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Section 3.33. Hydrocarbon Gas Vapor-Measuring Devices[1]

A. Application

A.1. General. – This code applies to devices used for the measurement of hydrocarbon gas in the vapor state, such as propane, propylene, butanes, butylenes, ethane, methane, natural gas, and any other hydrocarbon gas/air mix.
(Amended 1984, 1986, 1988, and 1991)

A.2. Exceptions. – This code does not apply to:

(a) Liquid-measuring devices used for dispensing liquefied petroleum gases in liquid form. (Also see Section 3.32. Code for Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices.)

(b) Natural, liquefied petroleum, and manufactured-gas-vapor meters when these are operated in a public utility system.

(c) Mass flow meters. (Also see Section 3.37. Code for Mass Flow Meters.)
(Added 1994)

A.3. Additional Code Requirements. – In addition to the requirements of this code, Hydrocarbon Gas Vapor-Measuring Devices shall meet the requirements of Section 1.10. General Code.

S. Specifications

S.1. Design of Indicating and Recording Elements and of Recorded Representations.

S.1.1. Primary Elements.

S.1.1.1. General. – A device shall be equipped with a primary indicating element and may also be equipped with a primary recording element.

S.1.1.2. Units. – A volume-measuring device shall indicate, and record if equipped to record, its deliveries in terms of cubic meters or cubic feet, or multiple or decimal subdivisions of cubic meters or cubic feet.
(Amended 1972 and 1991)

S.1.1.3. Value of Smallest Unit. – The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed:

(a) 1 m^3 (1000 dm^3) (100 ft^3) when the maximum rated gas capacity is less than 280 m^3/h (10 000 ft^3/h);

(b) 10 m^3 (1000 ft^3) when the maximum rated gas capacity is 280 m^3/h (10 000 ft^3/h) up to, but not including, 1700 m^3/h (60 000 ft^3/h); and

(c) 100 m^3 (10 000 ft^3) when the maximum rated gas capacity is 1700 m^3/h (60 000 ft^3/h) or more.

(Amended 1972, 1988, and 1991)

[1]Title changed 1986.

S.1.1.4. Advancement of Indicating and Recording Elements. – Primary indicating and recording elements shall advance digitally or continuously and be susceptible to advancement only by the mechanical operation of the device.

S.1.1.5. Proving Indicator. – Devices rated less than 280 m^3/h (10 000 ft^3/h) gas capacity shall be equipped with a proving indicator measuring 0.025 m^3, 0.05 m^3, 0.1 m^3, 0.2 m^3, or 0.25 m^3 per revolution, (1 ft^3, 2 ft^3, 5 ft^3, or 10 ft^3 per revolution) for testing the meter. Devices with larger capacities shall be equipped as follows:

(a) Devices rated 280 m^3 (10 000 ft^3) up to but not including 1700 m^3/h (60 000 ft^3/h) gas capacity shall be equipped with a proving indicator measuring not greater than 1 m^3 (100 ft^3) per revolution.

(b) Devices rated 1700 m^3/h (60 000 ft^3/h) gas capacity or more shall be equipped with a proving indicator measuring not more than 10 m^3 (1000 ft^3) per revolution.

The test circle of the proving indicator shall be divided into ten equal parts. Additional subdivisions of one or more of such equal parts may be made.

(Amended 1973 and 1988)

S.1.2. Graduations.

S.1.2.1. Length. – Graduations shall be so varied in length that they may be conveniently read.

S.1.2.2. Width. – In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and in no case should it exceed 1.0 mm (0.04 in) for indicating elements and 0.5 mm (0.02 in) for proving circles.

S.1.2.3. Clear Interval Between Graduations. – The clear interval shall be not less than 1.0 mm (0.04 in). If the graduations are not parallel, the measurement shall be made:

(a) along the line of relative movement between the graduations at the end of the indicator; or

(b) if the indicator is continuous, at the point of widest separation of the graduations.

S.1.3. Indicators.

S.1.3.1. Symmetry. – The index of an indicator shall be symmetrical with respect to the graduations, at least throughout that portion of its length associated with the graduations.

