method of Test

The meter shall be sealed and submerged in water prior to pressurization. During pressurization and for at least 1 minute after maximum pressure has been reached, there shall be no leakage.

3.5 NOISE AND VIBRATION

Meters shall be essentially free of noise and vibration.

PART IV
IN-SERVICE PERFORMANCE

4.1 SCOPE

The purpose of this part is to establish in-service performance standards for gas meters used in revenue measurement of gaseous fuels. Test requirements are first outlined that are designed to reasonably ensure compliance with the in-service performance programs set forth in this part.

4.2 TEST REQUIREMENTS

4.2.1 General.

New meters, repaired meters and in-service meters shall be inspected and tested, and appropriate action taken to provide assurance that in-service meters conform to the accuracy requirements of this part.

4.2.2 Test of New or Repaired Meters.

Meters shall be inspected and tested in a meter shop or in other test facility and appropriate action shall be taken to ensure that the meters conform to the limits set forth in 4.2.5.

4.2.3 Test Equipment.

All meters shall be tested using appropriate test equipment and methods established in Part VII.

4.2.4 Test Flow Rates.

Meters shall be tested at two or more rates of flow as needed to ascertain their accuracy. When two rates are used, the low flow rate shall be equivalent to 20% to 40% of the applicable badged capacity and the high flow rate shall be equivalent to 80% to 120% of the applicable badged capacity.

4.2.5 Adjustment Limits.

Before being placed in service, meters shall be adjusted to an accuracy of 100% within the limits of +1.0% and –2.0% at a low flow rate (20% to 40% of capacity) and a high flow rate (80% to 120% of capacity). The numerical difference between the test values for these two rates should not exceed one percentage point.

4.3 IN-SERVICE PERFORMANCE PROGRAMS

4.3.1 Objectives.

The primary purpose of in-service performance testing is to provide service-life information on which the user may base a meter utilization program. The testing and maintenance procedures, meter design and the level of accuracy specified must be such that a realistic balance exists between the benefits realized from high accuracy levels and the cost of achieving these levels. Any program established should be reviewed periodically with a view toward improvement in light of the current state of the art.

4.3.2 Test Programs.

Statistical sampling and variable interval plans provide for differences in meters and operating conditions and encourage improvements in meter design and meter maintenance programs. Statistical sampling programs use statistical analysis techniques to monitor the accuracy of meters in service. Variable interval plans also rely on meter test data for the same purpose, but use different methods.

4.3.2.1 **Statistical Sampling**. A statistical sampling program for testing gas meters should conform to the general provisions set forth in this section and shall be based on accepted principles of statistical sampling.

Meters shall be divided into homogeneous groups such as year set, manufacturer, case type, diaphragm material, etc. However, any group of meters may be combined with another group with similar operating characteristics to provide an adequate sample size for analysis and control. Meters in any given group may be further subdivided according to location, age or other factors that may be disclosed by test data to have an effect on the performance of the meters. Subsequently, groupings may be modified or combined as justified by the performance records.

A sample shall be taken each year from each group. The sample taken shall be of sufficient size to demonstrate with reasonable assurance the condition of the group from which the sample is drawn. Meters removed from service on a routine basis may meet the sample requirements. However, if a larger sample is required for a particular group, an additional random sample shall be removed from service.

The sampling program shall be designed to accomplish the objectives set forth in 4.3.1, and it should include a statistically acceptable method for determining group performance and specify the degree of confidence to be applied to the test results of the sample meters.

An example of a sampling program is one that will, nine times out of ten, determine that as many as 75% of the meters in a meter control group are within the percent accuracy limits of 98% and 102% for low flow (check) rate with no more than 12.5% of the meters exceeding 102% accuracy. If a group of meters does not meet the performance criteria, as measured by the sample test results, then corrective action shall be taken.

The corrective action may consist either of a selective removal program to raise the accuracy performance of the group to acceptable standards or the removal of the entire group from service. The rate of removal should be such that the required corrective action is completed within four years.

