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Explanatory note

Temporary section to be removed in or after CIML approval stage of the draft Recommendation

See 1CD OIML R139-1 May 2017

Contents

Foreword

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This publication - reference OIML R 139-2, Edition 2018? - was developed by the Project Group p7 of the Technical Subcommittee TC 8/SC 7. It was approved for final publication by the International Committee of Legal Metrology in 2018?and will be submitted to the International Conference on Legal Metrology in 2020 for formal sanction. It supersedes the previous edition of R 139 (2014).

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Part 2: Metrological controls and performance tests

1 Metrological controls

1.1 General

In general (depending on national or regional legislation), legal metrological control can consist of type approval, initial and subsequent verification, and metrological supervision.
This Part gives general guidelines for each of these steps.

1.2 Responsibility for compliance with the requirements

1.2.1 Notwithstanding the kind of legal metrological control in a country, the manufacturer (or its formal representative) has the full responsibility that the instruments comply with the requirements in Part 1 at the moment they are delivered to the user.

1.2.2 After assignment, the owner of the instrument has the responsibility that the instrument is well maintained and complies with the requirements in Part 1 as long as the instrument is in use. The operational presence of the instrument at the owner's premises is considered as "in use".
Particular attention shall be paid to the future recovery of stored data (see R 139-1, 6.3.1).

1.2.3 Modification of an approved type

1.2.3.1 The beneficiary of the type approval shall inform the body issuing the approval of any modification or addition which concerns an approved type.

1.2.3.2 Modifications and additions shall be subject to a supplementary type evaluation when they influence, or are likely to influence, the measurement results or the instrument's regulatory conditions of use. The body having approved the initial type shall decide to which extent the examinations and tests described below shall be carried out on the modified type in relation with the nature of the modification.

1.2.3.3 When the body having approved the initial type judges that the modifications or additions are not likely to influence the measurement results, this body allows in writing that the modified instruments may be presented for initial verification without granting a supplementary type approval.
A new or supplementary type evaluation must be issued whenever the modified type no longer fulfils the provisions of the initial type approval.

1.2.3.4 The manufacturer may be granted permission to replace hardware elements which cannot influence the characteristics or the performance of the measuring systems merely comprising binary electric circuits (so-called purely binary or digital elements) by other functionally equivalent elements without having to submit the measuring instrument so as to demonstrate that it continues to operate as designed. The manufacturer will be held responsible regarding the continuation of operation under the specified rated conditions.
These hardware elements shall be identified during type evaluation and registered as such in the type approval certificate.

1.2.4 Application of the measuring system

A measuring system shall exclusively be used for measuring gas having characteristics within its field of operation, as specified by the manufacturer, validated during type evaluation and as stated in the type approval certificate (see R 139-1, 8.2 q).
The field of operation of a measuring system shall be within the fields of measurement of each of its constituent elements, in particular the meter.

1.3 Uncertainty

1.3.1 Each test comprises measurements applying harmonized test setups for the verification of compliance with requirements. Measurement uncertainty is an attribute of each measurement. For every measurement result that is reported during testing of a measuring instrument or system within the framework of this Recommendation the measurement uncertainty associated with the corresponding measured value(s) and determined error(s) of indication shall be known and where relevant shall be reported.

Note: Exceptions considered not relevant to be reported in the test report include the uncertainty values associated with individual measured values which are obtained for the purpose of assessing a component of measurement uncertainty associated with the repeatability or reproducibility of the measuring instrument/system and/or testing procedure, or where it is determined on the basis of a previous reported assessment that a component of measurement uncertainty is not significant in a particular measurement application.

1.3.2 The uncertainty associated with the test method shall be taken into account in the decision on the applicability of the test method.

When a test is conducted, the expanded uncertainty[1] on the determination of errors on indications of mass shall be:

- for type evaluation less than one-fifth of the applicable MPE;
- for verifications less than one-third of the applicable MPE.

However, if the above-mentioned criteria cannot be met, the test results can be approved alternatively by reducing the applied maximum permissible errors with the excess of the uncertainties. In this case the following acceptance criteria shall be used:

- for type evaluation $\pm\left(\tfrac{6}{5}\cdot \mathrm{MPE}-U\right)$
- for verifications $\pm\left(\tfrac{4}{3}\cdot \mathrm{MPE}-U\right)$

while $U \leq \mathrm{MPE}$

1.3.3 The estimation of expanded uncertainty U is calculated according to the *Guide to the expression of uncertainty in measurement* [4] applying a coverage probability which corresponds the application of a coverage factor k = 2 for a normal distribution and which comprises approximately 95 % of the measurement results.

1.3.4 For the calculation of the uncertainty, the uncertainty contributions related to the EUT need to be taken into account, in particular the scale interval and, if applicable, the intrinsic instability at zero flow.
The repeatability error of the EUT, however, shall not be included in the uncertainty.

1.3.5 In the case of a repeatability test (not performed in conjunction with accuracy tests), the above ratios apply to the stability of measurement standards.

2 Instrument evaluation

Examinations and testing of measuring instruments are intended to verify compliance with the requirements laid down in Part 1 of this Recommendation.

If a specimen does not pass a specific part of the examination or test and as a result needs to be modified or repaired, the applicant shall apply this modification to all the specimens submitted for the test. These modified specimen(s) shall again be subjected to this particular test. If the testing laboratory has well-founded reasons to believe that the modification could have a negative impact on the result of another test or tests already performed, these tests shall be repeated as well.

1) As defined in OIML G 1-100 [4], 2.3.5

2.1 Examinations

The instrument shall be inspected and the documentation shall be studied so as to obtain a general appraisal of its design and construction.

2.1.1 Design examination

The design examination aims at verifying that the design of devices and their checking facilities comply with the provisions of this Recommendation.

It includes in general

- an examination of the construction and of the electronic sub-systems and components used so as to verify their appropriateness for their intended use,
- verification that in all considered cases these devices comply with the provisions of R 139-1, 6.10,while taking into consideration the faults likely to occur, and
- verification of the presence and effectiveness of the test device(s) for the checking facilities.

In particular, the conformity to the referred requirements regarding the following aspects shall be examined:

a) presentation of the measurement result (R 139-1, 5.1, 6.2);
b) measuring range (R 139-1, 5.3);
c) environmental classes and rated operating conditions (R 139-1, 5.5);
d) construction (R 139-1, 6.1);
e) price indicating device (R 139-1, 6.2.8);
f) printing device (R 139-1, 6.2.9);
g) storage of measuring results (R 139-1, 6.3);
h) data transmission (R 139-1, 6.4);
i) zero-setting device (R 139-1, 6.5);
j) pre-setting device (R 139-1, 6.6);
k) calculator (R 139-1, 6.7);
l) emergency power supply device (R 139-1, 6.8);
m) protection against fraud (R 139-1, 6.9);
n) checking facilities (R 139-1, 6.10);
o) software (R 139-1, 6.11);
p) guarantee of delivery of the measured quantity (R 139-1, 6.14.3);
q) inscriptions (R 139-1, 7);
r) verification of the contents of the instruction manual (R 139-1, 8);
s) sealing (R 139-1, 9);
t) stamping plate (R 139-1, 10);
u) suitability for testing (R 139-1, 11).

2.1.2 Software evaluation

The software evaluation procedure concerns evaluation of compliance to the requirements as described in Part 1 Annex A and comprises a combination of analysis and validation methods and tests as shown in Table 1. The explanation of the abbreviations used and the relation to the methods as described in detail in OIML D 31 [26] is shown in Table 2.

Table 1 - Software validation procedures applicable for verification of compliance to the software requirements

Requirement (see annex A of Part 1)		Evaluation procedure (see Table 2)
A.1.1	Software identification	AD + VFTSw
A.1.2	Correctness of algorithms	AD + VFTSw
A.1.3	Fraud protection	AD + VFTSw (+ DFA/CIWT/SMT)[1]
	Parameter protection	AD + VFTSw(+ DFA/CIWT/SMT)[1]
A.2.1	Separation of electronic devices and sub-assemblies	AD
A.2.2	Separation of software parts	AD
A.2.3	Storage of data, transmission via communication systems	AD + VFTSw (+ CIWT/SMT)[1]
A.2.3.1	Data protection with respect to time of measurement	AD + VFTSw (+ SMT)[1]
A.2.4	Automatic storing	AD + VFTSw
A.2.3.4	Transmission delay	AD + VFTSw
A.2.3.5	Transmission interruption	AD + VFTSw
	Time stamp	AD + VFTSw

Table 2 - Cross references of evaluation procedures to those described in Annex C and detailed in OIML D 31

Abbreviation	Description	Related Annex C and OIML D 31:2008 Clause
AD	Analysis of the documentation and validation of the design	Annex C (C1) ➔ D 31 (6.2.3.1)
VFTM	Validation by functional testing of metrological functions	Annex C (C2) ➔ D 31 (6.2.3.2)
VFTSw	Validation by functional testing of software functions	Annex C (C3) ➔ D 31 (6.2.3.3)
DFA [1)]	Metrological data flow analysis	Annex C (C4) ➔ D 31 (6.2.3.4)
CIWT[1)]	Code inspection and walkthrough	Annex C (C5) ➔ D 31 (6.2.3.5)
SMT[1)]	Software module testing	Annex C (C6) ➔ D 31 (6.2.3.6)

[1)] The software validation methods DFA, CIWT and SMT in general are not applicable and may only be applicable if the measuring system is designed to allow software downloading.

2.2 Performance tests on the measuring system

2.2.1 General

2.2.1.1 The measuring instrument/system shall be submitted to performance tests to determine its correct functioning under various conditions.

2.2.1.2 The execution of performance tests on the measuring system comprises the verification that constituent elements of the system, not yet subjected to separate type evaluation, satisfy the applicable requirements, even in those cases where a separate type evaluation is not requested. This also includes the verification that in any case these constituent elements are compatible. However, when the measuring system contains a meter that has not yet been approved, it is only possible to perform tests on the complete system, as specified in 2.2.7 (without having to perform the influence quantity tests specified in 3.8 on the calculator). The tests to be performed for type approval for a measuring system shall therefore be determined on the basis of the type approval certificates already granted for the constituent elements of the system.

2.2.1.3 When none of the constituent elements have ever been submitted for a separate type evaluation, all of the tests laid down in this Recommendation shall be performed on the complete measuring system or, where applicable, on specific devices.

2.2.1.4 If the various constituent elements have all been evaluated and approved separately, it is possible to restrict the approval process to an examination of the documentation only. However, a functional test of the complete measuring system should always be performed in particular at the lowest temperature intended for all components of the gas piping.

Note: The above paragraph is to be interpreted such that influence factor test on the meter need not be performed once again.

2.2.1.5 It is also acceptable to reduce the type evaluation program when the measuring system includes constituent elements identical to those which equip another measuring system that has already been approved, and when the operating conditions of these elements are identical.

Note: It is advisable that constituent elements be subject to separate type evaluation when these are intended to equip several types of measuring systems. This is particularly recommended when the manufacturers of the various measuring systems are not identical and/or different bodies are in charge of the type evaluations.

2.2.2 Simulation and testing modules

2.2.2.1 As a general rule, tests shall be carried out on a complete measuring system or module, which is to be submitted for evaluation. This specimen shall represent a single type. Simulation of any part of the specimen to be tested should be avoided. In the case where simulation cannot be avoided, at least all those parts of the instrument that could be affected by a test and which play an active role in the measurements shall be part of the assembly submitted for the applicable test.

2.2.2.2 If the size or configuration of the measuring instrument does not permit specific or all tests to be executed on the instrument as a whole, or if only a separate module (see 3.11) of the measuring instrument is concerned, the tests, or the specific tests, shall be carried out on the modules separately, provided that these devices are included in a simulation setup which is proven valid to represent the normal operation.

Note: As a general rule, dismantling the measuring instruments or devices for the tests is to be avoided.

2.2.3 Assembly required for performance tests

2.2.3.1 Except in those cases specified in 2.2.2, tests shall be performed on a complete measuring system where size and configuration permit.

In those cases where tests are not performed on a complete system, they shall be carried out on a sub-system comprising at least the following devices:

a) measuring device;
b) calculator;
c) indicating device;
d) power supply device;
e) correction device, if appropriate.

2.2.3.2 This sub-system shall be included in a simulation setup which represents the normal operation of the measuring system. For example, the movement of the gas may be simulated by an appropriate device.

2.2.3.3 The calculator shall be in its final housing with all inputs and outputs connected and all peripheral equipment switched on.

2.2.3.4 In all cases, peripheral equipment may be tested separately.

2.2.4 Intermediate adjustments while performing tests

A measuring system shall fulfill the requirements without adjustment of the system or of its devices during the course of the tests. If an adjustment is carried out, it shall be verified that the measuring system would have been capable of fulfilling the full set of requirements with the new adjustment by restarting tests and/or recalculating errors obtained before adjustment if the corresponding tests are not performed again.

2.2.5 Preparations and preconditions for performance tests

2.2.5.1 General considerations

In general, the major factors affecting the accuracy of compressed gaseous fuel (CGF) measuring systems are:

a) the size of the meter, which shall be suitable for the maximum flow obtainable using the refueling system to which it is fitted.

Note: Higher flow rates will occur at the beginning of the refueling and just after each bank switching. Testing up to the measuring system’s specified allowed maximum flow capacity will reveal the effect of meter undersizing;

b) the quantity value of the measured batch; and

c) the ratio between the low flow rate portion and the total quantity of gas delivered in the refueling transaction;

Note: These low flow rates will occur prior to bank switching and just before the very end of the refueling. Larger low flow rate proportions may reduce the meter accuracy;

d) sudden flow acceleration and deceleration originating from interventions by the sequential control device.

The tests specified in the following sub clauses will take into account the influence of these potential accuracy reducing sources.

2.2.5.2 Test setup

2.2.5.2.1 Table 3 presents the indicative values of the minimum volume, V_{min}, for the test receiver (representing the vehicle fuel storage system) and the test reservoir volume, V_d (representing the refueling station fuel storage system) to be applied in the test, related to the capacity of the meter to be tested.

Table 3 - Indicative values of the minimum volume for the test receiver

Test receiver volume	Meter capacity					Unit
	$Q_{max} \leq 4$	$4 < Q_{max} \leq 12$	$12 < Q_{max} \leq 30$	$30 < Q_{max} \leq 70$	$Q_{max} > 70$	kg/min
V_{min}	10	30	90[1)]	300	600	L
V_d [2)]	50	150	800	1600	2400	L

1) 50 L may be accepted provided the test receiver volume fulfills the appropriate provisions specified in this Recommendation (which require at least 1000 scale intervals).