S.1.3.2. Length. – The index of an indicator shall reach to the finest graduations with which it is used.

S.1.3.3. Width. – The width of the index of an indicator in relation to the series of graduations with which it is used shall be not greater than the:

(a) *width of the narrowest graduation*;* and
*[*Nonretroactive as of January 1, 2002]*
(Amended 2001)

(b) width of the minimum clear interval between graduations.

When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width throughout the length of the index that coincides with the graduation.

S.1.3.4. Clearance. – The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm (0.06 in).

S.1.3.5. Parallax. – Parallax effects shall be reduced to the practicable minimum.

S.2. Design of Measuring Elements.

S.2.1. Pressure Regulation. – The vapor should be measured at a normal gauge pressure (psig) of:
(Amended 1991)

(a) 2740 Pa ± 685 Pa (11 in of water column [0.40 psig] ± 2.75 in of water column [0.10 psig]) for liquefied petroleum gas vapor; or

(b) 1744 Pa ± 436 Pa (7 in of water column [0.25 psig] ± 1.75 in of water column [0.06 psig]) for natural and manufactured gas.

When vapor is measured at a pressure other than what is specified above for the specific product, a volume multiplier shall be applied within the meter or to the billing invoice based on the following equation:

$$VPM = \frac{AAP + GP}{AAP + NGP}$$

Where:

VPM = Volume pressure multiplier
AAP = Assumed atmospheric pressure in Pa or psia
GP = Gauge pressure in Pa or psig
NGP = Normal gauge pressure in Pa or psig

The assumed atmospheric pressure is to be taken from Table 2. Corrections for Altitude, U.S. Customary Units and Table 2M. Corrections for Altitude, Metric Units.

When liquefied petroleum gas vapor is measured at a pressure of 6900 Pa (1 psig) or more, the delivery pressure shall be maintained within ± 1725 Pa (± 0.25 psig).

Pressure variations due to regulator lock off shall not increase the operating pressure by more than 25 %.
(Amended 1980, 1984, and 1991)

S.2.2. Provision for Sealing. – For devices or systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device, security shall be provided for those parameters as specified in G-S.8.2. Devices and Systems Adjusted Using Removable Digital Storage Devices. For parameters adjusted using other means, the following applies.

Adequate provision shall be made for applying security seals in such a manner that no adjustment or interchange can be made of any measurement element.
(Amended 2019)

S.2.3. Maintenance of Vapor State. – A device shall be so designed and installed that the product being measured will remain in a vapor state during passage through the meter.

S.2.4. Automatic Temperature Compensation. – A device may be equipped with an adjustable automatic means for adjusting the indication and registration of the measured volume of vapor product to the volume at 15 °C (60 °F).

S.3. Design of Discharge Lines.

S.3.1. Diversion of Measured Vapor. – No means shall be provided by which any measured vapor can be diverted from the measuring chamber of the meter or the discharge line therefrom.

S.4. Marking Requirements.

S.4.1. Limitations of Use. – If a device is intended to measure accurately only products having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately only when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently stated on the device.

S.4.2. Discharge Rates. – A device shall be marked to show its rated gas capacity in cubic meters per hour or cubic feet per hour.

S.4.3. Temperature Compensation. – If a device is equipped with an automatic temperature compensator, this shall be indicated on the badge or immediately adjacent to the badge of the device and on the register.

S.4.4. Badge. – A badge affixed in a prominent position on the front of the device shall show the manufacturer's name, serial number and model number of the device, and capacity rate of the device for the particular products that it was designed to meter as recommended by the manufacturer.

N. Notes

N.1. Test Medium. – The device shall be tested with air or the product to be measured.
(Amended 1991)

N.2. Temperature and Volume Change. – Care should be exercised to reduce to a minimum any volume changes. The temperature of the air, bell-prover oil, and the meters under test should be within 1 °C (2 °F) of one another. The devices should remain in the proving room for at least 16 hours before starting any proving operations to allow the device temperature to approximate the temperature of the proving device.

