

Sec. 3.33. Hydrocarbon Gas Vapor-Measuring Devices¹

A. Application

A.1. - 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, 1991)

A.2. - This code does not apply to:

- (a) Liquid-measuring devices used for dispensing liquefied petroleum gases in liquid form (for which see Sec. 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 (see Sec. 3.37. Code for Mass Flow Meters)
(Added 1994)

A.3. - See also Sec. 1.10; General Code requirements.

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, 1991)

S.1.1.3. Value of Smallest Unit. - Volume-Measuring Devices: 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 $100 \text{ m}^3/\text{h}$ ($10\,000 \text{ ft}^3/\text{h}$);
- (b) 10 m^3 (1000 ft^3) when the maximum rated gas capacity is $280 \text{ m}^3/\text{h}$ ($10\,000 \text{ ft}^3/\text{h}$) up to but not including $1700 \text{ m}^3/\text{h}$ ($60\,000 \text{ ft}^3/\text{h}$);
- (c) 100 m^3 ($10\,000 \text{ ft}^3$) when the maximum rated gas capacity is $1700 \text{ m}^3/\text{h}$ ($60\,000 \text{ ft}^3/\text{h}$) or more.
(Amended 1972, 1988, 1991)

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 $280 \text{ m}^3/\text{h}$ ($10\,000 \text{ ft}^3/\text{h}$) gas capacity shall be equipped with a proving indicator measuring 0.025 , 0.05 , 0.1 , 0.2 , or 0.25 m^3 per revolution, (1 , 2 , 5 , 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 ($10\,000 \text{ ft}^3$) up to but not including $1700 \text{ m}^3/\text{h}$ ($60\,000 \text{ ft}^3/\text{h}$) gas capacity shall be equipped with a proving indicator measuring not greater than 1 m^3 (100 ft^3) per revolution.
- (b) Devices rated $1700 \text{ m}^3/\text{h}$ ($60\,000 \text{ ft}^3/\text{h}$) 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 10 equal parts. Additional subdivisions of one or more of such equal parts may be made.

¹Title changed 1986.

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(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:

- (a) the width of the widest graduation, and
- (b) the 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. - Except when measured as a retail motor fuel, the vapor should be measured at a normal gauge pressure (psig) of:
(Amended 1991)

- (a) 2740 Pa \pm 685 Pa (11 in of water column (0.40 psig) \pm 2.75 in of water column (0.10 psig)) for liquefied petroleum gas vapor; or
- (b) 1744 Pa \pm 436 Pa (7 in of water column (0.25 psig) \pm 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 psia
GP = Gauge pressure in pascal or psig
NGP = Normal gauge pressure in pascal or psig

The assumed atmospheric pressure is to be taken from Tables 2 and 2M.

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 percent.
(Amended 1980, 1984, 1991)

S.2.2. Provision for Sealing. - Adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of any measurement element.

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 volume-measuring 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 m³ or 2 ft³. All flow rates shall be controlled by suitable outlet orifices.
(Amended 1973 and 1991)

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.

| <p align="center">Table 1. Capacity of Low-Flow Test Rate Orifices With Respect to Device Capacity</p> | | | |
|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------|-------------------------|
| Metric Units | | Inch-Pound 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 |

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(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, to develop the operating characteristics of a device, and any special elements and accessories attached to or associated with the device, shall be made as circumstances require. Any test except as set forth in N.4.1. is a special test.

N.4.2.1. Slow Test. - The device shall be tested at a rate not less than 20 percent 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. 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, 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.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 hydrocarbon gas vapor-measuring devices shall be 3 percent (1.03 proof) of the test draft on underregistration and 1.5 percent (0.985 proof) of the test draft on overregistration.