4.3.2.2 **Variable Interval**. A variable interval plan for testing gas meters should conform to the general provisions set forth in this section.

As stated above, meters shall be divided into homogeneous groups such as year set, manufacturer, case type, diaphragm material, etc. However, any group of meters may be combined with another group with similar operating characteristics to provide an adequate sample size for analysis and control. Meters in any given group may be further subdivided according to location, age or other factors that may be disclosed by test data to have an effect on the performance of the meters. Subsequently, groupings may be modified or combined as justified by the performance records.

The number of meters to be tested from each group during the current year shall be a percentage of the total original group and be dependent upon the results of the in-service performance tests made during the preceding year, or years, up to a maximum of three. The number or percentage of meters to be tested in each group is a function of the percentage of meters found outside the acceptable percent accuracy limits of 98% and 102% for check rate. The relationship used to determine the number of meters to be tested shall be designed to meet the objectives set forth in section 4.3.1 and shall provide for increasing the number of meters tested with increases in the percentage of meters outside the acceptable limits.

An example of a variable interval plan is one in which the formulas may provide for a removal rate of 4.5% when the percentage of meters outside the acceptable percent registration limits equals 20% and for a maximum removal rate of 25% when the percentage of meters outside the acceptable limits equals or exceeds 40%. The minimum number of meters to be removed from each group should be 200 meters or 10% of the total group, whichever is the lesser.

4.3.2.3 **Periodic Interval**. Periodic interval plans provide for a fixed interval test. The plans may fail to recognize the difference in accuracy characteristics of various types of meters due to technical advances in meter design and construction.

In order to provide incentives for modernization of meter maintenance programs, periodic interval plans should be established based on historical test data for the particular utility.

To initiate this program, a utility may elect to adopt a 10-year test period. As the historical test data are developed, a test period greater than 10 years can be adopted when the number of meters in the 98–102% registration category exceeds 70% of the total number of meters being tested. The periodic interval program should be reviewed periodically and modified when necessary to keep pace with modern technology and alternative meter test programs.

4.3.2.4 **Registration**. Meter test programs may be established based on "mileage" or the amount of gas passed through the meters. These programs should be reviewed periodically and revised when necessary to maintain performance levels equivalent to the other accepted plans.

4.4 **RECORDS**

Records of meter tests shall be maintained. For programs using meter groups, the records shall show the number of meters initially installed in each group, subsequent modifications or combinations of groups, and at the end of each year for each group, the number remaining in service, size of test sample, test results and corrective action taken.

PART V
METER INSTALLATION REQUIREMENTS

5.1 **SCOPE**

The purpose of this part is to establish installation requirements for gas meters used in revenue measurement of gaseous fuels.

5.2 **GENERAL REQUIREMENTS**

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 non-cathodic-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.

5.5 **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.

5.7 **METER SIZING**

Meters shall be sized to measure the expected load. The diversity of the total connected load and the maximum operating capacity should be considered. (See 3.3.)

5.8 **SPACING OF METERS**

When two or more meters are grouped, they shall be so spaced 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 serving different customers 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 supplied.

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 REQUIREMENTS**

Before a customer installs equipment or facilities that will require service at other than that provided under the supplier's base conditions, he 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 provision 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.

PART VI
AUXILIARY DEVICES FOR GAS METERS

6.1 SCOPE

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

a) Temperature Correcting Devices. These are integral parts of the meter and are tested only when the meter is tested.
b) Constant Pressure Correcting Indexes. The only test of these devices is to verify proper gear ratios.
c) Remote Reading Devices.
d) 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 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 **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, series 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 to 160°F (-40°C to 71°C), and shall be fitted with a cover or door of suitable material. Where applicable, 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 auxiliary devices.

6.1.6 **Installation**

6.1.6.1 **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 the auxiliary device and the entire assembly shall be suitably protected. Provisions shall be made for the independent removal of the meter or auxiliary device.

