BUREAU OF LAND MANAGEMENT
TESTING PROCEDURES and RECOMMENDATIONS[1]
LIQUID CORIOLIS METERS

PART 1: GENERAL

Part 1 of this document provides general guidance on testing of devices and processes. This guidance is for informational purposes only and does not establish new regulatory requirements. To the extent that there is any conflict between this document and the requirements found in 43 CFR subparts 3174 and 3175, subparts 3174 and 3175 will control.

1. PURPOSE OF TESTING PROCEDURES

The Bureau of Land Management (BLM) measurement regulations for oil (43 CFR 3174) and gas (43 CFR 3175) establish a Production Measurement Team (PMT) that "reviews changes in industry measurement technology, methods, and standards to determine whether regulations should be updated, and provides guidance on measurement technologies and methods not addressed in current regulation. The purpose of the PMT is to act as a central advisory body to ensure that oil and gas produced from Federal and Indian leases is accurately measured and properly reported." 43 CFR 3170.3.

The PMT will review specific makes, models, and sizes of measurement equipment to verify device performance. The goals are to determine whether device performance meets a minimum requirement, confirm the absence of statistically significant bias, and ensure the verifiability of a metering system. These goals are based on requirements of the BLM's oil and gas measurement regulations. See 43 CFR 3174.4. If the PMT concludes that the use of the specific make, model, and size of the device meets these three goals, it will recommend the BLM approve this make, model, and size of device, subject to any appropriate restrictions (conditions of approval). Upon approval, the BLM will post the make, model, and size of device on the list of approved equipment at www.blm.gov, along with any conditions of approval. Any operator of any federal or Indian lease may then use a BLM-approved device without any further review or approval.

Performance Requirements

Volume Measurement Uncertainty

To ensure that a measurement system meets the required overall volume measurement uncertainty specified for the flow category, the Production Measurement Team (PMT) has set a Maximum Permissible Error (MPE) for each component of the system. This analysis is based on the sensitivity of the overall reported value to each component by modeling changes to each component over an expected range and calculating a maximum sensitivity for each component. The maximum sensitivities are then used to determine the MPE of each component. The overall

[1] This is a guidance document. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. The document is intended only to provide clarity to the public regarding existing requirements under the law or agency regulations.

system performance that systems must meet are in Table 1 below, based on Table 1 to § 3174.4—VOLUME MEASUREMENT UNCERTAINTY LEVELS.

TABLE 1: OIL FLOW CATEGORIES

Flow Category	Averaging Period Volume	Overall Volume Measurement Uncertainty	MPE for Meter	MPE for Density for use as CMS
High Volume	≥30,000 bbl/month	±0.5%	±0.40%	±0.50%
Low Volume	<30,000 bbl/month	±1.5%	±1.35%	±0.50%

Statistically Significant Bias

The PMT will only recommend BLM approval of those devices without statistically significant bias as determined by the Threshold of Significance as defined in 43 CFR 3170.3.

Verifiability

While the focus of the testing procedures is on device uncertainty, bias, and operating limitations, 3174.4(c) and 3175.31(d) also establish verifiability as one of the key performance requirements of any measurement device or procedure at an FMP. Verifiability includes the ability of the BLM to independently calculate the quantity and quality values reported to the federal government for oil and gas removed or sold from the lease based on source records and field observations.

If the PMT determines the BLM cannot independently verify the performance of the device, the PMT will not recommend approval of the device regardless of how well it may perform. An application for approval should contain a detailed description of how the device or method achieves the verifiability performance standard.

Conditions of Approval

Equipment will be approved for ranges of operation. These approvals are termed the Conditions of Approval (COA). The COAs state the ranges over which the approved device may operate in the field based on the PMT analysis of the results of this testing procedure.

The MPE may change based on the overall system performance levels indicated above. Therefore, the same device may be approved for a wider range for one level of system than another. Additionally, a device may not be approved for one level of system but may be approved for use on another level. For example, a meter might be approved for an operating range for the 1.5% uncertainty category that is much wider than the range it would be approved for in the 0.5% uncertainty category.

2. MODEL NUMBERS AND SOFTWARE VERSIONS

A model number should represent a unique design and manufacturing process at a manufacturing facility for which the performance outcomes derived by these testing procedures will apply. The device manufacturer should provide a way for the BLM to easily differentiate the new device from previous models in the field.

Model numbers can contain both critical and non-critical characters. A critical character is a part of the model number that indicates an aspect of the device that affects the performance of the device, whereas a non-critical character identifies a feature or add-on that does not affect the performance of the device. For example, the model number of "YRF-121A6S4" has the following meaning:

- "YRF-121" is the base model number of the device
- "A" represents the meter size
- "6" represents the range
- "S" represents the material of construction
- "4" represents the type of connection to the process piping

In this example, the PMT would only recognize "YRF-121A6" as the model number if testing demonstrates that neither the material of construction nor the type of connection affects device performance. Therefore, all variations of material of construction or type of connection would be included in the PMT recommendation of device approval. It is critical that a device manufacturer indicate in the application the parts of the model number that have measurement implications. If non-metrological elements of the overall model number are not identified as part of the application, the PMT will assume the approval applies only to the complete model number provided, and therefore all model number variations will require a separate approval.

A software version, most commonly referred to as firmware version, must represent a unique computer code for which the performance of the software will apply. As with model numbers, the PMT is only concerned with software versions, or changes to software versions, that involve the calculation of quantity or quality or the BLM's ability to verify those calculations. If the manufacturer's testing indicates that an updated software version does not affect the calculation of quantity or quality, or the BLM's ability to verify those calculations, the manufacturer must notify the PMT of the new software version for the approval to be updated. Ideally, the critical characters of the software version would remain constant and maintain the approval with only non-critical characters changing in updates that do not affect the performance.

3. MODEL UPDATES OR CHANGES IN MANUFACTURING PROCESS

Any change in the design or manufacturing process that affects, or has the potential to affect, the performance of the device requires a new application to the PMT. For example, a manufacturer submits a differential pressure meter, with a model number of "YRF-121A6S4" to the PMT for testing and the BLM approves it. This particular model has a wetted-surface roughness of 50 micro-inches. At some point, the manufacturer changes the manufacturing process that results in a surface roughness of 100 micro-inches. Because the wetted surface roughness has the potential

to alter the performance of this device, the device must be re-submitted to the PMT for review and BLM approval. If it is determined that the device performance changes because of a design or manufacturing process change, the manufacturer should include a way to distinguish the modified device from the previously approved device. For example, the manufacturer could assign a new model number to the modified device.

4. APPROVAL OF A RANGE OF SIZES (FAMILY OF DEVICES)

The PMT will only consider recommending approval for the size of device that was submitted. The PMT may consider recommending a range of sizes for approval if test data were submitted that demonstrates the test results from multiple device sizes can be shown to be representative of the performance of other sizes in the same model family. The PMT may consider other approaches for approval of a family of meter models. A manufacturer may contact the PMT for specific information on how to seek a family of meters consideration.

