NIST OFFICE OF WEIGHTS AND MEASURES

Examination Procedure Outlines (EPOs) for Commercial Weighing and Measuring Devices

EPO 29

Hydrogen Gas Retail Vehicle Fuel Dispensers

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EPO No. 29
NIST Examination Procedure Outline (EPO) for
Hydrogen Gas Retail Vehicle Fuel Dispensers

1. Scope.

It is recommended that this outline be followed as minimum criteria for examining retail fuel dispensers used to measure hydrogen gas deliveries into internal combustion engine and fuel cell vehicles. Nonretroactive requirements are followed by the applicable date in parentheses.

2. Safety Notes.

When excerpting this Examination Procedure Outline for duplication, the NIST EPO Safety Annex (Safety Considerations and Glossary of Safety Key Phrases) should be duplicated and included with this outline.

Safety policies and regulations vary among jurisdictions. It is essential that inspectors and servicepersons be aware of all safety regulations and policies in effect 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 of the importance in 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.

Prior to beginning any inspection, the inspector should read and be familiar with the NIST EPO Safety Annex - "Safety Considerations and Glossary of Safety Key Phrases." The terms and key phrases in each safety reminder of this outline are found in the glossary of the EPO Safety Annex. 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. As a minimum, the following safety precautions should be noted and followed during the inspection:

- **Asphyxiation**
- **Chemicals and Hazardous Materials**
- **Clothing**
- **Electrical Hazards**
- **Emergency Procedures**
- **Eye Protection**
- **Fire Extinguishers**
- **First Aid Kit**
- **Grounding**
- **High Pressure Gas**
- **Ignition Sources**
- **Lifting**
- **Location**
- **Obstructions**
- **Safety Data Sheets (SDS)**
- **Nature of Product**
- **Personal Protection Equipment**
  - e.g. Safety Shoes, Safety Aprons, Gloves, etc., if deemed necessary

- **Static Discharge**
- **Safety Cones/Warning Signs**
- **Traffic**
- **Transportation of Equipment**

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions; pay particular attention to the condition of the test tank high pressure fittings and hoses.**
- **Be familiar with the hazardous products that will be present both at and within proximity of the inspection site. Learn hydrogen gas properties (being colorless, odorless, highly flammable, etc.) to stay alert to hazardous testing conditions.**
- **Be familiar with protective measures in place on site such as gas sensors or flame detectors signals/alarms to alert personnel that a hazardous condition is detected.**
- **Obtain and read copies of the applicable SDS (Safety Data Sheets).**
- **Know the applicable emergency procedures and the location and operation of fire extinguishers and emergency shut-offs.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Make sure there is adequate ventilation to permit fumes to dissipate before proceeding with the inspection of the dispenser.**
- **Use proper grounding procedures! Use proper low resistance grounding strap with recommended minimum conductance rating and correct connections consistent with the device under test. See the National Electrical Code (NEC) or your local Occupational Safety and Health Administration (OSHA) for these requirements. Also see NFPA 77 "Recommended Practice on Static Electricity."**
- **In the case of leaks, spills, or exposed wiring causing hazardous testing conditions, it is recommended that the testing be discontinued until any unsafe conditions are corrected.**
- **Use personal protective equipment appropriate for both site conditions and the inspections/testing procedures.**
- **Be certain that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

3. Equipment List.

NOTE: The equipment list section will need to be reviewed and modified based on whether the methodology selected uses either one of three or a combination of the following three means recognized in NIST HB 44 of a: (1) master meter (transfer) standard; (2) gravimetric procedure; and/or (3) Pressure Volume Temperature (PVT) with a calibrated volumetric standard to verify the hydrogen gas dispenser's performance. NIST Office of Weights and Measures has developed an expanded procedure for use in proving the reference scale's performance is adequate for use to determine the accuracy of test loads of compressed gas deliveries when using the gravimetric test procedure. The reference scale verification procedure has been proved in compressed natural gas motor fuel dispenser applications. In principle the procedure is practical for use to verify the reference scale's accuracy when the gravimetric test procedure is being used for other product or device applications. Further data is being collected on the use of the

expanded reference scale verification procedure in the evaluation of retail hydrogen deliveries. The "Reference Scale Selection Criteria, Performance Requirements, and Use in Accuracy Verification for CNG RMFD and Other Applications" is available as part of NIST EPO Annex 2.

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

3.1. Scale

Intrinsic safety - scale meets Underwriters Laboratory (UL) Area Classification Class 1 Division 2 Group B. Scale equipment must be located outside of classified area which is 15 ft from the hose fueling connection to the dispenser.