2) The actual test reservoir volume(s) applied shall be such to ensure the flow rate drops below 120 % of Q_{min} at a point of time anywhere within the last 20 seconds of each flow test. If a sequential control device is used, this condition only applies to the highest (last) bank (see 2.2.5.2.4).

This provision does not apply where the meter or the measuring system is designed to stop the flow when the flow rate drops below Q_{min} and where the test is performed until the flow stops.

The sizes of pipework and valves utilized on the test receiver shall be adequate and at least equivalent to those normally utilized on the category of vehicles for which the measuring system is intended. In this context the different capacities of the meters are typically related to the combination of the type of gas for which these are designed and their designation for refueling of the different types of vehicles, such as cars, medium weight trucks and heavy duty vehicles (e.g. large trucks and buses).

2.2.5.2.2 During a fast filling of the vehicle the test reservoir, representing the refueling station fuel storage system, shall be capable of supplying the gas at the allowable maximum gas pressure (P_v) at the end of the test. Information on the actual test reservoir volume used during the type evaluation tests shall be presented in the type approval certificate.

2.2.5.2.3 The sizes of pipework and valving of the test rig shall be such that the flow capacity of the meter or measuring system will not be reduced when connected to the test rig. In addition, unless otherwise agreed to by the measuring system's manufacturer, the test rig's control system shall be such that the maximum gas flow rate obtainable during testing will not exceed the measuring system's specified allowable maximum gas flow rate.

2.2.5.2.4 Where relevant (see 2.2.7.2), the test reservoir volume shall be subdivided into three compartments. A volume ratio of 2:1:1 for the low bank, medium bank and high bank respectively is recommended. The test rig shall include a refueling sequential control device and piping and valving suitable for generating the specified maximum and minimum flow rates of the measuring system.

Note 1: The use of a common test rig for multiple meter sizes (flow capacities), may be possible when allowing for necessary adjustments or modifications in the test rig configuration.

Note 2: The receiver volumes have been selected to reasonably represent a range of onboard CGF storage sizes of the different vehicle fuel capacities, and to minimize test equipment for cost and handling reasons.

Note 3: The presented ratio of the test reservoir bank volumes is, up to a reasonably high degree, the typical representation of many actual conditions of use of refueling systems at the major storage stations.

2.2.5.2.5 Simulated signals and/or any fluid other than the one intended to be measured may be used for testing, provided that these do not influence the determination of the result of the test. If necessary, corrections shall be applied which shall be recorded in the test report. Additional rationale shall be recorded in the test report when no corrections are made.

Note: Some measurement principles allow for instance the use of nitrogen or dry air instead of natural gas without applying corrections. Refer to 2.2.7.6 and B.3.5 for applicability and further information.

2.2.6 Types of measuring systems

For the purpose of the tests, three types of measuring systems are considered:

a) measuring systems utilizing a sequential control device of a refueling station;
b) measuring systems that already incorporate their own sequential control device;
c) measuring systems for refueling stations that do not utilize a sequential control device.

The sequential control device of the test rig shall not be used for testing measuring systems of types b and c.

2.2.7 Accuracy test program applicable to the different types of measuring systems

The following test program (see 2.2.7.1 up to and including 2.2.7) is appropriate for current technologies and may require adaptation if new technologies are applied. In all the following tests the pressure in the test receiver at the end of the test shall be P_v (the allowed maximum vehicle fast fill pressure).

2.2.7.1 Tests at variable flow rate

The flow rate of the gas in a measuring system varies during the course of a delivery. The flow rate curve depends on the available supplying conditions. This results in a variety of operating conditions for a measuring system. For the CGF dispenser for vehicles, the variety of operating conditions (filling curves) per delivery is limited as a consequence of the limited tank (vessel) volume, the compression needed for sufficient storage efficiency, and safety requirements. Taking this into account, repetitive testing of such a system by simulating these variable operating conditions is deemed to provide sufficient proof of accuracy.

Note 1: Since the main object of the test is to detect the way in which the meter manages to cope with changes in the flow rate with the focus on the fast pressure changes during the bank switching, the pressure ratios are initially not fixed values, but shall be suitably fixed for a meter based on the low, medium and high storage pressures to be applied in practical measuring systems.

Note 2: Table 8 indicates the applicability of the tests.

Table 4 indicates the sequence and conditions in which the testing shall be carried out. Each bank shall be activated in the course of each test.

Table 4 - Test at variable flow rate

<table>
<tr><th>Test #</th><th>Phase #</th><th>Action sequence</th></tr>
<tr><td rowspan="3">Test 0</td><td>Phase 1</td><td>1. Ensure that the initial test receiver pressure is 0 kPa (or higher if so required for safety reasons)
2. Ensure that the initial station storage pressure is P_{stl} in the low pressure bank
3. Record the initial mass indication of the reference weighing instrument used
4. Alternatively, set the mass indication to zero
5. Connect the nozzle
6. Start the time tracking at the start of the delivery
7. Fill the testing vessel up to about the percentage of the mass capacity established for the low pressure phase
8. Stop filling and time tracking at the same instance
9. Disconnect the nozzle
10. Record the indication of the weighing instrument, dispenser and time tracking
11. Calculate the error</td></tr>
<tr><td>Phase 2</td><td>1. Ensure that the initial station storage pressure is as established for the medium pressure P_{stm} bank
2. Reconnect the nozzle and continue following the phase 1 sequence starting at sub 6, filling the testing vessel up to the percentage of mass capacity established for the medium pressure phase</td></tr>
<tr><td>Phase 3</td><td>1. Ensure that the initial station storage pressure is as established for the high pressure bank (P_{sth})
2. Reconnect the nozzle and continue following the phase 1 sequence starting at sub 6, filling the testing vessel up to the percentage of mass capacity established for the high pressure phase</td></tr>
</table>

Note: The tests in Table 4 shall be repeated at least three times. The MPEs and the requirement concerning repeatability are applicable as described in detail in 3.4.2

2.2.7.1.1 Tolerance on batch sizes

The tolerance to be applied to the afore-mentioned percentages of the maximum capacity of the test cylinders is ± 5 %.

2.2.7.2 Accuracy tests involving three banks

Measuring systems tested with three banks may be used in all situations, regardless of the total number of banks (1, 2, 3, 4…). The procedure may need to be adapted by national authorities, in particular for tests on the site of use and/or taking into consideration the specific design of filling stations.

2.2.7.2.1 Three bank testing shall be carried out under the following set of conditions, where P_{st} is the maximum station storage pressure and P_v the maximum allowable vehicle fast fill pressure. Each bank shall be activated in the course of each test.

Table 5 - Tests with sequential control

Test #	Initial state
Test 1	Initial test receiver pressure of 0 kPa or higher if so required for safety reasons Initial station storage pressure of P_{st} in all banks
Test 2	Initial test receiver pressure of 0.5 P_v Initial station storage pressure: - high bank at P_{st}, - medium bank at close to P_v, - low bank at 0.75 P_v.
Test 3	Initial test receiver pressure of 0.75 P_v Initial station storage pressure: high bank at P_{st}, medium bank at close to P_v, low bank at 0.75 P_v.

2.2.7.2.2 The bank volumes shall be such that refueling into the specified test cylinders will cause the activation of all stages of the operation of the refueling sequential control device. Where a sequential control device is not included in a measuring system, it shall complete the switching action from one bank to another within 3 s. Where a sequential control device is included in a measuring system, it shall complete the switching action from one bank to another within the minimum possible delay as designed by the manufacturer (if relevant). Where relevant the maximum allowed speed (the tested one) shall be specified in the type approval certificate.

2.2.7.2.3 The minimum totalized mass quantity to be applied in the execution of Test 1 and Test 2 shall be at least twice the minimum measured quantity per test and at least the minimum measured quantity in the execution of Test 3.

2.2.7.2.4 The average maximum, medium and minimum flow rates are calculated through dividing the sequential measured masses by the applicable recorded filling time period.

2.2.7.2.4 The test volume ratio of the receiver test reservoir and the storage bank shall be as specified in 2.2.5.2.1, 2.2.5.2.2 and 2.2.5.2.4. It may be necessary to close some valves on the test reservoir cylinders to achieve the required test reservoir volume and bank proportions.

2.2.7.3 Accuracy tests involving only one bank

Tests without sequential controls shall be performed applying the following conditions:

Table 6 – Initial settings for tests on systems without sequential control

Test #	Initial state
Test 4	Initial test receiver pressure of 0 kPa or higher if so required for safety reasons Initial station storage pressure at P_{st}
Test 5	Initial test receiver pressure of 0.5 P_v Initial station storage pressure at P_{st}
Test 6	Initial test receiver pressure of 0.75 P_v Initial station storage pressure at P_{st}
Test 7 (minimum measured quantity)	The conditions for Test 6 are adapted in order to test the minimum measured quantity. For this purpose, the pressure does not have to be P_v in the test receiver at the end, but may be any pressure (as close as practical to P_v) such that the quantity of transferred gas shall be at least the minimum measured quantity.

For tests without bank switching, the test reservoir pipework can simply be changed so that all test reservoir cylinder banks are joined together, i.e. there are no high, medium or low banks; the reservoir in this case is a uniform station storage pressure system.

2.2.7.4 Tolerance on gas pressure

The tolerance on the applied gas pressure for all tests is ± 10 % of the indicated pressure.

2.2.7.5 Durability test

Meters without any internal moving parts (e.g. Coriolis meters) because of their construction are expected not to require the following durability test for proving their sustainability on the mechanical properties.

If applicable it is recommended to perform the durability test on site in real conditions of use. It shall involve at least a total mass equal to 100 hours running at 0.8 Q_{max}, or alternatively at least involving the number of actions for 2000 deliveries in actual use. When the durability test is performed in a laboratory, it consists in performing a total mass of gas equal to 100 hours running at 0.8 Q_{max}, representing the real use and at least involving an action of the sequential control device where applicable.

Depending on whether the measuring system is intended to operate with or without a sequential control device the recommended test is Test 1 (Table 5) or Test 4 (Table 6) respectively.

After the durability test, the meter is again subjected to the following tests:

- for meters or measuring systems utilizing a sequential control device, Test 1 (Table 5) shall be performed at least 3 times;
- for meters or measuring systems not utilizing a sequential control device, Test 4 (Table 6) shall be performed at least 3 times;
- the mean value of the corresponding initial intrinsic errors is calculated;
- the mean value of the corresponding errors after the durability test is calculated;
- the deviation between these two values shall remain within the limit specified in R 139-1, 5.8.2;
- the repeatability shall meet the requirement of R 139-1, 5.4.

Note 1: In accordance with 2.2.5.2.5, substitute fluid (gas or liquid) may be applied in the durability test, for example for safety reasons.

Note 2: National authorities may have the possibility to authorize the provisional use of instruments subjected to type approval for specific test purposes (after demonstration of acceptable performance in a laboratory).

2.2.7.6 Testing the gas influence factors

Tests should be carried out at the limits of the meter's field of operation, i.e. at the limits of possible pressure, temperature and density for the gas.

The test lab may have the ability to validate alternative test methods and procedures and make use of these for testing gas influence factors.

In that case, evidence of validity of the test method shall be provided in the test report, showing that the performance criteria are met. Such an alternative method is only acceptable as long as the rationale comprises a fully documented justification on the reason for use of the alternative and proof of application of state-of-the-art testing practices.

Annex B gives information on a substitution test method for Coriolis meters. This information is only indicative and may not apply to all technologies and designs of meters.

The manufacturer shall specify and establish the validity of gas temperatures when operating in the specified range of ambient temperatures.

If the influence of the temperature of the gas needs to be tested according to Annex B, the following tests shall be performed for each temperature limit:

a) Test 1 for measuring systems utilizing a sequential control device (types a and b);
b) Test 4 for measuring systems for refueling stations not utilizing a sequential control device (type c).

In tests at the temperature limits, at least the meter or measuring system shall be placed in a controlled temperature chamber for a sufficient conditioning time to ensure that they are at the intended test temperature prior to the beginning of the test. The gas supply system need not be placed in the temperature chamber provided that the temperature of the gas is at the appropriate temperature limit specified in R 139-1, 15.1.1 with a tolerance of ± 5 °C.

This approach to dealing with the temperature of the gas may also be applied to the pressure and density of the gas.

For the performance of temperature tests a liquid instead of a gas may be used. In this case there is no need to provide evidence about the similar behavior of the liquid and the gas.

2.2.7.7 Specific tests

If on the basis of the measuring principle the following parameters are expected to have a critical influence on the results, the following tests shall also be carried out:

a) determination of the zero stability;
b) tests with flow disturbances.

For tests with flow disturbances, the applicable maximum permissible errors are those specified for the measuring system and not those fixed for the meter. These tests are performed in accordance with the state of the art (see in particular the relevant ISO Standards), taking into consideration

- flow disturbances existing in real life refueling station equipment,
- design of meters and measuring systems, and
- circumstances which are known to affect their performances.

3 Type evaluation

3.1 Submission of assembly

3.1.1 Number of specimens to be submitted

Type evaluation shall be carried out on at least one specimen, which represents the definitive type. The evaluation shall comprise the examination and tests specified in 2.1 and 2.2.

Additional samples of the same type may be considered necessary by the body responsible for the type evaluation, e.g. to estimate the reproducibility of the measurements.

If the request for type evaluation concerns several versions of the same type or aims to cover several measuring ranges, the body involved and responsible for the evaluation decides on which version(s) shall be submitted and the range(s) to be selected for the evaluation.

3.1.2 Simultaneous evaluation

In order to accelerate the test procedure, the testing laboratory may carry out different tests simultaneously on different specimens. In this case, the body responsible for the evaluation decides which version or measuring range will be subjected to a specific test, and it shall be verified that all submitted instruments are of the same type and that in comparison to the original specimen no additional measures were taken to boost the immunity to the influence quantity.

In principle no more than two additional specimens shall be used for simultaneous evaluation.

Table 7 specifies which tests may be performed on the additional specimens.

3.1.3 MPE during on site evaluation

Where, during type evaluation, some of the tests need to be executed at a different location, the MPE as specified in R 139-1, 5.2.1 applies regardless of these test locations.