5. SELECTION OF DEVICES TO TEST

The following sample sizes are to be used based on the quantity of the device produced annually for the intended use of liquid hydrocarbon measurement.

Units per Year	Minimum Number of Devices Tested
2 – 50	2
51 – 500	3
501 – 35,000	5
35,001+	8

If a device is manufactured at more than one facility, each facility's device shall be considered as a separate device for the purpose of this testing and shall be noted as such through the model number.

The manufacturer should provide the BLM with a method for selection of random samples for the testing. This methodology should be included in the test report as describe in Section 6.3.4 of Part 2.

6. MANNER IN WHICH DEVICE IS SUBMITTED TO THE TESTING FACILITY

Devices submitted to a test facility for testing under these procedures should be delivered in the same manner as if they were delivered to a customer in the field. For example, if the manufacturer determines and adjusts for the characteristics of each individual device that comes off the assembly line in normal practice, the same procedure should be used for the devices submitted to the test facility. If, on the other hand, the manufacturer applies default, generic, and/or normal configuration settings and/or adjustments for characteristics to the device in normal practice, those same characteristics and/or settings and adjustments should be used for this evaluation and testing.

7. DEVICES MARKETED UNDER A DIFFERENT NAME

In some cases, the make and model of a device that the BLM will encounter in the field may actually be manufactured by a different entity with a different make and model number (e.g., a device marketed by a different company under a private label with a different nameplate and model number). If either the original manufacturer or the private label submitted data for the device to the PMT for review, and the BLM approved it, the PMT may consider extending the approval recommendation to the other company, without requiring additional testing. The PMT would only consider this if:

7.1 An authorized representative of the manufacturer submits a letter to the PMT

- confirming the manufacturer manufactures the device and supplies it to the entity marketing the device;
- provides concurrence that the marketing company is licensed to market the device under a different name and model number; and
- includes the specific model number(s) and size(s) of devices the manufacturer supplies to the marketing company; and

7.2 An authorized representative of the marketing company submits a self-certified affidavit to the PMT

- listing <u>all</u> changes the marketing company makes to the device; or
- certifying that the marketing company receives the device from the manufacturer and rebrands the device without making any changes to the device or its settings that would affect the performance of the device; and
- providing a cross-reference between the model number provided by the manufacturer with the model number placed on the device by the marketing company, if applicable.

If the conditions of 7.1 and 7.2 are met, the alternate company can contact the PMT to have the equivalent model added to the list of approved equipment.

8. CHANGE OF COMPANY NAME

A company that has purchased the assets of a manufacturer whose device is covered by a BLM approval, or has changed the name of the manufacturer, and that wishes to transfer the original manufacturer's approval to the new name, should submit a request to the PMT.

9. PATENT ISSUES

If multiple manufacturers make and market a product from the same patent, each manufacturer must apply for a separate approval. The PMT will only consider the data submitted and whether the device can meet the performance standards of 43 CFR 3174 or 3175 when reviewing the device and making a recommendation to the BLM.

10. MULTIPLE APPLICATIONS FOR A SINGLE DEVICE

If the PMT receives more than one application for a single device, the PMT will consider the information in the following order of priority:

- (1) Data received from the primary equipment manufacturer conducted at qualified test facilities not affiliated with the applicant;
- (2) Data received from the primary equipment manufacturer conducted at qualified test facilities affiliated with the applicant, as allowed by regulation;
- (3) Data received from parties other than the primary equipment manufacturer conducted at qualified test facilities not affiliated with the applicant;
- (4) Data received from parties other than the primary equipment manufacturer conducted at qualified test facilities affiliated with the applicant (only with prior approval from the PMT before submission of the application).

11. DATA FORMAT

Raw test data should be submitted in a single electronic .xls, .csv, or .txt format and test results analysis or summary must be in a single format that does not require special software to review.

12. PROPRIETARY AND CONFIDENTIAL INFORMATION

The Freedom of Information Act ("FOIA") provides that any person may obtain records from a federal agency upon request. *See* 5 U.S.C 552(a)(3)(A). However, FOIA also provides that certain types of records are exempted from the agency's general obligation to release records in response to a request. 5 U.S.C § 552(b). Importantly, 5 U.S.C. § 552(b)(4) establishes an exemption for "trade secrets and commercial or financial information obtained from a person and privileged or confidential." This FOIA exemption is commonly referred to as "Exemption 4." When trade secrets and/or commercial or financial information is voluntarily provided to an agency, it is considered "confidential," and therefore protected from release under Exemption 4, when it is the kind of information that would customarily not be released to the public by the person or entity who submitted it to the agency. *See e.g., Judicial Watch v. Department of the Army*, 466 F.Supp.2d 112, 125 (D.D.C. 2006).

The Department of the Interior (Department) has enacted regulations that establish the procedures the BLM will follow in handling confidential information that is requested under FOIA. *See* 43 C.F.R. § 2.26-2.36. The Department encourages submitters of confidential information to designate materials as confidential at the time of submission. *Id*. at § 2.26. This assists the BLM in successfully identifying information that is potentially protected from release under Exemption 4. Marking materials as confidential also triggers a requirement that BLM notify the submitter of a FOIA request seeking those materials. *Id.* at § 2.27

The BLM will notify a submitter when it receives a FOIA request for information that has been designated as confidential or, though it has not been marked as confidential, is otherwise identified by the BLM as potentially confidential information. *Id.* The submitter will then have an opportunity to object to the release of the information. *Id.* §§ 2.28, 2.30. The necessary contents of an Exemption 4 objection statement are detailed at 43 C.F.R. § 2.31. If the submitter

does not respond to the notice within the timeframe specified, the submitter will be considered to have no objection to disclosure of the information. *Id.* § 2.30(b).

The BLM, not the submitter, is responsible for deciding whether the information will be released. *Id.* § 2.32. If the BLM decides to disclose the information over the submitter's objections, the BLM will notify the submitter and provide an explanation of why the submitter's objections do not support withholding the information. *Id.* § 2.33. If the BLM decides to withhold the information and a lawsuit is filed seeking to compel disclosure of the information, the BLM will promptly notify the submitter of this development. *Id.* § 2.34.

If the BLM determines that the requested information is protected from release under Exemption 4, the BLM has no discretion to release that information. *Id.* § 2.36. Release of information protected from release by Exemption 4 is prohibited by the Trade Secrets Act (18 U.S.C. § 1905). 43 C.F.R. § 2.36.