- Capacity is sufficient to weigh the test cylinder, optional chocks, and the cart to include when the test cylinder is filled to capacity with hydrogen gas;
- Appropriate division size; and
- Power cord design meets requirements for use in a hazardous/explosive environment and is of sufficient length. The power source should be located in close proximity to the dispenser under test within a distance that permits use of the scale's properly rated power cord(s). Avoid use of any underrated extension cords or the problematic practice of daisy chaining multiple extension cords to reach the power source.

Note: See the Appendix to EPO No. 29 for information on Scale Selection Criteria and Verifying Scale Accuracy.

3.1.1. Mass Standards

- OIML Class F 1
- ASTM Class 1

3.2. Test Cylinder

- Rating – must be equivalent to or greater than the service pressure marked on the dispenser as required by CSA/ANSI HGV 4.1-2020 "Hydrogen Dispensing Systems."
- Compatible fittings
- Bleed valve
- Pressure gauge and pressure relief valve
- Drain hose
- Means for grounding the cylinder prior to connecting to dispensing equipment such as a quick connect ground strap. Check with the manufacturer of the test equipment or local safety official about proper measures to eliminate static electricity hazards.

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.

The test cylinder tank internal temperature and pressure must be continuously monitored during filling to prevent overheating.

As far as safety requirements, the test cylinder is treated the same as the vehicle fuel storage tank and is equipped with CSA/ANSI HPRD 1-2021 Thermally activated pressure relief devices for compressed hydrogen vehicle (HGV) fuel containers.

3.3. Other Equipment.

- Means for grounding all other equipment, such as a quick connect ground strap

3.4. Optional Equipment.

- Card or other remote device (RFID, swipe card, etc.) to activate a transaction;
- Cart;
- Test cylinder supports (Chocks);
- Weather shield/wind screen for the weighing operation (when tenting the scale perimeter select shelter materials that do not have the tendency to build up a static charge).

4. Inspection.

NOTE: Code references used throughout the document are drawn from NIST HB 44 General Code (Section 1.10) and Hydrogen Gas-Measuring Devices Code (Section 3.39). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item.

Pre-Inspection Notes.

- A site shall be selected to locate the scale in the vicinity of the dispenser that is: level, protected from wind/weather, and is not subject to any sources of vibration (such as vehicular traffic and/or equipment operation).
- Ensure that the plan for the return or venting of hydrogen product after the test meets all safety regulations and policy to include an assessment of potentially hazardous conditions that are addressed in the facilities emergency plan.
- Ensure that the scale is given sufficient warm-up time.

4.1. Accessibility and assistance in inspecting, testing, and sealing.

Code Reference: 1.10: G-UR.2.3., G-UR.4.4.

Device must be readily accessible for purposes of inspection, testing, and sealing. Assistance shall be provided by the firm if needed.

4.2. General Considerations.

Code Reference: 1.10: G-S.3., G-UR.1.1., G UR.1.2., 3.39: UR.1.1

4.2.1. Selection and Suitability.

4.2.1.1. Equipment suitable for service.

4.2.2. Installation.

Code Reference: 1.10: G-S.2., G-UR.2.1., G UR.2.2., 3.39: UR.2.1., UR.2.2.

Installed in accordance with manufacturer's instructions does not facilitate fraud or adversely affect operation nor impede communications between indicator/recorder.

4.2.3. Position of Equipment.
Code Reference: 1.10: G-UR.3.3.

During direct sales, indications are readable from a reasonable customer and operator position.

4.2.4. Use and Maintenance.
Code Reference: 1.10: G-UR.3.1., G-UR.4.1., G UR.4.2., 3.39: UR.3.4.

Proper operation and maintenance of equipment.

4.2.5. Computing Capability.
Code Reference: 3.39: UR.1.1.

Hydrogen gas vehicle refueling dispenser shall be the computing type and indicate mass, unit price, and total price of each delivery

4.3. Indicating and Recording Elements.
Code Reference: 3.39: S.1.3.4., S.6.

- Recorded information for the transaction must agree with the indications on the dispenser.
- Recorded values shall be adequately and clearly defined.

4.3.1. Design.
Code Reference: 1.10: G-S.5.1., 3.39: S.1.1.

Shall have clear accurate indicator.

4.3.2. Computing Type
Code Reference: 3.39: S.1.2.

Vehicle fueling dispensers shall be the computing type indicating mass, unit price, and total price.

4.3.3. Units.
Code Reference: 3.39: S.1.3.1., S.1.4.

Quantity indications in kilograms and decimal subdivisions thereof.

