EPO No. 28

Examination Procedure Outline for

Compressed Natural Gas (CNG)
Retail Motor-Fuel Dispensers

It is recommended that this outline be followed for examining retail motor-fuel dispensers used to measure compressed natural gas. Non-retroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the "Safety Considerations" section and the "Glossary of Safety Key Phrases" should be duplicated and included with the outline.

The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. The inspector should read and be familiar with the introductory section on safety found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Safety policies and regulations vary among jurisdictions. It is essential that inspectors or servicepersons be aware of all safety regulations and policies in place at the inspection site and to practice their employer's safety policies. The safety reminders included in this EPO contain general guidelines useful in alerting inspectors and servicepersons to the importance of taking adequate precautions to avoid personal injury. These guidelines can only be effective in improving safety when coupled with training in hazard recognition and control.

Asphyxiation

Chemicals, Petroleum Products, and Hazardous Materials

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

High Pressure Gas

Ignition Sources

Lifting

Location

Material Safety Data Sheet (MSDS)

Nature of Product

Personal Protection Equipment

Safety Shoes

Safety Cones/Warning Signs

Static Discharge

Traffic

Transportation of Equipment

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Equipment List:

The following criteria should be considered when selecting equipment for the test.

Scale
- Intrinsic safety - scale meets Underwriters Laboratory (UL) Area Classification Class 1 Division 2 Group D (scale equipment must be located outside of classified area which is five feet from the hose fueling connection to the dispenser)
- Capacity
- Appropriate division size
- Type of power source

See the Appendix to EPO 28 for information on Scale Selection Criteria and Verifying Scale Accuracy.

Mass Standards
- Class F

Test Cylinder
- Rating - must be equivalent to or greater than the service pressure marked on the device under test as required by the ANSI/IAS NGV 4.1/CSA 12.5 "NGV Dispensing Systems," Standard for Natural Gas Vehicle Dispensing Systems
- Compatible fittings
- Bleed valve
- Pressure gauge
- Drain hose
- Means for grounding the cylinder prior to connecting to dispensing equipment such as a quick connect ground strap

Note: Service pressure is the settled pressure at a uniform gas temperature of 21 ºC (70 ºF) and full gas content. It is the pressure for which the equipment has been constructed under normal conditions. This is different from the maximum working pressure.

Optional Equipment:
- Cart
- Test cylinder supports (chocks)
- Weather shield/wind screen (for the weighing operation)

H-44 General Code and
Mass Flow Metering Devices
Code References

Pretest Determinations:

1. Select a site to locate the scale in the vicinity of the dispenser that is level and protected from wind and weather. Ensure that the scale is given a sufficient warm-up time.

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Pretest Determinations (cont.):

2. Determine the scale error.
   Sufficient test weights should be available to verify the gross load to be applied during testing. The scale should be sensitive to 0.03 % or less of the total net weight of the product in the test cylinder. The value of the scale division should not exceed one-tenth of the tolerance applied to the device.

3. Scale capacity must be sufficient to weigh the test cylinder, optional chocks, and cart when filled to capacity with product.

4. Tolerances.
   Applicable requirements.....G-T., T.1.
   Applicable tolerances in NIST Handbook 44.
   Basic values.....T.2.
   Applicable tolerances for CNG application.

Inspection:

Safety First!!!

Check the inspection site carefully for safety hazards and take appropriate precautions pay particular attention to the condition of the test tank high pressure fitting and hoses.

Learn the nature of hazardous products used at or near the inspection site; obtain and read copies of Material Safety Data Sheet (MSDS).

Know emergency procedures and location and operation of fire extinguisher and emergency shut-off system.

Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.

Use personal protection equipment and clothing appropriate for the inspection site.

Make sure there is adequate ventilation to permit fumes to dissipate before proceeding with the inspection of the dispenser.

If product is leaking (most CNG contains an odorant), or inadvertently released, or exposed wiring cause hazardous testing conditions it is recommended that the testing be immediately discontinued until the unsafe conditions are corrected.

Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.