Table 7 - Parallel testing on multiple specimen

Tests that shall be performed on one and the same specimen	Tests that may be divided amongst no more than two additional specimens
• Repeatability • Variable flow • One /three bank testing • Durability • Where applicable: preset function test	• Ambient temperature test • Gas temperature test • Pressure test • Vibration test • Power supply voltage variation tests • Verification of checking facilities • Damp heat test • Radiated and conducted RF EM • Bursts on mains and control lines • Surges on mains and control lines • Dips and interruptions • DC ripple • Emergency power • Electrostatic discharge

3.1.4 Modules which may be accepted for separate type evaluation

If preferred by the manufacturer and accepted by the body responsible for type evaluation the following modules of measuring systems may be submitted separately for type testing and approval:

a) meter (see 3.11.1);
b) transducer (see 3.11.1);
c) calculator (including the indicating device) (see 3.11.2);
d) ancillary devices providing or memorizing measurements results (see 3.11.3);
e) self-service device (see 3.11.4);
f) printing devices (see 3.11.5).

The constituent elements of a measuring system shall comply with the relevant requirements, even when they have not been subject to separate type evaluation (except, of course, in the case of ancillary devices that are exempted from the controls).

As far as possible the type approval certificate of a constituent element shall contain the necessary metrological information on compatibility with other elements.

3.2 Submission of documentation for type evaluation

3.2.1 General documentation

The documentation submitted with the application for type approval shall include:

a) description of its general principle of measurement;
b) (mechanical) drawings and/or photographs;
c) electric/electronic diagrams;
d) lists of the essential sub-assemblies/modules, components (in particular electronics and other essential ones) with their essential characteristics;
e) functional description of the various electronic devices;
f) flow diagram of the logic, showing the functions of the electronic devices;
g) for measuring systems and meters fitted with correction devices, a description of how the correction parameters are determined;
h) assembly drawing with identification of the different components;
i) drawing(s) presenting the security sealing plan and the provisions and location for verification marks;
j) drawing of regulatory markings;
k) general information on the software required for a micro-processor equipped measuring instrument;
l) test inputs or outputs, their use, and their relationships with the parameters being measured;
m) installation requirements;
n) operating instructions that shall be provided to the user;
o) if applicable: the references of the approval certificates of the constituent elements;
p) overview of any purely digital elements that are considered to be replaceable (in accordance with 1.2.3.4);
q) documents or other evidence that support the assumption that the design and characteristics of the instrument comply with the requirements of this Recommendation and in particular concerning the requirements in R 139-1, 6.10.

3.2.2 Software documentation

For type evaluation, the manufacturer of the measuring system shall explain and document all program functions, relevant data structures and software interfaces of the legally relevant part of the software that is implemented in the instrument. No hidden undocumented functions shall exist.

The commands and their effects shall be described exhaustively in the software documentation to be submitted for type approval. The manufacturer shall state that the documentation concerning the commands is complete. If commands can be entered via a user interface, they shall be described extensively in the software documentation to be submitted for type approval.

Furthermore, the application for type approval shall be accompanied by a document or other evidence that supports the assumption that the design and characteristics of the software of the measuring system comply with the requirements of this Recommendation.

Typical documentation (for each measuring instrument and/or its constituents) basically includes:

a) description of the legally relevant software and how the requirements are met:
   - list of software modules that belong to the legally relevant part, including a declaration that all legally relevant functions are included in the description;
   - description of the software interfaces of the legally relevant software part and of the commands and data flows via this interface including a statement of completeness;
   - description of the generation of the software identification;
   - list of parameters to be protected and description of protection means;

b) description of the security means of the operating system (password, etc. if applicable);

c) description of the (software) sealing method(s);

d) overview of the system hardware, e.g. topology block diagram, type of computer(s), type of network, etc. Where a hardware component is deemed legally relevant or where it performs legally relevant functions, this should also be identified;

e) description of the accuracy of the algorithms (e.g. filtering of A/D conversion results, price calculation, rounding algorithms, etc.);

f) description of the user interface, menus and dialogues;

g) the software identification and instructions for obtaining it from an instrument in use;

h) list of commands of each hardware interface of the measuring instrument / electronic device / sub-assembly including a statement of completeness;

i) list of durability errors that are detected by the software and if necessary for understanding, a description of the detecting algorithms;

j) description of data sets stored or transmitted;

k) if fault detection is realized in the software, a list of faults that are detected and a description of the detecting algorithm;

l) operating manual.

3.2.3 Specific documentation concerning the execution of performance tests

When the verification of a measuring system or of a meter intended to measure gas may be carried out with air (or with another fluid), this shall be specified by the manufacturer and the validation shall be confirmed by appropriate tests. If necessary in this case, a more restricted range or a shift for maximum permissible errors may be laid down in the type approval certificate, in order to account for deviations and to provide for compliance to the maximum permissible errors for gas.

3.2.4 Specific documentation on durability

Documentation shall be provided specifying **some** life time estimation of the meter which contains a guarantee that the individual meters of the type will operate in conformity to the requirements in part 1 of this Recommendation over a minimum period of time of at least 5 years after the individual meter has been installed, unless the type of meter has previously proven conformity to the durability requirement as laid down in the R 139-1,5.5 sub-clauses through the execution of the durability test (according to R 139-2, 2.2.7.5)

3.2.5 Additional documentation

More detailed documentation may be required if this is deemed necessary by the type evaluating laboratory, either to be able to study the quality of the instrument, or to be able to lay down the approved type, or both.

3.3 Examinations and tests to be performed during type evaluation

3.3.1 Examinations

The examinations to be performed at type evaluation are specified in 2.1.

3.3.2 Tests to be performed during type evaluation

Overviews of the tests to be performed during type evaluation are presented in Tables 8, 11 and 12.

3.3.3 Overview of accuracy tests during type evaluation

Table 8 summarizes the required accuracy tests during type evaluation for various meter and measuring systems according to their configuration, i.e. whether they are used in conjunction with a sequential control system.

In principle all accuracy and influence tests (excluding disturbance tests) shall be performed on one and the same specimen.

Some tests may, however, need to be performed on site. This can be accepted provided that it is assured that test results will be equivalent to those which would be obtained when the tests were performed under reference conditions.

Note: When applied, the rationale providing the assurance may need to be reported or referred to.

3.4 Tests applicable to the meter

3.4.1 General considerations concerning the assembly for testing

According to the request of the manufacturer, a type evaluation may be performed and type approval may be granted for a meter alone or any sub-assembly including a meter. However, in any case the test program applicable to meters shall be performed independently of the contents of the request for type approval.

In principle, the meter is tested as a stand-alone unit. However, it may be tested in any sub-assembly or a complete measuring system provided it is possible to assume that test results would be equivalent if they were performed on the stand-alone meter.

Table 8 - Test program

Test name	Referring to:			Applicable to meters:		Applicable to measuring systems for:			
						CGF excluding hydrogen			hydrogen
Test(s) named:	Sub clause	Table	Test #	All	intended for use with sequential control	for use with sequential control	with adjustable sequential control 1)	for use without sequential control	
Test(s) at variable flow rate	2.2.7.1	4	0	3 times 2)					
Test(s) with sequential control	2.2.7.2	5	1		n/a	3 times 2)	3 times 2)		
			2		optional, 3 times 2)	3 times 2)	n/a		
			3		n/a	3 times 2)	n/a		
Test(s) without sequential control	2.2.7.3	6	4	3 times 2)		n/a		3 times 2)	3 times 2), 3)
			5	3 times 2)		n/a		3 times 2)	3 times 2), 3)
			6	n/a		n/a		3 times 2)	n/a
			7	n/a		twice 2)		twice 2)	twice 2), 3)
Test(s) on durability	2.2.7.5	-	-	once 2)					
Test(s) on preset function (if present)		-	-			once 2)		once 2)	once 2)
Test(s) on gas influence factors	2.2.7.6	-	-	twice 2) per influence factor					
Test(s) with flow disturbances etc.	2.2.7.7	-	-	Optional, twice 2)	twice 2) if not yet performed on meter			twice 2) if not yet performed on meter	

Note:

1) Test at extreme adjustment limits

2) Tests are mandatory unless otherwise indicated

3) Tests 4, 5 and 7 may be performed in random order and optimized to minimize the total testing time.

3.4.2 Test program (see Table 8)

3.4.2.1 Test 0 (see 2.2.7.1 and Table 4) shall be performed at least 3 times consecutively while maintaining the same conditions in order to establish the intrinsic behavior of the meter.

When defining $E_{t,p}$ the error per individual test cycle (t), per individual phase (p), each of the individual (typically 9) error values $E_{n,m}$ in the matrix shall not exceed the MPEs specified in R 139-1, 5.2.1 for the meter (where n = 1 to t and m = 1 to p).

The repeatability requirement concerns the repeatability within the same phase number of each of (typically 3) consecutive tests. This implies that the repeatability error has to be calculated for each of the three arrays $E_{n,1}$, $E_{n,2}$ and $E_{n,3}$ (where n = 1 to t).

3.4.2.2 Tests 4 and 5 (see 2.2.7.3 and Table 6) shall be performed at least 3 times consecutively in the same conditions in order to establish the dynamic behavior of the meter.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the meter. The requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

3.4.2.3 The durability test (see 2.2.7.5) shall be performed.

If the meter is intended to be included in a measuring system utilizing a sequential control device, the test shall be performed so that the meter operates in conjunction with such a device.

In the case of a meter accompanied with a particular sequential control device, this particular device shall be subject to the test associated with the meter. If the result could be dependent on the type of sequential control device (whether or not it is included in a measuring system) and according to the manufacturer's specifications, the device providing the most severe flow switching effects shall be used. Any appropriate information shall be indicated in the type approval certificate.

The requirement on durability specified in R 139-1, 5.8.2 shall be fulfilled and the requirement on repeatability specified in R 139-1, 5.4 (3.1.6) shall be fulfilled.

3.4.2.4 If applicable (see Annex B *Tests on gas influence factors* and 2.2.7.6) shall be performed.

If the test is applicable, each test shall be performed twice. The individual registered error values shall not exceed the MPEs specified in R 139-1, 5.2.1 for the meter. [2]
If it is decided not to perform the corresponding tests the rationale for this decision shall be provided in the test report.

3.4.2.5 If the manufacturer specifies that the meter is intended to be included in a measuring system utilizing a sequential control device, the corresponding information is laid down in the type approval certificate, and Test 2 (see 2.2.7.2) shall be performed at least 3 times consecutively in the same conditions.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the meter.

The requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

3.4.2.6 Where appropriate, specific tests (see 2.2.7.7) may be performed.
The corresponding information is included in the type approval certificate.
If testing is applicable, each test shall be performed twice. Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the meter.

3.5 Tests applicable to the measuring system

3.5.1 Measuring systems utilizing a sequential control device

3.5.1.1 Tests 1, 2 and 3 shall be performed on the complete system at least 3 times consecutively in the same conditions.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the measuring system.

The requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

3.5.1.2 Test 7 shall be performed on the complete system at least twice.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.4 for the measuring system.

3.5.1.3 If relevant and not already performed on the meter, specific tests (see 2.2.7.7) are performed.

If applicable, each test shall be performed twice.
Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the measuring system.

3.5.1.4 For measuring systems that may be used with a sequential control device (incorporated or not) fitted with adjustment parameters, Test 1 shall be performed at least 3 times consecutively under the same conditions for each extreme value of the adjustment parameters.

When a parameter is tested, other parameters are at reference condition as specified by the manufacturer.
Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.4 for the measuring system.

The requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

3.5.2 Measuring systems for refueling stations not utilizing a sequential control device

3.5.2.1 Tests 4, 5 and 6 shall be performed on the complete system at least three times consecutively under the same conditions.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the measuring system.

The requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

3.5.2.2 Test 7 shall be performed on the complete system at least twice.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.4 for the measuring system.

3.5.2.3 If relevant and not already performed on the meter, specific tests (see 2.2.7.7) are performed.

If testing is applicable, each test shall be performed twice.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2.1 for the measuring system.

3.5.3 Measuring systems specific for hydrogen fuel

3.5.3.1 Tests 4 and 5 shall be performed at least three times on the complete system and test 7 shall be performed at least twice.

Each individual error shall not exceed the MPEs specified in R 139-1, 5.2 for the measuring system.

3.5.3.2 Each test may be performed consecutively under the same conditions or all of the tests may be performed in a cyclic consecutive order (e.g. in the sequence # 4, # 5, # 7, # 4, # 5, # 7, # 4 , # 5).

For Test 4 and Test 5, the requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

3.5.4 Preset function

If a measuring system is equipped with a preset function, a test shall be performed to verify compliance with the requirement as specified in R 139-1, 6.6.5.

3.6 Specific provisions

When it is the intention that the initial verification of the meter or of the system is to be performed with

a) a fluid (instead of the gas or gases which it is intended to measure when in use), or
b) only with one gas (if the system is intended to measure two or more gases when in use),

specific tests, similar to those referred to in 3.2.3**,** shall be performed in order to determine whether a shift and/or reduction of maximum permissible errors is needed and if so to what extent.

In general this determination should involve more than one meter in order to take into account the reproducibility of the type of meter or measuring system.

The provisions in this paragraph shall be implemented in such a way that it may be assumed that the measuring systems in use will not exceed the maximum permissible errors when employing the gas or all the gases they are intended to measure.

3.7 Execution of initial tests

Prior to the execution of the performance tests, the initial intrinsic error shall be determined in order to verify compliance with the requirements of R 139-1, 5.2 and to establish the reference for all further performance tests. The error curve of the indicated mass (= measurand) shall be established in a reproducible manner.

In the case of multiple indicating/printing devices, the indication of all these devices shall be recorded for every value of the measurand.

3.7.1 Overview of the execution of the initial tests

Table 9 - Execution of the initial tests

Preconditions:	The EUT shall be switched on in the operation mode for a time period of at least the warm-up time specified by the manufacturer. Subsequently the EUT is adjusted to indicate a useful reference value which may be as close to the zero indication as practicable prior to the test.
Condition of the EUT:	Power is to be “on” for the duration of the test. The EUT shall not be readjusted at any time during the test.
Execution:	While maintaining the reference conditions stable and applying a (simulated) flow rate, at least five different values of the measurand shall be recorded. Each record shall contain: a) date and time; b) temperature; c) relative humidity; d) measurand value; e) indicated value; f) error value; g) functional performance.
Allowed variations:	All functions shall operate as designed. All error values shall be within the maximum permissible error as specified in R 139-1, 5.2.