6.1.7 **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 ± 3°C), normal atmospheric pressure, clean gas].

6.2 **CONSTANT-PRESSURE-COMPENSATING INDEX**

6.2.1 **Construction**

6.2.1.1 **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.

6.2.1.2 **Gear Ratios**. The gear train between the prover test dial and the dial farthest to the right 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.

6.2.1.3 **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 letterings must be of contrasting color. The index face shall be permanently marked with the actual gear ratio in fractional form.

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

a) 14.4 psi (absolute) (99.28 kPa) atmospheric pressure
b) 14.73 psi (absolute) (101.56 kPa) contract base pressure
c) 2, 5, 10, 15, 20, 30, or 50 psi gauge (13.8, 34.5, 68.9, 103.4, 137.9, 206.8 or 344.7 kPa) metering pressure

6.2.3 **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-foot (150 m) increments for the elevations from 0 to 5,000 feet (1,500 m) above sea level.
c) Contract base absolute pressures of 14.65 psia (101.01 kPa) and 14.73 psia (101.56 kPa) and gauge pressures of 1/4 psi (1.73 kPa) and 1/2 psi (3.45 kPa) above atmospheric.

6.2.4 **Application.**

A small indicated gas volume error is sometimes introduced by the use of pressure-compensating indexes because 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 at other than the standard design atmospheric pressure and base pressure shall be considered.

6.3 REMOTE METER READING DEVICES

6.3.1 Monitoring.

6.3.1.1 **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

6.3.1.2 **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 electro-mechanical switching
b) Encoder-register with electro-optical switching

6.3.2 General System Requirements

6.3.2.1 **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.

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

6.3.2.3 **Readability**. The remote reading read-out shall have the same readability as required for the standard displacement meter index as detailed in Section 2.8. If the remote reading system has an electrically, illuminated display, it shall be readable under all conditions of lighting, including direct sunlight.

6.3.2.4 **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 conductor. 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.

6.3.2.5 **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.

6.3.3 **Encoder Specification.**

The encoding index that is to be attached to the gas meter shall be identified with the following information, in addition to the requirements of 6.1.4:

a) Unit of measurement (e.g., cubic feet × 100)

6.3.4 **Remote Index Specification.**

The remote read-out unit shall provide for positive identification of the customer to prevent billing errors. Unit of measurement shall be indicated. Provision shall be made in the design to permit the resetting of the remote index.

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 BASIS

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
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:

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

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 currently available and accepted for testing the accuracy of meters.

7.5.2 **Test Requirements**.

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, and start/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, which 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, which 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 (0.3°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 4.2.4.

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 outlet 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.

7.6 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 the 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 VII.

TABLE VII

SPECIFICATION, PROVER SEALING FLUID

Viscosity at 100°F (37.8°C)	55-75 seconds Saybolt (11×10^{-6} to 14.5×10^{-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 E.