Use proper grounding procedures!
Use proper low resistance grounding strap with recommended minimum conductance rating and correct connections consistent with the device under test.[1]

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[1]See the National Electrical Code or your local Occupational Safety and Health Administration (OSHA) for these requirements.

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Inspection (cont.):

1. General considerations.
   - Selection ..... G-UR.1.1.
     Equipment suitable for service.
   - Installation ..... G-UR.2.1., G-UR.2.2., UR.2.1.
     Installed in accordance with manufacturer's instructions and does not adversely affect operation nor impede communications between indicator/recorder.
   - Position of equipment ..... G-UR.3.3.
     During direct sales, indications are readable from a reasonable customer and operator position.
   - Accessibility ..... G-UR.2.3.
     Located or such facilities provided for access to permit inspection, testing, and sealing.
   - Assistance ..... G-UR.4.4.
     If required, operator to provide assistance in testing.
   - Use and maintenance ..... G-UR.3.1., G-UR.4.1.
     Proper operation and maintenance of equipment.

2. Marking G-S.1., S.5., G-UR.2.1.1.,
   - Location S.5.1. (1/1/03)
   - Visible markings of the following information:
     Pattern approval mark.
     Name and address of manufacturer.
     Model designation.
     - Model prefix ..... (1/1/03)
     - Nonrepetitive serial number ..... (1/1/68)
     - Serial number prefix ..... (1/1/86), (1/1/01)
     - Accuracy class ..... (1/1/95)

     Maximum and minimum flow rates (quantity/unit time).
     Maximum working pressure.
     Applicable temperature range (if other than -10 °C to 50 °C).
     Minimum measured quantity.
     Product limitations, if applicable.
     Remanufacturer information as appropriate.
     - Name and ID of manufacturer ..... (1/1/02)
     - Model number if different from original model number ..... (1/1/02)

     - Gasoline volume equivalent conversion factor ..... S.5.2.
     - Software version for not-built-for purpose software-based devices ..... (1/1/04)
       - Software prefix ..... (1/1/07)
       - Location ..... G-S.1.1.(1/1/04)

3. Indicating and recording elements ..... S.1.3.4., S.6.
   - Design ..... G-S.5.1., S.1.1.
     Shall have clear accurate indicator.
   - Computing type[2] ..... S.1.2.

[2]Indicates an exception to this requirement for dispensers used exclusively for fleet sales, other price contract sales and truck refueling.

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Inspection (cont.):

Mass display for inspection and testing.
Gasoline Liter Equivalent (GLE) for units based on mass in kilograms, 1 GLE = 0.678 kg CNG
(GLE Display = Mass Display$_{kg}$ ÷ 0.678 kilograms/GLE), or
Gasoline Gallon Equivalent (GGE) for units based on mass in pounds, 1 GGE = 5.660 lb CNG
(GGE Display = Mass Display$_{lb}$ ÷ 5.660 pounds/GGE).

Units ..... S.1.3.1.1.
Quantity indications in GLE or GGE.

Readability ..... G-S.5., G-S.6. (1/1/77), G-S.7.
Appropriate and accurate indicator and recorder.
Clear and identified operational controls and indicator.
Lettering is clear and tends not to become obliterated.

Values of intervals ..... G-S.5.3.
Values of graduated intervals shall be uniform.

Maximum value of quantity-value divisions ..... S.1.3.3.(b)
For units indicating in GLE, value is not greater than 0.01 GLE.
For units indicating in GGE, value is not greater than 0.001 GGE.
Mass division shall not be greater than 0.001 kg or 0.001 lb.

Auxiliary indications ..... S.2.6.1.
All money value and quantity divisions are identical to those of the primary element.

Unit price and product identity.
Display on each side ..... S.2.5.1., S.2.5.2.
Post information in direct sale[2] ..... UR.3.1.
Selection of unit price[2] ..... S.2.5.3.(1/1/98)

Advancement and return to zero.
Return indication to zero.
Does not return beyond zero position ..... S.2.1.
Reset not operable during delivery ..... S.2.2.
Return primary indicator to zero prior to delivery ..... S.2.8.(1/1/98), UR.3.7.

