NIST | OFFICE OF WEIGHTS AND MEASURES

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

EPO No. 23

Vehicle–Tank Meters (VTMs)
Power Operated

EPO25.20250618 (content current as of 2025-06-18)

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EPO No. 23
NIST Examination Procedure Outline (EPO) for Vehicle–Tank Meters (VTMs) Power–Operated

1. Scope.

It is recommended that this outline be followed as minimum criteria for examining all power-operated vehicle-tank meters – analog or digital. Nonretroactive requirements are followed by the applicable date in parentheses. The outline may be applied to devices with or without Automatic Temperature Compensating Systems. Do not use this outline for testing vehicle-tank metering systems used to measure milk, LPG, cryogenics, or carbon dioxide. This EPO does not apply to gravity-discharge vehicle tank meters (covered in NIST EPO 24) or vehicle-mounted mass flow meters. Nonretroactive requirements are followed by the applicable date in parentheses.

2. Safety Notes.

When excerpting this Examination Procedure Outline for duplication, the 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 or servicepersons be aware of all safety regulations and policies in place at the inspection site and 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.

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," including the introductory section on safety found at the beginning of this annex. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of the terms and key phrases in each safety reminder of this outline are found in the glossary of the EPO Safety Annex.

- **Clothing**
- **Electrical Hazards**
- **Emergency Procedures**
- **Eye Protection**
- **Fire Extinguisher**
- **First Aid Kit**
- **Grounding/Bonding**
- **Ignition Sources**
- **Lifting**
- **Location**
- **Nature of Product**
- **Obstructions and Overhead Hazards**
- **Personal Protection Equipment**
    - e.g., Barrier Cream, Eye Protection, Gloves, Hard Hat, Safety Aprons, Safety Shoes, etc. as deemed necessary

- **Safety Cones/Warning Signs**
- **Safety Data Sheets (SDS)**
- **Static Discharge**
- **Support – for prover**
- **Switch Loading**
- **Traffic**
- **Transportation of Equipment**
- **Weather**

Also:

- **Chemicals**
- **Hazardous Materials**
- **Petroleum Products**
- **Wet and Slick Conditions**

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the prover when it is filled with product - don't forget to chock the wheels of the prover.**
- **Learn the nature of hazardous products used at or near the inspection site – obtain and read copies of SDSs.**
- **Know emergency procedures and location and operation of fire extinguisher and emergency shut offs.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use caution in moving around in wet, slippery areas and climbing on prover, storage tanks, and vehicles.**
- **Use personal protection equipment and clothing appropriate for the inspection site.**
- **If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected.**
- **Be sure a first aid kit is available and that it is appropriate for the type of inspection activity.**

3. Inspection.

NOTE: Code references used throughout the document are drawn from NIST HB 44 General Code (Section 1.10) and Vehicle-Tank Meters Code (Section 3.31). 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.

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

3.1.1. The device must be readily accessible for purposes of testing.

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

3.1.2. Assistance shall be provided by the firm if needed.

Code Reference: 1.10: G-UR.4.4.

3.1.3. Testing devices at a central location.

Code Reference: 1.10: G-UR.4.6.

3.2. Selection and Suitability.

3.2.1. Selection and suitability, general.

The device must be suitable for the service in which it is used with respect to the elements of its design, including flow rate, computing capability, the details of its indicating and recording elements, and the value of its smallest unit and unit prices.

Code Reference: 1.10: G-UR.1.1., G-UR.1.2., 3.31: UR.1.1., UR.1.2.

Vehicle-mounted systems (except those used solely for the sale of aviation fuel into aircraft-related operations) shall be equipped with a recording element.

Code Reference: 1.10: G-S.5.6., 3.31: S.1.1.1., UR.2.2.

3.2.2. Minimum delivery required.

Code Reference: 1.10: G-UR.1.3.

3.2.3. Computing capability, computing-type device.

Code Reference: 3.31: S.1.4.

Computing-type devices shall be suitable with regard to computing capability, display of the unit price and total price, recorded representations, money-value computations, and agreement of indications.

Code Reference: 3.31: S.1.4.1, S.1.4.2., S.1.4.3., S.1.4.4., UR.1.2.

3.2.4. Environment.

The device shall be suitable for use in the environment in which it is installed and used.

Code Reference: 1.10: G-UR.1.2.

3.2.5. Permanence.

Code Reference: 1.10: G-S.3.

3.3. Installation

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

3.3.1. Facilitation of fraud.

Code Reference: 1.10: G-S.2.

Installation shall not facilitate fraud. Examine the system and any associated equipment to ensure the assembly, installation, and construction do not facilitate fraud

Code Reference: 1.10: G-S.2.

3.3.2. Diversion of measured product.

Examine discharge lines and valves to ensure the system is installed such that measured liquid cannot be diverted. (See also "Discharge Lines and Valves.")

Code Reference: 1.10: G-S.2., 3.31: S.3.1.

For multiple-product, single-discharge hose metering systems equipped with means for clearing the discharge hose, verify installation of the system complies with the requirements outlined in "Discharge Lines and Valves."

Code Reference: 3.31: S.3.1.1., UR.2.6.

3.3.3. Installed in accordance with manufacturer's instructions.

Code Reference: 1.10: G-UR.2.1.

A device installed in a fixed location shall be installed so that neither its operation nor its performance will be adversely affected by any characteristic of the foundation, supports, or any other detail of the installation.

Code Reference: 1.10: G-UR.2.1.

3.3.4. Discharge Rate.

A device shall be installed such that the actual maximum discharge rate will not exceed the marked maximum discharge rate. Automatic means for regulating the flow shall be incorporated into the system, if necessary.

Code Reference: 3.31: UR.1.1.

3.3.5. Position of equipment.

The device shall be installed so that there is no obstruction between a primary indicating element or recording element and the measuring element. Otherwise, there shall be convenient and permanently installed means for direct oral or visual communication between an individual located at the primary element and an individual located at the measuring element.

Code Reference: 1.10: G-UR.2.2.

A device or system equipped with a primary indicating element and used in direct sales shall be positioned so that its indications may be accurately read and the measuring operation may be observed from some reasonable "customer" and "operator" position. The positioning shall be determined on a case-by-case basis, considering the individual circumstances, including the size and character of the indicating element.

Code Reference: 1.10: G-UR.3.3.

3.3.6. Visibility of Markings.

Code Reference: 1.10: G-UR.2.1.1.

3.4. Use.

3.4.1. Facilitation of fraud.

Code Reference: 1.10: G-S.2.

3.4.2. Method of operation.

The device and any associated equipment are to be operated and maintained as intended by the manufacturer.

Code Reference: 1.10: G-UR.3.1., G-UR.4.1.

3.4.3. Operation of associated and nonassociated equipment.

Code Reference: 1.10: G-UR.3.2.

3.4.4. Liquid measured.

The metering system shall only be used to measure the same liquid or one with the same general properties as that used for calibration and approval unless the meter is recalibrated with a different product and retested and approved by the weights and measures jurisdiction having authority over the device.

Code Reference: 3.31: UR.1.4.

3.4.5. Return of Indicating and Recording Elements to Zero.

The primary indicating elements and primary recording elements (when returnable to zero) shall be returned to zero immediately before each delivery is begun and after the pump has been activated and the product to be measured supplied to the measuring system.

Code Reference: 3.31: UR.2.1.

A ticket shall not be inserted into the ticket printer until indications that are resettable to zero have been returned to zero as described above.

Code Reference: 3.31: UR.2.3.

3.4.6. Computing capability, computing-type devices.

The unit price at which the device is set to compute shall be displayed on the face of the device.

Code Reference: 3.31: UR.1.2.

3.4.7. Ticket Printer, Customer Ticket/Recording Means.

Code Reference: 3.31: UR.2.2.

VTMs shall be equipped with a means to record all sales through the meter and shall comply with G-S.5.6.6. Recorded Representations.

A copy of the ticket shall be left with the customer at the time of delivery unless otherwise specified by the customer.

UR.2.2. does not apply to VTMs used solely for aviation fueling into aircraft or aviation-related operations.

Code Reference: 3.31: UR.2.2.1.

3.4.8. Ticket in Printing Device.

Code Reference: 3.31: UR.2.3.