4.3.4. Readability.
Code Reference: 1.10: G-S.5., G-S.6. (1/1/77), G S.7., 3.39: S.1.3.4.

- Appropriate and accurate indicator and recorder.
- Clear and identified operational controls and indicator.
- Lettering is clear and tends not to become obliterated.

4.3.5. Values of Intervals.
Code Reference: 1.10: G-S.5.3., 3.39: S.1.3.2.

Values of graduated intervals shall be uniform.

4.3.6. Indication of delivery.
Code Reference: 3.39: S.2.7.

Dispenser automatically shows on its face the initial zero and quantity delivered.

4.3.6.1. Auxiliary Indications.
Code Reference: 3.39: S.2.1.5.1.

All money value and quantity divisions are identical to those of the primary element.

4.3.7. Unit Price and Product Identity.
Code Reference: 3.39: S.2.4.1., S.2.4.2., UR.3.1.

- Display on each face.
- Post information product identity on each side of the dispenser.

4.3.8. Multiple Unit Price Dispensers.
Code Reference: 3.39: S.2.4.3.

Selection of unit price prior to delivery on using customer controls. The unit price is not permitted to change during the delivery.

4.3.9. Maximum Value of Quantity-Value Division
Code Reference: 3.39: S.1.3.3., S.1.4.(a)

The value of the quantity division is not greater than 0.5 % of the MMQ and does not exceed 0.001 kg when the flow rate is 30 kg/min or less.

4.3.10. Quantity and Total Price Display
Code Reference: 3.39: S.2.5.2.

On completion of a delivery displays on the face the total price and quantity for 5 minutes or until the initiation of the next transaction.

4.3.11. Advancement and Return to Zero.
Code Reference: 3.39: S.2.1., UR.3.5.

- Primary elements automatically or manually readily return the indication to zero.
- Does not return beyond zero position.

4.3.12. Recorded Representations.
Code Reference: 3.39: S.2.6.

4.3.12.1. For a transaction conducted on a point-of-sale system activated with a debit card, credit card, or cash, a printed receipt shall be available through a built-in or separate recording element and contain:

- Total mass delivery;
- Unit price;
- Total computed price; and
- Product identity.

4.3.12.2. Quantity delivered includes identification number, time, date, and seller.
Code Reference: 3.39: S.6.1.

4.3.13. General.
Code Reference: 1.10: G-S.5.6., 3.39: UR.3.2., UR.3.3.

Present digitally recorded information for the total price, total quantity, and price per unit for the sale, where the customer may be given the option to receive information electronically or in hard copy. For vehicle-mounted systems tickets are not in the device while in motion but are inserted immediately before the delivery to provide a copy at the time of delivery or as otherwise specified by the customer.

4.4. Provision for Sealing.
Code Reference: 1.10: G-S.8. (1/1/90), 3.39: S.3.3., Table S.3.3.

Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or for physically applying a security seal in such a manner that requires the security seal to be broken before an adjustment or interchange can be made of:

- any individual measuring element;
- any adjustable element for controlling delivery rate when such rate tends to affect the accuracy of deliveries;
- the zero-adjustment mechanism; and
- any metrological parameter that will affect the metrological integrity of the device or system.

4.4.1. Physical Means of Security. For devices designed with a physical means of security, check for:

4.4.1.1. Accessibility of the Adjusting Mechanism.
Code Reference: 3.39: S.3.3.

When applicable, the adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

4.4.1.2. Presence of Security Seals.
Code Reference: 1.10: G-UR.4.5., 3.39: S.3.3.

Check for the presence of security seals on the device. A security seal shall be affixed to any adjustment mechanism designed to be sealed. Document missing seals on the official report and apply new seals as needed.

4.4.2. Audit Trails.

4.4.2.1. Audit Trails - Format.
Code Reference: 1.10: G-S.8. (1/1/90), 3.39: S.3.3., Table S.3.3.

For devices using an audit trail(s) as a means of security, the audit trail(s) shall use the format set forth in Table S.3.3. Categories of Devices and Methods of Sealing.

4.4.2.2. Audit Trail Information.
Code Reference: 1.10: G-S.8. (1/1/90), 3.39: S.3.3., Table S.3.3.

If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. Note that on some systems an electronic copy of the event log may also be available; however, the system must still be able to provide a hard copy. Examine these records for any signs of misuse of adjustments.

4.4.2.3. Event Logger.

Code Reference: 3.39: S.3.3., Table S.3.3.

If security is provided using an event logger, the event logger shall include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter.

The event logger information shall be available at the time of inspection either as a printed copy or in electronic format. The information may be printed by the device, printed by another on-site device, or transmitted electronically.