Additional information on the Department's FOIA process can be found in the Department's Freedom of Information Act Handbook (383 DM 15) and in the Bureau of Land Management's FOIA Manual (1278 – External Access to BLM Information**).**

PART 2: CORIOLIS METER TEST PROCEDURE (LIQUID)

1. GENERAL APPROVAL PROCESS STATEMENT

Information provided in the application package will be used to determine the COAs for the device(s) under test. The BLM will approve devices and limit the application of each device to ranges and conditions based on the results of this testing. (43 CFR 3174.2(g)) For example, if a meter were not tested for the effects of vibration, the BLM cannot determine that the meter can perform in such an environment, and therefore would not be approved use in such an environment.

2. DEFINITIONS

For this Part 2 test procedure, the following definitions apply:

2.1. *Coriolis meter* means a device that consists of sensors and a transmitter, which convert the output from the sensors to signals representing volume and density (43 CFR 3174.1).

2.1.1. *Coriolis sensor*s consist of a mechanical assembly consisting of the housing, the measurement sensor(s), the support structure, the vibrating conduit (one or more parallel measurement tubes), the vibration drive system, and any correction device.

2.1.2. *Coriolis transmitter* means an electronic device that converts the phase shift and frequency or period signal(s) from the Coriolis sensor into digital or analog signal(s) indicating volume, flow rate, and/or density.

2.2. *Correction device* refers to a device incorporated or connected to the meter for automatically correcting the Coriolis sensor output such as, the internal temperature (case temperature) sensor(s) as part of the Coriolis meter.

2.3. *Indicated Volume* for the purpose of this test procedure, means the uncorrected (without the meter factor) mass of liquid divided by the Coriolis meter determined density.

3. GENERAL TEST OPTIONS

This testing procedure addresses the testing of Coriolis meters (as defined in Section 2.1) used for liquid hydrocarbon measurement. Coriolis meters must be tested as intended for their usage.

The applicant determines the ranges for variables within this test procedure. The BLM can only approve devices based on the results of the testing data submitted for review.

If various Coriolis transmitter options are available for a Coriolis sensor, each sensor/transmitter combination must be tested in order to be considered for approval. Special consideration will be allowed for a reduction in some testing requirements for combinations of devices that have been approved in other testing. The applicant should communicate with the PMT on the specific testing requirements for combinations of devices.

4. TEST FACILITY AND GENERAL TEST REQUIREMENTS:

4.1. Facility uncertainty: For each performance test, the test report should document the facility uncertainty associated with each specific test. This facility uncertainty should be supported by a certifying authority, for example an ISO17025 Scope of Accreditation statement.

4.2. Reference ambient conditions should be maintained within the following ranges**:** (Ref OIML R 117-2, 4.3, 2019).

Temperature (ambient): 60°F to 95°F.

Relative Humidity: 25% to 75%.

Atmospheric pressure: 11 PSI to 15 PSI.

Ambient conditions should be documented at the start and end of each performance test (i.e., for the complete 5.1.1 performance test, not each run within that test). During each test, the ambient temperature should not vary more than ± 10°F, and relative humidity should not vary more than ± 10%, within the reference ranges above. See Section 6.6.

4.3. All devices under test should output pulses proportional to the indicated volume of fluid passing through the device. The basis for FMP measurement COAs and performance determination is on volume measurement results. The K Factor and Meter Factor associated with the device should be stated prior to the testing.

4.4. Minimum test duration/volume: Unless otherwise specified, each test duration should be at least 60 seconds or the time it takes to measure an indicated volume of at least 1 barrel, whichever is the greater, ensuring stable flow characteristics throughout this time. The PMT might accept a shorter duration/volume with prior approval based on evidence that proper testing can be achieved, particularly with smaller meters.

4.5. Test Liquid: The device should be tested with the liquid that the device is intended to measure or another liquid with the general physical characteristics (ref NIST Handbook 44-2020). The liquid type for each test should be documented in the test report. The PMT might accept other fluids for specific test if evidence is presented that the fluids have similar characteristic effects for that specific test, or other testing has been conducted that supports that use of an alternative fluid. Equations or characteristics of the test liquid (i.e., viscosity and density) should be provided with the report.

4.6. Base conditions**:** (ref 43 CFR 3174.1).

Temperature: 60°F.

Pressure: Atmospheric or 14.696 psia.

4.7. No adjustments of the testing system, device, or any of its elements should be made during any performance test (for example: all individual baseline accuracy tests should be conducted with no adjustments to the testing system, device, or any of its elements)**.** If adjustments are necessary, documentation of adjustments and justification should be addressed in the test report.

Note: Normal operations of the testing system (i.e., accounting for a buoyancy effect on the scale measurement) are not considered an adjustment to the testing system.

4.8. For all tests, the device should have low-flow cut-off and damping set as recommended by the manufacturer for the application in service, or as required by the test. "Low-flow cut-off" features should not be set at flow rates higher than 20 % of the application-defined minimum flow rate. If the test is performed under no-flow condition, the low-flow cut-off and damping should be set to zero, so changes can be observed.

4.9. A detailed description of device internal configuration settings as tested should be included in the test report.

5. PERFORMANCE TEST REQUIREMENTS FOR CORIOLIS METERS:

5.1. Test parameters: All test parameters shall be specified by the applicant.

5.1.1. Indication at zero flow rate (Ref OIML R 117-2, 5.3.1, 2019).

Objective: Determine any trends in zero shift and verify zero stability.

Test: Three identical test for zero-offset without significant fault.

Procedure: For each test:

1. Fill the meter with liquid product.
2. Isolate the meter with appropriate valves (such as double-bleed valves).
3. Ensure there is no flow through the meter, and that the liquid conditions are stable.
4. Set the meter to the normal measurement mode.
5. Set the meter to the bi-directional mode (if applicable).
6. Disable the low for cut-off option of the meter.
7. Monitor the indication of the meter for a minimum of 180 seconds.
8. Verify compliance with the requirements.

Procedure should be conducted a minimum of three times and flow should be recorded through the meter between test in excess of Q_{min}.

Test data recording: (Ref OIML R 117-3, F.2.1, 2019) Minimum recorded test data includes run duration (seconds), raw flow indication readings both before and during the test and corresponding converted flow rate units, pressure (PSI), and temperature (°F).

5.1.2. Baseline Accuracy (Ref OIML R 117-2, 5.3.2, 2019).

Objective: Determine volumetric flow rate measurement accuracy at each flow rate. The minimum and maximum rated flowrates that are prescribed for this test by the applicant will determine the flowrate range that is expressed in the COAs for the device. If a data plate is fixed to the device with manufacturer's specified flowrate range, that range should serve as the minimum and maximum flowrates for this test.