3.4.9. Use of Automatic Temperature Compensation (ATC).

Code Reference: 3.31: UR.2.5.

3.4.10. Clearing the Discharge Hose.

Code Reference: 3.31: UR.2.6.

The user of a manifold flush system or similar mechanism shall comply with the following.

Code Reference: 3.31: UR.2.6.

A manifold flush system or similar mechanism shall not be used during commercial transactions, and the following restrictions apply:

- The inlet valves for the system shall not be connected to any hose or piping when not in use.
- When the flushing system is in operation, the discharge hose is only to be connected to the port for the product type being flushed.
- Following the flushing process, indications and recording elements must be reset to zero before beginning a commercial delivery.

Code Reference: 3.31: UR.2.6.1.

The user shall take steps to ensure the system is properly flushed to minimize the potential for cross contamination.

Code Reference: 3.31: UR.2.6.2.

Whenever, prior to delivery, a different product is pumped through the discharge hose to avoid contamination, a record shall be maintained. Records shall be kept for a period of 12 months and available for inspection by the weights and measures authority.

Code Reference: 3.31: UR.2.6.3.

3.4.11. Credit for Flood Volume.

Code Reference: 3.31: UR.2.4.

3.5. Maintenance.

3.5.1. Maintained in proper operating condition.

The device and any associated equipment are to be maintained in proper operating condition.

Code Reference: 1.10: G-UR.4.1.

3.5.2. Abnormal performance.

Code Reference: 1.10: G-UR.4.2.

3.5.3. Errors shall not be in favor of the device owner.

Code Reference: 1.10: G-UR.4.1.

Adjustments not used to compensate for worn or faulty parts and made to bring errors as close to zero value as practicable.

Code Reference: 1.10: G-UR.4.3.

3.5.4. Use of Adjustments, Multiple Linearization Factors.

Code Reference: 3.31: UR.3.1.

3.6. Indicating and Recording Elements.

3.6.1. Design.

Code Reference: 3.31: S.1.1.1., S.2.4.

3.6.1.1. Units.

3.6.1.2. Value of Smallest Unit.

Code Reference: 3.31: S.1.1.2.(a).

Shall not exceed 0.5 L (0.1 gal) on devices with a maximum flow of 750 L/min (200 gal/min) or less.

Code Reference: 3.31: S.1.1.3.(b).

Shall not exceed 5 L (1 gal) on jet fuel aviation refueling systems with a maximum flow of more than 375 L/min (100 gal/min).

Code Reference: 3.31: S.1.1.3.(c).

3.6.1.3. Readability.

Code Reference: 1.10: G-S.5., G-S.6. (1/1/77), G-S.7., 3.31: S.1.2., S.1.3.

3.6.1.3.1. Indicating and recording elements must be clear, definite, and easily read.

Code Reference: 1.10: G-S.5., 3.31: S.1.2., S.1.3.

3.6.1.3.2. Required markings shall be distinct, easily readable, and of a permanent nature.

Code Reference: 1.10: G-S.6. (1/1/77), G-S.7.

3.6.1.4. Values of Intervals.

Values of the graduated intervals must be uniform throughout the series of indicating elements or, if equipped, recording elements.

Code Reference: 1.10: G-S.5.3.

For devices indicating or recording in more than one unit, the values must be appropriately identified.

Code Reference: 1.10: G-S.5.3.1.

3.6.1.5. Computing-type devices.

3.6.1.5.1. Display of unit price.

Code Reference: 3.31: S.1.4.1., UR.1.2.

3.6.1.5.2. Recorded representations.

Code Reference: 3.31: S.1.4.2.

3.6.1.5.3. Money-value computations.

Code Reference: 3.31: S.1.4.3.

3.6.1.5.4. Money-values, mathematical agreement.

Code Reference: 3.31: S.1.4.4.

3.6.1.6. Advancement and return to zero of indicating and recording elements.

It shall not be possible to advance primary indicating and recording elements except by mechanical operation of the device.

Code Reference: 3.31: S.1.1.4.

Indicating and recording elements may only be advanced to zero by the mechanical operation of the device, UNLESS:

Code Reference: 3.31: S.1.1.4.

a. Advancement cannot be stopped until zero is reached, OR

b. The indicating elements are automatically obscured until the elements reach a correct zero position.

Primary indicating and/or recording elements shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of primary indicating elements and of primary recording elements (if these are returnable to zero), beyond their correct zero position.

Code Reference: 3.31: S.1.1.5.

3.6.1.7. Recorded representations.

3.6.1.7.1. General.

Code Reference: 1.10: G-S.5.6.

Vehicle-mounted systems (except those used solely for the sale of aviation fuel into aircraft-related operations) shall be equipped with a recording element.
Code Reference: 3.31: S.1.1.1., UR.2.2., UR.2.2.1.

3.6.1.7.2. Computing-type devices.

Code Reference: 3.31: S.1.4.2.

3.6.1.7.3. Gross and net indications for devices with ATC.

Code Reference: 3.31: S.2.5.3.

3.7. Provision for sealing.

3.7.1. Sealing, General.

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

Code Reference: 1.10: G-S.8. (1/1/90), 3.31: S.2.2., Table S.2.2. (1/1/95), S.2.5.4.

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

Code Reference: 1.10: G-S.9.

3.7.2. Physical Means of Security.

For devices designed with a physical means of security, check for:

3.7.2.1. Accessibility of the Adjusting Mechanism.

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

Code Reference: 3.31: S.2.2.

- The device shall be installed and located such that access is provided to permit inspecting and applying security seals.

Code Reference: 1.10: G-UR.2.3.

- **Presence of Security Seals.** 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.

Code Reference: 1.10: G-UR.4.5., 3.31: S.2.2.

3.7.2.2. Provisions for sealing ATC (for systems equipped with ATC).

Code Reference: 3.31: S.2.5.4.

3.7.3. Audit Trails, General.

3.7.3.1. Audit Trails, Format. 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.2.2. Categories of Device and Methods of Sealing.

Code Reference: 1.10: G-S.8.(1/1/90), 3.31: S.2.2., Table S.2.2. (1/1/95).

3.7.3.2. Audit Trail Information – Review and Document. 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, a printed copy of the information shall be available on demand through the device or through another on-site device at the time of the inspection. 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.

Code Reference: 1.10: G-S.8. (1/1/90), 3.31: S.2.2., Table S.2.2. (1/1/95).

3.7.3.3. Event Logger. 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 on demand at the time of inspection through the device or through another on-site device.

In addition to providing a printed copy of the information, the information may be made available 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.)

Code Reference: 3.31: S.2.2., Table S.2.2. (1/1/95).

3.7.3.4. Single Provision for Sealing Multiple Elements. 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).

3.7.3.5. Parameters Accessed Via Removable Digital Storage.

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.

Code Reference: 1.10: G-S.8.2., 3.31: S.2.2., Table S.2.2. (1/1/95).

3.8. Marking Requirements.

3.8.1. General.

Code Reference: 1.10: G-S.1.

3.8.1.1. Clear and Permanent Marking. Equipment shall be clearly and permanently marked for the purposes of identification.

Code Reference: 1.10: G-S.1.

3.8.1.2. Visibility of G-S.1. Marking Information. The required information shall be located so that it is readily observable without the necessity of the disassembly of a part requiring the use of any means separate from the device.

Code Reference: 1.10: G-S.1.

3.8.1.3. Name or ID identification of manufacturer.

Code Reference: 1.10: G-S.1.(a).

3.8.1.4. Model designation.

Code Reference: 1.10: G-S.1.(b).

3.8.1.4.1. Model designation identifier and abbreviations.

Code Reference: 1.10: G-S.1.(b)(1) (1/1/03).

3.8.1.5. Nonrepetitive serial number.

Code Reference: 1.10: G-S.1.(c) (1/1/68).

3.8.1.5.1. Serial number identifier and abbreviations.

Code Reference: 1.10: G-S.1.(c)(1) (1/1/86), G-S.1.(c)(2) (1/1/01).

3.8.1.6. Software version or revision identifier, software-based devices.

3.8.1.6.1. Software version or revision identifier for not-built-for-purpose software-based devices.

Code Reference: 1.10: G-S.1.(d) (1/1/04).

