Appendix – D

HYDROCARBON GAS VAPOR METERS

(For Vapor Laboratory Requirements See REF V)

(Agenda Item 8)

Pre-Test Considerations

1. All temperature values used in formulas to determine percent error must be converted to absolute temperature (Rankine) by adding 460 to the temperature value (i.e., 460 + 70°F = 530).

Pre-Test Inspection

1. Identification and marking requirements. **G-S.1 [1.10], S.4 [3.33]**

   1.1. Manufacturer's or distributor's name, model number and serial number.

   1.2. Rated capacity.

   1.3. If a meter is equipped with an automatic temperature compensator, this shall be indicated on the badge (identification plate) or immediately adjacent to the badge and on the register. (Nonretroactive as of January 1, 1995.) **4002.5 [3.33]; (b.) Page D3-31**

   1.4. Limitation of use.

2. Type approval. **B&P 12500.5**

3. Indicating elements.

   3.1. Shall indicate in terms of cubic feet or cubic meters. **S.1.1.2 [3.33]**

   3.2. 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: **S.1.1.3 [3.33]**

      (a) 100 cubic feet or 1 cubic meter when the maximum rated gas capacity is less than 10,000 cubic feet per hour.

      (b) 1,000 cubic feet or 10 cubic meter when the maximum rated gas capacity is 10,000 cubic feet per hour up to but not including 60,000 cubic feet per hour.

      (c) 10,000 cubic feet or 100 cubic meter when the maximum rated gas capacity is 60,000 cubic feet per hour or more.

   3.3. Advancement of indicating and recording elements. Primary indicating and recording elements shall advance digitally or continuously and be susceptible of advancement only by the mechanical operation of the device. **S.1.1.4 [3.33]**

4. Meters removed for complaint.

   4.1. Meters removed because of complaint should be held in testing room at least 16 hours with inlet and outlet ports open to allow temperature equalization. **N.2 [3.33]**

4.2. Proof testing shall be done with meter in same condition as received.

4.3. The first set of results (open and check rate) shall be recorded and used as the official test.

5. Meters removed for routine test.

5.1. Inspect for loose screws and obvious damage to seals, glass, case and threads.

5.2. Indexes should be removed for inspection as necessary and left off until completion of leak test.

5.3. Inspect indexes for type of registration, alignment of numbers and freedom of movement. Record total registration in the case of meters that will be returned to service in the same location.

NOTE: Indexes on American W series meters should not be removed as the seal between drive shaft and 0 ring is disturbed and may cause subsequent leaks.

Pre-Test Determinations

1. Temperature requirements.

1.1. Before beginning proof test, meters should be held in prover room at least 16 hours after leak test with inlet and outlet ports open to allow temperature equalization. **N.2 [3.33]**

1.2. Proof testing may be done within a temperature range of 60°F to 90°F.

1.3. Temperature range between prover room air, bell prover oil, and meter under test shall be held within 2°F (a difference of 5°F will result in a test error of about 1 percent). Testing is not recommended if the environmental temperature fluctuates greater than ±2°F during the test or if temperature between bell prover oil and outlet air are greater than 1°F. **N.2 [3.33]**

1.4. Temperature range between the air outlets of the prover and meter should be held to 1°F. If temperature range exceeds 1°F, a correction will need to be applied to proof results (see proof testing).

2. Bell prover requirements.

2.1. Operating pressure of 2 cu. ft. to 10 cu. ft. bell provers shall be 1.5 inch of water column.

2.2. Bell provers should be tested for leaks prior to use. A leak test can be made by setting prover at a specific mark. If there is no perceptible movement in ten minutes, the prover may be considered to be leak free.

3. Preparation of test rate caps.

3.1. Meters are proof tested at two rates, a capacity (open) rate and a check rate of 20% of marked capacity or the check rate, if marked on the device, whichever is less. **N.4 [3.33]**

3.2. Rate caps are drilled to a specific size orifice to release air at the desired rate and thus control the meter speed.