Test: Three identical tests for each volumetric flow rate. Flow rate operating range identified by minimum volumetric flow rate, Q_{min}, and maximum volumetric flow rate, Q_{max}. Testing should be conducted at a minimum of six individual volumetric flow rates* as determined by the following formula:

$$Q = K^{n_F - 1} \text{ x } Q_{max}$$

Where n_F is a sequence number of the flow rate test, and

$$K = \left[\frac{Q_{min}}{Q_{max}}\right]^{\frac{1}{N_F - 1}}$$

Where N_F is the number of flow rates as in the following table*:

Q_{max} / Q_{min} ratio	N_F
<12	6
13-21	7
22-35	8
>35	9

** Volumetric flow rates shall be within ±10% of calculated Q.*

** For turn-down ratios that are not a whole number, the ratio shall be rounded to the nearest whole number.*

**When testing for an expanded flow range, new test points are added outside the old flow range, without the need to recalculate the old test points.*

For example, if the test has a Qmax of 100, and a Qmin of 10, the flowrates would be as follows:

$$K = \left[\frac{10}{100}\right]^{\frac{1}{6-1}}$$

$$K = [0.1]^{\frac{1}{5}}$$

$$K = 0.631$$

$$\underline{Q = K^{n_F - 1}} \text{ x } Q_{max}$$

$$Q_1 = K^{1-1} \cdot Q_{max} = 0.631^0 \cdot 100 = 100$$
$$Q_2 = K^{2-1} \cdot Q_{max} = 0.631^1 \cdot 100 = 63.1$$
$$Q_3 = K^{3-1} \cdot Q_{max} = 0.631^2 \cdot 100 = 39.8$$
$$Q_4 = K^{4-1} \cdot Q_{max} = 0.631^3 \cdot 100 = 25.1$$
$$Q_5 = K^{5-1} \cdot Q_{max} = 0.631^4 \cdot 100 = 15.8$$
$$Q_6 = K^{6-1} \cdot Q_{max} = 0.631^5 \cdot 100 = 10.0$$

Procedure: For each flow rate test, the minimum duration/volume, as previously defined should flow through the device. The accuracy should be determined at least three times for each volumetric flow rate.

Test data recording: (Ref OIML R 117-3, F.2.3, 2019) Minimum recorded test data includes test volumetric flow rate, indicated volumetric flow rate, test volume, indicated volume, indicated density (lb_m/ft^3), fluid pressure at meter under test (PSI), and fluid temperature at meter under test (°F).

5.1.3. Limits of working range accuracy (Ref OIML R 117-2, 5.3.3, 2019).

Objective: Determine operating range limitations of fluid temperature, pressure and density. These limitations represent the ranges over which the error of the device does not exceed the threshold of significance.

Test: Three identical tests for each of three volumetric flow rates for each identified flow parameter range limit (i.e., minimum and maximum).

Flow parameters:

1. Fluid temperature operating range (T_{min} and T_{max}) within which the threshold of significance is met. If a data plate is fixed to the device with manufacturer's specified fluid temperature range, that range should serve as the minimum and maximum temperatures for this test.
2. Fluid pressure operating range (P_{min} and P_{max}) within which the threshold of significance is met. If a data plate is fixed to the device with manufacturer's specified pressure range, that range should serve as the minimum and maximum pressures for this test.
3. Fluid density operating range (ρ_{min} and ρ_{max}) within which the threshold of significance is met. If a data plate is fixed to the device with manufacturer's specified density range, that range should serve as the minimum and maximum densities for this test.

Volumetric flow rates* defined by:

1. Q_{min},
2. At one of the baseline accuracy flowrates less than or equal to: (($Q_{max} - Q_{min}$) x 0.25) + Q_{min},
3. Q_{max}.

** Volumetric flow rates shall be within ±10% of calculated Q.*

Procedure: For each parameter test, only one parameter is varied for each test, the reported values for temperature and pressure should be maintained within ± 1%, of their respective operator-specified value. The same test fluid must be applied for all tests other than the ρ_{min} and ρ_{max} tests. The minimum duration/volume, as previously defined shall flow through the Coriolis meter. Procedure should be conducted minimum three times for each flow rate for a minimum of 54 individual tests.

Test data recording: (Ref OIML R 117-3, F.2.5, 2019) Minimum recorded test data includes test parameter (T_{min}, $T_{max,}$ P_{min}, P_{max}, ρ_{min}, or ρ_{max} as appropriate), test volumetric flow rate, indicated volumetric flow rate, test volume, indicated volume, indicated density (lb_m/ft^3), temperature at meter under test (°F), and pressure at meter under test (PSI)..

5.1.4. Influence Effects (Ref OIML R 117-2, 4.8 and 5.6, 2019).

Objective: Determine accuracy or limitations of influence effects on device performance and zero reading. The results of this test will dictate the approved operating range.

Influence parameters:

1. Ambient high temperature;
2. Ambient low temperature;
3. Exposure to damp heat; and
4. Random vibration.

5.1.4.1. Ambient high temperature, as specified by applicant:

Test: Expose device to the applicant specified high ambient temperature for a period of no less than 2 hours after meter has reached temperature stability. The change in ambient temperature should not exceed 2°F/min during heat up and cooling down.

One test for each flow rate, including a zero reading before and after each test. Flow rates* defined by:

1. Q_{min},
2. Q_{max}.

**Flow rates shall be within ±10% of calculated Q.*

The device should be tested;

1. At each flowrate after the ambient temperature has been held at 60° F for at least 1 hour,
2. At each flowrate after the ambient temperature has been held at the applicant specified high temperature for 2 hours,

3. At each flowrate after the ambient temperature has been held at 60° F for at least 1 hour. (The PMT will accept this return to baseline as the first step in the ambient low temperature test of 5.1.4.2)

During the tests, the device should be in operation.

Test data recording: (Ref OIML R 117-3, F.1.1.1, 2019) Minimum recorded test data includes test condition (°F), zero reading (raw flow indication readings both before and after the test and corresponding converted flow rate units), test volumetric flow rate, indicated volumetric flow rate, test volume, indicated volume.

5.1.4.2. Ambient low temperature: Expose device to the applicant-specified low ambient temperature for a period of no less than 2 hours after meter has reached temperature stability. The change in ambient temperature should not exceed 2 °F/min during cooling down and heating up.

One test for each flow rate, including a zero reading before and after each test. Flow rates* defined by:

1. Q_{min},
2. Q_{max}.

**Flow rates should be within ±10% of calculated Q.*

The device should be tested;

1. At each flowrate after the ambient temperature has been held at 60° F for at least 1 hour (The PMT will accept the return to baseline from the third step in the ambient high temperature test of 5.1.4.1 as this baseline test),
2. At each flowrate after the ambient temperature has been held at the applicant specified low temperature for 2 hours,
3. At each flowrate after the ambient temperature has been held at 60° F for at least 1 hour.

During the tests, the device should be in operation.