The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1000 records are required. (**Note:** Does not require 1000 changes to be stored for each parameter.)

4.4.3. Adjustments Using Removable Digital Storage Devices.

Code Reference: 1.10: G-S.8.2., 3.39: S.3.3., Table S.3.3.

For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device*, such as a secure digital (SD) card, USB flash drive, etc., security shall be provided for those parameters using either:

(1) an event logger in the device; or

(2) a physical seal that must be broken in order to remove the digital storage device from the device (or system).

* This applies only to removable digital storage devices that must remain in the device or system for it to be operational.

4.4.4. Multiple Elements that Share a Common Provision for Sealing.

Code Reference: 1.10: G-S.8.1. (1/1/10).

For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified.

4.4.5. Metrologically Significant Software Updates.

Code Reference: 1:10: G-S.9.

A metrologically-significant software change is a sealable event.

4.4.6. Automatic Timeout, Pay-at-Vehicle Fueling Dispensers.

Code Reference: 3.39: S.2.8. (1/1/20).

After authorization, the device must de-authorize in two minutes if not activated. If the time limit to deauthorize the device is programmable, it shall not accept an entry greater than two minutes.

4.5. Marking.

4.5.1. General Markings.

Code Reference: 1.10: G-S.1.

4.5.1.1. Identification – General.

Code Reference: 1.10: G-S.1.

- Name and address of manufacturer and, if required by a jurisdiction, the manufacturer's trademark.
  Code Reference: 1.10: G-S.1.(a), 3.39: S.5.(b)
- Model designation or product name selected by the manufacturer.
  Code Reference: 1.10: G-S.1.(b), 3.39: S.5.(c)
- Model prefix.
  Code Reference: 1.10: G-S.1.(b)(1) (1/1/03)
- Nonrepetitive serial number.
  Code Reference: 1.10: G-S.1.(c) (1/1/68), 3.39: S.5.(d)
- Serial number prefix.
  Code Reference: 1.10: G-S.1.(c)(1) (1/1/86)
- Pattern approval mark (i.e., National Type Evaluation Program (NTEP) Certificate of Conformance (CC) Number).
  Code Reference: 1.10: G-S.1.(e) (1/1/03), 3.39: S.5.(a)
- NTEP CC Number identifier.
  Code Reference: 1.10: G-S.1.(e)(1)

4.5.1.2. Identification – Software Version Markings.

- Software version or revision identifier, software-based devices.
  Code Reference: 1.10: G-S.1.(d) (1/1/04)
- Software version or revision identifier for not-built-for-purpose software-based devices.
  Code Reference: 1.10: G-S.1.(d) (1/1/04)
- Preface software version or revision identifier for all software-based devices.
  Code Reference: 1.10: G-S.1.(d)(1)(i) (1/1/07)
- Software version or revision identifier continuously displayed or accessible via the display.
  Code Reference: 1.10: G-S.1.(d)(1)(ii) (1/1/22)

4.5.1.3. Device-Specific Hydrogen Dispenser Additional Identification and Markings Information.

Code Reference: 3.39: S.5.

- Accuracy class.
  Code Reference: 3.39: S.5.(e)
- Maximum and minimum flow rates (quantity/unit time).
  Code Reference: 3.39: S.5.(f)
- Maximum working pressure.
  Code Reference: 3.39: S.5.(g)
- Applicable temperature range (if other than -10 °C to 50 °C).
  Code Reference: 3.39: S.5.(h)
- Minimum measured quantity.
  Code Reference: 3.39: S.5.(i)

- Product limitations, if applicable.
  Code Reference: 3.39: S.5.(j)

4.5.1.4. Remanufacturer information as appropriate.

- Name, initial or trademark of last remanufacturer.
  Code Reference: 1.10: G-S.1.2.(a) (1/1/02)
- Model number if different from original model number.
  Code Reference: 1.10: G-S.1.2.(b) (1/1/02)

4.5.2. Location, Not-Built-For Purpose, Software-Based Devices.
Code Reference: 1.10: G-S.1.1. (1/1/04)

4.5.3. Visibility of required markings after installation.
Code Reference: 1.10: G-UR.2.1.1.

4.5.4. Location of Marking Information, Hydrogen-Fuel Dispensers.
Code Reference: 3.39: S.5.1.

4.5.5. Money-Operated Devices, Responsibility.
Code Reference: 1.10: G-UR.3.4.

4.6. Measuring Elements.

4.6.1. Security Seals.

4.6.1.1. General.
Code Reference: 1.10: G-S.8. (1/1/90), G-S.9., 3.39: S.3.3., Table S.3.3.

Security seal on adjusting mechanism. Check for the presence of security seals on the device. A security seal shall be affixed to any adjustment mechanism designed to be sealed. Document missing seals on the official report and apply new ones as needed.
Code Reference: 1.10: G-UR.4.5, 3.39: S.3.2., S.3.3.