3.8.1.6.2. Software version or revision identifier for all software-based devices

Code Reference: 1.10: G-S.1.(d) (1/1/22).

3.8.1.6.3. Software version or revision identifier preface.

Code Reference: 1.10: G-S.1.(d)(1)i. (1/1/07).

3.8.1.6.4. 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).

3.8.1.6.5. Abbreviations for "version."

Code Reference: 1.10: G-S.1.(d)(2) (1/1/07).

3.8.1.7. NTEP CC Number.

Code Reference: 1.10: G-S.1.(e).

3.8.1.7.1. NTEP CC Number identifier.

Code Reference: 1.10: G-S.1.(e)(1) (1/1/03).

3.8.1.8. Location of G-S.1. Information, Not-Built-For Purpose, Software-Based Devices.

Code Reference: 1.10: G-S.1.1. (1/1/04).

3.8.1.9. Devices or Main Elements Remanufactured as of January 1, 2002.

Code Reference: 1.10: G-S.1.2. (1/1/02).

3.8.1.9.1. Name and ID of remanufacturer or distributor.

Code Reference: 1.10: G-S.1.(a)(1/1/02).

3.8.1.9.2. Model number if different from original number.

Code Reference: 1.10: G-S.1.(b)(1/1/02).

3.8.1.10. Values Identified.

Code Reference: 1.10: G-S.5.2.4.

If graduations, indications, or recorded representations are intended to have specific values, these values shall be adequately defined and markings positioned as close as practicable to the values being identified.

3.8.1.11. Permanence of indications and markings.

Code Reference: 1.10: G-S.5.2.5.

Graduations, indications, or recorded representations and their defining figures, words, and symbols shall be of such character that they will not tend easily to become obliterated or illegible.

3.8.1.12. Marking, Operational Controls.

All switches, lights, displays, pushbuttons, and other operational controls and features must be clearly and definitely identified

Code Reference: 1.10: G-S.6. (1/1/77).

3.8.1.13. Visibility of required markings after installation

Code Reference: 1.10: G-UR.2.1.1.

3.8.1.14. Money-operated devices, responsibility.

Code Reference: 1.10: G-UR.3.4.

3.8.1.15. Limitation of Use.

Any limitation on a device's use shall be clearly and permanently marked on any device intended to measure accurately:

Code Reference: 3.31: S.5.1.

- only products having particular properties,
- only under specific installation conditions, or
- only when used in conjunction with specific accessory equipment.

3.8.1.16. Discharge rates

Code Reference: 3.31: S.5.2.

- A meter shall be marked to show its designed minimum and maximum discharge rates.
- The minimum discharge rate shall note exceed 20 % of the maximum discharge rate.

3.8.1.17. For Devices Equipped with ATC Systems for Refined Petroleum Products, Markings.

Primary indicating elements, recording elements, and recorded representations shall be clearly and conspicuously marked to show the volume has been adjusted to the volume at 15 °C or 60 °F.

Code Reference: 3.31: S.5.6.

3.9. Measuring Elements.

3.9.1. Air/vapor elimination.

Code Reference: 3.31: S.2.1.

3.9.1.1. Effective, automatic means to eliminate air/vapor shall be provided.

3.9.1.2. Verify air/vapor eliminator vent lines are made of appropriate, non-collapsible material.

3.9.2. Security Seals.

3.9.2.1. General.

Code Reference: 1.10: G-S.8. (1/1/90), G-S.9., G-UR.4.5., 3.31: S.2.2., Table S.2.2. (1/1/95).

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.

3.9.2.2. Directional flow valves.

Code Reference: 3.31: S.2.3.

Valves intended to prevent reversal of flow shall be automatic in operation. However, on equipment used exclusively for fueling aircraft, such valves may be manual in operation.

3.9.2.3. Zero-Set-Back Interlock, Electronic Vehicle-Tank Meters.

Code Reference: 3.31: S.2.4. (1/1/06).

Except for VTMs used solely for the delivery of aviation fuel, a device shall be equipped with a zero-set-back interlock such that, after individual or multiple deliveries at one location have been completed the interlock shall automatically engage to prevent a subsequent delivery until the indicating and any recording elements have been returned to their zero position.

For individual deliveries, if there has been no product flow for three minutes, the transaction must be completed before additional product flow is allowed. The three-minute timeout shall be a sealable feature of an indicator.

3.9.2.4. Provision for Thermometer Well.

Code Reference: 3.31: S.2.5.5., S.2.6. (1/1/12).

Means (e.g., thermometer well) for determining the temperature of the liquid for test purposes are required on VTMs as follows:

- All VTMs equipped with automatic temperature compensating systems.

Code Reference: 3.31: S.2.5.5.

- Effective and nonretroactive as of January 1, 2012, all VTMs, including those without automatic temperature compensating systems.

Code Reference: 3.31: S.2.6. (1/1/12).

Means for determining the temperature (e.g., the thermometer well) shall be located either in the:

a. Liquid chamber of the meter; or

b. Meter inlet or discharge line immediately adjacent to the meter.

Code Reference: 3.31: S.2.5.5., S.2.6. (1/1/12).

3.10. Discharge Lines and Valves.

3.10.1. Directional flow valves. (see Measuring Elements above)

Code Reference: 3.31: S.2.3.

3.10.2. Diversion of Measured Liquid.

Code Reference: 3.31: S.3.1.

3.10.2.1. Diversion, general.

Examine discharge line and valves to ensure measured liquid cannot be diverted from the measuring chamber or discharge line.

Code Reference: 3.31: S.3.1.

Two or more outlets may be installed only if automatic means are provided to ensure: S.3.1.

a. Liquid can only flow from one outlet at a time; and

b. The direction of flow for which the mechanism may be set at any time is clearly and conspicuously indicated.

The provisions of S.3.1. do not apply to:

(1) Equipment used to exclusively fuel aircraft.

(2) Multiple-product, single-discharge hose metering systems that are equipped with "manifold flush" types of systems used to flush the discharge hose, provided those systems comply with paragraph S.3.1.1. as outlined below.

3.10.3. Means for Clearing the Discharge Hose.

Code Reference: 3.31: S.3.1.1. (portions nonretroactive as of 1/1/24), UR.2.6.1.

Multiple-product, single-discharge hose metering systems may be equipped with systems specifically designed to facilitate clearing of the discharge hose prior to delivery to avoid product contamination. These are sometimes referred to as "manifold flush" systems. In such systems, a valve used to temporarily divert product from the measuring change of the meter to a storage tank shall be installed only if the following are met:

a. the discharge hose remains of the wet hose type;

b. the valve and associated piping are approved by the weights and measures authority having jurisdiction over the system prior to commercial use;

c. the valve is permanently marked with its purpose (e.g., flush valve);

d. the valve is installed in a conspicuous manner and as far from the hose reel as practical;

e. the system clearly and automatically indicates the direction of product flow during operation of the flush system;

f. clear means, such as an indicator light or audible alarm, is used to identify when the valve is in use on both the quantity indications and any associated recorded representations (e.g., using such terms as "flushing mode" or "not for commercial use");

g. effective, automatic means shall be provided to prevent passage of liquid through any such flush system during normal operation of the measuring system; and

h. no hoses or piping are connected to the inlet when it is not in use.

See also section "4. Use" of this EPO for additional restrictions on use.

Code Reference: 3.31: UR.2.6., UR.2.6.1.

3.10.4. Facilitation of Fraud.

Examine the system and any associated equipment to ensure the assembly, installation, and construction do not facilitate fraud.

Code Reference: 1.10: G-S.2.

3.10.5. Leaks.

No leaks should exist in the system on the outlet side of the meter.

Code Reference: 1.10: G-UR.4.1., 3.31: S.3.1.

Note: If leaks are detected on the inlet side of the meter, a notation should be made on the inspection report and the firm should be made aware of the location of the leak for purposes of safety.

3.10.6. Discharge Hose.

3.10.6.1. Hose Fill/Zero Start. The hose shall be filled with liquid before the zero condition is established.

Code Reference: 3.31: UR.2.1.

3.10.6.2. Pump-Discharge Unit, Wet-Hose Type, Shut-Off Valve. The discharge hose shall be of the wet-hose type with a shutoff valve at its outlet end.

