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**SINGLE PATH ULTRASONIC GAS
METERS**
(Under 1400 Cubic Feet Per Hour Capacity)

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Secretariat



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PREFACE

This publication represents a basic standard for safe operation and substantial and durable construction for single path ultrasonic gas meters having a gas flow rating of under 1400 cubic feet per hour (39.6 m³/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 single path ultrasonic gas 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 SINGLE PATH ULTRASONIC GAS METERS

In 1966, the American Gas Association and its members requested the establishment of a project within the American National Standards Institute for the development of suitable standards for displacement-type gas meters. The B109 Committee was formed in Jan 1967 and was endorsed by the Mechanical Standards Board of ANSI.

In 1982, ANSI revised its procedures and established committees to become “separate” accredited standards committees with procedures approved by the Audit and Accreditation Board of ANSI.

The ANSI B109 Committee is responsible for development of standards for gas displacement meters, gas service regulators, and related devices. The following meter and regulator standards have since been approved under the guidance of this committee:

ANSI B109.1 – Diaphragm-Type Gas Displacement Meters (Under 500 Cubic Feet Per Hour Capacity) (initially approved 1973)

ANSI B109.2 - Diaphragm-Type Gas Displacement Meters (500 Cubic Feet Per Hour Capacity and Over) (initially approved 1980)

ANSI B109.3 – Rotary-Type Gas Displacement Meters (initially approved 1980)

ANSI B109.4 – Self-Operated Diaphragm-Type Natural Gas Service Regulators (initially approved in 1997)

The ANSI procedures require a review of standards every five years. The standards have been kept active via reaffirmation and/or updates.

The present ANSI B109 Committee was reconstituted in September 2007 and is comprised of 18 members with equal representation from three groups – Equipment Manufacturers, Consumers/Users, and General Interest/Individuals – to provide balance on the committee. AGA is the secretariat of the ANSI B109 Committee and provides support to maintain the ANSI accreditation and procedures.

In 2009, the ANSI B109 Committee formed a task group to develop a performance-based gas meter standard that would help create a method for assessing metrological and technical attributes of emerging metering technologies to which another meter-specific standard, document or practice, developed through a consensus process, does not apply. Those efforts contributed to this standard.

The main goal of this standard is to provide a pathway to advance the development and acceptance of the specific technologies around Single Path Ultrasonic gas measurement.

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SCOPE

This standard applies to single path ultrasonic gas meters, designed for revenue measurement of fuel gas, having a flow rating of less than 1400 cubic feet per hour (39.64 m³/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 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.

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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 **REMOTE READING 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 **CONNECTIONS, METER.** The integral parts of the meter designed for attachment to meter swivels, pipe, or other piping components.
- 1.8 **FLOW RATE.** The actual quantity of gas passing through the gas meter divided by the time taken for this quantity to pass through the gas meter
 - Low Flow Cutoff rate (LFC) – Flow output is set to zero until the measured flow exceeds the cutoff value. Flow rate when exceeded begins the measurement of gas
- 1.9 **CUBIC FOOT, METERED.** The quantity of gas that occupies 1 cubic foot when under pressure and temperature conditions existing in the meter.
- 1.10 **CUBIC FOOT, STANDARD.** That quantity of gas at base conditions occupies a volume of 1 cubic foot. (See BASE CONDITION)
- 1.11 **CUBIC METER, STANDARD.** That quantity of gas at base conditions occupies a volume of 1 cubic meter. (See BASE CONDITION)
- 1.12 **FLOW RATE, PILOT.** A minimum flow rate that a meter is required to register with a prescribed accuracy.
- 1.13 **HUBS, METER.** Same as 1.10, CONNECTIONS, METER.
- 1.14 **INDEX, METER.** The device that displays the volume of gas that has passed through the meter.
- 1.15 **INDEX RATE.** The uncorrected flow rate calculated by dividing the registration by time.
- 1.16 **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).
- 1.17 **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.
- 1.18 **LOGS, EVENT.** Electronic means for a standard, centralized way for applications (and the operating system) to record important software and hardware events.
- 1.19 **LOGS, SECURITY.** Electronic means to capture information associated with security events and metrological parameter changes.
- 1.20 **LOGS, INTERVAL DATA.** Electronic means to capture data that pertains to interval consumption and billing relevant information
- 1.21 **MAOP.** Maximum Allowable Operating Pressure equivalent to manufacturer's maximum working pressure.
- 1.22 **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.
- 1.23 **METER, GAS.** A device for measuring the volume of flowing gas.
- 1.24 **METER, NEW.** A meter of all new materials as received from the manufacturer; never used in service.