Test data recording: (Ref OIML R 117-3, F.1.1.2, 2019) Minimum recorded test data includes test condition (°F), zero reading (raw flow indication readings both before and after the test and corresponding converted flow rate units), test volumetric flow rate, indicated volumetric flow rate, test volume, indicated volume.

5.1.4.3. **Exposure to damp heat**: Expose device to conditions of high humidity combined with cyclic temperature changes to show that such conditions will not create a condition that would affect accuracy. The test comprises exposure of the meter to cyclic temperature variation between 75 °F and 130 °F while maintaining the relative humidity above 95 % during the temperature change and the low temperature phases and at or above 93 % RH at the upper temperature phases.

Condensation is expected to occur on the meter during the temperature rise.

The device shall be tested in two (2) twenty-four (24) hour cycles:

1. temperature rise during 3 hours conditioning,
2. temperature maintained at upper value until 12 hours from the start of the cycle,
3. temperature lowered to lower temperature level within a period of 3 to 6 hours, the declination (rate of fall) during the first hour and a half being such that the lower temperature level would be reached in a 3-hour period, and
4. temperature maintained at the lower level until the 24-hour period is completed.

The stabilizing period before and the recovery period after the cyclic exposure should be such that the temperature of all parts of the meter is within 35 °F of its final value.

Special electrical conditions and recovery conditions may need to be specified.

During the tests, the device should be in operation. Simulated inputs are permitted. After the application of the disturbance and recovery, the meter should be tested at a minimum of one flowrate within the applicant specified flowrate range.

Test data recording: (Ref OIML R 117-3, F.1.1.3, 2019) Minimum recorded test data includes test condition (°F), zero reading (raw flow indication readings both before and after the test and corresponding converted flow rate units), test volumetric flow rate, indicated volumetric flow rate, test volume, indicated volume.

5.1.4.4. Random vibration: For vibration testing, devices should be subject to two categories of test. Type "a" test in which the vibration will be applied to the meter while it is in use. This test is designed to show the effects of vibrations that exist in any location during normal operation. The type "b" test will have the vibration applied to the meter while it is not in operation and then verify the performance was not negatively affected. This test is designed to show the effects that are experienced by portable devices.

Random vibration testing requires three tests at each flow rate at fluid density operating range of minimum density, ρ_{min}, and three tests at each flow rate at maximum density, ρ_{max}.

a. For all locations. Example: normal vibration expected at any meter location.

   Test requirements are as follows[2]:

   1. Total frequency range of 10-150 Hz.

[2] *General Requirements for Measuring Instruments – Environmental Conditions,* International Organization of Legal Metrology D011, 2013 Edition

2. Total RMS level of 7 m s^{-2},
3. ASD level 10-20 Hz is 1 m^2 s^{-3},
4. ASD level 20-150 Hz is -3 db/octave.

b. For locations with high or very high levels of vibration. Example: meter mounted directly on machine, truck, or trailer (vibration or shock source), Test requirements are as follows[3]:

1. Total frequency range of 4-2000Hz.
2. Total RMS level of 78 m s^{-2},

Simulated inputs are permitted.

The device should be tested in three, mutually perpendicular axes, mounted on a rigid fixture by its normal mounting means for no less than 2 minutes per axis.

The device should normally be mounted so that the gravitational force acts in the same direction as it would during normal use. The meter orientation during this test dictates the meter installation orientation of an approval.

For type "a" testing the device power supply should be "on" when the influence factor is applied. During the application of the influence factor, the device should then be tested at Q_{min} and Q_{max}.

For type "b" testing the device power supply should not be "on" when the influence factor is applied. After the application of the influence factor, the device should then be tested at Q_{min} and Q_{max}.

Test data recording: (Ref OIML R 117-3, F.1.1.4, 2019) Minimum recorded test data includes test condition (vibration), zero reading (raw flow indication readings both before and after the test and corresponding converted flow rate units), test volumetric flow rate, test density, indicated volumetric flow rate, test volume, indicated volume, indicated density, and meter orientation.

6. TEST REPORT CONTENTS

6.1. Summary of tests and results and conclusions

6.2. Test facility information

6.2.1. Name and location of the facility

6.2.2. A statement that the facility's measurement systems for mass, length, time, and temperature are traceable to NIST primary standards or other primary standards if approved by the BLM.

6.2.3. The uncertainty determined at a 95% confidence level of each standard used in the testing. If the uncertainty of a standard is a function of the magnitude of the variable tested, the report should include the uncertainty of the standard at each test

[3] John C. Gagliardi, and Walter K. Utt, "Vibration Environmental Testing for Large Haulage Trucks", United States Department of the Interior – Bureau of Mines, RI 9482, 1993

point. The report should include a complete description of how the uncertainty or uncertainties were determined.

6.2.4. Date and time of each test

6.2.5. Description of fluids used, including viscosity, composition, and density

6.2.6. Log of all required baseline conditions (temperature, humidity, atmospheric pressure, etc.) taken over the test periods.

6.3. Device information

6.3.1. Name of the device manufacturer

6.3.2. Type, name, and description of the device

6.3.3. Model number, size/range, and serial number of each device tested

6.3.3.1. Identify critical and non-critical characters of the model number

6.3.3.2. Provide description of what critical characters represent (See Part 1 Sec2 of this document)

6.3.3.3. Provide description of what non-critical characters represent (See Part 1 Sec2 of this document)

6.3.4. Methodology used for random selection of devices

6.3.5. A description and drawing of the test facility piping for device testing

6.3.6. All configuration parameters for each meter tested

6.4. Device Specifications

6.4.1. Return to zero. Indicate one: Electronic, Key, Manual, Time Delay, Other

6.4.2. Totalizer. Indicate one: Mechanical volume, Electronic volume, Other (explain)

6.4.3. Pulsar. Indicate one: Electronic pulsar, Mechanical pulsar

6.4.4. Display. Indicate one: Diagnostic check, Segment check, N/A

6.4.5. Minimum Measured Quantity

TABLE 2: MINIMUM MEASURE QUANTITY EXAMPLE TABLE

	0.1	0.01	0.001	Other
Barrels				
Ft^3				
Other				

6.4.6. Power backup. Indicate one: N/A, Battery backup, Uninterruptible power supply, Other

6.5. Test results

6.5.1. Clear indication of the test type (baseline, influence test: type of influence, etc.)

6.5.2. Clear indication of the make, model, size/range for which the results apply

6.5.3. Test parameters including flow rate, fluid properties, pressure, temperature, etc.

6.5.4. Table of the results of each test required in this procedure

6.5.5. Comments regarding any difficulties, upsets, or unexpected events

6.6. Data format

Raw test data should be submitted in a single electronic .xls, .csv, or .txt format and test results analysis or summary should be in a single format that does not require special software to review.