Code Reference: 3.31: S.3.2.

3.10.6.3. Pump-Discharge Unit, Dry-Hose. In addition to the required wet-hose, a pump-discharge unit may also be equipped with a dry-hose without a shutoff valve at its outlet end if:

- The dry hose is as short as practicable.
- Effective means are incorporated to ensure liquid can flow through only one of the discharge hoses at any one time and the meter and wet-hose remain full of liquid at all times.

Code Reference: 3.31: S.3.2.

3.10.6.4. Reinforcement. A discharge hose shall be adequately reinforced.

Code Reference: 3.31: S.3.4.

3.10.6.5. Discharge Valve. A discharge valve is only permitted on a wet-hose type device and shall be located at the discharge end of the line.

Any other shutoff valve on the outlet side shall be of the automatic or semiautomatic, predetermined stop-type or shall be operable only:

a) By means of a tool (but not a pin) entirely separate from the device, or

b) By mutilation of a physical security seal with which the valve is sealed open.

Code Reference: 3.31: S.3.5.

3.10.7. Antidrain Valve.

In a wet-hose, pressure-type device an effective antidrain valve shall be incorporated in the discharge valve or immediately adjacent to the valve. The antidrain valve shall function to prevent the drainage of the discharge hose.

Code Reference: 3.31: S.3.6.

Systems used exclusively for the fueling and defueling aircraft may be of the pressure type without an antidrain valve.

Code Reference: 3.31: S.3.6.

3.11. Automatic Temperature Compensation (ATC) for Refined Petroleum Products.

Code Reference: 3.31: S.2.5.

3.11.1. Automatic Temperature Compensation.

A device may be equipped with an automatic means for adjusting the indication and registration of the measured volume to the volume of product at 15 °C (60 °F)

Code Reference: 3.31: S.2.5.1.

3.11.2. Provisions for Deactivating ATC.

On a device equipped with an ATC that will indicate or record only terms of the compensated quantity, provision shall be made for deactivating the automatic temperature compensating system so that the meter may indicate and record, if equipped to record, in terms of the uncompensated volume.

Code Reference: 3.31: S.2.5.2.

3.11.3. Gross and net indications.

Devices equipped with ATC shall indicate or record both the gross and net volumes for testing purposes. Gross and net volumes need not be simultaneously displayed.

Code Reference: 3.31: S.2.5.3.

3.11.4. Provisions for Sealing ATC.

For devices and systems in which the ATC system can be disconnected and/or adjusted 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. (See this reference in the Inspection portion of this EPO.)

Code Reference: 1.10: G-S.8.2., 3.31: S.2.2.

For other devices, adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that an ATC system cannot be disconnected and no adjustment may be made to the system.

Code Reference: 3.31: S.2.2. S.2.5.4., Table S.2.2. (1/1/95).

3.11.5. Temperature Determination, Thermometer Well.

A metering system equipped with an automatic temperature compensating mechanism shall be equipped with a thermometer well for determination of the temperature of the liquid as outlined in Discharge Lines and Valves above.

Code Reference: 3.31: S.2.5.5.

3.11.6. Temperature Compensated Volume, Markings.

Primary indicating and recording elements on devices equipped with automatic temperature compensating systems shall be marked to show that the volume delivered has been adjusted to 15 °C (60 °F).

Code Reference: 3.31: S.5.6.

3.11.7. Use of Automatic Temperature Compensator (ATC).

Code Reference: 3.31: UR.2.5.

3.11.7.1. When to Be Used. ATCS shall be connected and operable at all times. ATCS may not be removed or replaced with a non-ATCS device without written permission of weights and measures authority.

Code Reference: 3.31: UR.2.5.1.

3.11.7.2. Period of Use. When fuel is bought or sold on an automatic temperature compensated basis, it shall be bought or sold using this basis over at least a consecutive 12-month period, unless otherwise agreed to by both the buyer and seller in writing.

Code Reference: 3.31: UR.2.5.2.

3.11.7.3. Invoices and Reference Temperature. Invoices shall be marked to show volume delivered has been adjusted to the volume in terms of liters corrected to 15 ºC or gallons corrected to 60 ºF.

Code Reference: 3.31: UR.2.5.3.

3.12. Facilitation of Fraud.

Examine the system and any associated equipment to ensure the assembly, installation, and construction do not facilitate fraud

Code Reference: 1.10: G-S.2.

3.12.1. Automatic Timeout.

For individual deliveries, if there is no product flow for three minutes the transaction must be completed before additional product flow is allowed.

Code Reference: 3.31: S.2.4. (1/1/06).

3.12.2. The three-minute timeout shall be a sealable feature of an indicator.

Code Reference: 3.31: S.2.4. (1/1/06).

3.13. Totalizers.

3.13.1. Totalizers, General. Verify proper operation.

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

4. Pretest Determinations.

NOTE: Code references used throughout the document are drawn from NIST HB 44 General Code (Section 1.10) and Vehicle-Tank Meters Code (Section 3.31). 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.

4.1. Test Methods.

This EPO was designed around the use of volumetric, neck-type test standards. 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 other test standards and apparatus are used, corresponding adjustments to the test procedures described in this EPO may be needed to reflect the use of that equipment.

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

4.2. Test Draft Size.

Code Reference: 3.31: N.3.

4.2.1. Minimum Test.

Test drafts shall be equal to at least the amount delivered by the device in 1 minute at its maximum discharge rate.

Code Reference: 3.31: N.3.

4.2.2. Transfer Standard Test.

For tests conducted using a calibrated transfer standard meter, the minimum quantity for any test draft shall be equal to or greater than the amount delivered in one minute at the flow rate being tested.

Code Reference: 3.31: N.3.1.

4.3. Prover Design and Condition.

Ensure prover is of appropriate capacity and has a valid calibration certificate and its security seals are intact.

Inspect prover's interior surface for dents, product clingage, rust, water, or other foreign material.

Prover sight glass must be clean and fittings must not leak.

4.4. Thermometers.

4.4.1. Thermometers may be of the partial immersion or digital type. (See NIST HB 105-6 *Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures, 6. Specifications and Tolerances for Thermometers*, 1997, for additional information).

4.4.2. Accuracy: Thermometers shall be matched.

a. ± 0.5 °C, have a range of at least 0 °C to 50 °C, and be divided in increments of no greater than 0.5 °C for liquid-in-glass thermometers and 0.1 °C for digital thermometers; or

b. ± 1 °F, have a range of at least 0 °F to 120 °F, and be divided in increments of no greater than 1 °F for liquid-in-glass thermometers and 0.1 °F for digital thermometers.

4.5. Tolerances.

4.5.1. Acceptance/Maintenance Tolerances.

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

4.5.2. Application.

Code Reference: 1.10: G-T.3., 3.31: T.1.

4.5.3. Intermediate values.

Code Reference: 1.10: G-T.4.

4.5.4. Tolerances on Tests When Type 2 Transfer Standards are Used.

When Type 2 transfer standards are used to conduct accuracy tests, adjust the tolerances as described in G-T.5. Tolerances on Tests When Type 2 Transfer Standards Are Used.

Code Reference: 1.10: G-T.5.

4.5.5. Basic values.

Code Reference: 3.31: T.2., Table 1.

4.5.6. Repeatability.

Code Reference: 3.31: T.3.

When multiple tests are conducted at approximately the same flow rate and draft size, the range of the test results shall not exceed 40 % of the absolute value of maintenance tolerance. The results of each test shall be within the applicable tolerance.

4.5.7. Product Depletion Test.

Code Reference: 3.31: T.4.

See also procedures in “Additional Tests for All Meters, Step 2. Product Depletion Test” in the “Test” section of this EPO.

The purpose of the product depletion test is to examine the effectiveness of the air/vapor eliminator or air/vapor elimination means.

The product depletion test compares the results of a “normal test” with another test (also run at the normal flow rate) during which the product supply is depleted during the test, thus creating the potential for introducing air/vapor into the metering system.

The difference or range in results for the two tests is calculated as shown below.

(Normal Test Result) – (Product Depletion Test Result)

This difference or range cannot exceed the product depletion test tolerance.

The difference between the test results for any normal test and the product depletion test shall not exceed the following.