- 1.25 **METER, NEW TYPE.** A gas meter sufficiently different in design or materials of construction so affecting performance as to require qualification as a new-type meter under this standard.
- 1.26 **MILEAGE.** See 1.41, REGISTRATION.
- 1.27 **PERCENT ACCURACY.** The volume indicated by the meter (V_m) divided by the volume indicated by the standard (V_s) taken as a percentage.

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

- 1.28 **PERCENT REGISTRATION.** See 1.1, ACCURACY, METER and Appendix D. Same as 1.29 PERCENT ACCURACY.
- 1.29 **PRESSURE, ABSOLUTE.** Atmospheric pressure plus gauge pressure. Abbreviated as psia.
- 1.30 **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.
- 1.31 **PRESSURE DIFFERENTIAL.** The difference in pressure between two points in a flowing gas system.
- 1.32 **PRESSURE, GAUGE.** Pressure measured relative to atmospheric pressure. Abbreviated as psig.
- 1.33 **PRESSURE, METER.** The pressure in a meter under operating conditions. (Usually considered to be the meter's inlet pressure.)
- 1.34 **PROVER.** Device for measuring the accuracy of gas meter registration.
- 1.35 **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. See ANSI B109.1 Appendix E.
- 1.36 **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.
- 1.37 **PROVER, SONIC FLOW.** Also referred to as SONIC FLOW 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.
- 1.38 **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.
- 1.39 **REGISTRATION.** The indicated volume of gas passed through a meter.
- 1.40 **SEAL.** A device designed to give evidence of tampering with a meter.
- 1.41 **SINGLE PATH ULTRASONIC METER.** A type of flow meter that measures the velocity of a fluid with ultrasound to calculate volume flow. Using a single pair of ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound. This velocity measurement is then transformed into a volumetric measurement.
- 1.42 **STANDARD CONDITIONS.** See 1.4, BASE CONDITIONS.
- 1.43 **COMPRESSIBILITY.** Deviation of a real gas from the ideal gas laws relative to changes in pressure and temperature.
- 1.44 **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.
- 1.45 **TEMPERATURE, BASE.** A reference temperature to which measured gas volumes are corrected. See 1.4 BASE CONDITIONS
- 1.46 **TEMPERATURE, FLOWING.** The temperature of the gas at flowing conditions.
- 1.47 **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
TOP-CONNECTED METERS**

Meter Capacity Class	Connection Designation		Center-to-Center Dimensions [reference only] (Dim. A., Fig.1)
	Male Customary (SI)	Female Customary (SI)	
175	20 Lt	NA	6" (152.4 mm)
250	20 Lt	NA	6" (152.4 mm)
400	30 Lt	NA	8 ¼" (209.6 mm)
500	45Lt-1½" NPT (DN 40)	1½" NPT (DN 40)	11" (279.4 mm)
900	45Lt-1½" NPT (DN 40)	1½" NPT (DN 40)	11" (279.4 mm)