3.3. The flow rate of a particular meter rate cap in cubic feet per hour may be determined by using a stopwatch as follows:

3.3.1. Flow rate caps to be used with a bell prover at a pressure of 1.5 inch water column can be timed for 1 cu. ft. on the prover scale. Record pressure of bell prover during establishment of pilot load rate cap flow rate for purpose of setting regulator during pilot load test.

3.3.2. To determine the correct rate caps to be used with meter capacity rated for other than air, apply the following equation by using the information supplied from the ID badge of the meter undergoing proof testing.

$$\text{Air Capacity} = \text{Gas Capacity X } \sqrt{\text{Specific Gravity of Gas}}$$

Example: Meter "AXYZ" rated capacity is 110 cfh with propane.

$$\text{Using Air as a Test Medium} = 110 \text{ x } \sqrt{1.53 \text{ sp.gr. (Propane)}}$$

Air Capacity = 136 cfh

Reference:

Propane	=	1.53 sp. gr.
Natural Gas	=	0.60 sp. gr.
Air	=	1.00 sp. gr.
Butane	=	2.006 sp. gr.

Note: Meters Flow capacity are normally based on specific gravity of 0.60 unless otherwise specified on the ID badge.

3.4. Using the following formula to determine flow-rate/hour:

$$\text{Cubic Feet/Hour} = \frac{3600}{\text{Time (in seconds)}}$$

3.5. Rate cap drill sizes are determined by trial and error. Start with smallest hole in center of cap and test for rate/hour using above formula. Increase drill size as necessary to obtain proper rate cap flow rate.

Tests

1. Leak test.

1.1. Slowly pressurize the meter (not exceeding 5 psi per second) to the maximum allowable operating pressure (MAOP) of the meter. Submerge meter at flow rate equivalent to one revolution in one minute. Do not subject meter to pressure exceeding 1.5 times the rated MAOP. **4002.5 [3.33]; (a.) Page D3-32**

NOTE: This test should be done with water temperature at ambient temperature or allow meters to equalize 16 hours after removal, but prior to "proof testing".

1.1. While the meter is submerged, examine case and index drive shaft for leaks. A meter that leaks at any point is unsatisfactory.

1.3. After removing meter from water, dry index compartment thoroughly with compressed air before reinstalling cover. Dry out the index recess before installing index and cover.

1.4. Use caution in meshing index drive gears. On some models, the gears will turn off the shaft if turned opposite to direction of normal rotation.

2. Low flame test. **N.4.2.2 [3.33]**

2.1. Meters shall be given a low flame (pilot) test as prescribed by Table 1. **N.4.2.2 [3.33]**

Table 1. Capacity Of Low Flow Test Rate Orifices With Respect To Device Capacity

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

2.2. Circulate air through the meter being tested to take up all the slack in the bellows, gears, etc., before performing the low flame (Pilot) test. Start the test with pointer of proving indicator at a convenient division on the upswing.

2.3. During pilot load test, it is important to maintain a constant pressure equal to the pressure of the bell prover when the rate cap flow rate drill size was established, especially when using a regulator with a timer.

2.4. Meter is unsatisfactory if there is no continuous movement when air, at a pressure of 1.5 inches water column, is passed through a proper drill size orifice on the outlet side of the meter being tested within 60 minutes.

3. Proof testing. (See EPO NO. 31-2, 1.1.)

3.1. Connect meter to prover and differential pressure gage. (Use small amount of grease on meter fitting threads.)

3.2. Make leak test of meter and hose connections as follows before installing rate cap:

3.2.1. Block fitting on outlet side of meter with palm of hand or plug.

3.2.2. Pressurize fittings and meter by opening prover outlet valve.

3.2.3. Close prover outlet valve and watch for pressure drop on manometer, which would indicate a leak.

3.2.4. Small leaks can be found by brushing soapsuds on all fittings and connections.

3.3. Install capacity flow rate cap on meter outlet.

Purge small meters (630 ft^3 or less) with 5 cu. ft. of air and larger sizes (greater than 630 ft^3) with 10 cu. ft. of air.