Provision for sealing ..... G-S.8.(1/1/90), G-UR.4.5.,
Audit trail format ..... S.3.5.(1/1/95), (1/l/96), (1/1/01)
Metrological integrity protected by means of security.
Affix a seal to adjustment mechanisms.

Recorded representations, point of sale systems ..... S.2.7.(1/1/86)
Cash register interfaced with dispenser shall record:
Total volume.
Unit price.
Total computed price.
Product identity.

4. Measuring elements.
Means of security on adjusting mechanism ..... G-S.8.(1/1/90), G-UR.4.5.,
Audit trail format ..... S.3.5.(1/1/95), (1/1/96), (1/1/01)

[2]Indicates an exception to this requirement for dispensers used exclusively for fleet sales, other price contract sales and truck refueling.

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Inspection (cont.):

Adequate security or sealing for:
Measurement element.
Adjustable elements that affect accuracy.
Zero adjustment mechanism.
If device is equipped with an audit trail, note audit trail information (e.g., counter values) on report or for devices with an event logger, print and attach event log to inspection report for future reference and comparison.
Directional flow valves..... S.4.3.
Prevent flow reversal if it adversely affects device.

5. Discharge hose..... S.4.1., S.4.4., UR.1.1.(1/1/98)
No means of product diversion from measuring element.
It is apparent if there are two or more delivery outlets.
Discharge valve may be installed on wet-hose type.
Other shutoffs on outlet side of meter are automatic or semiautomatic predetermined stop type or operable by a separate tool or sealed open by means of security.
Length..... UR.1.1. (1/1/98)
Pressurizing the discharge hose..... S.3.7.
Discharge hose shall automatically pressurize prior to registration of delivery.

6. Automatic Density Correction ..... S.3.6.

Test Notes:

Wear appropriate personal protection equipment such as nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from discharged product or propelled objects.

Be certain the scale is intrinsically safe!
Scale meets Underwriters Laboratory (UL)
Area Classification Class 1 Division 2 Group D
(Equipment location is outside of classified area which is five feet from hose connection to dispenser).

Do not leave an activated dispenser unattended!

Ground test tank and scale properly during fueling and return of product.

1. Connect grounding cables to equipment.

2. Determine the tare weight of the test tank and record.
Repeat this process prior to each delivery.

3. To determine proper operation of totalizer, observe and record the totalizer indications before and after all test drafts ..... S.7.(1/1/98)

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Test Notes (cont.):

4. After each test draft:
   a. Print ticket if device is so equipped ..... G-S.5.6., UR.3.4.
      All recorded values shall be digital.
      Total-price, quantity, and unit price must be on the receipt.
   b. Check price computations on all indicators (including consoles) and on recorded representations[2] ..... G-S.5.5., S.2.6.
      Mathematical agreement of associated quantity or indication to the nearest one cent.
   c. Check all indicated and recorded values for proper comparability ..... G-S.5.2.2., G-S.5.2.2.(d)(1/1/86), S.2.5.4.(a), S.2.5.4.(b)(1/1/98)

      Check design of digital indication to determine that:
      Like values agree.
      Values coincide with analog value to nearest minimum graduation.
      Value rounds off to nearest minimum unit.
      Digital zero display all places to the right and at least one place to the left of the decimal point.

Tests:

Ground test tank and scale properly during fueling and return of product.

Use proper lifting techniques when lifting test tank!

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.

Be aware of vehicular and pedestrian traffic when moving between dispenser and product return area.

1. Normal test ..... S.3.7., N.3., N.4., N.6.1, T.2., T.3.

   Computer jump:
   Remove nozzle from dispenser and connect to test cylinder. (Test cylinder pressure should not be greater than 200 psi to simulate an actual delivery.)
   Turn nozzle valve from "OFF" position to "FILL" position.
   Empty discharge hose.
   Turn nozzle valve to "OFF" position.
   Activate dispenser.
   Observe dispenser indications, if computer jump occurs take appropriate action.

[2]Indicates an exception to this requirement for dispensers used exclusively for fleet sales, other price contract sales and truck refueling.