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.**

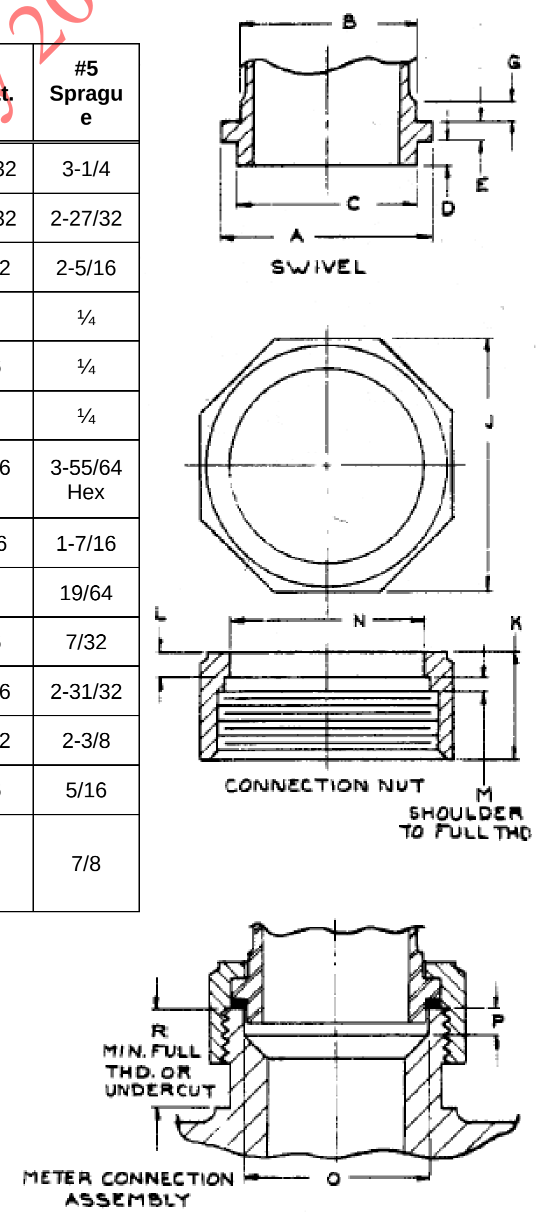
Transfer provers shall be calibrated under controlled temperature, pressure and flowing conditions and the accuracy of the prover determined at a sufficient number of points to enable a reliable flow rate versus accuracy curve to be drawn over the full range of its intended use. Calibration tests shall 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
CONNECTION DIMENSIONS, NOMINAL

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

Connection Designation	5 Lt.	10 Lt.	#1 Sprague	1" Pittsburgh	20 Lt.	#2 Sprague	30 Lt.	45 Lt.	#4 Sprague	60 Lt.	100 Lt.	#5 Sprague
A Dia.	1	1-5/16	1-15/32	1-15/32	1-11/16	1-3/4	1-29/32	2-1/8	2-7/32	2-5/16	2-27/32	3-1/4
B Dia.	27-32	1-3/32	1-5/16	1-5/16	1-3/8	1-5/8	1-21/32	1-29/32	1-61/64	1-29/32	2-13/32	2-27/32
C Dia.	¾	1	1	1	1-5/16	1-15/64	1-1/2	1-45/64	1-1/2	1-29/32	2-7/32	2-5/16
D	5/32	5/32	3/16	3/16	3/16	3/16	¼	¼	3/16	¼	¼	¼
E	1/8	1/8	5/32	5/32	5/32	7/32	5/32	5/32	3/16	5/32	3/16	¼
G	7/64	1/8	3/16	3/16	5/32	7/32	11/64	3/16	3/8	3/16	¼	¼
J Flats	1-19/64 Oct.	1-39/64 Oct.	1-7/8 Hex	1-7/8 Hex	2 Oct.	2-7/32 Hex	2-7/32 Oct.	2-1/2 Oct.	2-13/16 Oct.	2-41/64 Oct.	3-7/16 Oct.	3-55/64 Hex
K	11/16	11/16	27/32	7/8	13/16	31/32	29/32	31/32	1-1/16	31/32	13/16	1-7/16
L	1/8	9/64	5/32	3/16	5/32	5/32	11/64	3/16	¼	3/16	¼	19/64
M (Max.)	5/32	5/32	7/32	3/16	3/16	¼	3/16	3/16	7/32	3/16	3/16	7/32
N Dia.	7/8	1-5/32	1-11/32	1-11/32	1-13/32	1-43/64	1-11/16	1-15/16	2	1-15/16	2-7/16	2-31/32
O Dia.	13/16	1-1/16	1-1/16	1-1/8	1-11/32	1-5/16	1-35/64	1-3/4	1-19/32		2-9/32	2-3/8
P (Min.)	7/32	7/32	¼	¼	¼	¼	5/16	5/16	¼	5/16	7/16	5/16
R – Min Full Thd. or Undercut	7/16	7/16	17/32	17/32	½	19/32	19/32	5/8	5/8	5/8	3/4	7/8

NOTE: All dimensions are posted in inches. Metric conversion is not provided



APPENDIX B
THREAD SPECIFICATIONS

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

Note: Unified Thread Form – Throughout except as noted.