2.2.2 Top-Mounted Connections.

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

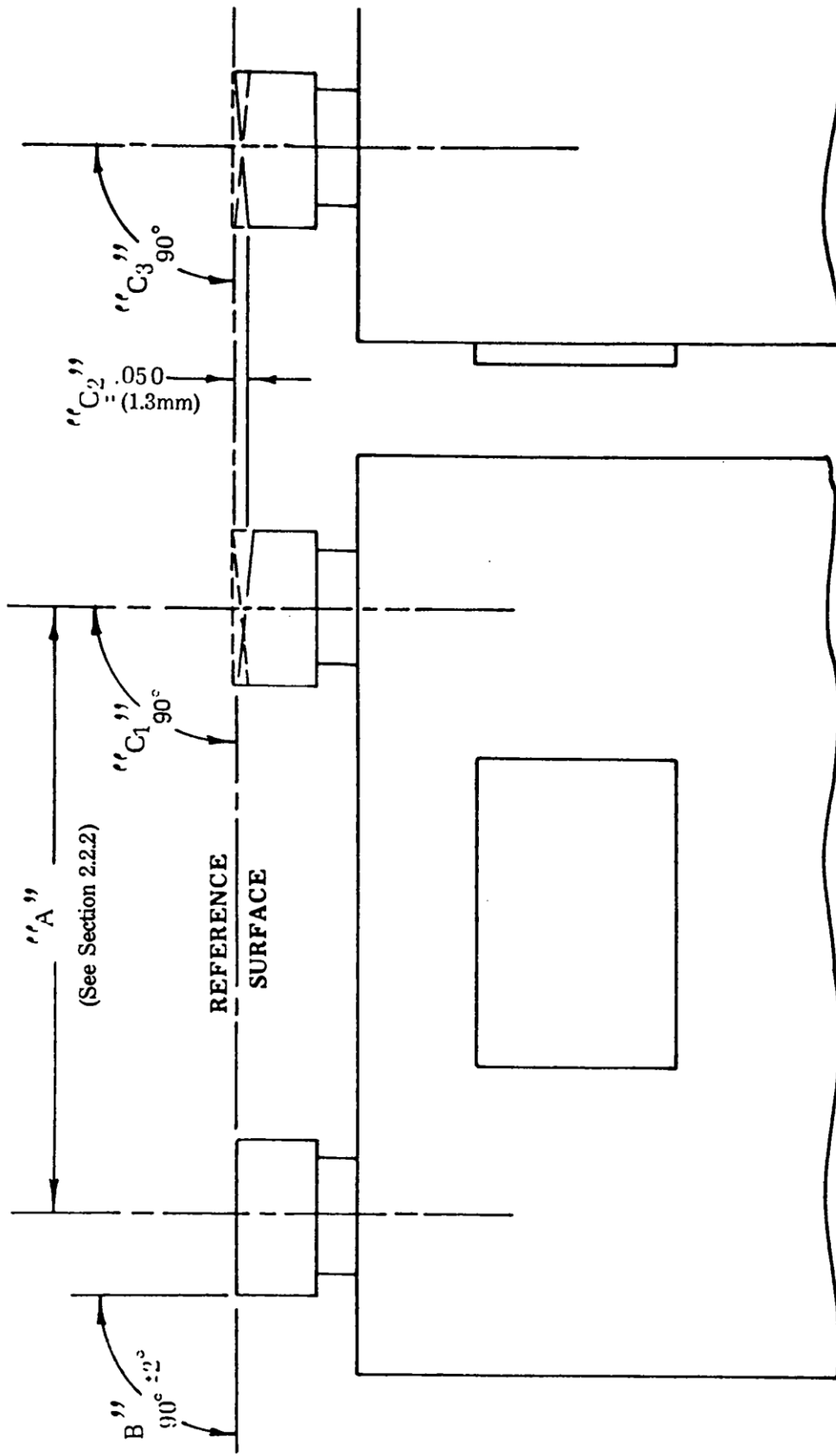


Figure 1. Top-mounted hub tolerances.

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 “C₂”), and
- b) the nominal axis of the connections must be perpendicular ($90^\circ \pm 1^\circ$) to the plane (Dimensions “C₁” and “C₃”).

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.

2.2.3.1 For meters utilizing an axial flow in and out configuration in resemblance to a diaphragm-type gas displacement meters, 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 METER IDENTIFICATION

2.3.1 Identification 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 or index housing for the service life of the meter. 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. Acceptable methods of markings can be embossing, etching; stamping, laser marking 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 meter should state in the markings that it is “temperature compensating
- g) Meter capacity at a 0.5-inch (125 Pa) water column pressure differential.

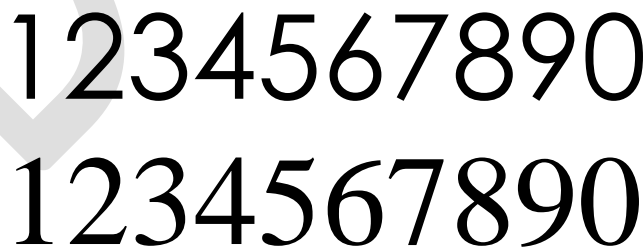


Figure 2. Suggested styles of numbers and characters on meter badge should follow fonts similar to Century Gothic (top) or Times New Roman (bottom). The intent is to maintain the openness of characters such as “3”, “6” and “9” to prevent confusion with other characters.

2.3.3 Purchaser's Badge.

Space shall be provided on the meter and or for the attachment of a purchaser's badge and shall be of sufficient size to include the purchaser's meter identification information utilizing methods outlined in 2.3.2.

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.

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 Direct Reading Indexes (Digital Type)

2.8.2.1 The digits of the counter shall be arranged to appear in a horizontal straight line that can be viewed easily.

2.8.2.2 A 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.

2.8.2.3 Index and markings shall not be adversely affected by environmental conditions and shall be readable in sunlight and stated meter operational conditions. [Reference 2.13]

2.8.2.4 The manufacturer may incorporate devices for the reduction of condensation, where condensation may adversely affect the performance of the device.

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).

MIL-STD-202-107 "Thermal Shock", Test Condition A, environmental chamber testing is an alternative if meter submersion in water is not suitable. Temperatures may be adjusted to match the procedure above for similar conditions. Thermal cycling values may be established at 140°F (+60.0°C) for the high, 20°F (-6.7°C) for low, and 40°F (+4.4°C) for the mid temperatures. The manufacturer may choose to test at temperatures, test condition, and soaking times exceeding liquid bath test criteria if desired.