- For meters rated higher than 380 Lpm (100 gpm): 0.5 % of the volume delivered in one minute at the maximum flow rate marked on the meter.
- For meters rated at 380 Lpm (100 gpm) or lower: 0.6 % of the volume delivered in one minute at the maximum flow rate marked on the meter.

Example #1 of Calculating the Product Depletion Test Tolerance in Gallons and Cubic Inches:

Maximum Flow Rate Marked on the Device: 200 gpm

Product Depletion Test Tolerance: 0.5%

The amount delivered in one minute at the maximum flow rate marked on the meter =
1 minute x 200 gallons/minute = 200 gallons

Product Depletion Test Tolerance in Gallons =
0.5 % x 200 gallons = 1.0 gallons or 231 cubic inches

Example #2 of Calculating the Product Depletion Test Tolerance in Gallons and Cubic Inches:

Maximum Flow Rate Marked on the Device: 100 gpm

Product Depletion Test Tolerance: 0.6%

The amount delivered in one minute at the maximum flow rate marked on the meter =
1 minute x 100 gallons/minute = 100 gallons

Product Depletion Test Tolerance in Gallons =
0.6 % x 100 gallons = 0.6 gallons or 138.6 cubic inches

Test drafts shall be of the same draft size and run at approximately the same flow rate.

Code Reference: 3.31: T.4.

The result of the product depletion test may fall outside of the applicable test tolerance as specified in Table 1. Accuracy Classes and Tolerances for Vehicle-Tank Meters Other Than Vehicle-Mounted Milk Meters.

Code Reference: 3.31: T.4.

4.5.8. Automatic Temperature-Compensating Systems.

The difference between the meter errors expressed as a percentage determined with and without the automatic temperature-compensating system activated shall not exceed the applicable tolerance.

Code Reference: 3.31: T.2.1.

Example of Calculating the Tolerance for a Test of a Metering System Equipped with a Mechanical Automatic Temperature-Compensating (ATC) System:

- ATC Tolerance for Metering System with a Mechanical ATC: 0.2 %
- Test Result from a Normal Test with the ATC Activated: -0.12 %
- Test Result from a Normal Test with the ATC Deactivated: +0.01 %
- Difference between the meter errors (expressed as a percentage) with and without the ATC activated:

  (Normal Test ATC Activated) – (Normal Test ATC Deactivated) =
  (-0.12 %) – (+0.01 %) = 0.13 %

The metering system in this example MEETS the ATC tolerance since the difference of 0.13 % is less than the applicable ATC tolerance of 0.2 %.

4.6. Test Liquid.

Verify the test liquid is the same as that to be commercially measured or is a liquid with the same general physical characteristics. Note the product used during the test on the official report. It is also recommended the official affix a seal or tag or otherwise mark the system indicating the product used during the test.

Code Reference: 3.31: N.1.(a).

4.7. Test Product Quantity and Setup.

Ensure that sufficient product is available for conducting multiple test drafts. Also consider the distribution of product among compartments for multiple compartment vehicles. Ensure that it will be possible (for multi-compartment or single-compartment vehicles) to empty a compartment or the entire tank during the conduct of the "product depletion test" and that an additional source of product (e.g., from another compartment, a separate vehicle, or other supply) is available to complete the product depletion test.

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, eye protection (to prevent injury from splashed product), and a hard hat (to prevent injury from overhangs and projections).**
- **Use proper grounding/bonding procedures. Be sure that the prover is equipped with an explosion proof motor.**
- **Carefully inspect electrical supply lines to test equipment for wear and damage; correct potentially hazardous conditions before use, protect lines from damage during use**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Remove fire extinguisher(s) from storage receptacle(s) and set out for easy access.**
- **Use proper lifting techniques to lift and move equipment!**
- **Be aware of vehicular and pedestrian traffic in the area.**
- **Device operator should be present at all times during test – the operator (not the inspector) should operate the device under test.**
- **Never leave equipment unattended while it is in operation.**

5. Test Notes.

NOTE: Code references used throughout the document are drawn from NIST Handbook 44 (HB 44) General Code (Section 1.10) and Vehicle-Tank Meters Code (Section 3.31). 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.

5.1. Totalizers.

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

To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. Provide this information to the device owner to account for the product dispensed and returned to the device owner's tank during official tests.

Mark any delivery tickets or recorded representations as appropriate to indicate they were generated as part of an official test and to deter the potential for their misuse. Return all delivery tickets or recorded representations used during the test to the device owner at the end of the test.

5.2. Test Equipment Setup and Leveling.

5.2.1. Test Equipment Setup.

Before reading the indication on the prover, set up and level the prover and ensure valves and return pumping mechanisms are functional.

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.

5.2.2. Ensure the test equipment is properly grounded.

Prior to dispensing product into the prover, verify that all valves in the proving system are closed and that the prover pumping mechanism is functional.

5.2.3. Leveling the Prover.

Check for the proper operation of the level indicators on the prover.

Prior to dispensing product into the prover, level the prover by repositioning the prover by moving or adjusting it until the prover is level according to the level indicating means provided on the prover (and as verified by the calibration laboratory).

After filling the prover with product and before reading the indications on the prover, re-check the level of the prover to ensure the weight of the product has not affected the level condition. Re-level the prover as necessary.

5.3. Wet Prover.

If the prover is dry, it must be prepared for use by first "wetting" it. To wet the prover, fill it to capacity and empty it following proper drain procedures. Repeat the wetting procedure if the prover has been emptied and set unused for an extended period of time or if test and/or environmental conditions are such that there are any questions about the wet condition of the prover.

5.4. Evaporation and Volume Change.

Code Reference: 3.31: N.2.

Exercise care so the product temperature in the prover is the same as or as close as practical to that at the meter. Take care to minimize changes in volume of the test liquid due to temperature changes and evaporation losses.

5.5. Temperature Corrections.

Code Reference: 3.31: N.5.

Corrections shall be made for any changes in volume resulting from the differences in liquid temperatures between the time of passage through the meter and time of volumetric determination in the prover. When adjustments are necessary, appropriate petroleum measurement tables shall be used.

Temperature readings are to be taken to the nearest 0.25 °C or 0.5 °F or for digital thermometers, to the nearest increment. Take the temperature of the test liquid in the prover immediately following each accuracy test. For provers equipped with more than one thermometer, the temperature of the test liquid is the mathematical average of the individual readings.

A thermometer placed in the thermowell adjacent to the meter is to be used to determine meter temperature. Meter temperature is to be taken during each delivery when meter indications reach quantities equal to 1/3 and 2/3 of the capacity of the prover and the two values averaged.

5.6. Read and Record Results Immediately.

Read and record the indications on the prover immediately after delivery.

5.7. Eye Level and Reading the Meniscus.

When reading the indications on the prover, position yourself so that the bottom of the meniscus is at eye level and observe the reading on the gauge scale opposite the bottom of the meniscus.

- If the level of the liquid is not exactly at the zero line, the value shown on the scale will be recorded as "plus" if above the zero line and "minus" if below the zero line.
- If the reading is between graduations, "round off" the results to the nearest graduation.

- If the reading is exactly in the middle of two graduations, read and report the results to one-half the graduation or follow your jurisdiction's policy for reporting such a result.

5.8. Confirm Results.

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 under the "Test" section of this EPO.

5.9. Drain Procedures.

Bottom drain provers require a 30-second drain (or as specified otherwise on the calibration report or marked on the prover) after the main flow ceases.

See NIST HB 105-3, *Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures, 3. Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards*, 2010, Section 7 Test Methods and References.

Code Reference: NIST 105-3.

5.10. Return to Zero.

The primary indicating elements and the primary recording elements (when these are returnable to zero) shall be returned to zero immediately before each delivery and after the pump has been activated and product to be measured has been supplied to the measuring system.

Code Reference: 3.31: UR.2.1.

5.11. Recorded Representations.

Vehicle-mounted systems shall be equipped with a means to record all sales where product is delivered through the meter and shall comply with G-S.5.6. Recorded Representations. This provision does not apply to vehicle-mounted metering systems used solely for the delivery of aviation fuel into aircraft and for aircraft-related operations.