6.7. Statement of ambient conditions

Example: Ambient Conditions

	At start	At end
Temperature °F		
Relative humidity %		
Atmospheric pressure psia		
Time		

7. DATA ANALYSIS AND DETERMINATION OF PERFORMANCE

7.1. Test Parameters

7.1.1. Indication at Zero Flow Rate (Section 5.1.1)

The stability of the zero-flow rate is determined by looking at what the meter reads before and after a test. All values are to be reported in BBL/HR.

$$Zero_{BF} = Zero\ Taken\ Before\ Flowing$$
$$Zero_{AF} = Zero\ Taken\ After\ Flowing$$
$$Deviation = abs(Zero_{BF} - Zero_{AF})$$

The Possible Zero Error (PZE) is then the maximum of:

- the absolute values of the Zeroes
- the Deviations determined

for the 6 tests performed.

7.1.2. Baseline Accuracy (Section 5.1.2)

For each Test performed in 5.1.2, the percent error is calculated as follows:

$$\%\ Error_i = \frac{Q_{DUTi} - Q_{STDi}}{Q_{STDi}} \cdot 100\%$$

Where:

$$Q_{DUT} = Volume\ Flowrate\ of\ Device\ Under\ Test$$
$$Q_{STD} = Volume\ Flowrate\ of\ Reference\ Standard$$
$$i\ denotes\ each\ Test\ Number\ in\ the\ test\ series$$

The Accuracy of a test is defined as:

$$Accuracy_i = maximum(abs(\%\ Error_i), \mu_i)$$

Where:

$$\mu = Uncertainty\ in\ Volumetric\ Flowrate\ of\ Reference\ Standard\ in\ \%$$

The Baseline Accuracy is defined as the maximum of the Accuracies for all Test Numbers, in percent of reading.

7.1.3. Limits of Working Range Accuracy (Section 5.1.3)

If the device is within the Threshold of Significance (TOS) for the limits of the working range accuracy, then it passes that test. The T_s is defined as:

$$T_s = \pm\sqrt{U_a{}^2 + U_b^2}$$

Where:
T_s = Threshold of Significance
U_a = Baseline Accuracy
U_b = Uncertainty (95 percent confidence) of data set
See 43 CFR 3170.3
The TOS is calculated for each test, and the percent error of each test point must be within the TOS for the device to pass.

7.1.4. Influence Effects (Section 5.1.4)

The Influence Effects are analyzed in the same manner as the Limits of Working Range tests, but if the accuracy associated with an effect is outside of the TOS, the stated accuracy of the device will increase by the difference between the percent error and the TOS.

All 60°F Ambient Temperature Tests must fall within the TOS to pass. The Ambient Temperature Effect is the maximum effect determined by 7.1.4.1 and 7.1.4.2. The manufacturer may alternatively state an Ambient Temperature Effect as a function of ambient temperature. In this case, all data from 7.1.4.1 and 7.1.4.2 must fall within the stated Ambient Temperature Effect.

7.1.4.1. Ambient High Temperature (Section 5.1.4.1)

The Ambient High Temperature Test may add to the stated accuracy of the device if the flow rate shifts by more than the TOS. The amount that is added to the stated accuracy is equal to the maximum difference between the percent error and the TOS.

7.1.4.2. Ambient Low Temperature (Section 5.1.4.2)

The Ambient Low Temperature Test may add to the stated accuracy of the device if the flow rate shifts by more than the TOS. The amount that is added to the stated accuracy is equal to the maximum difference between the percent error and the TOS.

7.1.4.3. Exposure to Damp Heat (Section 5.1.4.3)

The tests in 5.1.4.3 are handled in the same manner as the Limits of Working Range Tests.

7.1.4.4. Random Vibration (Section 5.1.4.4)

a. The tests in 5.1.4.4.a are handled in the same manner as the Ambient High Temperature and Ambient Low Temperature Tests
b. If the tests in 5.1.4.4.b are performed, they are handled in the same manner as the Limits of Working Range Tests

7.2. Calculation of Device Performance

The overall performance of the device should be calculated utilizing the information obtained in 7.1. For a device to be recommended for approval by the PMT, it should meet all PASS/FAIL criteria, and the overall performance of the device should be within the Maximum Permissible Error (MPE) determined for flow category.

The performance of the device is calculated at any flow rate utilizing the following equation:

$$Performance\ (\frac{BBL}{HR}) = \pm(PZE + Q \cdot (BA + ATE + VIB_a))$$

Where:

$$PZE = Possible\ Zero\ Error$$

$$Q = Flow\ Rate\ in \frac{BBL}{HR}$$

$$BA = Baseline\ Accuracy\ Determined\ in\ 7.1.2$$

$$ATE = Ambient\ Temperature\ Effect\ Determined\ in\ 7.1.4$$

$$VIB_a = Vibration\ Effect\ Determined\ in\ 7.1.4.3.a$$

PZE, BA, ATE, and VIB_a represent the maximum values for all devices tested in the sample size as required by Section 1 Part D, or as part of a family of meters approval.

This can be expressed in percent of reading by:

$$Performance\ (\%\ Read) = \pm\frac{Performance\ \left(\frac{BBL}{HR}\right)}{Q} \cdot 100\%$$

PART 3: ELECTRICAL, ELECTROSTATIC, ELECTROMAGNETIC, AND RF INTERFERENCE TEST PROCEDURE

1. DEFINITIONS.

For this Part 3 Testing Procedure, the following definitions apply:

1.1 *Device* means a component involved in the test. A component could be a metering device, transducer, transmitter, or other electrical device that affects or could affect measurement.

1.2 *Interruptible device* means a circuit that can stop the execution of a running program.

1.3 *Non-interruptible device* means a circuit that cannot stop the execution of a running program.

1.4 *Significant fault* means a fault greater than one fifth of the absolute value of the maximum permissible error for the measured quantity.

2.TEST FACILITY AND GENERAL TEST REQUIREMENTS:

2.1 Reference ambient conditions shall be within the following ranges**:** (Ref OIML R 117-2, 4.3, 2019).

Temperature (ambient): 60°F to 95°F.
Relative Humidity: 25% to 75%.
Atmospheric pressure: 11 psia to 15 psia.

Ambient conditions should be documented at the start and end of each test. During each test, the temperature should not vary more than ± 10°F, and relative humidity should not vary more than ± 10% within reference range.

2.2 Pass/Fail criteria: For interruptible and non-interruptible devices/systems: Any significant fault occurring during or after the applied influence, and/or all functions do not operate as designed will be a fail criteria. For interruptible devices only, if device's internal checking facility detects a malfunction and acts upon it in accordance with applicant's specifications, it will be considered a pass criteria. Any errors must be recorded with the test data.

2.3 If the device has installation requirements that would be present in the field to mitigate electrical issues (such as grounding), those should be declared in the testing report and the device should be installed with such measures during all testing.