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Tests (cont.):

Note: A test cylinder is not necessary for the computer jump test on dispensers equipped with an autovent system. To test, turn dispenser on and observe the indication display for computer jump when the dispenser shuts off.

Minimum test procedures and draft sizes are as follows:

Place empty test cylinder on the scale.
Access mass display of the dispenser.
Tare weight of the test cylinder, chocks, and stand.
Connect the nozzle to the test cylinder.
Fill the test cylinder to 1/3 capacity full at maximum flow rate.

Stop delivery manually if delivery hose pressure exceeds allowable safety limits.

Disconnect the nozzle from the test cylinder.
Compare mass display to scale indication.
Determine dispenser error ..... T.2.
Leave product in test cylinder.
Tare the weight of the test cylinder, chocks and stand.
Connect the nozzle to the test cylinder.
Begin the fill operation with product in the cylinder; fill cylinder to 2/3 capacity[3] at maximum flow rate.

Stop delivery manually if delivery hose pressure exceeds allowable safety limits.

Disconnect the nozzle from the test cylinder.
Compare mass display to scale indication.
Determine dispenser error ..... T.2.
Tare the weight of the test cylinder, chocks, and stand.
Connect the nozzle to the test cylinder.
Begin the fill operation with product in the cylinder; fill cylinder to capacity at maximum flow rate.

Stop delivery manually if delivery hose pressure exceeds allowable safety limits.

Disconnect the nozzle from the test cylinder.
Compare mass display to scale indication.
Determine dispenser error ..... T.2.

[3]Based on the example of selecting a scale with a division size of 0.02 d, if 300 divisions (d) or 2.27 kilograms (5 pounds) is greater than 1/3 of the test cylinder capacity, then the test cylinder should be emptied to accommodate a delivery of at least 300 d or 2.27 kilograms (5 pounds) otherwise a larger tank is necessary.

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Tests (cont.):

Return product to owner/operator of dispenser ..... UR.3.8.
Place empty test cylinder on scale (scale may be supported by chocks and stand.)
Tare the weight of the test cylinder, chocks, and stand.
Connect the nozzle to the test cylinder.
Fill test cylinder to capacity at maximum flow rate.

Stop delivery manually if delivery hose pressure exceeds allowable safety limits.

Disconnect the nozzle from the test cylinder.
Compare mass display to scale indication.
Determine dispenser error ..... T.2.
Return product to owner/operator of dispenser.
Repeating previous tests ..... T.3., N.6.1.1.
Applicable tolerance for three or more consecutive tests at the same flow rate and draft size under controlled conditions.
Return product to owner/operator of dispenser.
If the meter minimum measured quantity (MMQ) is less than the smallest test draft, conduct a test with a test draft quantity equal to the MMQ value..... N.4.

2. Check effectiveness of zero-setback interlock ..... S.3.8., UR.3.6., UR.3.7.
No subsequent delivery until indicating and recording elements are returned to zero.
After delivery is complete, the dispenser starting lever (mechanism) is shut off, interlock is engaged, and discharge nozzle is placed in the designed hanging position. (**Note:** This does not apply to nozzle control.)

To check the effectiveness, first remove nozzle from hanging position.

Reset computer to zero and turn on dispenser.

Attempt to return the nozzle to its designed hanging position, <u>carefully</u> remove nozzle and connect it to the test tank and open valve. Move the dispenser starting lever (mechanism) to "ON" position and attempt to dispense product. (**Note:** This does not apply to nozzle control.)

Product should not flow without resetting the indications to zero.

3. Check operation of low-flow cut-off valve ..... UR.2.3.
Valve stops registration when flow is below the low-flow cut-off value.
Valve shall not be set lower than the minimum flow rate.

Connect nozzle to empty test tank and dispense product. Slowly begin to close the valve on the test tank to the minimum attainable flow rate. Product delivery should not occur below the mass flow meter minimum flow rate.

4 Power loss test ..... S.2.4.1., S.2.4.2.
For transactions in progress at power loss, information shall be retainable for 15 minutes.
Device memory shall retain quantity of product and total sales price during power loss.