4.6.1.2. Automatic Density Correction
Code Reference: 3.39: S.3.4.

Automatic compensation is used in any system where measurements are affected by changes in the density or volume-measuring systems where density changes are due to changes in temperature, pressure, and product composition.

4.7. Discharge Hose.
Length and Protection.
Code Reference: 3.39: UR.1.2.

4.7.1. Pressurizing the Discharge Hose.
Code Reference: 3.39: S.3.5.

Automatic to a pressure equal to or above the receiving vessel prior to delivery without advancing the indications.

4.7.2. Length–General

Code Reference: 3.39: UR.1.2.

- No means of product diversion from the measuring element.
  Code Reference: 3.39: S.4.1.
- Directional flow valves prevent flow reversal if it adversely affects device.
  Code Reference: 3.39: S.4.2.

4.8. Facilitation of Fraud.

Facilitation of Fraud, General.

Code Reference: 1.10: G-S.2.

4.9. Totalizers for EVFS Systems.

Code Reference: 3.39: S.7.

5. Pretest Determinations.

NOTE: Code references used throughout the document are drawn from NIST HB 44 General Code (Section 1.10) and Hydrogen Gas-Measuring Devices Code (Section 3.39). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item.

5.1. Tolerances.

5.1.1. Acceptance/Maintenance Tolerances.

Code Reference: 1.10: G-T.1., G-T.2.

5.1.2. Application.

Code Reference: 1.10: G-T.3., 3.39: T.1.

5.1.3. Basic Values.

Code Reference: 3.39: T.2., Table T.2, T.4.

5.1.4. Repeatability.

Code Reference: 3.39: T.3.

5.2. Determine the Scale Error.

Sufficient test weights should be available to verify the gross weight load to be applied during testing. The reference scale should be sensitive to 0.03 % or less of the total net weight of the product in the test cylinder (see the Appendix to this EPO for more details on scale selection criteria). The value of the scale division should not exceed one-tenth of the tolerance applied to the device.

5.3. Test Draft Size.

Code Reference: 3.39: N.3., N.4.

5.4. Test Methods.

Code Reference: 1.10: G-N.3., N.4., Appendix A: Section 3. Testing Apparatus.

This EPO was developed to apply to the use of gravimetric test method. The Hydrogen Gas-Measuring Devices Code recognizes three test methods using a: (1) master meter (transfer) standard; (2) gravimetric procedure; and/or (3) Pressure Volume Temperature (PVT) with a calibrated volumetric standard to verify the hydrogen gas dispenser's performance. However, this does not preclude the use of other test methods and apparatus that have been approved by the Director as described in NIST Handbook 44, Appendix A, Section 3. Testing Apparatus. If either methods (1) or (3) described above; or some combination of methods (1), (2), and (3); or other test standards and apparatus are used, corresponding adjustments to the test procedures described in this EPO may be needed to address the adequacy of the test standard equipment and conditions associated with each methodology.

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as: nonskid safety shoes (to prevent possible injury from condensate or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from cryogenic temperatures of discharged product.**
- **Be certain the scale is intrinsically safe! Scales shall meet Underwriters Laboratory (UL) Area Classification Class 1 Division 2 Group B (Equipment location is outside of classified area, which is 15 feet from hose connection to the dispenser).**
- **Do not leave an activated dispenser unattended!**
- **Ground the test standard equipment properly!**
- **When venting hydrogen gas, the release must be at a sufficient height so as to not expose personnel, equipment, or property to the radiant heat created by the discharge process and the stack should be properly grounded to avoid problems with lighting and static electricity as well as separation from other hazardous chemicals/gases when returning product to storage.**

6. Test Notes.

NOTE: Code references used throughout the document are drawn from NIST Handbook 44 (HB 44) General Code (Section 1.10) and Hydrogen Gas-Measuring Devices Code (Section 3.39). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST Handbook 44 (HB 44) General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item.

6.1. Connect Grounding Cables to Equipment.

6.2. Totalizers.

Code Reference: 3.39: S.7.

To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. The system shall include this design feature for the quantity delivered for each device and this information shall be readily available on site or through on-site internet access.

6.3. Level Test Standard.

Before reading the indications on the test standard, level the reference scale (used in the gravimetric test method), verify the location of the test cylinder and any associated gauges/sensors and the framework

(used for stability and transport) to ensure their proper orientation and placement within the perimeter of the scale platform. Follow instructions for the proper orientation in the operation of other types of test standard equipment.