Code Reference: 1.10: G-S.5.6., 3.31: S.1.1.1., UR.2.2., UR.2.2.1.

A copy of the ticket issued by the device shall be left with the customer or as otherwise specified by the customer.

Code Reference: 3.31: UR.2.2.

For any recorded representation created by a computing-type device that includes the total computed price, verify the recorded representation also includes the total volume of the delivery and appropriate fraction and the corresponding price per unit of the quantity.

Code Reference: 3.31: S.1.4.2.

Verify that any options for obtaining a recorded representation are appropriate. On systems equipped with a means to issue a recorded representation, the recorded representation shall be made available to the customer in hard copy form unless otherwise specified by the customer. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability of issuing an electronic recorded representation, the customer may also be given the option of receiving the recorded representation electronically (e.g., via cell phone, computer, etc.) in lieu of or in addition to a hard copy.

Code Reference: 1.10: G-S.5.6., 3.31: S.1.1.1., UR.2.2., UR.2.2.1.

A ticket shall not be inserted into a device equipped with a ticket printer until immediately before each delivery is begun and until indications which are returnable to zero have been returned to zero.

Code Reference: 3.31: UR.2.1., UR.2.3.

In no case shall a ticket be in the device when the vehicle is in motion on a public street, highway, or thoroughfare.

Code Reference: 3.31: UR.2.3.

5.12. Steps After Each Test Draft.

a. Print a ticket/receipt if the device is so equipped and verify required information is provided and correctly recorded and that it complies with the provisions of G-S.5.6. Recorded Representations.

Code Reference: 1.10: G-S.5.2.2., G-S.5.6.

b. Computing-Type Devices.

Verify means is provided to display in a manner that is clear to the operator and an observer the unit price at which the device is set to compute. The unit price is not required to be displayed continuously.

Code Reference: 3.31: S.1.4.1.

For printed tickets which display the total sale price, verify the total quantity of the delivery and the unit price is also printed on the ticket.

Code Reference: 3.31: S.1.4.2.

Money-Value Computations. Check price computations on all indications (including auxiliary indications) and on recorded representations.

Code Reference: 3.31: S.1.4.3.

Money-Values, Mathematical Agreement. Check for agreement of values among indications and recorded representations.

Code Reference: 1.10: G-S.5.5., 3.31: S.1.4.4.

c. Agreement of Indications. Check for agreement of values among indications and recorded representations.

Code Reference: 1.10: G-S.5.2.2., 3.31: S.1.4.4.

d. For systems equipped with automatic temperature compensation, check recorded representations and invoices to determine if deliveries which are adjusted to 15 °C or 60 °F show that the volume has been adjusted to 15 °C or 60 °F.

Code Reference: 3.31: S.5.6., UR.2.5.3.

5.13. Use of Adjustments.

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 equipment is properly maintained and errors are not predominantly in favor of the device user.

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

5.14. Multiple Linearization Factors.

For a measuring system capable of being programmed with multiple linearization factors, it is necessary to verify all enabled linearization factors. When any device is adjusted, it is the user's/owner's responsibility to ensure errors are within tolerance and any adjustments which are made are made to bring performance errors as close as practicable to zero value. Verify all enabled linearization factors are appropriate. This can be done through physical testing at each of the points where a factor has been enabled or through a combination of physical testing and empirical analysis.

Code Reference: 1.10: G-UR.4.1., G-UR.4.2., G-UR.4.3., 3.31: N.4.6., UR.3.1.

5.15. Normal Tests, General.

Normal tests are conducted at the maximum discharge flow rate that can be developed under the conditions of the installation. Additional tests conducted at flow rates down to and included one-half of the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered "normal tests."

For example:

Rated minimum discharge flow rate = 20 gpm

Maximum flow rate developed in the installation = 60 gpm

The sum of the:

(rated minimum discharge flow rate) + (maximum discharge flow rate developed in the installation)

= 20 gpm + 60 gpm

= 80 gpm

One half of this sum:

80 gpm ÷ 2 gpm = 40 gpm

In this example, any tests conducted on the example retail motor-fuel dispenser at flow rates down to and including 40 gpm are considered "normal" tests.

Code Reference: 3.31: N.4.1.

5.16. Special Tests, General.

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

Code Reference: 3.31: N.4.2.

Special tests shall be made at a minimum discharge rate equal to the lesser of:

- 20 % of the marked maximum discharge rate;

OR

- The minimum discharge rate marked on the device.

Since flow rates can vary during testing based on conditions in the fueling system, it is recommended that tests be conducted at a flow rate slightly above the targeted values referenced in N.4.2. Special Tests. This avoids the possibility that the flow rate used during testing might drop below the targeted flow rate and helps ensure tests are not conducted at flow rates outside of the metering system's designed operating limits.

Code Reference: 3.31: N.4.2.

SAFETY REMINDER!!!

- **Avoid switch loading product! Test devices dispensing low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline and Ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high vapor-pressure products.**
- **If supply or return lines are not coupled at their discharge ends, they must be held in place continuously while product flows through the line.**
- **Use proper lifting techniques to lift and move equipment.**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic in the area.**

6. Test.

NOTE: Code references used throughout the document are drawn from NIST HB 44 General Code (Section 1.10) and Vehicle-Tank Meters Code (Section 3.31). 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.

6.1. General Test Considerations, All Meters.

- Verify all valves are closed and prover is level. Recheck the level when the prover is full of product.
- Examine the prover piping to ensure there is no entrapment of air and that there are no leaks.
- Start testing with a wet prover. Use proper draining procedures each time the prover is emptied, as described in the Test Notes.
- Prior to Each Test Run:
  - Insert a meter ticket and set the preset stop mechanism for the rated capacity of the prover prior to each test.
  - Start the pump.
  - Reset the meter to zero.
  - Open the prover delivery valve.
- Read the thermometers at the meter and in the prover as described in Test Notes, and record the reading to the nearest 0.25 °C or 0.5 °F. The requirement for a thermometer well is nonretroactive as of 2012 for non-compensated metering systems; for systems not equipped with a thermometer well, the temperature is taken at the prover only.

Code Reference: 3.31: S.2.6.

- Allow time for product settling and foam dissipation prior to taking prover reading.
- For an analog device, record the ending meter reading to the nearest 0.1 gallon. For a digital-indicating device, record the meter indication to the smallest quantity division available, e.g., test mode indication.

- Corrections shall be made for any changes in volume resulting from the differences in liquid temperatures between the time of passage through the meter and time of volumetric determination in the prover. When adjustments are necessary, appropriate petroleum measurement tables shall be used.

Code Reference: 3.31: N.5.

- If any test result is at, near, or outside of applicable tolerances, repeat the test to confirm the results. If necessary, conduct a repeatability test as outlined in "Repeatability Test."
- If two consecutive tests are found to exceed applicable tolerance values, discontinue accuracy testing and proceed to the next portion of the EPO.
- Check totalizer against actual amount dispensed.

6.2. Accuracy Tests - Overview

6.2.1. Non-Temperature-Compensated Meters

1. Normal Test – full flow, normal tolerance

Code Reference: 3.31: N.4.1., T.2., Table 1.

2. Special Test – slow flow, special tolerance

Code Reference: 3.31: N.4.2., T.2., Table 1.

3. Proceed to "Additional Tests for All Meters."

6.2.2. Temperature-Compensated Meters

6.2.2.1. Normal Test - Temperature Compensator Activated

6.2.2.1.1. Full Flow, Normal Tolerance.

Compare the compensated volume indicated or recorded by the metering system to the delivered volume indicated in the prover corrected to 15 °C (60 °F).

Code Reference: 3.31: N.4.1., N.4.1.2., T.2., Table 1, T.2.1.

6.2.2.2. Normal Test - Temperature Compensator Deactivated

6.2.2.2.1. Full Flow, Normal tolerance.

Compare the uncompensated volume indicated or recorded by the metering system and corrected to 15 °C (60 °F) to the volume indicated in the prover corrected to 15 °C (60 °F).

Code Reference: 3.31: N.4.1., N.4.1.2., T.2., Table 1, T.2.1.

6.2.2.3. Compare the Compensated and Uncompensated Values.

Compare the meter errors determined with and without the temperature-compensated system activated. For systems that indicate or record both compensated and uncompensated volume for every delivery, this comparison may be performed with a single test run using the compensated and uncompensated values indicated and/or recorded by the metering system.