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Tests (cont.):

5. Security seal--apply wire security seal to secure adjusting mechanism (if applicable) ..... G-UR.4.5., S.3.5.

   Note on the official report the number of gasoline gallon equivalents of product dispensed during the test.

   After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments ..... G-UR.4.1., G-UR.4.3.

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Appendix to Examination Procedure Outline No. 28 for

Compressed Natural Gas (CNG)
Retail Motor-Fuel Dispensers

Reference Scale
Selection Criteria and Accuracy Verification

Scale Selection Criteria[4]:

Steps should be taken to eliminate the uncertainty[5] associated with reading weight values on the reference scale (test standard). The size of the scale division (*d*) for the reference scale should be taken into account along with the size of the net load because the relationship between these two values significantly affects the degree of accuracy to which a device can be tested. The size of *d* for the reference scale should be considered as part of the process for establishing the minimum test draft size so the draft is of a sufficient size to adequately evaluate the performance of the device under test. The size of d for the reference scale also affects the rounding error associated with reading the reference scale's indications to the nearest division. Note that a weight classifier is not suitable for use as a reference scale using these test procedures.

A digital electronic reference scale will round indications to the nearest scale division, which introduces a potential error of one-half *d* for each weight determination. Using a scale with a higher resolution, error weights to increase the readability of weight values, or the use of a larger test draft can reduce the rounding error. A combination of these approaches might be used to reduce errors. Each scenario must be evaluated on a case-by-case basis to ensure that you have selected the right approach or combination of approaches.

Likewise, when a mechanical scale is used error weights must be used in order to determine the weight indications as accurately as possible.

Reference Scale Division Value
Applying these principles, the "rounding error" (caused by reading the indicated weight value to the nearest scale division) can be held to an acceptably small level if the value of the scale division does not exceed one-tenth of the tolerance applied to the smallest net load likely from the CNG dispenser. This also ensures that the cumulative errors that can occur when reading scale indications, along with other factors that contribute to uncertainty in the reference scale's performance, do not use up the entire tolerance allowed for the test standard. When tolerances for the CNG dispenser were established, the inaccuracies associated with the use of the test standard were taken into account.

If the size of the test draft or net load must be small due to the capacity limitations of the available test cylinder(s) or when dispenser accuracy is being verified at the minimum attainable flow rate, then a reference scale must be selected with an appropriate division size. Consider an example in which the acceptance tolerance of ± 1.5 % for an Accuracy Class 2.0 mass flow meter (MFM) application (CNG) applies; the combined weight of the empty tank and the metered CNG is 22 kg; where the tank weight is 20 kg; and the CNG product weight is 2 kg.

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[4]The scale selection criteria and minimum test draft size for mass flow meter technology are discussed in the 1987 Report of the Committee on Specifications and Tolerances, Item 330-2 Recognize Mass Units for Metering.
[5]NIST IR 6919 Recommended Guide for Determining and Reporting Uncertainties for Balances and Scales (available on the NIST WMD web site at http://ts.nist.gov/WeightsAndMeasures/upload/NISTIR6919.pdf) includes a comprehensive description of how to determine and address uncertainties in balances and scales.

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The tolerance is applied to the smallest net load indicated on the device under test (MFM), which in this case is 2 kg. The scale division selected for the reference scale is based on one-tenth of the tolerance applied to the smallest test load delivered during the test of the CNG dispenser and is calculated as follows:

Reference scale division (d) $\leq$ Smallest Test Load × Tolerance for the device under test × 1/10
$\leq$ 2 kg × 0.015 × 0.1
$\leq$ 0.003 kg

Thus, the scale division for the reference scale should be no greater than 0.003 kg or 3 g. Since the Scales Code of NIST Handbook 44 requires that the value of a scale division (d) be expressed in units of 1, 2, or 5, the reference scale division in this example must be no greater than 2 g.