- Ensure the ground surface on which the standard or trailer rests is firm and stable and is adequate to safely bear the weight of the test apparatus when the standard is full of product.
- Level the Test Standard:
  - When the test cylinder is full of product, re-check that the reference scale remains level to ensure the weight of the product has not affected the level condition. Make adjustments as needed.

6.4. Verify the Tare Weight of the Test Cylinder.

Determine the tare weight of the test tank and record.

Repeat this process prior to each delivery.

6.5. Dry Test Equipment Surfaces.

If condensate forms on test equipment surfaces and fixtures as part of the test procedure, include a supply of towels to dry those areas that are part of the weight verification test procedure.

6.6. Read and Record Results.

Read and record the indications on the test standard and dispenser after establishing the appropriate point the test cylinder has reached equilibrium. Read and record the dispenser transaction display information.

6.7. Automatic Timeout, Pay-at-the Vehicle Fueling Dispenser.

Code Reference: 3.39: S.2.8. (1/1/20)

For a pay-at-the vehicle fueling dispenser, once the device has been authorized, it must de-authorize within two minutes if the device has not been activated. To verify this operation, first authorize the dispenser. Next, without dispensing product, wait two minutes and then attempt to dispense product. The system must not dispense product.

If the time limit to deauthorize the device is programmable, it shall not accept an entry greater than two minutes.

6.8. Confirm Results.

Code Reference: 3.39: N.6.2. (1/1/20)

If the result of any test is at, near, or exceeds the applicable tolerance limit, repeat that test to confirm the results and to help ensure you did not inadvertently introduce error into the test process. If necessary, conduct a "Repeatability Test" as described in the "Test" section of this EPO.

6.9. Steps After Each Test Draft.

a. Print a ticket/receipt and verify required information is provided and correctly recorded.
   Code Reference: 1.10: G-S.5.6., G-S.5.6.1., 3.39: UR.3.3.
b. Verify that the options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with this

capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy.

Code Reference: 1.10: G.S.5.6.

c. For transactions conducted with point-of-sale systems or devices activated by debit cards, credit cards, and/or cash, verify that all required information is printed on the receipt.

Code Reference: 3.39: S.2.6., UR.3.3.

d. Check price computations on all indicators (including consoles) and on recorded representations.

Code Reference: 1.10: G-S.5.5., 3.39: S.2.5.1.

e. Check for the agreement of values between indications and recorded representations.

Code Reference: 1.10: G-S.5.2.2., 3:39: S.2.4.4., S.6.

6.10. Display of Quantity and Total Price After Delivery.

Code Reference: 3.39: S.2.5.2.

Verify, after a delivery is completed, that the quantity and total price are displayed for at least 5 minutes or until the next transaction is initiated by a customer.

6.11. Use of Adjustments.

Code Reference: 1.10: G-UR.4.1., G-UR.4.2., G-UR.4.3.

Verify that adjustments are used only to correct for conditions that these elements are designed to control and that adjustments are made to bring performance errors as close to zero value as possible. Verify that equipment is properly maintained and that errors are not predominantly in favor of the device owner.

6.12. Normal Tests.

Code Reference: 3.39: N.6.1.

The test draft shall be made at flows representative of that during normal delivery. The pressure drop between the dispenser and the proving system shall not be greater than that for normal deliveries. The control of the flow (e.g., pipework or valve(s) size, etc.) shall be such that the flow of the measuring system is maintained within the range specified by the manufacturer.

SAFETY REMINDER!!!

- **Ground test tank and scale properly during fueling and return of product.**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Use proper lifting techniques when lifting all test cylinders!!!**
- **Be aware of vehicular and pedestrian traffic when moving between the dispenser and reference scale site locations.**
- **Stop delivery manually if delivery hose pressure exceeds allowable safety limits.**
- **When venting hydrogen gas, the release must be at a sufficient height so as to not expose personnel, equipment, or property to the radiant heat created by the discharge process. The stack should be properly grounded to avoid possible problems with lighting and static electricity.**
- **Ensure separation from other hazardous chemicals/gases.**

7. Test.

NOTE: Code references used throughout the document are drawn from NIST HB 44 General Code (Section 1.10) and Hydrogen Gas-Measuring Devices Code (Section 3.39). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item.

7.1. Gravimetric Test Procedure.

7.1.1. Computer Jump.

Code Reference: 3.39: S.3.5., N.2., N.4.2., T.2., Table T.2., T.3.