Connection Designation	5 Lt.	10 Lt.	#1 Sprague	1" Pittsburgh	20 Lt.	#2 Sprague	30 Lt.	45 Lt.	#4 Sprague	60 Lt.	100 Lt.	#5 Sprague
Threads/Inch	12	11½	12	1¼-11½ N.P.S.	11½	11½	11½	11½	11½	11½	11½	8
External Major Diameter	1.1138 1.1310	1.4234 1.4411	1.5759 1.5931	---	1.8164 1.8341	1.8578 1.8755	2.0348 2.0525	2.2543 2.2720	2.3208 2.3385	2.4253 2.4430	3.001 3.006	3.4407 3.4632
External Pitch Diameter	1.0669 1.0769	1.3746 1.3846	1.5290 1.5390	---	1.7676 1.7776	1.8090 1.8190	1.9860 1.9960	2.2055 2.2155	2.2720 2.2820	2.3765 2.3865	2.9445 2.9495	3.3706 3.3820
External Minor Diameter	1.0288	1.3344	1.4909	---	1.7274	1.7688	1.9458	2.1653	2.2318	2.3363	2.896	3.3098
Internal Major Diameter	1.1390 Min.	1.4491 Min.	1.6011 Min.	1.650 1.656	1.8421 Min.	1.8835 Min.	2.0605 Min.	2.800 Min,	2.3465 Min.	2.4510 Min.	3.031 Min.	3.4712 Min.
Internal Pitch Diameter	1.0849 1.0962	1.3926 1.4043	1.5470 1.5585	1.588 1.591	1.7856 1.7974	1.8270 1.8390	2.0040 2.0160	2.2235 2.2358	2.2900 2.3023	2.3945 2.4068	2.961 2.969	3.3900 3.4049
Internal Minor Diameter	1.049 1.060	1.355 1.367	1.511 1.522	1.543 1.550	1.748 1.760	1.789 1.801	1.966 1.978	2.186 2.198	2.252 2.265	2.357 2.369	2.922 2.937	3.336 3.351
Pipe Size Normally Used	½"	¾"	1"	1"	1'	1¼"	1¼"	1½"	1½"	1½"	2"	2" F

NOTE: All dimensions are posted in inches. Metric conversion is not provided

APPENDIX C
GENERAL SERVICE CAPACITY EQUATION

The capacity of diaphragm meters at temperatures within the manufacturer's limiting range and at pressures within the design working pressure can be approximated by the following equation:

$$Q = 2.18C\left(\frac{0.6}{G}\right)^{0.5}\left(\frac{520}{T+460}\right)^{0.5}\left(\frac{P_s + P_a}{14.73}\right)^{0.75}$$

Where:

Q = Recommended gas meter capacity in ft^3/h at specified condition.

$$2.18 = \text{Differential pressure correction factor} = \left(\frac{1.9}{0.4}\right)^{0.5}$$

C = Meter Capacity Class (See Sec. 3.2)

G = Specific gravity of gas (Air = 1.0)

T= Operating temperature, °F

P_s = Service pressure, psig (see note)

P_a = Actual atmospheric pressure, psia

NOTE: When P_s exceeds 250 psig, meter capacity shall be limited to that flow that will produce a differential pressure h_m of 8 inches w.c.