3.4. Position meter proving hand on upswing by opening prover outlet valve. When meter proving hand reaches predetermined point, stop it by closing prover outlet valve.

3.5. Position prover at desired starting point.

3.6. Test Run

(a) Before beginning test run, recheck prover and meter for exact position.
(b) Open prover outlet valve and allow meter to run.
(c) While air is flowing through the meter, record the temperature on the outlet side of both prover and meter.
(d) When meter has run through desired number of cubic feet, stop meter proving circle hand at exact starting point with prover outlet valve.
(e) Record the reading from the prover scale or fine reader.
(f) Calculate meter % error.
(g) Record the results.

NOTE: Examples are on pages EPO No. 31-6 and 31-7 calculation of meter % error.

NOTE: When calculating, use the following number of decimal places and proper rounding to determine the digit final value:

0.0	Temperature Readings
0.00	Percent Error
0.000	Volume Indications
0.0000	Correction Factors

3.7. Repeat the preceding steps with check rate cap. Record results.

3.8. Tolerances. Maintenance and acceptance tolerances for hydrocarbon gas vapor-measuring devices are 3% of the test draft on underregistration and 1.5% of the test draft on overregistration. **T.1 [3.33]**

3.8.1. If the difference in airflow temperature between the prover and meter is maintained at

1°F or less

Calculation of Meter % Error

Note: In the following calculations for temperature correction you must use Rankine absolute temperature values (Temperature in °F + 460 = °Rankine). Round off calculations to the fourth digit.

In the formulas: V_m = Volume registered by meter
V_p = Prover volume - uncorrected
T_b = Base temperature (60ºF)
T_p = Temperature at outlet side of prover

Example: A meter registers that 2 cubic feet have passed through it, and the prover indicates 2.025 cubic feet. The prover airflow temperature indicates 72°F while airflow at the outlet side of meter under test indicates 72.8°F. Temperature difference is 0.8°F.

For non-temperature compensated meters:

$$\frac{\mathbf{V_m - V_p}}{\mathbf{V_p}} \mathbf{\ x\ 100 = \%\ Error\ in\ meter\ indication}$$

$$\frac{2\,\text{cf} - 2.025\,\text{cf}}{2.025\,\text{cf}} \text{ x } 100 \quad \frac{-0.025}{2.025} \text{ x } 100 = \underline{-1.23\%\,(\text{underregistration})}$$

For temperature compensated vapor meters:

The volume of air metered by a temperature compensated meter is automatically corrected to 60ºF. This formula corrects the volume of the bell prover to 60ºF using $(T_b/T_p)\ (V_p)$

$$\frac{\mathbf{V_m - [(T_b/T_p)\,(V_p)]}}{\mathbf{(T_b/T_p)\,(V_p)}} \mathbf{\ x\ 100 = \%\ Error}$$

$$\frac{2\,\text{cf} - [((60°\text{F} + 460)/72°\text{F} + 460))\ (2.025\,\text{cf})]}{[((60°\text{F} + 460/(72°\text{F} + 460))\ (2.025\,\text{cf})]} \text{ x } 100 = \%\,\text{Error}$$

$$\frac{2 - [(520/532)\ (2.025)]}{(520/532)\ (2.025)} \text{ x } 100 = \%\,\text{Error}$$

$$\frac{2 - [(0.9774)\ (2.025)]}{(0.9774)\ (2.025)} \text{ x } 100 = \%\,\text{Error}$$

$$\frac{2 - 1.979}{1.979} \text{ x } \underline{100 = 1.06\%\,(\text{overregistration})}$$

3.8.2. If the difference in airflow temperature between the prover and meter is **greater than 1°F**

Calculation of Meter % Error

Note: In the following calculations for temperature correction you must use Rankine absolute temperature values (Temperature in °F + 460 = °Rankine). Round off calculations to the fourth digit.