3.7.2 Reference conditions

Except for the parameter being tested, the following reference conditions presented in Table 10 shall be maintained by the testing laboratory during the tests:

Table 10 - Reference conditions

	Parameter	**Value**
a)	Ambient temperature	20 °C ± 5 °C
b)	Temperature of the gas (if applicable) (1), (2)	Rated operating conditions range declared by the manufacturer
c)	Relative humidity	60 % RH ± 15 %
d)	Atmospheric pressure	86 kPa to 106 kPa

e)	Vibration	Negligible (3)
f)	DC mains voltage (3)	Less than 10 % of the variation specified by the manufacturer of the EUT
g)	AC mains voltage (3)	U_{nom} ± 1 %
h)	AC mains frequency (3)	f_{nom} ± 0.5 % (4)
i)	Radio-frequency, electromagnetic fields (frequency > 80 MHz)	< 0.2 V/m (4)
j)	Radio-frequency, electromagnetic fields (frequency 150 kHz ÷ 80 MHz)	< 0.2 V/m (4)
k)	Electrostatic discharge	None
l)	Power frequency magnetic field	< 1 A/m (4)
m)	Bursts (transients) on signal, data and control lines (1)	Negligible (4)
n)	Surges on signal, data and control lines (1)	Negligible (4)
o)	AC mains voltage dips, short interruptions and voltage variations (1)	Negligible (4)
p)	Bursts (transients) on AC and DC mains (1)	Negligible (4)
q)	Ripple on DC mains power (1)	Negligible (4)
r)	Surges on AC and DC mains power (1)	None (4)
(1) For parts of the meter that are required to be tested with gas (2) Substitute gas or liquids may be used for safety reasons (3) If applicable (4) As in a normal laboratory condition these conditions can be expected to be fulfilled without specific measures, it is usually not deemed necessary to measure/monitor these values.		

3.8 Execution of tests under rated operating conditions (“Influence tests”)

The type of measuring instrument is presumed to comply with the provisions specified in R 139-1, 5.2 to 5.5, if it passes the tests specified in 3.8 confirming that the error of the measuring instrument as a consequence of the influence test parameter does not exceed the maximum permissible error specified in R 139-1, 5.2.

When the effect of the application of one influence quantity is being evaluated, for all other influence quantities the ranges as specified in the reference conditions specified in 3.7.1 shall be maintained. The sequence of the tests shall start with the initial test (test under reference conditions); the further “influence tests” can be carried out in any order chosen.

3.8.1 Overview of influence factor tests

Table 11 - Overview of influence factor tests

Sub clause	Table	Test
3.7.1	14	Initial test
3.8.2	17	Dry heat
3.8.2	18	Cold
3.8.3	19	Vibration (random)

3.8.4	20	AC mains voltage variation
3.8.4	22	DC mains voltage variation
3.8.5	23	Low voltage of internal battery

Note: Some influence quantities are likely to have a constant effect on measurement results and not a proportional effect related to the measurand value. The fault limit value is related to the measured mass; therefore, in order to be able to compare the results obtained in different laboratories, it is necessary to perform a test on a mass corresponding to that delivered in one minute at the maximum flow rate, but not less than a quantity corresponding to the appropriate number of scale intervals specified in Annex C. Some tests, however, may require more than one minute, in which case they shall be carried out in the shortest possible time.

3.8.2 Static temperatures

At the discretion of the testing laboratory, despite the test procedures in brief presented, the tests in 3.7 and 3.8.2 may be combined, using the following sequence:

- reference temperature;
- specified high temperature;
- specified low temperature;
- reference temperature.

Note concerning the influence of the gas temperature:

The test temperature is the ambient temperature and not the temperature of the gas used. It is therefore recommended to use a simulation test method so that the temperature of the gas does not influence the test results.

Table 12 - Dry heat

Applicable standards:	IEC 60068-2-2 [6]; IEC 60068-3-1 [10]
Test method:	Exposure to dry heat (non-condensing)
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.5.2 under conditions of high ambient temperature specified in R 139-1, 5.5.2 a
Test procedure in brief (*):	The test comprises exposure of the EUT to a temperature (T_{ah}) under “free air” conditions for a 2-hour period after the EUT has reached temperature stability. The change of temperature shall not exceed 1 °C/min during heating up and cooling down. The EUT shall be tested for at least one flow rate (or simulated flow rate as input signals): • at the reference temperature of 20 °C following conditioning; • at the temperature (Tah) 2 hours after temperature stabilization; • after recovery of the EUT at the reference temperature of 20 °C.
Test level specifications:	1) Temperature: (T_{ah}) 2) Duration: 2 hours 3) Number of test cycles: One cycle
Allowed effects:	During the application of the influence factor: • all functions shall operate as designed; and

	• all errors shall be within the maximum permissible errors.
(*) This test procedure has been presented in condensed form and for information only. It is adapted from the referenced IEC publications. Before conducting the test, the applicable publications should be consulted.	

Table 13 - Cold

Applicable standards:	IEC 60068-2-1 [5]; IEC 60068-3-1 [10]
Test method:	Exposure to low temperature
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.5.2 under conditions of low ambient temperature specified in R 139-1, 5.5.2 b
Test procedure in brief (*):	The test comprises exposure of the EUT to a temperature (T_{al}) under “free air” conditions for a 2-hour period after the EUT has reached temperature stability. The change of temperature shall not exceed 1 °C/min during heating up and cooling down. The EUT shall be tested for at least one flow rate (or simulated flow rate as input signals): • at the reference temperature of 20 °C following conditioning; • at the temperature of –25 °C or –10 °C, 2 hours after temperature stabilization; • after recovery of the EUT at the reference temperature of 20 °C.
Test level specifications:	1) Temperature: (T_{al}) 2) Duration: 2 hours 3) Number of test cycles: One cycle
Allowed effects:	During the application of the influence factor: all functions shall operate as designed; and all errors shall be within the maximum permissible errors.
(*) This test procedure has been given in condensed form, for information only, and is adapted from the referenced IEC publication. Before conducting the test, the applicable publication should be consulted. This comment also applies to the test procedures hereafter.	

3.8.3 Mechanical influences

Table 14 - Vibration (random)

<table>
<tr><td>Applicable standard:</td><td colspan="3">IEC 60068-2-47 [8]; IEC 60068-2-64 [9] ; IEC 60068-3-8 [12]</td></tr>
<tr><td>Test method:</td><td colspan="3">Exposure to random vibration</td></tr>
<tr><td>Object of the test:</td><td colspan="3">Verification of compliance with the provisions in R 139-1, 5.5.2 after being exposed to conditions random vibration specified in R 139-1, 5.5.2 f</td></tr>
<tr><td>Test procedure in brief (*):</td><td colspan="3">The EUT shall subsequently be tested in the three, mutually perpendicular axes while mounted on a rigid fixture using its normal mounting means.
The EUT shall normally be mounted in such a way that the gravity vector direction is the same as it would be in normal use. Where on basis of the measurement principle the direction of the effect can be assumed to be negligible, the EUT may be mounted in any position.
For the purpose of applying the test, the EUT:
• is to be switched off;
• is not to be mounted on a piping system;
• is not to be installed in any kind of protection case.</td></tr>
<tr><td rowspan="7">Test level specifications:</td><td>Parameter</td><td>Value</td><td>Unit</td></tr>
<tr><td>Total frequency range</td><td>10 – 150</td><td>Hz</td></tr>
<tr><td>Total RMS level</td><td>1.6</td><td>$m \cdot s^{-2}$</td></tr>
<tr><td>ASD level 10–20 Hz</td><td>0.05</td><td>$m^2 \cdot s^{-3}$</td></tr>
<tr><td>ASD level 20–150 Hz</td><td>–3</td><td>dB/octave</td></tr>
<tr><td>Number of axes</td><td>3</td><td></td></tr>
<tr><td>Duration per axis (or a longer period if necessary for carrying out the measurement)</td><td>2</td><td>min</td></tr>
<tr><td>Allowed variations:</td><td colspan="3">After the application of the influence factor:
• all functions shall operate as designed; and
• all errors shall be within the maximum permissible errors.</td></tr>
</table>

3.8.4 Electrical mains power supply variation

Table 15 - AC mains voltage variation

Applicable standards:	IEC/TR3 61000-2-1 [14]; IEC 61000-4-1 [15]
Test method:	Applying low and high level AC mains power supply voltage (if applicable)
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.5.2 under conditions of AC mains network voltage changes between upper and lower limit specified in R 139-1, 5.5.2 i
Test procedure in brief:	The test comprises exposure of the EUT to the specified power supply condition for a period sufficient for achieving temperature stability while the EUT is operating under normal atmospheric conditions and subsequently performing the required measurements.
Test level specifications:	Mains voltage: upper limit: U_{nom1} + 10 % lower limit: U_{nom2} – 15 % Number of test cycles: One cycle
Allowed effects:	During the application of the influence factor: • all functions shall operate as designed; and • all errors shall be within the maximum permissible errors.
Notes:	1) For three-phase mains power supplies, the voltage variation is applicable for each of the phases successively. 2) The values of U_{nom} are those as inscribed on the measuring instrument. U_{nom1} concerns the highest and U_{nom2} concerns the lowest value in the case a range is specified. If only one nominal mains voltage value (U_{nom}) is presented then $U_{nom1} = U_{nom2} = U_{nom}$.

Table 16 - DC mains voltage variation

Applicable standards:	IEC 60654-2 [13]
Test method:	Applying low and high level DC mains power supply voltage (if applicable)
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.5.2 g under conditions of DC mains voltage changes between upper and lower limit
Test procedure in brief:	The test comprises exposure of the EUT to the specified power supply condition for a period sufficient for achieving temperature stability, while the EUT is operating under normal atmospheric conditions and subsequently performing the required measurements.
Test level specifications:	The upper limit is the DC level at which the EUT has been manufactured to automatically detect high-level conditions. The lower limit will be the DC level at which the EUT has been manufactured to automatically detect low-level conditions. The EUT shall comply with the specified maximum permissible errors at voltage levels between the two levels. Testing may be restricted to subsequent exposure to the upper and lower voltage level.
Number of test cycles:	One cycle.
Allowed effects:	During the application of the influence factor: • all functions shall operate as designed; and • all errors shall be within the maximum permissible errors.

3.8.5 Electrical battery power supply variation

Table 17 - Low voltage of internal battery

Applicable standards:	None
Test method:	Applying minimum supply voltage (if applicable)
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.5.2 under conditions of low battery voltage specified in R 139-1, 5.5.2 g
Test procedure in brief:	The test comprises exposure of the EUT to the specified low voltage level condition of the battery(s) during a period sufficient for achieving temperature stability and for performing the required measurements. The maximum acceptable value of the internal impedance of the battery and the minimum battery supply voltage (U_{bmin}) shall be specified by the manufacturer of the instrument. In the case of simulating the battery by making use of an alternative electrical power supply source such as in bench testing, the internal impedance behavior of the specified type of battery shall also be simulated in addition to the simulation of the voltage and current specifications. The alternative power supply shall be capable of delivering sufficient current at the applicable supply voltage. The test sequence is as follows: - Let the power supply stabilize at the nominal voltage as defined in the rated operating conditions and apply the measurement and/or loading condition; - Record the following data: a) date and time; b) temperature of the environment; c) power supply voltage; d) functional mode; e) measurements and/or loading condition; f) indications (as applicable); g) errors; h) functional performance; - Verify compliance with the clauses mentioned in the object of the test; - Repeat the above procedure with the actual supply voltage at (U_{bmin}) and again at 0.9 (U_{bmin}) and note the following data: i) power supply voltage; j) indications; k) errors; l) other relevant responses of the instrument.
Test level specifications:	Lower limit of the voltage: The lowest voltage specified at which the EUT functions properly according to the specifications.
Number of test cycles:	At least one test cycle for each functional mode.
Allowed effects:	During the application of the influence factor: • all functions shall operate as designed; and • all errors shall be within the maximum permissible errors.

3.9 Further influence quantity tests (tests for potential disturbances)

3.9.1 The type of measuring instrument is presumed to comply with the provisions specified in R 139-1, 5.7, if it passes the tests presented in Table 18. The sequence of execution of these “disturbance tests” may be in any order.

Table 18 - Overview of further influence quantity tests

Sub clause	Table	Test
3.9.4.1	19	Damp heat, cyclic
3.9.4.2	20	Radio frequency electromagnetic fields (direct exposure)
3.9.4.2	21	Inducing common mode radio frequency currents (indirect exposure to EM fields)
3.9.4.3	22	Electrostatic discharge
3.9.4.4	23	Surges on AC and DC mains power lines
3.9.4.4	24	Surges on signal, data and control lines
3.9.4.5	25	AC mains voltage dips, short interruptions, and voltage variations
3.9.4.5	26	Bursts (transients) on AC and DC mains and on signal lines
3.9.4.5	27	Voltage dips, short interruptions and voltage variations on DC mains power
3.9.4.5	28	Ripple on DC input power

3.9.2 The following brief descriptions of tests (presented in Tables 19–28) contain the test procedures and applicable further test conditions. This is in addition to the general information available in the various test procedures applicable as presented in the referred IEC standards.

3.9.3 Instruments not equipped with any active electronic circuits or components (e.g. semiconductor circuits) are presumed to comply with the provisions in R 139-1, 5.7, after passing the influence quantity test “damp heat, cyclic” specified in 3.9.4.1 (Table 19). Such observations shall be recorded in the test report.

3.9.4 Instruments that are not (either directly or indirectly) connected to a DC mains power network, or instruments connected to battery charger systems incorporating switch mode converters, are presumed to comply with the provisions in R 139-1, 5.7, without being subjected to the test presented in 3.9.8 (Table 28).