EXPLANATION:

The exponent 0.75 in the last factor (the pressure factor) of the equation has been chosen so that the stress and wear on a meter operating at elevated pressure is about the same as if the meter were operating near atmospheric pressure. If the service capacity were calculated using an exponent of 1, at high pressure the meter would operate at the same index rate as at low pressure, but the resulting increased differential pressure would cause an increase in stress and wear. If, on the other hand, the service capacity were calculated using an exponent of 0.5, the differential pressure would remain the same as at low pressure, but the meter's capacity would be unnecessarily restricted. But, by using the exponent of 0.75, this equation calculates a service capacity, which at high pressure permits the differential pressure to increase somewhat while decreasing the index rate. Experience has shown that with this trade-off between differential pressure and index rate, the stress and wear on a meter operating at elevated pressure is about the same as if the meter were operating near atmospheric pressure.

Example: What would be the recommended maximum capacity of a Capacity Class 1400 meter operating at 25 psig with a 0.57 specific gravity gas, a temperature of + 40°F, a barometric pressure of 14.70 psia and a base pressure of 14.73 psia?

$$Q = (2.18)(140\ 0)\left(\frac{0.6}{0.57}\right)^{0.5}\left(\frac{520}{40+460}\right)^{0.5}\left(\frac{25+14.70}{14.73}\right)^{0.75}$$

$Q = 6717\ ft^3/h$

An approximation of the operating differential pressure across a meter in service at elevated pressure (with imposed higher densities due to pressure increase) may be obtained from the following:

$$h_m = \left(\frac{(0.4)(Q)^2 (14.73)}{C^2 (P_s + P_a)} \right) + 0.1$$

Where:

h_m = Estimated operating differential pressure in inches w.c., at a flow rate of Q and at a service pressure of P_s

In the above example, the differential pressure would approximate:

$$h_m = \frac{(0.40)(6717)^2 (14.73)}{(1400)^2 (25 + 14.70)} + 0.1 = 3.52$$

ESTIMATED INDEX RATE

The uncorrected index rate of a meter operating at elevated pressure may be approximated as follows:

$$\text{Index rate} = \frac{(14.73)}{(P_s + P_a)} (Q)$$

In this same example, the index rate would be:

$$\text{Index rate} = \frac{(14.73)}{(25 + 14.70)} (6717) = 2492$$

APPENDIX D
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 E
PROPER BELL CALIBRATION BY PHYSICAL MEASUREMENT

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

THEORY:

By inspection of Figure E-1:

(1) $Q = B + W$

(2) $B = V - M$

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

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.

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).