2.14 GAS SHUT-OFF DEVICE

The gas meter may be equipped with a device that shuts off the gas flow. This device may be integral or connected to the gas meter, provided that it does not influence the metrological integrity of the meter.

2.15 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 Size, Inches (SI)	Bending Moment		Torsion	
	Pound- feet	Newton- meters	Pound- feet	Newton- meters
20 Lt (or smaller)	60	81	200	270
30 Lt	80	108	250	340
45Lt-1½" NPT (DN 40)	200	270	300	405

For meters utilizing an axial flow in and out configuration in resemblance to a diaphragm-type gas displacement meters, 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.

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 (ft³/h)**

Meter Capacity Class	Minimum Capacity		Maximum Capacity	
	(ft ³ /h)	(m ³ /h)	(ft ³ /h)	(m ³ /h)
175	175	5.0	249	7.05
250	250	7.1	399	11.29
400	400	11.3	499	14.13
500	500	14.2	899	25.5
900	900	25.5	1399	39.6

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) 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
175	20 Lt
250	20 Lt
400	30 Lt
500	45 Lt
900	45 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).
- 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 flow through the meter.

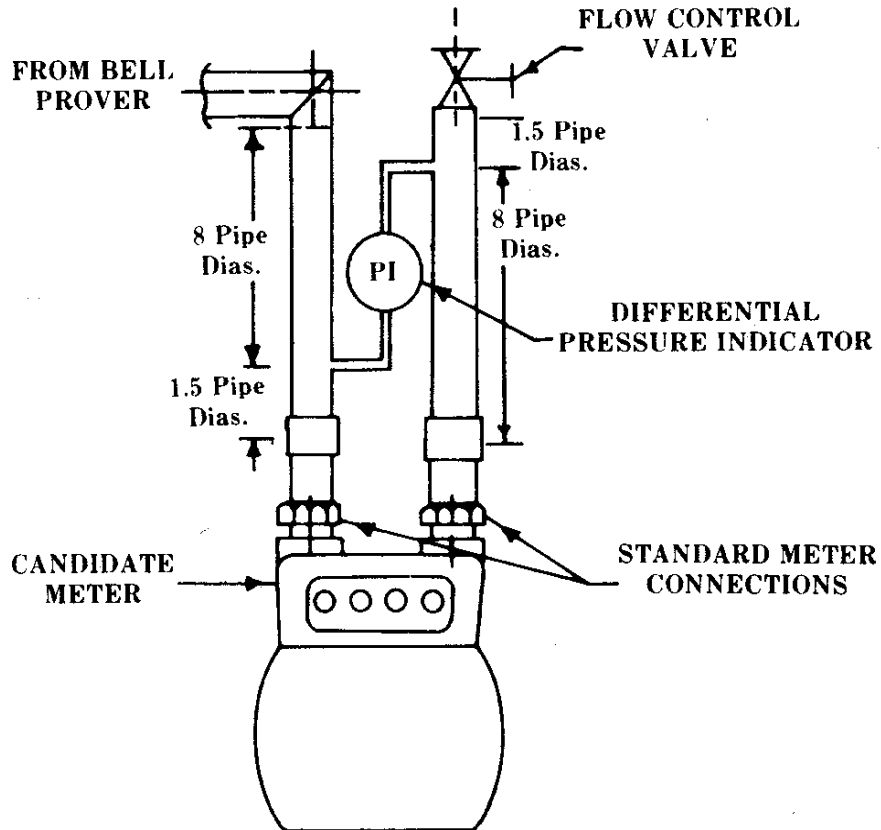


Figure 3. Test apparatus and arrangement for determining the meter capacity class.

- 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 suitable time measurement device, 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

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

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% 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
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
500	1.00	0.028	50	1.4	100	2.8	400	11.3
900	1.8	0.051	90	2.5	180	5.1	720	20.4
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 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. The design shall be suitable for the intended purpose and expected service conditions. The construction shall be mechanically and electrically sound, and the materials (e.g. finish) shall be such as to provide assurance of long life and sustained accuracy.

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 2,000 times the capacity class flow rate per hour, the accuracy of the meter shall be within the limits specified in Table VI.