3.9.4.1 Immunity to atmospheric disturbances

Table 19 – Damp heat, cyclic (condensing) test

Applicable standards:	IEC 60068-2-30 [7]; IEC 60068-3-4 [11]
Test method:	Exposure to damp heat with cyclic temperature variation
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.7 after being exposed to the conditions of high humidity combined with cyclic temperature changes specified in R 139-1, 5.7.3a
Test procedure in brief:	The test comprises exposure of the EUT to cyclic temperature variations between 25 °C and the temperature (T_{ah}), while maintaining the relative humidity (RH) above 95 % during the temperature changes and during the low temperature phases, and at or above 93 % RH at the upper temperature phases. Condensation is expected to occur on the EUT during the temperature rise. The 24 h cycle comprises: 1) temperature rise during a 3-hour period; 2) temperature maintained at upper value during a period of 12 hours from the start of the cycle; 3) temperature lowered to the lower value 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 value would be reached in a 3-hour period; 4) temperature maintained at the lower level until the 24-hour cycle is completed. The stabilizing period before and recovery after the cyclic exposure shall be such that the temperature of all parts of the EUT is within 3 °C of its final value. When the disturbance is applied the EUT shall be in switched off mode.
Test level specifications:	1) Upper temperature: $< T_{ah} >$ °C 2) Duration: 24 hours 3) Number of cycles: 2
Allowed effect:	After the application of the disturbance and the subsequent recovery, either the difference between each indication before the test and the associated indication after the test shall not exceed the fault limit values specified in R 139-1, 5.6.1, or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10.

3.9.4.2 Immunity to Radio Frequency Electromagnetic (RF EM) fields

Table 20 - Direct exposure to RF EM fields

<table>
<tr><td>Applicable standard:</td><td colspan="3">IEC 61000-4-3 [17]; IEC 61000-4-20 [23]</td></tr>
<tr><td>Test method:</td><td colspan="3">Exposure to radiated radio frequency electromagnetic fields</td></tr>
<tr><td>Object of the test:</td><td colspan="3">Verification of compliance with the provisions in R 139-1, 5.7 in case of direct exposure to the electromagnetic fields specified in R 139-1, 5.7.1 a</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="3">The EUT shall be exposed to electromagnetic fields in the frequency range and with a field strength amplitude as specified below, while maintaining a field uniformity as required and defined by the referred standard.
The EUT shall be exposed to the modulated wave field. The frequency sweep shall be made only pausing to adjust the RF signal level or to switch RF-generators, amplifiers and antennas if necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value.
The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond.
Adequate EM fields can be generated in facilities of different type and setup, the use of which is limited by the dimensions of the EUT and the frequency range of the facility.</td></tr>
<tr><td rowspan="6">Test level specifications:</td><td>Parameters</td><td>Value(-s)</td><td>Unit</td></tr>
<tr><td rowspan="2">Frequency range</td><td>26 – 3000 (1)</td><td rowspan="2">MHz</td></tr>
<tr><td>80 – 3000 (2)</td></tr>
<tr><td>Amplitude</td><td>10</td><td>V/m</td></tr>
<tr><td>Modulation:
AM (sine wave)</td><td>80
1</td><td>%
kHz</td></tr>
<tr><td>Allowed effect:</td><td colspan="3">Either the difference between any indication during the test and the indication under reference conditions shall not exceed the fault limit values given, or the measuring system shall, in compliance with R 139-1, 6.10, detect and act upon a potential significant fault.</td></tr>
<tr><td>Notes:</td><td colspan="3">(1) IEC 61000-4-3 [17] only specifies test levels above 80 MHz. For frequencies in the lower range the test method for common mode currents in the radio frequency range is applicable (Table 21).
(2) For EUTs lacking any cabling (mains or other input port) needed for applying the test specified in Table 21, the lower limit of the test in this Table 20 shall be 26 MHz, taking into account that the test specified in Table 21 cannot be applied (refer to Annex F of IEC 61000-4-3 [17]). In all other cases both the tests in 3.9.4.2 apply.</td></tr>
</table>

Table 21 - Indirect exposure to RF EM fields by inducing common mode RF currents

<table>
<tr><td>Applicable standard:</td><td colspan="4">IEC 61000-4-6 [20]</td></tr>
<tr><td>Test method:</td><td colspan="4">Injection of RF common mode currents representing exposure to RF electromagnetic fields</td></tr>
<tr><td>Object of the test:</td><td colspan="4">Verification of compliance with the provisions in R 139-1, 5.7 while being exposed to the electromagnetic fields specified in R 139-1, 5.7.1 b or, when applicable, R 139-1, 5.7.2 a</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="4">An RF current, simulating the influence of EM fields shall be coupled or injected into the mains power supply and input ports of the EUT using coupling/decoupling devices as defined in the referred standard.</td></tr>
<tr><td rowspan="4">Test level specifications:</td><td>Level index(1)</td><td>2</td><td>3</td><td>Unit</td></tr>
<tr><td>Frequency range(2)</td><td colspan="2">0.15 – 80</td><td>MHz</td></tr>
<tr><td>RF amplitude (50 Ω):</td><td>3</td><td>10</td><td>V (e.m.f.)</td></tr>
<tr><td>Modulation:
AM (sine wave)</td><td colspan="2">80
1</td><td>%
kHz</td></tr>
<tr><td>Allowed effect:</td><td colspan="4">Either the fault value shall not exceed the fault limit values presented in R 139-1, 5.6.1, or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10.</td></tr>
<tr><td>Notes:</td><td colspan="4">(1) Test level with index 3 is only applicable for measuring systems which may be installed in an industrial environment.
(2) For the frequency range 26 – 80 MHz, the testing laboratory may either carry out the test according to Table 20 or according to Table 21. In the event of dispute, the results according to Table 21 shall prevail.</td></tr>
</table>

3.9.4.3 Immunity to electrostatic discharges

Table 22 - Electrostatic discharges

<table>
<tr><td>Applicable standard:</td><td colspan="4">IEC 61000-4-2 [16]</td></tr>
<tr><td>Test method:</td><td colspan="4">Exposure to electrostatic discharges (ESD)</td></tr>
<tr><td>Object of the test:</td><td colspan="4">Verification of compliance with the provisions in R 139-1, 5.7 in the case of direct exposure to discharging an electric static charge as specified in R 139-1, 5.7.3 b or to the effect of such discharges in the neighborhood of the EUT</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="4">The test comprises exposure of the EUT to electrical discharges.
An ESD generator and test setup shall be used with a performance as defined in the referred standard, which includes complying with the dimensions, materials used and conditions.
Before starting the tests, the performance of the generator shall be verified.
At least 10 discharges per preselected discharge location shall be applied. The time interval between successive discharges shall be at least 1 second.
For an EUT not equipped with a ground terminal, the EUT shall be fully discharged between discharges.
Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied.
Direct application:
• in the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT before activation of the discharge;
• in the air discharge mode on insulated surfaces, the EUT is approached by the charged electrode until a spark discharge occurs.
Indirect application:
• the discharges are applied in the contact mode to coupling planes mounted in the vicinity of the EUT.</td></tr>
<tr><td rowspan="3">Test level [1)]specifications:</td><td>Parameter</td><td>Mode</td><td>Value</td><td>Unit</td></tr>
<tr><td rowspan="2">Test voltage</td><td>contact discharge</td><td>6</td><td>kV</td></tr>
<tr><td>air discharge</td><td>8</td><td>kV</td></tr>
<tr><td>Allowed effect:</td><td colspan="4">Either the difference between any indication during the test and the indication under reference conditions shall not exceed the fault limit values given in R 139-1, 5.6 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10.</td></tr>
<tr><td>Note:</td><td colspan="4">[1)] In this case “level” means up to and including the specified level (i.e. the test shall also be performed at the specified lower levels in the standard).</td></tr>
</table>

3.9.4.4 Immunity to surges

Table 23 - Surges on AC and DC mains power lines

<table>
<tr><td>Applicable standard:</td><td colspan="4">IEC 61000-4-5 [19]</td></tr>
<tr><td>Test method:</td><td colspan="4">Introducing electrical surges on the mains power lines</td></tr>
<tr><td>Object of the test:</td><td colspan="4">Verification of compliance with the provisions in R 139-1, 5.7 under conditions where the electrical surges as specified in R 139-1, 5.7.3 c are superimposed on the mains supply voltage</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="4">A surge generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT.
The test comprises exposure of the EUT to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard.
At least 3 positive and 3 negative surges shall be applied.
On AC mains supply lines the surges shall be synchronized with the AC supply frequency and shall be repeated such that injection of surges on all the 4 phase shift angles 0°, 90°, 180° and 270° with the mains frequency is covered.
On DC power lines, at least 3 positive and 3 negative surges shall be applied. The injection network depends on the lines the surge is coupled into and is defined in the referred standard.
The test pulses shall be continuously applied during the measuring time.</td></tr>
<tr><td rowspan="3">Test level specifications:</td><td>Parameter</td><td>Mode</td><td>Value</td><td>Unit</td></tr>
<tr><td rowspan="2">Surge voltage peak</td><td>Line to line:</td><td>1.0</td><td>kV</td></tr>
<tr><td>Line to earth:</td><td>2.0</td><td>kV</td></tr>
<tr><td>Allowed effect:</td><td colspan="4">After the application of the disturbance and recovery, either the difference between any indication before the test and the indication after the test shall not exceed the fault limit values given in R 139-1, 5.6.1 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10.</td></tr>
</table>

Table 24 - Surges on signal, data and control lines

<table>
<tr><td>Applicable standard:</td><td colspan="5">IEC 61000-4-5 [19]</td></tr>
<tr><td>Test method:</td><td colspan="5">Introducing electrical surges on signal, data and control lines</td></tr>
<tr><td>Object of the test:</td><td colspan="5">Verification of compliance with the provisions in R 139-1, 5.7 under conditions where the electrical surges as specified in R 139-1, 5.7.3 d are superimposed on I/O and communication port</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="5">A surge generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT.
The test comprises exposure of the EUT to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard.
A 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 in the referred standard.
The test pulses shall be continuously applied during the measuring time.</td></tr>
<tr><td rowspan="5">Test level specifications:</td><td>Parameter</td><td>Cabling</td><td>Mode</td><td>Value</td><td>Unit</td></tr>
<tr><td rowspan="4">Surge voltage peak</td><td rowspan="2">Unbalanced lines</td><td>Line to line:</td><td>1.0</td><td>kV</td></tr>
<tr><td>Line to earth:</td><td>2.0 (1)</td><td>kV</td></tr>
<tr><td rowspan="2">Balanced lines</td><td>Line to line:</td><td>N/A</td><td>-</td></tr>
<tr><td>Line to earth:</td><td>2.0</td><td>kV</td></tr>
<tr><td>Note:</td><td colspan="5">(1) Normally tested with primary protection</td></tr>
<tr><td>Allowed effect:</td><td colspan="5">After the application of the disturbance and recovery, either the difference between any indication before the test and the indication after the test shall not exceed the fault limit values given in R 139-1, 5.6.1 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10.</td></tr>
</table>

3.9.4.5 Immunity to power source disturbances

Table 25 - AC mains voltage dips and short interruptions

<table>
<tr><td>Applicable standards:</td><td colspan="7">IEC 61000-4-11 [21], IEC 61000-6-2 [25]</td></tr>
<tr><td>Test method:</td><td colspan="7">Introduction of short-time reductions of mains voltage</td></tr>
<tr><td>Object of the test:</td><td colspan="7">Verification of compliance with the provisions in R 139-1, 5.7 under conditions of short time mains voltage reductions as specified in R 139-1, 5.7.1 e</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="7">A test generator shall be used which is suitable to reduce the amplitude of the AC mains voltage for the required period of time. The performance of the test generator shall be verified before connecting the EUT.
The mains voltage reduction tests shall be repeated 10 times with an interval of at least 10 seconds between the tests.</td></tr>
<tr><td rowspan="3">Test level specifications:</td><td>Test / Parameter</td><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>Unit</td></tr>
<tr><td>Amplitude reduction to</td><td>0</td><td>0</td><td>40</td><td>70</td><td>80</td><td>% of the rated voltage</td></tr>
<tr><td>Duration</td><td>0.5</td><td>1</td><td>10 (1) / 12 (2)</td><td>25 (1) / 30 (2)</td><td>250 (1) / 300 (2)</td><td>cycles</td></tr>
<tr><td>Allowed effect:</td><td colspan="7">During the application of the disturbance and recovery, either the difference between any indication before the test and the indication during the test shall not exceed the fault limit values given in R 139-1, 5.6.1 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10.</td></tr>
<tr><td>Notes:</td><td colspan="7">(1) Applicable for 50 Hz mains frequency
(2) Applicable for 60 Hz mains frequency</td></tr>
</table>

Table 26 - DC mains voltage dips, short interruptions and voltage variations

<table>
<tr><td>Applicable standard</td><td colspan="4">IEC 61000-4-29 [24]</td></tr>
<tr><td>Test method:</td><td colspan="4">Introduction of voltage dips, short interruptions and voltage variations on DC mains power lines</td></tr>
<tr><td>Object of the test:</td><td colspan="4">Verification of compliance with the provisions in R 139-1, 5.7 under conditions of voltage dips, voltage variations and short interruptions on DC mains power as specified in R 139-1, 5.7.1 g</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="4">A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified.
The EUT shall be exposed to voltage dips and short interruptions for each of the selected combinations of test level amplitude and duration, using a sequence of three dips/interruptions and intervals of at least 10 s between each test event.
The most representative operating modes of the EUT shall be tested three times at 10 s intervals in the most representative operating modes for each of the specified voltage variations.
The disturbances are applied during all the time necessary to perform the test; therefore, more disturbances than indicated above may be necessary.
During the tests, the EUT shall be in operation; simulated inputs are permitted. Tests shall be performed at a minimum of one flow rate.</td></tr>
<tr><td rowspan="8">Test level specifications:</td><td>Kind of test</td><td>Parameter</td><td>Value</td><td>Unit</td></tr>
<tr><td rowspan="2">Voltage dips</td><td>Voltage level</td><td>40 and 70</td><td>% of the rated voltage</td></tr>
<tr><td>Duration</td><td>0.1</td><td>s</td></tr>
<tr><td rowspan="3">Short interruptions</td><td>Impedance</td><td>High and/or low</td><td></td></tr>
<tr><td>Voltage level</td><td>0</td><td>% of the rated voltage</td></tr>
<tr><td>Duration</td><td>0.01</td><td>s</td></tr>
<tr><td rowspan="2">Voltage variations</td><td>Voltage level</td><td>85 and 120</td><td>% of the rated voltage</td></tr>
<tr><td>Duration</td><td>10</td><td>s</td></tr>
<tr><td>Allowed variations:</td><td colspan="4">During the application of the disturbance and recovery, either the difference between any indication before the test and the indication during the test shall not exceed the fault limit values given in R 139-1, 5.6.1 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10</td></tr>
</table>