- Remove nozzle from dispenser and connect the nozzle to test cylinder. (Test cylinder pressure should not be greater than 95 % of the nominal working pressure 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.

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.

7.1.2. Minimum test procedures and draft sizes are as follows.

Code Reference: 1.10: G-UR.3., 3.39: S.3.1., S.4.1.

For this and subsequent tests, verify other conditions of use do not exceed marked or manufacturer-specified limitations.

7.1.3. Test Draft at the Minimum Measured Quantity (MMQ).

Code Reference: 3.39: N.5.

- Place empty test cylinder on the scale.

NOTE: Empty test cylinder must have a minimum of 2 MPa pressure before the dispensing system will begin a delivery.

- Tare the weight of the test cylinder, chocks, and stand.
- Connect the nozzle to the test cylinder.
- Fill the test cylinder to at least the amount delivered by the device for the system's declared minimum measured quantity.

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

- Disconnect the nozzle from the test cylinder.
- Compare dispenser display indication to scale indication.
- Determine dispenser error.

  Code Reference: 3.39: T.2.
- Leave product in test cylinder.

7.1.5. Test Draft Two Times the MMQ.

- 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 test cylinder; fill test cylinder to approximately two times the minimum measured quantity.
  Code Reference: 3.39: N.3., N.4.2.
- Disconnect the nozzle from the test cylinder.
- Compare dispenser display indication to scale indication.
- Determine dispenser error.
  Code Reference: 3.39: T.2.
- Leave product in test cylinder.

7.1.6. Test Draft Five Times the MMQ or Four Kilograms.

- 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 test cylinder; fill test cylinder to approximately five times the minimum measured quantity or four kilograms; whichever is greater.
  Code Reference: 3.39: N.4.2.
- Disconnect the nozzle from the test cylinder.
- Compare dispenser display indication to scale indication.
- Determine dispenser error.
  Code Reference: 3.39: T.2.
- Return product to owner/operator for proper storage or disposal.
  Code Reference: 3.39: UR.3.6.

7.1.6.1. Check operation of low-flow cut-off valve.

Code Reference: 3.39: 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 measuring system minimum flow rate.

7.2. Repeatability Test.

Code Reference: 3.39: N.6.2., T.3.

If necessary, conduct a repeatability test. A repeatability test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size.

7.3. Money-Value Computations and Recorded Representations.

Check money-value computations.

Code Reference: 1.10: G S.5.5., 3.39: S.2.5.

Print a ticket if device is so equipped and check price computations as outlined in "Test Notes."

Code Reference: 1.10: G-S.5.2.2., 3.39: S.2.4.4., S.2.6.

7.4. RFI/EMI Test. (electronic equipment only).

Code Reference: 1.10: G-N.2., G-UR.1.2., G UR.3.2., G-UR.4.2.

This testing is typically done during the inspection of a new installation. It is conducted subsequently only if a problem is suspected:

- Radio Frequency Interference (RFI)
- Electromagnetic Interference (EMI)

7.5. Zero-Set-Back Interlock.

7.5.1. Check the effectiveness of the zero-set-back interlock. No subsequent delivery shall be possible until the indicating and recording elements are returned to zero.

Code Reference: 3.39: S.3.6.

7.5.2. On equipment with remote pumping systems, activate one dispenser and check all others operated by the same pump to ensure that they will not operate without activating the individual starting levers.

Code Reference: 3.39: S.3.6.

7.5.3. 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.)

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

7.5.5. Reset computer to zero and turn on dispenser.

7.5.6. Attempt to return the nozzle to its designed hanging position, carefully 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.)

7.5.7. Product should not flow without resetting the indications to zero.

Code Reference: 3.39: S.3.6.

7.6. Power Loss Test.

Code Reference: 3.39: S.2.3.

Ensure that information (such as the quantity and unit price, or total sales price) needed to complete transactions in progress at the time of a power loss can be determined for at least 15 minutes at the dispenser or customer-accessible console or at another on-site device and that user information is retained in device memory.

It is not typically necessary nor is it recommended to repeat this test for every inspection; however, this does not preclude the test from being conducted when deemed necessary by the regulatory authority or service person to ensure continued compliance with this requirement. As a minimum, this test should be conducted on the examination of a system or device that is put into service for the first time to verify proper installation and set-up. It may also be warranted in response to specific complaints where the test would be relevant. NIST recommends that, prior to conducting a test to verify compliance with these requirements, consult your supervisor to verify your jurisdiction's or organization's policy regarding this test.

8. Post-Test Tasks.

NOTE: Code references used throughout the document are drawn from NIST Handbook 44 (HB 44) General Code (Section 1.10) and Hydrogen Gas-Measuring Devices Code (Section 3.39). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST Handbook 44 (HB 44) General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item.