N.3. Test Drafts. – Except for low-flame tests, test drafts shall be at least equal to one complete revolution of the largest capacity proving indicator and shall in no case be less than 0.05 m^3 or 2 ft^3. All flow rates shall be controlled by suitable outlet orifices.
(Amended 1973 and 1991)

Table 1.
Capacity of Low-Flow Test Rate Orifices with Respect to Device Capacity

Metric Units		U.S. Customary Units	
Rated Capacity	**Low-Flow Test Rate**	**Rated Capacity**	**Low-Flow Test Rate**
Up to and including 7 m^3/h	0.007 m^3/h	Up to and including 250 ft^3/h	0.25 ft^3/h
Over 7 m^3/h up to and including 14 m^3/h	0.014 m^3/h	Over 250 ft^3/h up to and including 500 ft^3/h	0.50 ft^3/h
Over 14 m^3/h	0.1 % of capacity rate	Over 500 ft^3/h	0.1 % of capacity rate

N.4. Test Procedures. – If a device is equipped with an automatic temperature compensator, the proving device reading shall be corrected to 15 °C (60 °F), using an approved table.
(Amended 1972)

N.4.1. Normal Tests. – The normal test of a device shall be made at a rate not to exceed the capacity rate given on the badge of the meter.

(Amended 1988)

N.4.1.1. Automatic Temperature Compensation. – If a device is equipped with an automatic temperature compensator, the quantity of the test draft indication of the standard shall be corrected to 15 °C (60 °F).

N.4.2. Special Tests. – "Special" tests shall be made to develop the operating characteristics of a device and any special elements and accessories attached to or associated with the device. Any test except as set forth in N.4.1. Normal Tests shall be considered a special test.

N.4.2.1. Slow Test. – The device shall be tested at a rate not less than 20 % of the marked capacity rate, or (at the check rate) not less than the minimum flow rate if marked on the device, whichever is less.

(Amended 1988)

N.4.2.2. Low-Flame Test. – The device shall be tested at an extremely low-flow rate as given in Table 1. Capacity of Low-Flow Test Rate Orifices with Respect to Device Capacity. The test shall consist of passing air at a pressure of 375 Pa (1.5 in water column) through the meter for not less than 60 minutes. The meter shall continue to advance at the conclusion of the test period.

(Amended 1990 and 1991)

N.4.2.3. Pressure Regulation Test. – On devices operating at a pressure of 6900 Pa (1 psig) or more, a pressure regulation test shall be made at both the minimum and maximum use load to determine the proper operation of the regulator and the proper sizing of the piping and dispensing equipment. These tests may include a test of 24 hours during which the pressure is recorded.

(Added 1984)

N.4.3. Repeatability Tests. – Tests for repeatability should include a minimum of three consecutive test drafts of approximately the same size and be conducted under controlled conditions where variations in factors such as temperature, pressure, and flow rate are reduced to the extent that they will not affect the results obtained. When conducting the tests, the minimum discharge rate shall be the minimum flow rate marked on the device or at least 20% of the marked capacity rate, whichever is less, and the maximum discharge rates shall not exceed the capacity rate as marked by the manufacturer.

Note: The repeatability test will not be performed at the low-flame flow rate for these devices as the time required would be unrealistic.

(Amended 2019)

N.5. Temperature Correction. – Corrections shall be made for any changes in volume resulting from the difference in air temperatures between time of passage through the device and time of volumetric determination in the proving device.

N.6. Frequency of Test. – A hydrocarbon gas vapor-measuring device shall be tested before installation and allowed to remain in service for 10 years from the time last tested without being retested, unless a test is requested by:

(a) the purchaser of the product being metered;

(b) the seller of the product being metered; or

(c) the weights and measures official.

T. Tolerances

T.1. Tolerance Values on Normal Tests and on Special Tests Other Than Low-Flame Tests. – Maintenance and acceptance tolerances for normal and special tests for hydrocarbon gas vapor-measuring devices shall be as shown in Table T.1. Accuracy Classes and Tolerances for Hydrocarbon Gas Vapor-Measuring Devices.