2.4 For all testing in Part 3, the meter's low flow cut off must be set to zero.

3. Test Procedure

Unless specified (see section 3.1.1.5)**,** determine "PASS" or "FAIL" condition on AC and DC circuits and signal data, and control lines as applicable to device for voltage influences, electrostatic, bursts and surges, and radiated electromagnetic fields.

3.1 Test: During each test the device shall be in operation. Simulated inputs are allowed. Tests should be conducted on a minimum of one flow rate of applicant's choice.

Influence parameters:

1. AC and DC mains;
2. Electrostatic discharge;
3. Bursts and surges on signal data;
4. Radiated electromagnetic field; and

5. Conducted currents generated by RF electromagnetic fields

3.1.1 AC and DC mains:

3.1.1.1 AC mains voltage variation (Ref IEC 61000-4-1): Test exposes device to continuous lower and upper limits of power supply condition for a period sufficient to achieve temperature stability and subsequently performing the required measurement while device is operating under normal atmospheric conditions.

Test: (Nominal voltage ranges are specified by manufacture and marked on device. If only one nominal voltage is marked on device, then lower nominal = upper nominal for purposes of this test).

1. Lower nominal voltage
2. Lower limit: lower nominal voltage – 15%.
3. Upper limit: upper nominal voltage + 10%
4. Upper nominal voltage

Test data recording: (Ref OIML R 117-3, F.1.2.1, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at the lower nominal voltage, lower limit, upper limit, and upper nominal voltage. This data should be submitted with the test report.

3.1.1.2 AC mains voltage dips, short interruptions and reductions (Ref IEC 61000-4-11): This test only applies to devices with rated input current less than 16 A per phase. Test exposes device to conditions of short-term mains voltage reductions. A test generator suitable to reduce the amplitude of the AC mains voltage for the specified time is required.

Test: The mains voltage reduction test should be repeated 10 times with intervals of at least 10 seconds between tests. The tests should be applied continuously during the measurement time. The interruptions and reductions are repeated throughout the time necessary to perform the whole test; for this reason, more than ten interruptions and reductions may be necessary.

1. Reduction to 0%, duration of 0.5 cycle.
2. Reduction to 0%, duration of 1.0 cycle.
3. Reduction to 40%, duration of 10/12 cycles.
4. Reduction to 70%, duration of 25/30 cycles.

Test data recording: The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report. (Ref OIML R 117-3, F.1.2.3, 2019)

3.1.1.3 Bursts on AC and DC power mains (Ref IEC 61000-4-4): A burst generator is required. This test consists of exposure to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω load are applicant specified.

Test: Both positive and negative polarity of burst should be applied. The duration of the test should not be less than one minute for each amplitude and polarity. The injection network on the mains should contain blocking filters to prevent the burst from being dissipated in the mains. At least 10 positive and negative randomly phased bursts should be applied. The bursts are applied during all the time necessary to perform the tests (more indicated may be necessary).

Test consists of: Amplitude peak value of 1 kV with a repetition rate of 5 kHz.

Test data recording: (Ref OIML R 117-3, F.1.2.4, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

3.1.1.4 Surges on AC and DC power mains (Ref IEC 61000-4-5): A surge generator is required for this test. This test consists of conditions where electrical surges are superimposed on the mains voltage. Exposure of the device to electrical surges for which rise time, pulse width, peak values of the output voltage/current on high/low impedance and a minimum time interval between two successful pulses are specified by the applicant.

Test: At least 3 positive and 3 negative surges should be applied. The surges are applied during all the time necessary to perform the test; more surges than indicated may be necessary. On AC mains supply lines, the surges should be synchronized with the AC supply frequency and should be repeated such that injection on surges on all 4 phase shifts 0°, 90°, 180°, and 270° with the mains frequency is covered.

Test consists of surge voltage peaks of two parameters:

1. Line to line at 1.0 kV. and
2. Line to earth at 2.0 kV.

Test data recording: (Ref OIML R 117-3, F.1.2.10, 2019) The voltage, simulated input value, and indicated measured value must be measured and recorded at each of the values required under this test. This data must be submitted with the test report.

3.1.1.5 DC mains voltage variation (Ref IEC 606540-2): This tests DC power mains voltage changes between upper and lower limits. The test comprises of exposure of the device to the specified power supply condition for a period sufficient for achieving temperature stability and subsequently performing the required measurements.

Test: The test consists of exposure of the device to the specified power supply condition while the device is operating under normal atmospheric conditions. The upper voltage limit is the DC level at which the device has been manufactured to automatically detect high-level conditions. The lower voltage limit is the DC level at which the device has been manufactured to automatically detect low-level conditions. Testing may be restricted to subsequent exposure to upper and lower voltage levels.

The DC operating range shall be specified by manufacturer but not less than the following:

$$U_{nom} - 15\% \leq U_{nom} \leq U_{nom} + 10\%$$

Test data recording: (Ref OIML R 117-3, F.1.2.2, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report. The test documentation should document device errors at voltage levels between the two levels.

3.1.1.6 DC mains voltage dips, short interruptions and variations (Ref IEC 61000-4-1, IEC 61000-4-29): A test generator is required for this test. Performance of the generator should be verified before starting the test.

Test: The device should be exposed to voltage dips, short interruptions, for each of the selected combinations of amplitude and duration, using a sequence of three dips/interruptions and intervals of at least 10 seconds between each test. The most representative operating modes of the device, as specified by applicant, should be tested three times at 10 second intervals for each of the specified voltage variations. If the device is an integrating instrument, the test pulses should be continuously applied during the measurement time. The disturbances are applied during all the time necessary to perform the test. To that purpose, more disturbances than indicated may be necessary.

Test consists of the following:

1. Voltage dips:

   Amplitude: 40 % and 70% of rated voltage.

   Duration: 0.01; 0.03; 0.1; 0.3; 1.0; t seconds

2. Short interruptions:

   Test Condition: High impedance and/or low impedance.

   Amplitude: 0% of rated voltage.

   Duration: 0.001; 0.003; 0.01; 0.03; 0.1; 0.3; 1.0; t seconds

3. Voltage variations:

   Amplitude: 85 % and 120% of rated voltage.

   Duration: 0.1; 0.3; 1.0; 3.0; 10.0; t seconds

Test data recording: (Ref OIML R 117-3, F.1.2.8, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data must be submitted with the test report.

3.1.1.7 DC power mains ripples (Ref IEC 61000-4-1, IEC 61000-4-17): A test generator is required. Before starting the test, the performance of the generator should be verified.

This test subjects the device to ripple voltages such as those generated by traditional rectifier systems and/or auxiliary service battery chargers overlying DC power supply sources. The frequency of the ripple voltage is the applicable power frequency or a multiple dependent on the rectifier system used for the mains. The waveform of the ripple, at the output of the test generator, has a sinusoid-linear character.