- 3.3.4 Zero Flow. The gas meter totalization shall not change when the flow rate is zero, while the installation conditions are free from flow pulsations. *Note: This requirement refers to stationary operating conditions. This condition does not refer to the response of the gas meter to changed flow rates.*
- 3.3.4.1 Requirements: Neither the meter display nor the internal register shall change in value (increase or decrease) when the meter is tested by the method given in 3.3.4.2 and Referenced in EN14236
- 3.3.4.2 Test: This test is carried out at the manufacturer's declared temperature extreme values and 68F as appropriate.
- 3.3.4.3 Record the meter display and the internal register of the meter. Fill the meter with air or dry pure methane at an elevated pressure and seal the inlet and outlet ports of the meter with gas tight fittings so as to maintain positive pressure at the lowest test temperature. Allow the meter to stabilize at the test temperature and then store for 24 h at the test temperature. Record the meter display and internal register and subtract the respective first readings from the second readings to indicate any registration change. Repeat the test at each test temperature. Neither the meter display nor the internal register shall change in value (increase or decrease) when the meter is tested by the method given. Registration should not exceed 0.25 cu. Ft. over the time duration. The meter index or alternative meter integration software may be utilized for the measurement.
- 3.3.4.4 Reverse Flow. Gas meters designed for unidirectional measurement shall either prevent reverse flow, or shall withstand incidental or accidental reverse flow without deterioration or change in their metrological properties concerning forward flow measurements.
- 3.3.5 Pulse Generator. A pulse generator may be used as a test element if the value of one pulse, expressed in units of volume or mass, and is indicated on meter 'or available via software'. The gas meter shall be constructed in such a way that the pulse value can be checked experimentally. The difference between the measured value of the pulse value and its value indicated on the gas meter shall not exceed 0.05 % of the latter.

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 METER CASE PRESSURE TEST

- 3.5.1 The meter case shall be able to withstand a burst test using an internal pressure equal to at least four times MAOP of the meter.

NOTE: Intent is to test to catastrophic failure via hydrotest or with suitable containment method"

3.6 NOISE AND VIBRATION

- 3.6.1 Meters shall be essentially free of noise and vibration.

3.7 Correctness of Algorithms and Functions:

3.7.1 The measuring algorithms and functions of the gas meter and/or its constituents shall be appropriate and functionally correct. It shall be possible to examine algorithms and functions either by metrological tests, software tests or software examination.

3.7.2 Gas Quality - The meter shall meet the performance requirements in Section 6 operating within the natural gas property ranges specified in AGA Report No. 4A, 2009 revision, Table 4.1.

3.8 Electrical Safety Design Requirements:

3.8.1 The meter, shall be analyzed, tested and certified by an applicable standards testing laboratory for Electrical Safety.

3.8.2 The meter shall be labeled as approved for operation in a National Electric Code Class I, Division 2, Group D, Hazardous Area, or similarly accepted electrical code for the regional location of the installation at a minimum.

3.8.3 The designer may specify a more severe Division / Group requirement to achieve a more conservative installation design

3.9 Electronic and Mechanical Sealing:

3.9.1 Purpose

3.9.1.1 Electronic and Mechanical sealing shall be provisions to protect against unauthorized modification or access of specific functions of the gas meter or indicate the unauthorized change. These means shall protect against influence to change accuracy, data, and or security by unauthorized parties.

3.9.1.2 The seals shall also support preventing the potential modification of the meter parameters, constants, factors, or algorithms used by the meter for trade measurement.

3.9.1.3 A means to secure a device so that access or changes to metrological adjustments and legally relevant parameters will be detectable through data and roll over alarm logging.

3.9.2 Authorization

3.9.2.1 Electronic Authorization shall be controlled by means of passwords, security keys or the like to protect against unauthorized changes.

3.9.2.1.1 The meter can be placed back into “sealed condition” utilizing proper security measures.

3.9.3 Data Logging

3.9.3.1 Tracking and Event Logging shall be available.

3.9.3.2 Altered parameters by authorized users shall be recorded in data logs along with date / time stamp and register reads as relevant.

3.9.3.3 If rollover of event and or interval logs occurs, oldest logs will be first to over-write.

3.9.3.4 Logs for security and metrological adjustments cannot be cleared without breaking the meter seals.

3.9.3.5 Modifications to non-relevant, non-legal or non-metrological parameters are not required to be logged.

3.9.4 Manufacturing Responsibility

3.9.4.1 During the normal course of operation, metrology functions should continue while other functions are ongoing.

3.10 Software:

3.10.1 Legally relevant parts of the software of a gas meter shall be segmented and identified with version displayed during operation or presented or printed in associated support software

3.10.2 The manufacturer shall maintain a record of all software revisions, including:

3.10.2.1 Revision number

3.10.2.2 Date of revision

3.10.2.3 Explanation of software modifications, additions, and the reason for any changes

3.10.2.4 Applicable meter models

3.10.2.5 Circuit board revisions for which the firmware/software is applicable

3.10.3 The manufacturer may provide firmware upgrades to improve the performance of the meter or add additional features. The manufacturer should notify the operator when new firmware is available and how the revision may affect the meter's uncertainty.