(Amended 1981 and 2003)

Table T.1.
Accuracy Classes and Tolerances for Hydrocarbon Gas Vapor-Measuring Devices

Accuracy Class	Application		Acceptance Tolerance	Maintenance Tolerance
3.0	Gases at low pressure (for example, LPG vapor)	**Overregistration**	1.5 %	1.5 %
		Underregistration	3.0 %	3.0 %

(Added 2003)

T.2. Repeatability. – When multiple tests are conducted at approximately the same flow rate and draft size, the range of the test results for the flow rate shall not exceed 0.9 % and the results of each test shall be within the applicable tolerance. Also see N.4.3. Repeatability Tests.

(Added 2002) (Amended 2019)

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Capacity Rate. – A device shall be so installed that the actual maximum flow rate will not exceed the capacity rate except for short durations. If necessary, means for flow regulation shall be incorporated in the installation, in which case this shall be fully effective and automatic in operation.

UR.1.2. Leakage. – The metering system shall be installed and maintained as a pressure-tight and leak-free system.

UR.2. Use Requirements.

UR.2.1. Automatic Temperature Compensation. – A compensated device may not be replaced with an uncompensated device without the written approval of the weights and measures authority having jurisdiction over the device.

UR.2.2. Invoices. – A customer purchasing hydrocarbon gas measured by a vapor meter shall receive from the seller an invoice for each billing period. The invoice shall clearly and separately show the following:

(a) The opening and closing meter readings and the dates of those readings.

(b) The altitude correction factor.

(c) The total cubic meters (cubic feet) billed, corrected for elevation.

(d) The charge per cubic meter (cubic foot) after correction for elevation.

(e) All periodic charges independent of the measured gas, such as meter charges, meter reading fees, service charges or a minimum charge for a minimum number of cubic meters (cubic feet).

(f) The total charge for the billing period.

If the vapor meter is equipped with an automatic temperature compensator, or any other means are used to compensate for temperature, the invoice shall show that the volume has been adjusted to the volume at 15 °C (60 °F).

(Amended 1988 and 1991)

UR.2.3. Correction for Elevation. – The metered volume of gas shall be corrected for changes in the atmospheric pressure with respect to elevation to the standard pressure of 101.56 kPa (14.73 psia). The appropriate altitude correction factor from Table 2M. Corrections for Altitude, Metric Units or Table 2. Corrections for Altitude, U.S. Customary Units shall be used. (The table is modified from NBS Handbook 117, Examination of Vapor-Measuring Devices for Liquefied Petroleum Gas.)

Elevation correction factors (ACF) were obtained by using the following equation:

$$ACF = \frac{GP \text{ of gas} + AAP}{\text{base pressure}}$$

Where:

GP	= gauge pressure
AAP	= assumed atmospheric pressure
base pressure	= 101.560 kPa = 14.73 psia
2740 Pa	= 11 in of water column = 0.397 psig
1744 Pa	= 7 in of water column = 0.253 psig

(Amended 1988)

UR.2.4. Valves and Test Tee. *– All gas meter installations shall be provided with a shut-off valve located adjacent to and on the inlet side of the meter. In the case of a single meter installation utilizing a liquefied petroleum gas tank, the tank service valve may be used in lieu of the shut-off valve. All gas meter installations shall be provided with a test tee located adjacent to and on the outlet side of the meter.*
[Nonretroactive as of January 1, 1990]

(Added 1989)

UR.2.5. Use of Auxiliary Heated Vaporizer Systems. – Automatic temperature compensation shall be used on hydrocarbon gas vapor meters equipped with an auxiliary heated vaporizer system unless there is sufficient length of underground piping to provide gas at a uniform temperature to the meter inlet. When required by weights and measures officials, a thermometer well (appropriately protected against freezing) shall be installed immediately up-stream of the meter.