In the formulas:
- V_m = Volume registered by meter
- V_p = Prover volume - uncorrected
- T_b = Base temperature (60ºF)
- T_m = Temperature at outlet side of meter
- T_p = Temperature at outlet side of prover

Example: A meter registers that 2 cubic feet have passed through it, and the prover indicates 2.030 cubic feet. The prover airflow temperature indicates 72°F while airflow at the outlet side of meter under test indicates 70.7°F. Temperature difference is 1.3°F.

For non-temperature compensated meters:

$$\frac{V_m - [(T_m/T_p)(V_p)]}{(T_m/T_p)(V_p)} \times 100 = \%\ \text{Error in meter indication}$$

$$\frac{2\text{ cu. ft.} - [((70.7°F + 460)/72°F + 460))\ (2.030\text{ cu. ft.})]}{[((70.7°F + 460)/72°F + 460))\ (2.030\text{ cu. ft.})]} \times 100 = \%\,\text{Error}$$

$$\frac{2 - [(530.7/532)\ (2.030)]}{(530.7/532)\ (2.030)} \times 100 = \%\,\text{Error}$$

$$\frac{2 - 2.025}{2.025} \times 100 = \underline{1.23\%\ \text{(underregistration)}}$$

For temperature compensated meters:

The volume of air metered by a temperature compensated meter is automatically corrected to 60ºF. This formula corrects the volume of the bell prover to 60ºF using $(T_b/T_p)\ (V_p)$.

$$\frac{V_m - [(T_b/T_P)(V_p)]}{(T_b/T_p)(V_p)} \times 100 = \%\,\text{Error}$$

$$\frac{2\text{ cu. ft.} - [((60°F + 460)/72°F + 460))\ (2.030\text{ cu. ft.})]}{[((60°F + 460)/(72°F + 460))\ (2.030\text{ cu. ft.})]} \times 100 = \%\,\text{Error}$$

$$\frac{2 - [(520/532)\ (2.030)]}{[(520/532)\ (2.030)]} \times 100 = \%\,\text{Error}$$

$$\frac{2 - 1.984}{1.984} \times 100 = \underline{0.81\%\ \text{(overregistration)}}$$

3.9. While making proof tests with check rate caps, observe pressure differential gauge for excessive fluctuations which could indicate more than normal friction in the meter. If at any time during the check run the differential pressure gauge indication exceeds .5 inch, reject the meter for exceeding manufacturer's differential working pressure.

4. Amount of test run.

4.1. Proving circles: Meters with a 1 cu. ft. proving circle shall be tested on a Bell prover for 2 cu. ft. Meters with a 2 cu. ft. proving circle are tested for 2 cu. ft. or even multiples of 2 cu. ft. which result in a complete circle of the proving hand to the original starting point. Larger meters with 5 or 10 cu. ft. proving circles are tested at multiples of 5 or 10 cu. ft.

5. Meter sealing. **S.2.2 [3.33]**

5.1. Sealing should be done with a corrosion resistant type of wire and in such a manner as to prevent removal of index cover or adjustment cover without breaking seal.

5.2. Inlet and outlet ports of meter should be plugged to prevent entry of dirt and insects during transportation or storage.

6. Hydrocarbon vapor meter invoices. **UR.2.2 [3.33]**

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 (from Table 2, 11 inch WC for propane). **UR.2.3 [3.33]**

(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.

NOTE:

(a) If the vapor meter is temperature compensated, the invoice must also reflect that the volume has been adjusted to the volume at 60°F.

(b) Meters operating higher than 1 psi uses a multiplier instead of altitude correction factor, since the altitude correction factor is already incorporated in the volume multiplier.
UR.2.3. [3.33]