3.10.4 The firmware revision number, revision date, meter serial number shall be available and capable of being displayed by the meter or interface device, for example:

3.10.4.1 Local display

3.10.4.2 Operator software interface

3.10.5 Provisions in the electronics and software are acceptable to detect anomalies for faults (checksum(s)) along with appropriate reactions and communications.

3.11 User Interfaces and Communications:

3.11.1 Measurement / Communications

3.11.1.1 If communication networks become unavailable, no cumulative billing measurement data shall be lost.

3.11.2 Maintenance and Reconfiguration

3.11.2.1 Updates to legally relevant metrology software for the gas meter in services shall be considered a modification of the gas meter and or repair of the meter and may require additional verification dependent on responsible authorities.

3.11.3 Data Management

3.11.3.1 Measurement data shall be stored automatically.

3.11.3.2 Data shall not be corrupted or damages under normal operating or storage conditions.

3.11.4 Inspection and Auditing Functions

3.11.4.1 It shall be possible for the auditor or the inspector to obtain and view the flow measurement constants and configuration parameters used by the meter; e.g., calibration factors, firmware revision number, revision date, serial number, checksum(s), and meter class.. It shall be possible to verify metrological flow calculation factors and parameters while the meter is in operation.

3.11.4.2 Provisions shall be made to prevent unauthorized alteration of those parameters that affect the performance of the meter. Suitable provisions may include, but not limited to, a sealable switch or jumper, a permanent programmable read-only memory chip, or allowing changes only to authenticated and authorized entities.

3.12 Electronics Design Testing

The design of the meter's electronics shall be tested to demonstrate that the meter will continue to meet the performance requirements while operating under the influences and disturbances specified in the current revisions of OIML R 137 *Gas Meters*, and OIML D 11, *General Requirements for Electronic Measuring Instruments*. OIML is the Organization Internationale de Metrologie Legale (i.e., the International Organization of Legal Metrology). OIML publishes these documents for the expressed purpose of harmonizing national performance requirements and testing procedures for gas meters.

For the climatic conditions, the requirements shall be for class H3, "open locations with average climatic conditions, thus excluding polar and desert environments." For the mechanical conditions, the requirements shall be for class M2, "locations with significant or high levels of vibration and shock"; e.g., transmitted from adjacent compressors. For the expected electromagnetic environment, class E1 is selected (minimum class), "this class applies to measuring instruments used in locations where electromagnetic disturbances correspond to those likely to be found in a residential, commercial and light industrial environment."

These test requirements shall apply to the design of all circuit boards, ultrasonic transducers, interconnecting wiring and customer wiring terminals. The electronics shall be in operation, measuring zero flow, and remain 100% functional during the tests. In the case of high-voltage transient and electrostatic discharge tests, the meter may temporarily stop functioning but shall automatically recover within 30 seconds. Pass and Fail criteria will vary per test from the Maximum Error, No Significant Fault After (NSFa), and or No Significant Fault During (NSFd).

The following sections provide a brief description of the required tests and severity levels. Note that the severity levels are listed here for information only and may change in future revisions of the OIML documents. For detailed testing procedures, the manufacturer may refer to the referenced OIML documents, which, in turn, refer to applicable International Electrotechnical Commission (IEC) publications.

B.1 Static Temperature, Dry Heat [IEC 60068-2-2]

Exposure to a static temperature of 131° F (55° C) during a period of two hours. The change of temperature shall not exceed 1.8° F/min (1° C/min) during heating up and cooling down. The absolute humidity of the air shall not exceed .00125 lb/ft³ (20 g/m³). Evaluation to Maximum Error.

B.2 Static Temperature, Cold [IEC 60068-2-1]

Exposure to a static temperature of -13° F (-25° C) during a period of two hours. The change of temperature shall not exceed 1.8° F/min (1° C/min) during heating up and cooling down. The humidity of the air shall be such that condensation is avoided at all times. Evaluation to Maximum Error.

B.3 Damp Heat, Steady State [IEC 60068-2-78]

Exposure to a constant temperature of 86° F (30° C) and a constant relative humidity of 93% for a period of four days. The handling of the electronics shall be such that no condensation of water occurs on this unit. Evaluation to Maximum Error.