(Added 1990)

Table 2M.
Corrections for Altitude, Metric Units

Elevation (meters)			Altitude Correction Factor		Assumed Atmospheric Pressure	Assumed Atmospheric Pressure Plus Gauge Pressure	
			2.74 kPa Gauge Pressure	1.74 kPa Gauge Pressure	(kPa)	2.74 kPa Gauge Pressure	1.74 kPa Gauge Pressure
	− 50 to	120	1.02	1.01	100.85	103.59	102.58
above	120 to	300	1.00	0.99	98.82	101.56	100.54
above	300 to	470	0.98	0.97	96.79	99.53	98.51
above	470 to	650	0.96	0.95	94.76	97.50	96.48
above	650 to	830	0.94	0.93	92.73	95.47	94.45
above	830 to	1020	0.92	0.91	90.70	93.44	92.42
above	1020 to	1210	0.90	0.89	88.66	91.40	90.39
above	1210 to	1400	0.88	0.87	86.63	89.37	88.36
above	1400 to	1590	0.86	0.85	84.60	87.34	86.33
above	1590 to	1790	0.84	0.83	82.57	85.31	84.29
above	1790 to	2000	0.82	0.81	80.54	83.28	82.26
above	2000 to	2210	0.80	0.79	78.51	81.25	80.23
above	2210 to	2420	0.78	0.77	76.48	79.22	78.20
above	2420 to	2640	0.76	0.75	74.45	77.19	76.17
above	2640 to	2860	0.74	0.73	72.41	75.15	74.15
above	2860 to	3080	0.72	0.71	70.38	73.12	72.12
above	3080 to	3320	0.70	0.69	68.35	71.09	70.08
above	3320 to	3560	0.68	0.67	66.32	69.06	68.05
above	3560 to	3800	0.66	0.65	64.29	67.03	66.01
above	3800 to	4050	0.64	0.63	62.26	65.00	63.98
above	4050 to	4310	0.62	0.61	60.23	62.97	61.95
above	4310 to	4580	0.60	0.59	58.20	60.94	59.92

Table 2.
Corrections for Altitude, U.S. Customary Units

Elevation (feet)			Altitude Correction Factor		Assumed Atmospheric Pressure	Assumed Atmospheric Pressure Plus Gauge Pressure	
			11 inch WC	7 inch WC	(psia)	11 inch WC (psia)	7 inch WC (psia)
	− 150 to	400	1.02	1.01	14.64	15.04	14.89
above	400 to	950	1.00	0.99	14.35	14.74	14.60
above	950 to	1 550	0.98	0.97	14.05	14.45	14.30
above	1 550 to	2 100	0.96	0.95	13.76	14.15	14.01
above	2 100 to	2 700	0.94	0.93	13.46	13.86	13.71
above	2 700 to	3 300	0.92	0.91	13.17	13.56	13.42
above	3 300 to	3 950	0.90	0.89	12.87	13.27	13.12
above	3 950 to	4 550	0.88	0.87	12.58	12.97	12.83
above	4 550 to	5 200	0.86	0.85	12.28	12.68	12.53
above	5 200 to	5 850	0.84	0.83	11.99	12.38	12.24
above	5 850 to	6 500	0.82	0.81	11.69	12.09	11.94
above	6 500 to	7 200	0.80	0.79	11.40	11.79	11.65
above	7 200 to	7 900	0.78	0.77	11.10	11.50	11.35
above	7 900 to	8 600	0.76	0.75	10.81	11.20	11.06
above	8 600 to	9 350	0.74	0.73	10.51	10.91	10.76
above	9 350 to	10 100	0.72	0.71	10.22	10.61	10.47
above	10 100 to	10 850	0.70	0.69	9.92	10.32	10.17
above	10 850 to	11 650	0.68	0.67	9.63	10.03	9.88
above	11 650 to	12 450	0.66	0.65	9.33	9.73	9.58
above	12 450 to	13 250	0.64	0.63	9.04	9.44	9.29
above	13 250 to	14 100	0.62	0.61	8.75	9.14	9.00
above	14 100 to	14 950	0.60	0.59	8.45	8.85	8.70

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