Code Reference: 3.31: N.4.1.2., T.2.1.

6.2.2.4. Special Test – Temperature Compensator Deactivated

Slow Flow, Special Tolerance.

Code Reference: 3.31: N.4.2., T.2., Table 1.

6.2.2.5. Proceed to "Additional Tests for All Meters."

6.3. Non-Temperature-Compensated Meters.

See also "General Test Considerations, All Meters" above.

6.3.1. General Considerations, Non-Temperature Compensated Meters.

- Read the temperature of the product at the meter at one-third and two-thirds prover capacity.
- If the result of any test is at, near, or outside the applicable tolerance, repeat that test to confirm the results.
- If necessary, conduct a repeatability test. See "Repeatability Test."

6.3.1.1. Normal Test.

- Normal Flow Rate
- Normal Test Tolerances

Code Reference: 3.31: N.2., N.4.1., N.5. T.2., Table 1.

a. Conduct a test at the full flow rate.

Fill the prover in a manner simulating actual use and determine the actual flow rate. The test should be run at the maximum discharge rate anticipated under the conditions of the installation. The actual rate of flow should be within the manufacturer's ratings of minimum and maximum flow.

Code Reference: 1.10: G-UR.3.1., 3.31: UR.1.1.

b. The temperature is taken at the meter and at the prover.

c. Follow steps using the NIST test report section for "non-compensated meters" to adjust the prover and meter indications to account for the effects of temperature on the volume indications.

- Correct the prover indications to account for changes in the prover volume resulting from the expansion/contraction of the prover metal due to temperature.
- Correct both the prover indications and the meter indications to the volume at 15 °C (60 °F) to account for changes in product volume due to changes in the temperature of the liquid between the meter and the prover. When a thermometer well is not provided, corrections for changes in product volume due to temperature are not applied to either the prover or meter indications.

Code Reference: 3.31: N.5., S.2.6.

d. Calculate the difference between the corrected prover indications and the corrected meter indications. This is the meter error.

e. Express the meter error as a percent.

f. The result of this test shall not exceed the normal test tolerances.

Code Reference: 3.31: T.2., Table 1.

6.3.1.2. Special Test.

- Slow Flow Rate

Code Reference: 3.31: N.2., N.4.2., N.5., T.2., Table 1.

- Special Test Tolerances

Code Reference: 3.31: N.2., N.4.2., N.5., T.2., Table 1.

a. Conduct a test at a flow rate that is at or slightly above the slower of:
   - the minimum discharge rate marked on the device; or
   - 20% of the minimum discharge rate marked on the device.

In no case shall the test be performed at a flow rate less than the minimum discharge rate marked on the device.

Code Reference: 3.31: N.4.2.

b. The temperature is taken at the meter and at the prover.

c. Follow steps using the NIST test report section for "non-compensated meters" to adjust the prover and meter indications to account for the effects of temperature on the volume indications.
   - Correct the prover indications to account for changes in the prover volume resulting from the expansion/contraction of the prover metal due to temperature.
   - Correct both the prover indications and the meter indications to the volume at 15 °C (60 °F) to account for changes in product volume due to changes in the temperature of the liquid between the meter and the prover. When a thermometer well is not provided, corrections for changes in product volume due to temperature are not applied to either the prover or meter indications.

Code Reference: 3.31: S.2.6., N.5.

d. Calculate the difference between the corrected prover indications and the corrected meter indications. This is the meter error.

e. Express the meter error as a percent.

f. The result of this test shall not exceed the special test tolerances.

Code Reference: 3.31: T.2., Table 1.

6.3.1.3. Proceed to "Tests for All Meters."

6.4. Temperature-Compensated Meters

See also "General Test Considerations, All Meters" above.

6.4.1. General Considerations, Temperature Compensated Meters.

- For tests conducted with the ATC deactivated, read the temperature of the product at the meter at one-third and two-thirds prover capacity.
- For systems that indicate or record in both "gross" (uncompensated) and "net" (compensated) quantities, it is not necessary to run multiple tests. "Compensated" and "Uncompensated" test results can be calculated from a single test draft using the "gross" and "net" indications along with observed temperature information.
- If the result of any test is at, near, or outside the applicable tolerance, repeat that test to confirm the results.
- If necessary, conduct a repeatability test. See "Repeatability Test."

6.4.1.1. Normal Test - Temperature Compensator Activated.

- Normal Flow Rate
- Normal Test Tolerances

Code Reference: 3.31: N.2., N.4.1., N.4.1.2., N.5., T.2., Table 1, T.2.1.

a. Conduct a test at the full flow rate.

Fill the prover in a manner simulating actual use and determine the actual flow rate. The test should be run at the maximum discharge rate anticipated under the conditions of the installation. The actual rate of flow should be within the manufacturer's ratings of minimum and maximum flow. The temperature is not taken at the meter.

b. The temperature is taken at the prover but not at the meter.

c. Follow steps using the NIST test report section for "compensated meters" to adjust the prover indications to account for the effects of temperature on the volume indications.

- Correct the prover indications to account for changes in the prover volume resulting from the expansion/contraction of the prover metal due to temperature.
- Correct the prover indications to the volume at 15 °C (60 °F). Since this test is conducted in the net mode, the meter indication will already be corrected to 60 °F by the automatic temperature compensating system. Consequently, the meter indication is read directly without applying any additional corrections.

d. Calculate the difference between the corrected prover indications and the corrected meter indications. This is the meter error.

e. Express the meter error as a percent.

f. The result of this test shall not exceed the normal test tolerances.

Code Reference: 3.31: T.2., Table 1.

6.4.1.2. Normal Test - Temperature Compensator Deactivated

- Normal Flow Rate
- Normal Test Tolerance

Code Reference: 3.31: N.2., N.4.1., N.4.1.2., N.5., T.2., Table 1, T.2.1.

a. Fill the prover and follow the procedures described in "Normal Test" procedures for Non-Temperature-Compensated Meters steps (a) through (e) above.

b. The result of this test shall not exceed the normal test tolerances.

Code Reference: 3.31: T.2., Table 1.

6.4.1.3. Verify Operation of Automatic Temperature Compensating System.

Code Reference: 3.31: N.4.1., N.4.1.2., T.2., Table 1., T.2.1.

Calculate the difference between the results of the normal test (in percent error) with the temperature compensator **activated** and the results of the normal test (in percent error) with the temperature compensator **deactivated**.

Difference in the Test Results =

(Normal Test ATC Activated Error in %) – (Normal Test ATC Deactivated Error in %)

The difference shall not exceed:

- 0.2 % for mechanical automatic temperature compensating systems; and

- 0.1 % for electronic automatic-temperature compensating systems.

Code Reference: 3.31: T.2.1.

6.4.1.4. Special Test - Temperature Compensator Deactivated

- Slow Flow Rate
- Special Test Tolerances

Code Reference: 3.31: N.2., N.4.2., N.5., T.2., Table 1.

a. Fill the prover and follow the procedures described in "Special Test" procedures for Non-Temperature-Compensated Meters steps (a) through (e) above.

b. The result of this test shall not exceed the special test tolerances.

Code Reference: 3.31: T.2., Table 1.

6.4.1.5. Reactivate the Temperature Compensator.

Have the device owner or operator reactivate the temperature compensator.

6.4.1.6. Proceed to "Tests for All Meters."

6.5. Additional Tests for All Meters

6.5.1. Repeatability Test.

Code Reference: 3.31: N.2., N.4.7., T.3.

If necessary, conduct a repeatability test.

A repeatability test should include a minimum of three consecutive test drafts and be of approximately the same draft size.

Tests should be conducted under controlled conditions where variations in factors such as temperature, pressure, and flow rate are reduced to the extent they will not affect the results of the tests.

Repeatability tests shall be conducted at flow rates within the minimum and maximum discharge rates marked on the device.

For devices equipped with an automatic temperature compensating (ATC) system, the results shall be based on the uncompensated (gross) volume. That is, with the ATC deactivated.

6.5.2. Product Depletion Test.

Code Reference: 3.31: N.2., S.2.1., N.4.5., N.5., T.4.