B.4 Damp Heat, Cyclic [IEC 60068-2-30]

Exposure to cyclic temperature variations between 77° F and 131° F (25° C and 55° C), maintaining the relative humidity above 95% during the temperature change and low temperature phases, and at 93% at the upper temperature phases. No condensation shall occur on the electronics during the temperature

rise. The test consists of two cycles of 24 hours each following the specified procedure per cycle.
Evaluation: NSFa

B.5 Random Vibration [IEC 60068-2-47]

Exposure to a random vibration level specified below.

Frequency range:	10-150 Hz
Total RMS level:	5.25 ft/s ² (1.6 m/s ²)
ASD level 10-20 Hz:	(.05 m ² /s ³)
ASD level 20-150 Hz:	-3 dB/octave
Number of axes:	3
Duration:	2 minutes or longer if necessary to check the various functions.
Evaluation:	Maximum Error

B.6 Mechanical Shock [IEC 60068-2-31]

The electronic unit, standing in its normal position of use on a rigid surface, is tilted at one bottom edge to a height of 1" (25 mm) and then is allowed to fall freely onto the test surface — once for each bottom edge. Evaluation: NSFa

B.7 Bursts (Transients) [IEC 61000-4-4]

Applicable for electronic measuring instruments containing active electronic circuits which during operation are permanently or temporarily connected to external electrical signal, data and/or control lines.

Exposure to bursts of voltage spikes having a double exponential wave form. Each spike shall have a rise time of 5 ns (nanoseconds) and a half amplitude duration of 50 ns. The burst length shall be 15 ms; the burst period (repetition time interval) shall be 300 ms. The peak value shall be 0.5 kV. Evaluation: NSFd while flowing at 20% Rated Capacity.

B.8 Electrostatic Discharge [IEC 61000-4-2]

Exposure to 10 electrostatic discharges with a time interval between each discharge of 10 seconds. If the electrode giving the discharge is in contact with the electronics, the test voltage shall be 6 kV. If the electrode is approaching the electronics and the discharge occurs by spark, the test voltage shall be 8 kV. Evaluation: NSFd while flowing 20% Rated Capacity, NSFa while flowing at 20% Rated Capacity.

3.13 Electronic Reliability Testing of Design – ALT

The construction shall be mechanically and electrically sound, and the materials (e.g. finish) shall be such as to provide assurance of long life and sustained accuracy. Accelerated life testing of electronics shall be conducted to demonstrate assurance of long life and sustained accuracy.

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. If an index/radio communications device can be replaced in the field without impacting the accuracy of the meter, a field replaceable index/radio shall be permitted.

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, 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, 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.

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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.

For types of gas meters for which the accuracy is affected by flow disturbances, manufacturers shall provide guidance for installation requirements if needed to ensure that the shift of the error due to these disturbances does not exceed one third of the maximum permissible error.

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.

5.12 Pressurizing and Depressurizing the System. In order to prevent internal damage to the meter, the system should be pressurized or depressurized slowly. Generally, the gauge pressure change should not exceed 5 psi (34 kPa) per second.

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PART VI

REMOTE READING DEVICES FOR GAS METERS

6.1 SCOPE

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

- a) Remote Reading Devices.
- b) Other Miscellaneous Associated Equipment.

The primary objectives are to:

- a) Provide a workable and realistic standard and acceptance criteria for new types of remote reading 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 Remote reading Devices.

Remote reading 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 remote reading 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 remote reading devices.

6.1.3 Inspection and Testing

6.1.3.1 New Devices. New remote reading 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 a remote reading device is installed, removed or tested.

6.1.4 Remote reading Device Identification.

Each remote reading 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 remote reading device.

6.1.5 Construction Requirements

6.1.5.1 Case Specifications. The cases of remote reading 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, remote reading devices shall be gasketed between the case and door. Provision for a seal or lock, or both, should be provided.

6.1.7 Acceptance Standards

6.1.7.2 **Accuracy — Laboratory Conditions.** When this standard refers to the accuracy of a remote reading 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 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 \times 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.

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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:

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

Substituting in the above equation:

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

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 Sonic Nozzle, Bell, Piston, and Transfer Provers

7.5.5.1 Description. The Sonic Nozzle prover is vacuum or positive pressure driven prover with arrays of sonic nozzles utilizing choked flow to provide precise flow rates. Bernoulli's principle is applied to calculate the chosen flow rates chosen by the user or automated by a computer.