Consider a second example in which the device under test indicates in inch-pound units; acceptance tolerance of ±1.5 % for an Accuracy Class 2.0 mass flow meter (MFM) application (CNG) applies; the combined weight of the empty tank and the metered CNG is 50 lb; the tank weight is 45 lb; and the CNG product weight is 5 lb. Using the same formula as above, the maximum scale division for the reference scale is calculated as follows:

Reference scale division (d) $\leq$ Smallest Test Load × Tolerance for the device under test × 1/10
$\leq$ 5 lb × 0.015 × 0.1
$\leq$ 0.0075 lb

Thus, the scale division for the reference scale should be no greater than 0.0075 lb. Since the Scales Code of NIST Handbook 44 requires that the value of a scale division (d) be expressed in units of 1, 2, or 5, the reference scale division must be no greater than 0.005 lb.

Minimum Test Draft Size
The scale division size will also affect the size of the test draft required to evaluate the meter. Consider two examples in which a CNG dispenser is to be tested:

In Example 1 the reference scale is equipped with a 5 g division. Error weights should be used to increase readability of the scale to the nearest 0.5 g. Each weight value is, thus ± 0.25 g, reading to the nearest 0.5 g, but since there are two weighings, one to determine the gross weight and the other to establish the tare weight, the potential for total rounding error doubles to 0.5 g. To limit the error for each weighing to one-tenth of the tolerance, the minimum test draft size is calculated as follows:

$$\frac{\text{Readability of scale using error weights (kg or lb)} \times 10}{\text{Tolerance for device under test}} = \text{Minimum test draft size (kg or lb)}$$

If the acceptance tolerance of ±1.5 % applies; the minimum test draft size for the above example is calculated as follows:

Example 1:

$$\frac{(0.5 \text{ g} \times 10)}{(0.015)} = 333.33 \text{ g} = 0.333 \text{ kg}$$

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Thus, if a scale with a 0.5 g (higher resolution) size is used, or a scale with 5 g division size and corresponding error weights to 0.5 g is used and a tolerance of ± 1.5 % is applied, the minimum test draft is recommended to be at least 0.333 kg.

Consider Example 2, where the reference scale is equipped with a 0.01 lb division. Error weights should be used to increase readability of the scale to the nearest 0.001 lb. Each weight value is thus ± 0.0005 lb, reading to the nearest 0.001 lb, but since there are two weighings, one to determine the gross weight and the other to establish the tare weight, the potential for total rounding error doubles to 0.001 lb. To limit the error for each weighing to one-tenth of the tolerance, the minimum test draft size is calculated as follows:

$$\frac{\text{Readability of scale using error weights (kg or lb)} \times 10}{\text{Tolerance for device under test}} = \text{Minimum test draft size (kg or lb)}$$

If the acceptance tolerance of ±1.5 % applies; the minimum test draft size for each of the above examples is calculated as follows:

Example 2:

$$\frac{(0.001 \text{ lb} \times 10)}{(0.015)} = 0.667 \text{ lb}$$

Thus, if a scale with a 0.001 lb division (higher resolution) size is used, or a scale with 0.01 lb division size and corresponding error weights to 0.001 lb are used and a tolerance of ±1.5 % is applied, the minimum test draft is recommended to be at least 0.667 lb.

Large relative errors result when rounding weight values for small loads. In the above examples, the potential error that occurs when rounding weight values can be reduced by increasing the test draft size. Other considerations may apply when determining the minimum test draft size such as average customer delivery and meter size. If the scale available for testing has a relatively large division size then the size of the test draft must be increased accordingly. (Also see the Tests section NOTE in EPO 28 for additional guidelines on determining the minimum test draft size.)

Verifying Scale Accuracy:

The Fundamental Considerations of NIST Handbook 44, specifies that it is necessary to limit the total error in a standard used without corrections to less than one-third of the tolerance applied to the device under test. For example, if applying the acceptance tolerance of 1.5 % to a CNG dispenser, the reference scale (i.e., the standard used for the test) must be accurate to at least 0.5 %. Consequently, it is necessary to thoroughly test the reference scale, verify that its results are repeatable, correct for any errors determined during the scale test, and use the scale properly. This takes considerable time and care under field conditions.