8.1. Security Means.

8.1.1. Adequate provision shall be made for applying a physical security seal and/ or providing other approved means of security such as a data change audit trail.

Code Reference: G-S.8. (1/1/90), G-S.8.1. (1/1/10), 3.39: S.3.3., Table S.3.3.

8.1.2. For devices and 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.

Code Reference: 1.10: G-S.8.2., 3.39: S.3.3.

8.1.3. For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified.

Code Reference: 1.10: G-S.8.1. (1/1/10)

8.1.4. A metrologically-significant software change is a sealable event.

Code Reference: 1.10: G-S.9.

8.1.5. Audit Trail Information.

Code Reference: 1.10: G-S.8. (1/1/90), 3.39: S.3.3., Table S.3.3.

If the system is equipped with an audit trail, note the event counter settings on the test report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. Note that some systems may be equipped to provide an electronic copy of the event counter or the event log in place of or in addition to providing a hard copy of the security information at the time of the inspection. This data shall not be affected or alterable. Examine these records for any signs of misuse of adjustments.

8.1.6. Security Seals.

Code Reference: 1:10: G-UR.4.5.

Check for the presence of security seals on the device. A security seal shall be affixed to any adjustment mechanism designed to be sealed. Document missing seals on the official report and apply new ones as needed.

8.2. Record Total Quantity.

Code Reference: 1.10: G-UR.4.1., G-UR.4.2., 3.39: S.7.

Note the final totalizer reading and record the total quantity of electricity dispensed and (where time-based fees are assessed in association with the electrical energy charging session service) the total time during the test on the official test report. Verify totalizers are working correctly.

8.3. Review/Analyze Results.

Code Reference: 1.10: G-UR.4.1., G-UR.4.3.

After all equipment at a location has been tested, review the results to determine compliance with requirements for equipment maintenance and use of adjustments.

Record the compliance action and disposition of the device on the report and explain the results to the device owner.

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Appendix to Examination Procedure Outline No. 29 for
Hydrogen Gas Retail Vehicle Fuel Dispensers Reference Scale

1. Selection Criteria Scale Selection Criteria.

[**Technical Note:** 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 (available on the NIST OWM web site at: **https://www.nist.gov/pml/owm/national-conference-weights-measures-ncwm-related-reports**).

NIST IR 6919 Recommended Guide for Determining and Reporting Uncertainties for Balances and Scales (available on the NIST OWM web site at: **https://www.nist.gov/pml/owm/nist-interagency-or-internal-reports-nistir**) includes a comprehensive description of how to determine and address uncertainties in balances and scales.]

Steps should be taken to eliminate the uncertainty 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 hydrogen gas-measuring 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 also be used to reduce errors and uncertainties. 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.

1.1. 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 delivered from the hydrogen gas 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.

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 measured quantity or attainable minimum flow rate, then it is essential to select a reference scale with an appropriate division size. Consider an example in which the acceptance tolerance of ±5.0 % for an Accuracy Class 7.0 hydrogen gas-measuring device application applies; the combined weight of the empty tank and the metered hydrogen gas is 26 kg; where the tank weight is 25 kg; and the hydrogen gas product weight is 1 kg.

The tolerance is applied to the smallest net load indicated on the device under test, which in this case is 1 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 hydrogen gas dispenser and is calculated as follows:

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

$\leq$ 1 kg × 0.05 × 0.1

$\leq$ 0.005 kg

Thus, the scale division for the reference scale should be no greater than 0.005 kg or 5 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 5 g but could also indicate in either units of 1 g or 2 g.

1.2. Minimum Test Draft Size.

The scale division size will also affect the size of the test draft required to evaluate the meter. Consider an example in which a hydrogen gas 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 1 g. To limit the error for each weighing to one-tenth of the tolerance, the minimum test draft size is calculated as follows:

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

Example 1:

If the acceptance tolerance of ± 5.0 % applies; the minimum test draft size for the above example is calculated as follows:

$$\frac{(5.0\text{ g} \times 10)}{0.05} = 100.0\text{ g} = 0.1\text{ kg}$$

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 ± 5.0 % is applied, the minimum test draft is recommended to be at least 0.1 kg.

Large relative errors result when rounding weight values for small loads. In the above example, 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.

2. 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 5.0 % to a hydrogen gas dispenser, the reference scale (i.e., the standard used for the test) must be accurate to at least one-third of the applicable device tolerance of 5.0 % (i.e., 1.67 %). Consequently, to ensure the error and uncertainty of the reference scale does not exceed this value, 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.

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