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 sufficient volume to cause the effect of partial volumetric counts of the meter mechanism, and metered volume indicator, to be less than $\pm 0.1\%$. 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 $\pm 0.5\%$ 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 $14.5 \times 10^{-6} \text{ m}^2/\text{s}$)
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

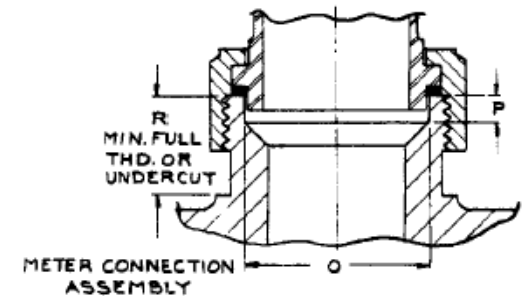
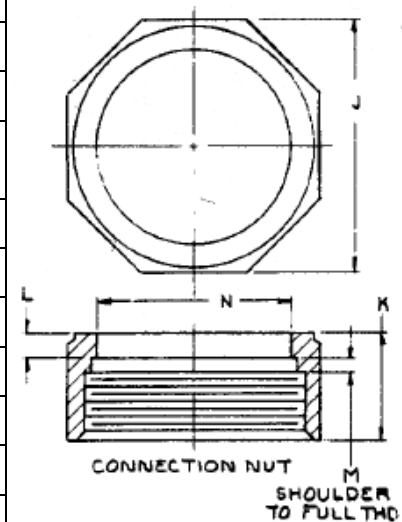
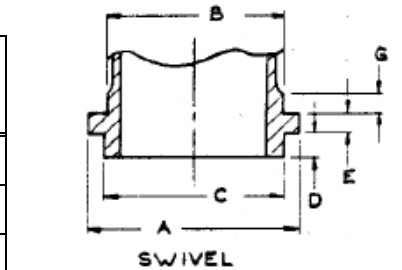
- A = Cylinder inside diameter
- B = Piston rod diameter
- C = Piston stroke

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.	3/4	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	1/4	1/4	3/16	1/4	1/4	1/4
E	1/8	1/8	5/32	5/32	5/32	7/32	5/32	5/32	3/16	5/32	3/16	1/4
G	7/64	1/8	3/16	3/16	5/32	7/32	11/64	3/16	3/8	3/16	1/4	1/4
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	1/4	3/16	1/4	19/64
M (Max.)	5/32	5/32	7/32	3/16	3/16	1/4	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	1/4	1/4	1/4	1/4	5/16	5/16	1/4	5/16	7/16	5/16
R - Min Full Thd. or Undercut	7/16	7/16	17/32	17/32	1/2	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	<u>1.1138</u> 1.1310	<u>1.4234</u> 1.4411	<u>1.5759</u> 1.5931	---	<u>1.8164</u> 1.8341	<u>1.8578</u> 1.8755	<u>2.0348</u> 2.0525	<u>2.2543</u> 2.2720	<u>2.3208</u> 2.3385	<u>2.4253</u> 2.4430	<u>3.001</u> 3.006	<u>3.4407</u> 3.4632
External Pitch Diameter	<u>1.0669</u> 1.0769	<u>1.3746</u> 1.3846	<u>1.5290</u> 1.5390	---	<u>1.7676</u> 1.7776	<u>1.8090</u> 1.8190	<u>1.9860</u> 1.9960	<u>2.2055</u> 2.2155	<u>2.2720</u> 2.2820	<u>2.3765</u> 2.3865	<u>2.9445</u> 2.9495	<u>3.3706</u> 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.	<u>1.650</u> 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	<u>1.0849</u> 1.0962	<u>1.3926</u> 1.4043	<u>1.5470</u> 1.5585	<u>1.588</u> 1.591	<u>1.7856</u> 1.7974	<u>1.8270</u> 1.8390	<u>2.0040</u> 2.0160	<u>2.2235</u> 2.2358	<u>2.2900</u> 2.3023	<u>2.3945</u> 2.4068	<u>2.961</u> 2.969	<u>3.3900</u> 3.4049
Internal Minor Diameter	<u>1.049</u> 1.060	<u>1.355</u> 1.367	<u>1.511</u> 1.522	<u>1.543</u> 1.550	<u>1.748</u> 1.760	<u>1.789</u> 1.801	<u>1.966</u> 1.978	<u>2.186</u> 2.198	<u>2.252</u> 2.265	<u>2.357</u> 2.369	<u>2.922</u> 2.937	<u>3.336</u> 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 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 ft³/h at specified condition.

2.18 = 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?

$$Q = (2.18)(1400) \left(\frac{0.6}{0.57} \right)^{0.5} \left(\frac{520}{40 + 460} \right)^{0.5} \left(\frac{25 + 14.70}{14.73} \right)^{0.75}$$

$$Q = 6717 \text{ ft}^3/\text{h}$$

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

FORM FOR PROPOSALS ON ANSI B109.6

Send to:

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1. Section/Paragraph

2. Proposal Recommends: (check one) new text

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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 (inserted wording) 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.)

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