Table 27 - Bursts (transients) on AC and DC mains and on signal lines

<table>
<tr><td>Applicable standard:</td><td colspan="5">IEC 61000-4-4 [18]</td></tr>
<tr><td>Test method:</td><td colspan="5">Introducing transients (bursts) on the mains power lines and on signal lines</td></tr>
<tr><td>Object of the test:</td><td colspan="5">Verification of compliance with the provisions in R 139-1, 5.7 under conditions where electrical bursts are superimposed on the mains voltage as specified in R 139-1, 5.7.1 c or R 139-1, 5.7.2 b and where applicable on input/output and communication ports as specified in R 139-1, 5.7.1 d or R 139-1, 5.7.2 c (whichever is applicable)</td></tr>
<tr><td>Test procedure in brief:</td><td colspan="5">A burst generator as defined in the referred standard shall be used.
The characteristics of the generator shall be verified before connecting the EUT.
The test comprises exposure to bursts of voltage spikes for which the output voltage on a 50 Ω and 1000 Ω load are defined in the referred standard.
Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity.
A capacitive coupling clamp as defined in the standard shall be used for coupling the bursts into the I/O and communication lines.</td></tr>
<tr><td rowspan="5">Test level specifications:</td><td colspan="2">Level index: (3)</td><td>2</td><td>3</td><td></td></tr>
<tr><td>Parameter</td><td>Bursts on:</td><td colspan="2">Value</td><td>Unit</td></tr>
<tr><td rowspan="2">Amplitude
(peak value):</td><td>supply lines (1)</td><td>1</td><td>2</td><td>kV</td></tr>
<tr><td>signal lines (2)</td><td>0.5</td><td>1</td><td>kV</td></tr>
<tr><td>Repetition rate:</td><td colspan="3">5</td><td>kHz</td></tr>
<tr><td>Allowed variations:</td><td colspan="5">During the application of the disturbance and recovery, either the difference between any indication before the test and the indication during the test shall not exceed the fault limit values given in R 139-1, 5.6.1 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10</td></tr>
<tr><td colspan="6">Notes:
(1) Only for instruments powered by AC or DC mains power supply.
(2) I/O signal, data and control ports.
(3) Test level with the index 3 refers to R 139-1, 5.7.2 b or 5.7.2 c which apply for measuring systems which may be installed in an industrial environment</td></tr>
</table>

Table 28 - Ripple on DC mains power

Applicable standard:	IEC 61000-4-17 [22]
Test method:	Introducing a ripple on the voltage on the DC input power port
Object of the test:	Verification of compliance with the provisions in R 139-1, 5.7 under conditions of ripple on the low voltage DC mains power as specified in R 139-1, 5.7.1 h
Test procedure in brief:	A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified. The test comprises exposure of the EUT to ripple on the voltages such as that generated by traditional rectifier systems and/or auxiliary service battery chargers overlaying on DC power supply sources. The frequency of the ripple is the power frequency or a multiple (2, 3 or 6) 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. The test shall be applied for at least 10 min or for the period of time necessary to allow a complete verification of the EUT's operating performance. During the tests, the EUT shall be in operation; simulated inputs are permitted. Tests shall be performed for at least one flow rate.
Test level specifications:	Ripple 2 % of the nominal DC voltage (1)
Notes:	(1) The test levels are a peak-to-peak voltage expressed as a percentage of the nominal DC voltage.
Allowed variations:	During the application of the disturbance and recovery, either the difference between any indication before the test and the indication during the test shall not exceed the fault limit values given in R 139-1, 5.6.1 or the measuring system shall detect and act upon a potential significant fault, in compliance with R 139-1, 6.10

3.10 Type evaluation report

The type evaluation report shall comply with R 139-3.

3.11 Testing of modules

3.11.1 Meters or measurement transducers

3.11.1.1 A type approval may be granted for a complete meter; it may also be granted for the measurement transducer only when this is intended to be connected to different types of calculators.

The examinations and tests shall be carried out on the meter alone or on the measurement transducer using appropriate devices. However, these may be carried out on the whole measuring system when it can be assumed that it will not influence the conclusion concerning the meter or the measurement transducer. The maximum permissible errors applicable to the meter apply in all cases.

Tests are normally carried out on the complete meter, fitted with an indicating device, with all the ancillary devices and with the correction device, if any. However, the meter subject to testing need not be fitted with its ancillary devices when the latter are not likely to influence the accuracy of the meter and when they have been verified separately (for example: electronic printing device). The measurement transducer may also be tested alone provided that the computing and indicating device has been subject to a separate type approval. If this measurement transducer is intended to be connected to a calculator fitted with a correction device, the correction algorithm as described by the manufacturer must be applied to the output signal of the transducer to determine its errors.

3.11.1.2 The test program specified in 3.3, 3.8 and 3.9 shall be performed on meters or measurement transducers.

3.11.2 Electronic calculators (including the indicating devices)

When an electronic calculator is submitted to separate tests, the tests are conducted on the calculator alone, simulating different inputs with appropriate standards.

3.11.2.1 Accuracy tests include an accuracy test on the indications of measurement results (mass or price to pay). For this purpose, the error obtained on the indication of the result is calculated considering the true value is the one calculated taking into account the value of the simulated quantities applied to inputs of the calculator and using standard methods for calculation. The maximum permissible errors are those fixed in 6.7.1 for the mass and only rounded errors for calculation of the price to pay.

3.11.2.2 Examinations and tests described in 3.8 and 3.9 shall be performed.

In general, the test volume is at least 10 000 scale intervals (see Annex A).

3.11.3 Emergency power supply

Where a test is deemed to be necessary to verify that the measuring system fulfils the requirement specified in R 139-1, 6.8.2, in general the instrument has to be supplied with electric power for a period of at least 12 hours preceding the test. Initially the battery (if provided) may be uncharged.

3.11.4 Ancillary devices providing or memorizing measurements results

3.11.4.1 On an ancillary device that provides primary indications, its indications shall be compared with those provided by an already approved indicating device having the same scale interval. Both mentioned indicating devices shall present exactly the same results.

As far as possible, the necessary conditions for compatibility with other devices of a measuring system have to be stated in the type approval certificate.

3.11.4.2 Specific electronic devices may be type evaluated separately when these are used for the transmission of primary indications or other information necessary for the determination of these indications. This applies, for example, for devices which compress information from two or more calculators and transmit it to a single printing device.

When the transmitted information comprises at least one analog (non- A/D converted) signal, the device shall be tested in conjunction with one of the other modules for which the maximum permissible error is specified in this Recommendation.

When the transmission only concerns digital information, the above provision may be applied as well; however, when the inputs and outputs of the device are available, the device may be tested separately, in which case it shall introduce no error or fault.

In both cases, the necessary conditions for compatibility with other devices of a measuring system shall be stated in the type approval certificate in the most extensive way.

3.11.4.3 If the ancillary device is a purely digital device, which

- is not needed to ensure correct measurement,
  - o or intended to facilitate the measuring operations,
  - o or could not in any way affect the measurement, and
- does not include the power supply for the measuring instrument, and
- is equipped with the necessary checking facilities,

the influence quantity tests do not need to be performed on the hardware of the ancillary device.

3.11.5 Self-service devices

Self-service devices are considered to be ancillary devices for which 3.11.4 is applicable.

3.11.6 Printing devices

Printing devices are considered to be ancillary devices for which 3.11.4 is applicable.

4 Initial verification

4.1 General considerations

The verification shall be carried out using suitable standards, having adequate accuracy. These standards shall be subjected to a suitable calibration program, assuring their traceability.

The initial verification of each individual instrument is intended to verify compliance with the requirements of 4–11 before being put into use.

As a general rule, tests should be carried out on the complete measuring system. If the size or configuration or the kind of test does not allow for the entire measuring system to be tested or if only a particular component or device of the system is concerned, the relevant test may be carried out on the applicable component or device separately. Such tests are only allowed to be performed if a simulated measurement setup can be achieved that reflects the rated operating conditions of the component or device.

The initial verification may be performed in two stages (see 4.4).

Note: Dismantling the instrument or its components for testing purposes is not what is intended.

4.2 Legal status of the instrument submitted for verification

Production measuring systems shall be in conformance with the approved type.

Initial verification of a measuring system includes a procedure to ensure that the individual measuring instruments conform to the approved type. But, notwithstanding this initial verification carried out by the appropriate legal authority or under its responsibility, the manufacturer has the full responsibility that the instrument complies with all the applicable requirements according to this Recommendation and other relevant requirements.

4.3 Initial verification in one stage

Initial verification of a measuring system may be carried out in a single stage provided that the system can be transported without being disassembled and can be verified under conditions representative of the intended conditions of use. The verification location may be the actual site where the system is to be operated. In other cases a two-stage initial verification shall be performed. When initial verification takes place in one stage, all examinations and tests in 4.4 to 4.6 shall be performed.

4.4 Initial verification in two stages

When initial verification takes place in two stages, the first stage shall include in principle the examinations below.

The first stage shall include

- an examination for conformity of the meter, including the associated ancillary devices (conformity with the respective types), and
- a metrological examination of the meter, including the associated ancillary devices.

The second stage shall include

- an examination for conformity of the measuring system, including the meter and the ancillary and additional devices, and
- a metrological examination of the measuring system; if possible, this examination is carried out within the limits of operating conditions for the system.

4.5 Examination at initial verification

Before starting the tests, the following examinations shall be performed (in the case of two stages, this shall be done as far as possible in the first stage):

- a visual inspection to determine the conformity with the approved type and to obtain a general appraisal of its design and construction (R 139-1, 6.1);
- completeness and correctness of the inscriptions/markings (R 139-1, 7);
- presence, completeness, and language of the documentation intended for the user (R 139-1, 8);
- compliance of the power supply voltage and frequency at the location of use with the specifications on the measuring instrument’s label;
- compliance of the practical environmental conditions with the relevant inscriptions and documentation;
- presentation of the measurement result (R 139-1, 5.1);
- (if applicable) adequate visibility of the indication(s) for the customer (R 139-1, 6.12.1.6);
- printing device and type of paper (R 139-1, 6.2.9.6);
- measuring range (R 139-1, 5.3);
- resolution (R 139-1, 5.1.4);
- verification of the measurements for protection against fraud where specified in the certificate of the approved type (R 139-1, 6.9);
- completeness of hardware such as durable storage/printing device and its compliancy with the approved type (R 139-1, 6.3, 6.2.9);
- compliance of the software with the approved type (R 139-1, 6.11);
- sealing devices (R 139-1, 9);
- provisions for stamping (R 139-1, 10);
- suitability for testing (R 139-1, 11).

4.6 Tests at initial verification

4.6.1 Metrological preconditions for performing tests

The performance tests shall be executed under rated operating conditions.

Before starting the tests, it shall be verified that the measuring system is switched on for the time period which, according to the manufacturer’s instructions, is considered to be sufficient to allow thermal stabilization (see R 139-1, 8.2 c).

4.6.2 Fluid to be used for the tests

When specified by the manufacturer and validated by type evaluation, the verification of a measuring system or of a meter intended to measure gas may be carried out with air (or with another fluid). In this case and if necessary, the type approval certificate will provide a more restricted range or a shift for maximum permissible errors, so that compliance with the maximum permissible errors will be fulfilled when measuring gas.

4.6.3 Stages of initial verification

4.6.3.1 At each stage the tests shall be performed with the gas or the gases to be measured except when the type approval certificate allows for an approach different from those as laid down in this Recommendation.

4.6.3.2 During the first stage at least the measuring device is involved (stand-alone or fitted with associated ancillary devices, or possibly included in a sub-system). Tests concerning the first stage may be carried out on a test bench, possibly in the factory of the manufacturer, or on the installed measuring system.

4.6.3.3 The calculator shall also be involved in this first stage. If necessary, the measuring device associated with the metering calculator may be verified separately from the operational calculator.

4.6.3.4 The second stage concerns the measuring system in actual working conditions. It is performed on the site of installation within actual operating conditions. The second stage may, however, be carried out at an alternative location chosen by the verification body if it is possible to transport the measuring system without disassembling it and when the tests can be performed under the intended operating conditions for the measuring system.

4.6.3.5 The initial verification of the electronic part of the measuring system shall include a procedure for verifying the presence and correct functioning of checking facilities if it is not possible to fully ensure conformity of these aspects during the type evaluation.

4.6.4 Tests to be performed

The testing procedure considered to be the ideal procedure is specified in 4.6.5. However, alternatively the more practical procedure specified in 4.6.6 may be applied. For hydrogen fuel measuring systems alternatively the procedure specified in 4.6.7 may be applied.

4.6.5 Preferred procedure

Note: For the numbers of the tests quoted in the following sub clauses refer to Table 5 in 2.2.7.2.1 and to Table 6 in 2.2.7.3.

4.6.5.1 The initial verification shall include at least the following:

- for all measuring systems, one test in any one possible condition available in the refueling station, provided that if applicable, the bank pressures shall be such that refueling into the specified test cylinders will cause the activation of all stages of the operation of the sequential control device;
- for measuring systems for refueling stations utilizing the sequential control device of a refueling station or systems that incorporate their own sequential control device, one test corresponding as far as possible to Test 1 (Test 3 may also be considered);
- for testing measuring systems that do not incorporate their own sequential control device or that are to be used in refueling stations not using a sequential control device, one test corresponding as far as possible to Test 4 (Test 6 may also be considered).

The type approval certificate may provide additional information on the tests to be performed.

4.6.5.2 At least one of the tests shall be performed on the site of the actual refueling station. Test 1 (and/or 3) or Test 4 (and /or 6), depending on the case, may be performed in the laboratory.

The test conditions shall be such that

- the maximum flow rate available in the particular refueling station for the particular measuring system shall be reached,
- the maximum flow rate available in the particular refueling station for the particular measuring system shall be smaller than or equal to the specified maximum permissible flow rate of the measuring system,
- the test conditions specified in 2.2.5.2 shall be met, and
- the sequential control action of the actual system shall be no faster than that used in the laboratory.

4.6.5.3 The tests can be performed at ambient temperature if within the rated operating conditions, whereby

a) each applicable test shall be performed twice, and

b) each individual error shall fulfill the requirement on MPEs specified in R 139-1, 5.2.1 or 5.2.3, depending on whether the verification is carried out on site or in the laboratory.