Test: The test should be applied for at least 10 minutes or for the period of time necessary to allow a complete verification of the device's operating performance.

Test shall be conducted at 2% of the nominal DC voltage.

Test data recording: (Ref OIML R 117-3, F.1.2.9, 2019) The voltage, simulated input value, and indicated measured value must be measured and recorded at each of the values required under this test. This data must be submitted with the test report.

3.1.2 Electrostatic discharge:

3.1.2.1 Electrostatic contact/air discharge (Ref IEC 61000-4-2): An ESD generator is required. This test consists of at least 10 discharges per applicant specified preselected discharge locations. For devices not equipped with a ground terminal, the device should be fully discharged between discharges.

Test: The time interval between successive discharges should be at least one second. The device must be in operation. Test should be conducted on at least one applicant specified flow rate.

Contact discharge is the primary test method. The contact should be on conductive surfaces, the electrode should be in contact with the device before activation of the discharge. The discharge spark will occur in the vacuum relay of the contact discharge tip.

On insulated surfaces only the air discharge mode can be applied. The device is approached by the charged electrode until a spark discharge occurs.

Test consists of the following voltage:

Contact discharge: 6 kV
Air discharge; 8 kV

Test data recording: (Ref OIML R 117-3, F.1.2.5, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

3.1.3 Bursts and surges on signal data:

3.1.3.1 Bursts on signal data (Ref IEC 61000-4-4): A burst generator is required. The characteristics of the generator should be verified prior to connecting to the device.

Test: The test comprises exposure to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω load are defined by applicant. Both positive and negative polarity of the bursts shall be applied. The duration for each test should not be less than 1 minute for each amplitude and polarity.

A capacitive coupling clamp should be used for the coupling of the bursts into the I/O and communication lines. The bursts are applied during all the time necessary to perform the test; for that purpose, more bursts than indicated may be necessary.

Test consists of: Amplitude peak value of 1.0 kV with a repetition rate of 5 kHz.

Test data recording: (Ref OIML R 117-3, F.1.2.6, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

3.1.3.2 Surges on signal data (Ref IEC 61000-4-5): Test on signal line only apply for I/O, signal, data and control ports, with cable lengths greater than 100 feet. Indoor DC signal, data, and control cables are exempt from this test.

A surge generator is required. The characteristics of the generator should be verified prior to connecting to the device.

Test: The test comprises of exposure to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and the minimum time interval between two successive pulses are defined by the applicant. At least 3 positive and 3 negative surges shall be applied. The applicable injection network depends on the kind of wiring the surge is coupled into and is defined by the applicant. The surges are applied during all the time necessary to perform the test: for that purpose, more surges than indicated may be necessary.

Test consists of:

1. Unsymmetrical lines:
    a. Line to line: 1.0 kV
    b. Line(s) to ground: 2.0 kV
2. Symmetrical lines, shielded I/O, and communication lines;
    a. Line(s) to ground: 2.0 kV

Test data recording: (Ref OIML R 117-3, F.1.2.7, 2019) The voltage, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

3.1.4 Radiated electromagnetic field: (Ref IEC 61000-4-3 and 61000-4-20): The device is exposed to electromagnetic field with field strength and field uniformity as defined by the applicant. The level of field strength refers to the field generated by the unmodulated carrier wave.

The device should be exposed to the modulated wave field. The frequency sweep should be made only pausing to adjust the RF signal level or to switch RF-generators,

amplifiers and antennas as necessary. Where the frequency range is swept incrementally, the step size should not exceed 1% of the preceding frequency value.

The dwell time of the amplitude modulated carrier at each frequency should not be less than the time necessary for the device to be exercised and to respond but should in no case be less than 0.5 seconds.

Adequate EM field can be generated in facilities of different type and setup, the use of which is limited by the dimensions of the device and the frequency range of the facility.

The expected most critical frequencies should be analyzed separately.

3.1.4.1 Fields of general origin:

Test:

Frequency range of 80-1000 MHz: 10 V/m.

Modulation: 80% AM, 1 kHz, Sine wave

Test data recording: (Ref OIML R 117-3, F.1.2.11, 2019) The field strength, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

3.1.4.2 Fields specifically caused by Wireless communication networks:

Test consists of:

Frequency range of 1.4 - 3 GHz: 10 V/m.

Modulation: 80% AM, 1 kHz, Sine wave

Test data recording: (Ref OIML R 117-3, F.1.2.12, 2019) The field strength, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

3.1.5 Conducted currents generated by RF electromagnetic fields (Ref IEC 61000-4-6): This test requires an RF generator, (de-)coupling devices, attenuators. This equipment should be verified before connecting to device.

Test: An RF EM current, simulating the influence of the EM fields should be coupled or injected into the power ports and I/O ports of the device using coupling/decoupling devices as defined by the applicant.

Test consists of:

RF amplitude: 10 V (e.m.f.),

Frequency range: 0.15 – 80 MHz,

Modulation: 80% AM, 1 kHz, Sine wave

Test data recording: (Ref OIML R 117-3, F.1.2.13, 2019) The field strength, simulated input value, and indicated measured value should be measured and recorded at each of the values required under this test. This data should be submitted with the test report.

4. TEST REPORT CONTENTS

4.1 Summary of tests and results and conclusions

4.2 Test facility information

- **4.2.1** Name and location of the facility
- **4.2.2** A statement that the facility's measurement systems for mass, length, time, and temperature are traceable to NIST primary standards or other primary standards if approved by the BLM.
- **4.2.3** The uncertainty determined at a 95% confidence level of each standard used in the testing. If the uncertainty of a standard is a function of the magnitude of the variable tested, the report should include the uncertainty of the standard at each test point. The report should include a complete description of how the uncertainty or uncertainties were determined.
- **4.2.3** Date and time of each test
- **4.2.4** Description of each simulated input including the parameter being simulated (pressure, temperature, flow rate, etc.) and the type of simulated input signal (Volts, milliamps, modbus, HART, etc.)
- **4.2.5** Log of all required baseline conditions (temperature, humidity, atmospheric pressure, etc.) taken over the test periods.

4.3 Device information

- **4.3.1** Name of the device manufacturer
- **4.3.2** Type, name, and description of the device
- **4.3.3** Model number, size/range, and serial number of each device tested
- **4.3.4** All configuration parameters for each device tested

4.4 Test results

- **4.4.1** Clear indication of the test type (baseline, influence test: type of influence, etc.)
- **4.4.2** Clear indication of the make, model, size/range for which the results apply
- **4.4.2** Test parameters including simulated inputs for each test run
- **4.4.3** Table of the results of each test required in this procedure
- **4.4.4** Comments regarding any difficulties, upsets, or unexpected events

4.5 Data format

Raw test data should be submitted in a single electronic .xls, .csv, or .txt format and test results analysis or summary should be in a single format that does not require special software to review.