6.5.2.1. General, Product Depletion Test.

- The purpose of the product depletion test is to examine the effectiveness of the air/vapor eliminator or air/vapor elimination means.
- The product depletion test compares the results of a "normal test" with another test (also run at the normal flow rate) during which the product supply is depleted during the test, thus creating the potential for introducing air/vapor into the metering system.

  The difference in results for the two tests is calculated as shown below.

  (Normal Test Result) – (Product Depletion Test Result)

  This difference cannot exceed the product depletion test tolerance.

See "Product Depletion Test" in the "Pre-Test Determinations" section of this EPO for guidance on calculating the applicable tolerance.

- The product depletion test is conducted at the normal flow rate.
- Test drafts shall be of the same size and run at approximately the same flow rate.
- Note: This test does not apply to vehicle-mounted metering systems used solely for the delivery of aviation fuel.

6.5.2.2. Product Depletion Test Procedures.

a. Start the product depletion test by dispensing product at a normal flow rate, drawing from a compartment containing less test fluid than one-half the capacity of the prover, with the pump in operation and pressure to the discharge nozzle.

b. Permit the test to continue until a lack of fluid supply causes the meter register to stop completely for at least 10 seconds.

c. If the meter indication fails to stop completely for at least 10 seconds, continue to operate the system for 3 minutes.

d. With the pump in operation, shut the manifold valve (or disconnect the whip-hose connection) from the now-empty compartment.

e. Finish the test by switching to another compartment with sufficient product to complete the test on a multi-compartment vehicle or by adding sufficient product to complete the test to a single-compartment vehicle. When adding product to a single-compartment vehicle, allow time for any entrapped vapor to disperse before continuing the test.

f. Compare the results of the product depletion test with the results of the normal test:

(Normal Test Result) – (Product Depletion Test Result)

This difference or range cannot exceed the product depletion test tolerance.

However, the result of the product depletion test may fall outside of the applicable test tolerance as specified in Table 1. Accuracy Classes and Tolerances for Vehicle-Tank Meters.

Example of Calculating the Product Depletion Test Tolerance in Gallons and Cubic Inches:

- Maximum Flow Rate Marked on the Device: 100 gpm
- Product Depletion Test Tolerance: 0.6%

The amount delivered in one minute at the maximum flow rate marked on the meter =

1 minute x 100 gallons/minute = 100 gallons

Product Depletion Test Tolerance in Gallons and Cubic Inches =

0.6 % x 100 gallons = 0.6 gallons or 138.6 cubic inches (in^3)

Example of Applying the Product Depletion Test Tolerance in Gallons:

- Maximum Flow Rate Marked on the Device: 100 gpm
- Product Depletion Test Tolerance: 0.6%
- Product Depletion Test Tolerance in Gallons: 0.6 gallons

(See the "Pre-Test Determinations" section of this EPO for examples of how to calculate the product depletion test tolerance.)

- Normal Test Result: +0.16 gallons
- Product Depletion Test Result: -0.72 gallons
- Calculate the Difference or Range Between the Normal Test Result and the Product Depletion Test Result:

  (Normal Test Result) – (Product Depletion Test Result) =
  (+0.16 gal) – (-0.72 gal) = 0.88 gallons
- The difference or range of 0.88 gallons between the two test results in this example exceeds the applicable product depletion test tolerance of 0.6 gallons.

Example of Applying the Product Depletion Test Tolerance in Cubic Inches:

- Maximum Flow Rate Marked on the Device: 100 gpm
- Product Depletion Test Tolerance: 0.6%

  (See the "Pre-Test Determinations" section of this EPO for examples of how to calculate the product depletion test tolerance.)
- Product Depletion Test Tolerance in Cubic Inches: 0.6 gallons = 138.6 cubic inches
- Normal Test Result: +37 in^3
- Product Depletion Test Result: -166 in^3
- Calculate the Difference or Range Between the Normal Test Result and the Product Depletion Test Result:

  (Normal Test Result) – (Product Depletion Test Result) =

  (+37 in^3) – (-166 in^3) = 203 in^3
- The difference or range of 203 cubic inches between the two test results in this example exceeds the applicable product depletion test tolerance of 138.6 cubic inches.

6.5.3. Anti-Drain Test.

For a wet hose system, check the effectiveness of the anti-drain valve or other means provided to prevent the drainage of the discharge hose.

Code Reference: 3.31: S.3.6., N.4.3.

6.5.4. Dry Hose System.

For a dry-hose system, check for complete drainage of the hose.

Code Reference: 1.10: G-S.2., 3.31: S.3.2.

6.5.5. Money-Value Computations and Recorded Representations.

As described in "Test Notes" under "Steps After Each Test Draft":

For computing devices, check money-value computations and mathematical agreement on all indications, including consoles and recorded representations.

Print a ticket/receipt (if the device is so equipped) and verify all required information is provided and correctly recorded.

6.5.6. Testing with Nonassociated Equipment.

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

Conduct tests as deemed necessary to determine nonassociated equipment and influences such as radio frequency interference (RFI) do not adversely affect the performance of a device.

6.5.6.1. Radio Frequency Interference (RFI) Test (Electronic Equipment Only). This testing is typically done during the inspection of a new installation. It is conducted subsequently only if a problem is suspected.

Test using only equipment that is or expected to be on site and in the vicinity of the metering system.

Results of such tests must indicate that the use of such equipment does not adversely affect the performance of the metering system.

6.5.7. Zero-Set-Back Interlock, Electronic VTMs.

Note: This requirement does not apply to vehicle-mounted metering systems used solely for the delivery of aviation fuel.

Check the effectiveness of the zero-set-back interlock. The zero-set-back interlock shall function such that, after individual or multiple deliveries at one location have been completed, the interlock shall automatically engage to prevent a subsequent delivery until the indicating and any recording elements have been returned to their zero position.

Code Reference: 3.31: S.2.4. (1/1/06).

6.5.8. Automatic Timeout Feature, Electronic VTMs.

Verify that, for individual deliveries, if there has been no product flow for three minutes, the transaction must be completed before additional product flow is allowed.

Code Reference: 3.31: S.2.4. (1/1/06).

The three-minute timeout shall be a sealable feature of an indicator.

6.5.9. Automatic Stop Mechanism.

Any automatic stop mechanism included in the system must operate properly. Handbook 44 does not include a limit for the accuracy of its operation; however, the device should stop flow within one-half the minimum interval indicated.

Code Reference: 1.10: G-UR.4.1.

7. Post-Test Tasks.

NOTE: Code references used throughout the document are drawn from NIST Handbook 44 (HB 44) General Code (Section 1.10) and Vehicle-Tank Meters Code (Section 3.31). 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.

7.1. Security Means.

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: 1.10: G-S.8. (1/1/90), G-S.8.1. (1/1/10), 3.31: S.2.2., Table S.2.2. (1/1/95), S.2.5.4.

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., 3.31: S.2.2.

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).

A metrologically-significant software change is a sealable event.

Code Reference: 1.10: G-S.9.

7.1.1. Audit Trail Information. 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.

Code Reference: 1.10: G-S.8. (1/1/90), 3.31: S.2.2., Table S.2.2. (1/1/95).

7.1.2. Security Seals. Check for the presence of security seals on the device. Document missing seals on the official report and apply new seals as needed.

Code Reference: 1.10: G-UR.4.5., 3.31: S.2.2., S.2.5.4.

7.2. Record Total Quantity.

Note the final totalizer reading and record the number of gallons of product dispensed during the test on the official test report. Verify totalizers are working correctly.

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

Mark any delivery tickets or recorded representations as appropriate to indicate they were generated as part of an official test and to deter the potential for their misuse. Return all delivery tickets or recorded representations used during the test to the device owner at the end of the test.

7.3. Review/Analyze Results.

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

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

7.4. Affix Tags and Seals.

Affix tags and seals as appropriate to designate the disposition of the device.

7.5. Record Compliance Action and Explain Results.

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

As needed, remind the device owner of their responsibility to maintain the equipment, correct abnormal performance, and use adjustments properly.

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

SAFETY REMINDER!!!

- **Avoid switch loading product! Test devices dispensing low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline and Ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high vapor-pressure products.**
- **Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.**