4.6.6 Alternative procedure

- For this procedure the following conditions apply:
- The tests are performed in conditions available in the refueling station, provided that, if applicable, the bank pressures shall be such that refueling into the specified test cylinders will cause the activation of all stages of the operation of the sequential control device.
- The test conditions shall be such that the maximum observed flow rate during the tests is no less than 80 % of the theoretical maximum flow rate available in the particular refueling station for the particular measuring system.
- It shall be checked by design that the theoretical maximum flow rate available in the particular refueling station for the particular measuring system is smaller than or equal to the specified maximum permissible flow rate of the measuring system.
- The tests at initial verification are performed at ambient temperature within the rated operating conditions.
- Tests sufficiently representing the real conditions of use are performed. In general this condition is fulfilled when following the sequence:
    - filling the test receiver from empty to P_v;
    - venting the test receiver to a pressure of 0.5 P_v;
    - re-filling the test receiver from 0.5 P_v to P_v.
- This sequence provides two metrological results to be compared with the MPEs. Each applicable test is performed at least twice and as far as necessary to fulfill the requirement in the first paragraph of this sub clause.
- Each individual error shall fulfill the requirement on MPEs specified in R 139-1, 5.2.3.
- The type approval certificate may provide additional information on the tests to be performed.

4.6.7 Alternative procedure for hydrogen fuel measuring systems

4.6.7.1 For hydrogen measuring systems the tests can be performed on-site. Either of gravimetric method or master meter method should be used. The tests can be performed at ambient temperature.

4.6.7.2 Tests 4 and 5 shall be performed at least three times on the complete system and test 7 shall be performed at least twice. Each individual error shall not exceed the MPEs specified in R 139-1, 5.2 for the measuring system.

4.6.7.3 Each test may be performed consecutively under the same conditions or all of the tests may be performed in a cyclic consecutive order (e.g. in the sequence # 4, # 5, # 7, # 4, # 5, # 7, # 4 , # 5). For Test 4 and Test 5, the requirement on repeatability specified in R 139-1, 5.4 shall be fulfilled.

The type approval certificate may provide additional information on the tests to be performed.

4.7 Verification marks, seals and document

After successful initial verification, the verification marks and the seals shall be attached and/or an accompanying document shall be produced according to national regulations.

5 Subsequent verification

For countries having a system of mandatory subsequent verification, an interval between verifications not exceeding 5 years is suggested. If during type evaluation the meter has not been subjected to the durability test as specified in 2.2.7.5, it is suggested to set the interval between the initial verification and the first subsequent verification not to exceed a 2 years’ time period.

The subsequent verification shall be carried out using suitable standards, of adequate accuracy. These standards shall be subjected to a suitable calibration program, assuring their traceability.

As a rule, the tests for subsequent verification shall be carried out on the complete instrument.

5.1 Examination prior to the subsequent verification

A subsequent verification may only be performed provided that:

- prior to the execution of the subsequent verification evidence is available that at initial verification the measuring instrument or system was in conformity with the approved type and still may be expected to be;
- the actual operating conditions comply with the relevant inscriptions and documentation.
- Furthermore it shall be verified that at least
- the appropriate verification marks are undamaged,
- the period elapsed since the previous verification does not exceed the prescribed period by more than 10 %,
- the seals are not broken,
- (if applicable) the correct type of paper is used for printing (risk of fading when exposed to light), and
- (if applicable) the visibility of the indication(s) for the customer is adequate.

Any non-conformities concerning these preconditions shall be reported and, where needed, acted upon.

5.2 Tests at subsequent verification

5.2.1 Subsequent verification tests shall be carried out as specified in 4.6.

5.2.2 The first stage of the verification (of the meter) shall only be repeated if the protective marks on the measuring element of the meter have been damaged. This stage may be replaced by a test of the measuring system if the conditions for the first stage of the verification are met and if the measuring system can undergo testing with a delivered gas quantity corresponding to the minimum measured quantity and larger quantities. For the determination of the errors, the maximum flow rate should be reached where possible.

5.2.3 The ancillary devices shall be considered as having been subjected to the preliminary examination if the protective marks are not damaged. It is sufficient to carry out a reduced number of measurements during the simplified examination of the ancillary devices.

Annex A
Minimum test quantities for measuring systems and devices

(Informative)

Provided that the assumption appears valid that the largest contribution to the measurement uncertainty is the rounding of the digital scale interval s, the following may be considered.

In the case of a digital scale interval *s* and determination of the errors of a meter it can be demonstrated that the probability distribution is rectangular[2)] and that the standard uncertainty u_s is:

$$u_s = \frac{s}{\sqrt{6}}$$

When taking into account a coverage factor equal to 2, the corresponding expanded uncertainty *U* is:

$$U = 2\,u_s$$

The relation between the requirement on uncertainty during type evaluation and the tolerance *T* is:

$$U \leq \frac{T}{5}$$

This is true when:

$$\frac{10\,s}{\sqrt{6}} \leq T$$

A.1 When determining the error of a complete measuring system with MPE = ± 1.5 %

In this case T = MPE = 1.5 10^{-2} Q

The quantity *Q* is equal to:

$$Q = n\,s$$

Where *n* is the number of scale intervals.

This leads to:

$$\frac{10\,s}{\sqrt{6}} \leq 0.015\,n\,s$$

Resulting in:

$$n \geq \frac{1000}{1.5\,\sqrt{6}} = 272.16$$

And when rounded, resulting in $n \geq 273$

A.2 When determining the error of a meter with MPE = ± 1 %

In this case the MPE ratio = 1.5/1 implying: $n \geq 1.5 \cdot 272.16$ resulting in $n \geq 409$

A.3 When determining the repeatability of a meter with a tolerance = ± 0.6 %

In this case the MPE ratio = 1.5/0.6 implying: $n \geq 2.5 \cdot 272.16$ resulting in $n \geq 681$

A.4 When determining the repeatability of a measuring system with a tolerance = ± 1 %

In this case the MPE ratio = 1.5/1 implying: $n \geq 1.5 \cdot 272.16$ resulting in $n \geq 409$

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2) u_s for one reading of the digit *s* has a rectangular distribution and = $s/2 \times 1/\sqrt{3}$. For two readings (start and finish of run), u_s is $\sqrt{2} \times s/2 \times 1/\sqrt{3} = s/\sqrt{6}$ which yields the same result as a rectangular distribution over half of the digit.

A.5 When determining the error of a calculator

In this case $T = 5 \cdot 10^{-4}$ n s implying: $n \geq 272.16 \cdot 1.5\ 10^{-2} / 5 \cdot 10^{-4}$ resulting in $n \geq 8165$

A.6 When determining the fault of a measuring system, calculator or other device

In this case T = FL (Fault Limit); implying T = MPE /10 = $1.5 \cdot 10^{-3}$ n s resulting in $n \geq 2722$

Conclusion

In general and except for testing at the minimum measured quantity, it is proposed to perform tests corresponding to cases 1) to 4) on quantities corresponding to at least 1 000 scale intervals and to perform tests corresponding to cases 5) and 6) on quantities corresponding to 10 000 scale intervals. However, in case of necessity (long tests) 5 000 scale intervals are sufficient for case 6).

Annex B
Test methods for influence quantities for Coriolis meters

(Informative)

Although this Annex is informative, the guidelines below should be respected if it is decided to perform tests according to it.

B.1 Scope

This Annex describes how influence quantity tests may be performed for Coriolis meters without the test means specified in 2.2. It concerns the tests on performance with respect to the influence factors and the disturbances, i.e. the tests as specified in 2.2.7.6, 3.8 and 3.9. All other tests shall be performed according to the applicable sub clauses of 2.2.

The method described is a substitution static method, and therefore not applicable to accuracy tests required for the gas or substitution fluid. It may be used in those cases where it would not be feasible to perform the tests in a normal situation (for instance in order to avoid having to implement a climatic chamber with normal test means) or where testing means do not exist (for instance testing means fully controlling the temperature of the gas).

The method may be applied to other meters utilizing an electronic sensor/transducer but could necessitate specific considerations. However, actually its application is considered limited to Coriolis meters only (which is actually the general applied technology for CGF dispensers).

The test method is not to be applied on a complete measuring system and, based on case to case decisions, may be performed on the meter or on an appropriate part of the meter (EUT).

B.2 Preliminary considerations

When it is decided to test a Coriolis meter according to the methods described in this Annex the following aspects of this type of meter should be taken into account.

B.2.1 Low flow cut-off

Coriolis meters in general are equipped with what is typically referred to as a “low-flow-cut-off” feature. This feature will not allow a flow rate below this cut-off value to be measured. Flow rates above this value are registered (without subtraction of the low-flow-cutoff value) as a measurement. During testing, it could be desirable to monitor all flow rate indications, even if they are below the normal low-flow-cut-off value. Therefore, during most performance tests the low-flow-cut-off will need to be set to zero.

For the applicable tests of this Annex, the low-flow-cut-off shall be set to zero.

During normal on-site operation a cut-off value different to zero will need to be applied. Generally, in practice the optimal value depends on the zero-stability of the meter, the minimum measured quantity of the complete measuring instrument, and the application.

B.2.2 No-flow conditions

Typically, Coriolis meters are measuring continuously, meaning that independent of flow or no-flow conditions the same processes will keep running.

B.2.3 Temperature measurement

Most Coriolis meters are equipped with an internal temperature sensor for the purpose of correction. In this case, the meter shall be tested with the temperature measurement function activated.

B.2.4 Pressure measurement

Pressure transmitters may be connected to a Coriolis meter for various purposes. When this is the case, the meter shall be tested with the pressure measurement function activated.

B.2.5 Warm-up time

All Coriolis meters use electronics, which are partly analogue. Because the characteristics of analogue components are temperature-dependent, the device's characteristics are only stable when the electronics have reached a stable temperature. The test shall be performed in conditions representative of the warm-up time of the meter in the complete measuring system.

B.2.6 Coriolis sensor

All the currently known Coriolis meters basically comprise two sensors: a flow sensor (usually consisting of one or two parallel measurement tubes) and a temperature sensor for correction of the temperature dependent vibration properties of the flow sensor.

The primary measurement signals of a Coriolis meter are

- a time difference value related to the mass flow rate through the flow sensor,
- a resonant frequency related to the density of the gas in the flow sensor, and
- a resistance value related to the temperature of the measurement tube(s).

The measurement tube(s) is/are set into motion (a sinusoidal vibration) by means of an alternating current through one or more so-called drive coils. The movement of the measurement tubes is detected using at least two pick-off coils.

As stated above, usually a temperature sensor is implemented to be able to perform corrections on the flow signals. The vibrating tube will become more or less rigid, as a function of its temperature. As a consequence of this purely mechanical phenomenon, the temperature of the measurement tubes will affect the primary signals for mass and density.

Performance tests, including tests on climatic effects, have to be carried out to verify that measuring instruments (or components thereof) operate within their maximum permissible errors over their rated operating conditions. In the case of Coriolis sensors, two separate effects may occur as a consequence of changing temperatures: a mechanical effect due to the changing vibration properties of the measurement tubes and an effect on the device's electronics. Applying the influence quantity test condition, in this case ambient temperature, will lead to two separate effects on the Coriolis flow sensor. Bearing in mind the original purpose of the performance tests, it may be necessary to observe these two effects separately.

Consequently, even if some parts of the flow sensor may be considered as mechanical components, they need to be subjected to the influence of gas temperature in accordance with 2.2.7.6 (see B.3.6). These tests could be performed using a fluid instead of a gas.

B.2.7 Coriolis transducer

An electronic device which processes the primary analog measurement signals is connected to the sensors. These signals are subsequently processed by a calculating device and sent to outputs such as an indicating device and/or to the (main) calculator. Before the mass flow rate can be determined, two important calculations are performed: a correction calculation based on the temperature of the measurement tubes and an adjustment for the zero-setting of the device (see B.2.8).

B.2.8 Zero-setting

The vibration-related behavior of a Coriolis flow sensor is mainly determined by the method of installation, changes in temperature and changes in density. Since a Coriolis meter continuously processes the sensor signals, also during no-flow conditions, any time difference between the signals of the pick-off coils is converted into a mass flow rate. Depending on the properties of the measurement tubes and the stresses on the tubes caused by the installation, a mass flow rate may also be observed during no-flow conditions. The observed mass flow rate during no-flow conditions is known as the zero-flow. After input of special commands the zero-flow value is determined by the measurement device. This value (which can be either a positive or a negative mass flow rate) is stored and memorized in the Coriolis transducer and subtracted from, or added to the flow rate values determined by the transducer.

B.3 Test methods

B.3.1 Categories of test methods for influence factors at type evaluation

The tests can be divided into three categories:

influence factor tests in 3.8;

disturbance tests in 3.9;

specific gas influence factor tests (2.2.7.6).

For each of these categories, specific information on the test method is given, although the same general principle applies.

B.3.2 General principle

All performance tests applicable to a certain EUT are performed one after another in one series of tests. Before the series of tests, the EUT's performance under reference conditions is determined. For each influence quantity, another test is then performed during the application of the quantity or after its application, according to what is appropriate. In the case of an effective influence, a change in flow rate (CF) is observed.

For the tests defined in 3.8 and 3.9, a virtual flow signal is created by implementing a systematic offset to obtain a flow rate as close as possible to $Q_{min.}$ The implementation of this offset must allow the detection of the disturbance effects on the electronic components of the sensors (including the coils). If this is not the case, the method described below for the application of 2.2.7.6 should be considered.

For the application of 2.2.7.6 the actual signal at zero flow is considered. For this purpose the low-flow-cut-off is set to zero.

For each influence quantity CF is recorded and the relative influence (RCF) is determined using the formula:

RCF (%) = CF / Q_{min} × 100

Note: For the application of B.2.6, RCF decreases as the flow rate increases and a reference to the minimum flow rate in the formula provides the most severe criterion.

The value of RCF shall be smaller than the applicable MPE or the fault limit value, according to the case.

During each measurement, the flow rate of the meter is monitored. In this way information on the stability of the device is obtained immediately. For the measurement under reference conditions, the flow rate should be stable. For some tests under influence quantities, some fluctuations in the flow rate are acceptable.