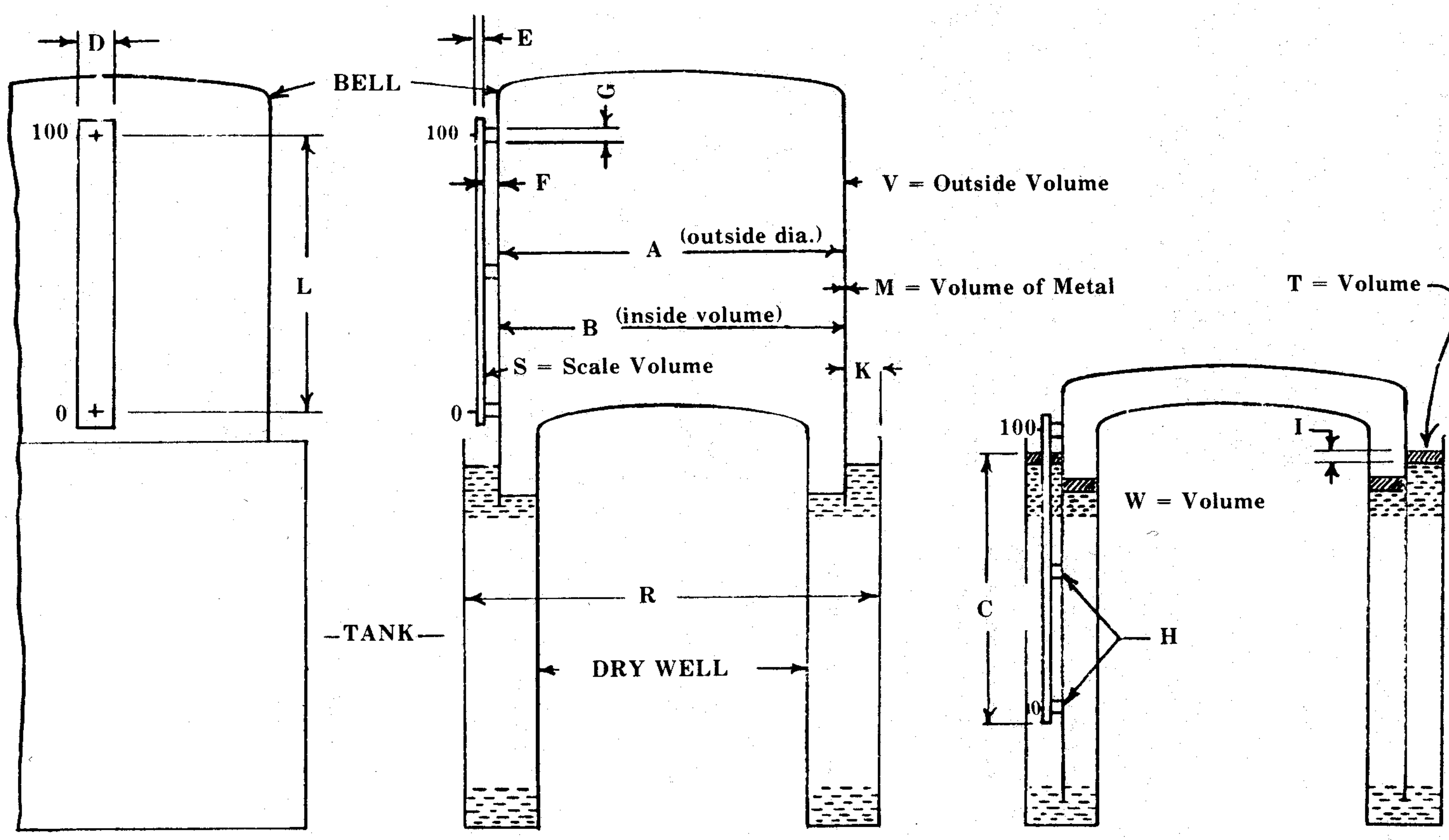


Figure E–1. Power bell calibration.

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 remeasure 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:

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

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

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

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

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

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:

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

APPENDIX F
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 Manufacturer 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 inches high.
Free Field Line 0.20 inches high.
Interpretation Line 0.1 inches high.

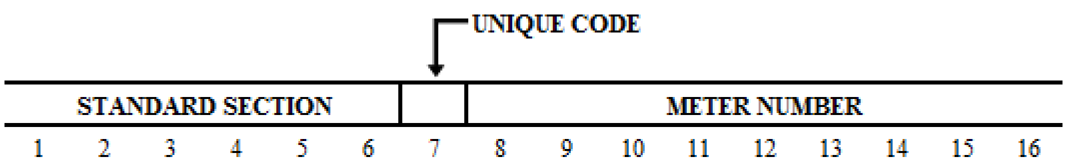
Number of Characters:
18 characters total, which are composed of 16 characters and two start-stop asterisks.

Number of lines on label: Three (3)
Line 1: Free text, specified by buyer's purchase order
Line2: 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



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 insures 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.

FORM FOR PROPOSALS ON ANSI B109.1

Send to:
American Gas Association
ATTN: Secretariat B109
400 North Capitol Street, NW, Suite 450
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.

I hereby grant the American Gas Association the non-exclusive, royalty-free rights, including non-exclusive, royalty-free rights in copyright, in this proposal and I understand that I acquire no rights in any publication of the American Gas Association in which this proposal in this or another similar or analogous form is used.

Date:

____
Signature (Required)

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Date Rec'd ____________________