(Amended 1981)

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 for other than motor fuel 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, 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 or 2 shall be used. (The table is modified from NIST Handbook 117.) (Amended 1988)

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
(Added 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)

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| 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 | | | | | |
| above | 120 to 300 | 1.02 | 1.01 | 100.85 | 103.59 | 102.58 |
| above | 300 to 470 | 1.00 | 0.99 | 98.82 | 101.56 | 100.54 |
| above | 470 to 650 | 0.98 | 0.97 | 96.79 | 99.53 | 98.51 |
| above | 650 to 830 | 0.96 | 0.95 | 94.76 | 97.50 | 96.48 |
| above | 830 to 1020 | 0.94 | 0.93 | 92.73 | 95.47 | 94.45 |
| above | 1020 to 1210 | 0.92 | 0.91 | 90.70 | 93.44 | 92.42 |
| above | 1210 to 1400 | 0.90 | 0.89 | 88.66 | 91.40 | 90.39 |
| above | 1400 to 1590 | 0.88 | 0.87 | 86.63 | 89.37 | 88.36 |
| above | 1590 to 1790 | 0.86 | 0.85 | 84.60 | 87.34 | 86.33 |
| above | 1790 to 2000 | 0.84 | 0.83 | 82.57 | 85.31 | 84.29 |
| above | 2000 to 2210 | 0.82 | 0.81 | 80.54 | 83.28 | 82.26 |
| above | 2210 to 2420 | 0.80 | 0.79 | 78.51 | 81.25 | 80.23 |
| above | 2420 to 2640 | 0.78 | 0.77 | 76.48 | 79.22 | 78.20 |
| above | 2640 to 2860 | 0.76 | 0.75 | 74.45 | 77.19 | 76.17 |
| above | 2860 to 3080 | 0.74 | 0.73 | 72.41 | 75.15 | 74.15 |
| above | 3080 to 3320 | 0.72 | 0.71 | 70.38 | 73.12 | 72.12 |
| above | 3320 to 3560 | 0.70 | 0.69 | 68.35 | 71.09 | 70.08 |
| above | 3560 to 3800 | 0.68 | 0.67 | 66.32 | 69.06 | 68.05 |
| above | 3800 to 4050 | 0.66 | 0.65 | 64.29 | 67.03 | 66.01 |
| above | 4050 to 4310 | 0.64 | 0.63 | 62.26 | 65.00 | 63.98 |
| above | 4310 to 4580 | 0.62 | 0.61 | 60.23 | 62.97 | 61.95 |
| above | 4580 to 4850 | 0.60 | 0.59 | 58.20 | 60.94 | 59.92 |

| Table 2. Corrections for Altitude, Inch-Pound 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 | 1550 | 0.98 | 0.97 | 14.05 | 14.45 | 14.30 |
| above | 1550 to | 2100 | 0.96 | 0.95 | 13.76 | 14.15 | 14.01 |
| above | 2100 to | 2700 | 0.94 | 0.93 | 13.46 | 13.86 | 13.71 |
| above | 2700 to | 3300 | 0.92 | 0.91 | 13.17 | 13.56 | 13.42 |
| above | 3300 to | 3950 | 0.90 | 0.89 | 12.87 | 13.27 | 13.12 |
| above | 3950 to | 4550 | 0.88 | 0.87 | 12.58 | 12.97 | 12.83 |
| above | 4550 to | 5200 | 0.86 | 0.85 | 12.28 | 12.68 | 12.53 |
| above | 5200 to | 5850 | 0.84 | 0.83 | 11.99 | 12.38 | 12.24 |
| above | 5850 to | 6500 | 0.82 | 0.81 | 11.69 | 12.09 | 11.94 |
| above | 6500 to | 7200 | 0.80 | 0.79 | 11.40 | 11.79 | 11.65 |
| above | 7200 to | 7900 | 0.78 | 0.77 | 11.10 | 11.50 | 11.35 |
| above | 7900 to | 8600 | 0.76 | 0.75 | 10.81 | 11.20 | 11.06 |
| above | 8600 to | 9350 | 0.74 | 0.73 | 10.51 | 10.91 | 10.76 |
| above | 9350 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 |