As a general principle, the selected flow rate should be the flow rate which generates a maximum flow rate variation. However, when it can be assumed that the flow rate which provides the larger variations may only concern pure transitory phenomena without leading to any inaccurate measurements, another flow rate may be chosen which provides a better match to the practical application.

B.3.3 Before starting the tests

To prevent damage to the flow sensor due to temperature expansion or contraction, except where necessary, the flow sensor should not be closed by means of rigid blinding flanges.

Before the temperature of the gas is fully stabilized, temperature convection will cause small flows of gas to move up and down through the EUT. On some meters this will appear as a flow indication where none is expected.

B.3.4 Specific aspects of the test method for influence factors

The object of an influence factor test is to verify that the EUT operates within its maximum permissible errors.

For ambient temperature tests, it should be possible to test the effects on the EUT's electronics separately when the mechanical effect due to changing the temperature of the tube can be eliminated. When one pick-off coil is connected in parallel to both applicable inputs, the mechanical effect of temperature changes is eliminated, whereas an effect on the electronics is still observed.

Where the effect of the influence factor on the mechanical parts of the EUT can be eliminated, the MPEs specified for the calculator in R 139-1, 6.7 apply.

Where the effect of the influence factor on the mechanical parts of the EUT cannot be eliminated, the MPEs specified for the meter in R 139-1, 5.2.1 apply.

B.3.5 Specific aspects of the test method for disturbances

Where tests are applied which are intended to simulate potential disturbances, the fault shall in all cases not exceed the fault limit.

B.3.6 Specific aspects of the test method for the gas influence factors

The complete flow sensor shall be used in the test; the applicable MPEs are those specified for the meter. The temperature correction shall be active and operate in the same manner as during normal measurements.

If it is not possible to heat up or cool down the gas inside the flow sensor to the required temperatures, the complete flow sensor may be placed in the temperature chamber. The measurements are performed when the temperature inside the flow sensor is stabilized at the temperature limits (T_{max} and T_{min}) of the rated operating conditions for the temperature of the gas specified by the manufacturer.

As an alternative, these tests may be performed using a liquid or air, nitrogen or some other gas provided that a sufficient level of equivalence is demonstrated.

For the test under the influence of pressure, the flanges closing the flow sensor shall be rigid enough so that the pressure limits (max and min) of the rated operating conditions for the pressure of the gas specified by the manufacturer may be reached.

When it is considered appropriate to test the meter according to the nature or density of the gas, the reference gas is that specified by the manufacturer.

Annex C
Description of selected software validation methods

(Informative)

C.1 Analysis of documentation and specification and validation of the design (AD)

Application:

Basic procedure, applicable during all software validation assessments.

Description:

The examiner evaluates the functions and features of the measuring instrument using the description in text and graphical representations and decides whether these comply with the requirements of the relevant OIML Recommendation. Metrological requirements as well as software-functional requirements (e.g. fraud protection, protection of adjustment parameters, disallowed functions, communication with other devices, update of software, fault detection, etc.) have to be considered and evaluated. This task may be supported by the Software Evaluation Report Format as presented in OIML D 31 [26], Annex B.

References:

For further details refer to OIML D 31 [26], 6.3.2.1.

C.2 Validation by functional testing of the metrological functions (VFTM)

Application:

For validating the correctness of algorithms for calculating the measurement value from raw data, for linearization of a characteristic, compensation of environmental influences, rounding in price calculation, etc.

Description:

Most of the evaluation and test methods described in OIML Recommendations are based on reference measurements under various conditions. Their application is not restricted to a certain technology of the instrument. Although not aimed primarily at validating the software, the test results can be interpreted as a validation of some parts of the software, in general those metrologically most important ones. If the tests described in the relevant OIML Recommendation cover all the metrologically relevant features of the instrument, the corresponding software parts can be regarded as being validated. In general, no additional software analysis or test has to be applied to validate the metrological features of the measuring instrument.

References:

For further details refer to OIML D 31 [26], 6.3.2.2 and the various specific OIML Recommendations.

C.3 Validation by functional testing of the software functions (VFTSw)

Application:

For validation of e.g. protection of parameters, indication of a software identification, software supported fault detection, configuration of the system (especially of the software environment), etc.

Description:

Required features described in the operating manual, instrument documentation or software documentation is checked in practice. If software is controlled and functions correctly, these features are to be regarded as validated without any further software analysis.

References:

For further details refer to OIML D 31 [26], 6.3.2.3 and the various specific OIML Recommendations.

C.4 Metrological dataflow analysis (DFA)

Application:

For analysis of the software design concerning the control of the data flow of measurement values through the data domains that are subject to legal control, including the examination of the software separation.

Description:

It is the aim of this analysis to find all parts of the software that are involved in the calculation of the measurement values or that may have an impact on them.

References:

For further details refer to OIML D 31 [26], 6.3.2.4.

C.5 Code inspection and walk through (CIWT)

Application:

Any feature of the software may be validated with this method if enhanced examination intensity is considered necessary.

Description:

The examiner walks through the source code assignment by assignment, evaluating the respective part of the code to determine whether the requirements are fulfilled and whether the program functions and features are in compliance with the documentation.

The examiner may also concentrate on algorithms or functions that he has identified as complex, error-prone, insufficiently documented, etc. and inspect the respective part of the source code by analyzing and checking.

References:

For further details refer to OIML D 31 [26], 6.3.2.5.

C.6 Software module testing (SMT)

Application:

Only if a high level of security and protection against fraud is required. This method is applied when routines of a program cannot be examined exclusively on the basis of written information and is appropriate and economically advantageous in validating dynamic measurement algorithms.

Description:

The software module under test is integrated in a test environment, i.e. a specific test program module that calls the module under test and provides it with all the necessary input data. The test program compares the output data from the module under test with the expected reference values.

References:

For further details refer to OIML D 31 [26], 6.3.2.6.

Annex D
Bibliography

(Informative)

Ref.	Standards and reference documents	Description
[1]	OIML V 2-200:2010with minor corrections ; 3rd Edition 2012 JCGM 200:2012	International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM). Vocabulary, prepared by a joint working group (JCGM) comprising by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, and OIML
[2]	OIML V 1:2013	International vocabulary of terms in legal metrology (VIML) (bilingual French-English) / Vocabulaire international des termes de métrologie légale (VIML)
[3]	OIML D 11:2013 *General requirements for measuring instruments - Environmental conditions*	Guidance document for establishing appropriate metrological performance testing requirements for environmental influence quantities that may affect the measuring instruments.
[4]	OIML G 1-100:2008 *Guide to the expression of Uncertainty in Measurement (GUM)*	Evaluation of measurement data - Guide to the expression of uncertainty in measurement
[5]	IEC 60068-2-1 Ed. 6.0 (2007-03) *Environmental testing* Part 2: *Test methods*- Section 1: Test A*: Cold*	Concerns exposure to low temperatures (cold) tests on both non-heat-dissipating and heat-dissipating specimens
[6]	IEC 60068-2-2 Ed 5.0 (2007-07) *Environmental testing* Part 2: *Test methods* – Section 2: Test B: *Dry heat*	Concerns exposure to high temperatures and low humidity (dry heath) tests on both non-heat-dissipating and heat-dissipating specimens and contains the following tests with gradual change of temperature: for non-heat-dissipating specimens, for heat-dissipating specimens and for heat-dissipating specimens powered throughout the test,
[7]	IEC 60068-2-30 Ed 3.0 (2005-08) *Environmental testing* Part 2-*Test methods* - Section 30 Test Db : *Damp heat, cyclic (12 + 12-hour cycle)*	Determines the suitability of components, equipment or other articles for use, transportation and storage under conditions of high humidity - combined with cyclic temperature changes and, in general, producing condensation on the surface of the specimen
[8]	IEC 60068-2-47 Ed 3.0 (2005-4) *Environmental testing* Part 2 *Test methods* - Section 47: *Mounting of specimens for vibration, impact and similar dynamic tests*	Provides methods of mounting components, and mounting requirements for equipment and other articles, for the families of dynamic tests in IEC 60068-2, that is impact (Test E), vibration (Test F) and acceleration, steady-state (Test G).
[9]	IEC 60068-2-64 Ed 2.0 (2008-04) *Environmental testing* Part 2: *Test methods,* Section 64: Test Fh: *Vibration, broad-band random and guidance*	Determines the adequacy of specimens to resist dynamic loads without unacceptable degradation of its functional and/or structural integrity when subjected to the specified random vibration test requirements.

Ref.	Standards and reference documents	Description
[10]	IEC 60068-3-1 Ed. 2.0 (2011-08) *Environmental testing* Part 3: *Supporting documentation and guidance* - Section 1: *Cold and dry heat tests*	Provides guidance regarding the performance of cold and dry heat tests.
[11]	IEC 60068-3-4 Ed. 1.0 (2001-08) *Environmental testing* Part 3: *Supporting documentation and guidance* - Section 4: *Damp heat tests*	The object of damp heat tests described is to determine the ability of products to withstand the stresses occurring in a high relative humidity environment, with or without condensation, and with special regard to variations of electrical and mechanical characteristics.
[12]	IEC 60068-3-8 Ed. 1.0 (2003) *Environmental testing* Part 3: *Supporting documentation and guidance* - Section 8: *Selecting amongst vibration tests*	Provides guidance for selecting amongst the IEC 60068-2 stationary vibration test methods Fc sinusoidal, Fh random and F(x) Mixed mode vibration.
[13]	IEC 60654-2 Ed. 1.0 (1979-01), with amendment 1 (1992-09) on Ed. 1.0 *Operating conditions for industrial-process measurement and control equipment* Part 2: *Power*	Provides the limiting values for power received by land-based and offshore industrial-process measurement and control systems or parts of systems during operation. Maintenance and repair conditions are not within the scope of this standard
[14]	IEC/TR 61000-2-1 Ed. 1.0 (1990-05) *Electromagnetic compatibility (EMC)* Part 2: *Environment* Section 1: *Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems*	This publication has the status of a technical report, and provides information on the various types of disturbances that can be expected on public power supply systems. The following disturbance phenomena are considered: - harmonics - inter-harmonics - voltage fluctuations - voltage dips and short supply interruptions - voltage unbalance - mains signalling - power frequency variation - DC components
[15]	IEC TR 61000-4-1 Ed.1.0 (2016-04) Basic EMC Publication *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques* Section 1: *Overview of IEC 61000-4 series*	Provides applicability assistance to the users and manufacturers of electrical and electronic equipment on EMC standards within the IEC 61000-4 series on testing and measurement techniques.
[16]	IEC 61000-4-2 Ed. 2.0 (2008-12) Basic EMC Publication *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques* Section 2: *Electrostatic discharge immunity test.*	Provides the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and from any person to adjacent objects. It additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures.
[17]	IEC 61000-4-3 consolidated Ed. 3.2 (2010-04) Basic EMC Publication *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques* Section 3: *Radiated, radio-frequency, electromagnetic field immunity test*	Provides the immunity requirements of electrical and electronic equipment to radiated electromagnetic energy. It establishes test levels and the required test procedures. Establishes a common reference for evaluating the performance of electrical and electronic equipment when subjected to radio-frequency electromagnetic fields from any source.

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[18]	IEC 61000-4-4 Ed. 3.0 (2012-04) *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques* Section 4: *Electrical fast transient/burst immunity test*	Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/bursts on supply, signal, control and earth ports.
[19]	IEC 61000-4-5 Ed. 3.0 (2014-5) *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques* Section 5: *Surge immunity test*	Provides the immunity requirements, test methods, and range of recommended test levels for electrical and electronic equipment to unidirectional surges caused by overvoltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions.
[20]	IEC 61000-4-6 Ed 4.0 (2013-10) *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques* Section 6: *Immunity to conducted disturbances, induced by radio-frequency fields*	Provides the immunity requirements of electrical and electronic equipment to conducted electromagnetic disturbances originating from intended radio-frequency (RF) transmitters in the frequency range 9 kHz up to 80 MHz. Equipment not having at least one conducting cable (such as mains supply, signal line or earth connection), which can couple the equipment to the disturbing RF fields is excluded.
[21]	IEC 61000-4-11 Ed.2.0 (2004-03) *Electromagnetic compatibility (EMC)* Part 4: *Testing and measuring techniques* Section 11:*Voltage dips, short interruptions and voltage variations immunity tests*	Provides the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. It applies to equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz AC networks. It does not apply equipment for connection to 400 Hz AC networks
[22]	IEC 61000-4-17 Consolidated Ed. 1.2 (2009-01) (incl. am. 1& am.2) *Electromagnetic compatibility (EMC) –* Part 4: *Testing and measurement techniques* Section 17: *Ripple on DC input power port immunity test*.	Provides test methods for immunity to ripple at the DC input power port of electrical or electronic equipment. This standard is applicable to low-voltage DC power ports of equipment supplied by external rectifier systems, or batteries which are being charged This test does not apply to equipment connected to battery charger systems incorporating switch mode converters.
[23]	IEC 61000-4-20 Ed 2.0 (2010-08) *Electromagnetic compatibility (EMC)* Part 4: *Testing and measurement techniques;* Section 20: *Emission and immunity testing in transverse electromagnetic (TEM) waveguides*	Provides radiated immunity test methods for electrical and electronic equipment using various types of transverse electromagnetic (TEM) waveguides. These types include open structures (for example, striplines and electromagnetic pulse simulators) and closed structures (for example, TEM cells).
[24]	IEC 61000-4-29 Ed. 1.0 (2000-08) *Electromagnetic compatibility (EMC) –* Part 4: *Testing and measuring techniques,* Section 29: *Voltage dips, short interruptions and voltage variations on DC input power port immunity tests*	Provides test methods for immunity to voltage dips, short interruptions and voltage variations at the DC input power ports of electrical or electronic equipment. This standard is applicable to low voltage DC power ports of equipment supplied by external DC networks.

Ref.	Standards and reference documents	Description
[25]	IEC 61000-6-2 Ed. 3.0 (2016-08) *Electromagnetic compatibility (EMC) –* Part 6 *Generic standards –* Section 2: *Immunity for industrial environments*	Defines the immunity performance requirements for electrical and electronic apparatus intended for use in industrial environments, both indoor and outdoor and for which no dedicated product or product-family immunity standard exists. This Standard also applies to apparatus which are battery operated and intended to be used in industrial locations
[26]	OIML D 31:2008	General requirements for software controlled measuring instruments