GEN – GENERAL CODE

COMBINED PROPOSAL:

GEN-19.1 D G-T.5. Tolerances on Tests When Transfer Standards are Used., Appendix A, Section 3.2. Tolerances for Standards., and Appendix D – Definitions: standards, field., ~~transfer standard.~~ and standard, transfer.

OTH-22.1 Appendix A: Fundamental Considerations, 3. Testing Apparatus

Note: *These proposals are a combined modification of the 2021 S&T Agenda Block 1 Item GEN-19.1 and OTH-22.1. Since the S&T Committee has changed item GEN-19.1 from "assigned" to "developing," the submitter has worked with NIST OWM to revise and combine the original proposals of GEN-19.1 AND OTH-22.1 to address discussions within the NCWM Field Standards Task Group and other comments received at the regional weights and measures meetings on the proposals. These items are related, so they are submitted as a single proposal.*

Source:
The NIST Office of Weights and Measures and Seraphin Test Measure Company have combined their previously separate proposals into a single proposal.

Purpose:

(a) Add a tolerance statement to the General Code that applies whenever a Type 2 transfer standard is used;

(b) Clarify in the Fundamental Considerations (Appendix A of Handbook 44) that the authority to approve field test standards rests with the regulatory official and that specific types of field test standards need not be identified in the body of a Handbook 44 Code in order to be approved by the weights and measures director;

(c) Add text to Section 3.2. Tolerances for Standards of the Fundamental Considerations (Appendix A of Handbook 44) to recognize the wide range of transfer standards already recognized in Handbook 44, explain the critical differences between field standards and transfer standards, and to specify the formula to be used to calculate the device tolerance when the uncertainty of the transfer standard exceeds the one-third requirement; and

(d) Add definitions to Appendix D of Handbook 44 for field standard and Type 1 and Type 2 transfer standards that identify the critical characteristics for field and transfer standards.

Item Under Consideration:
Amend Handbook 44, General Code as follows**:**

G-T.5. Tolerances on Tests When Type 2 Transfer Standards Are Used. – When Type 2 transfer standards are used, the following formula shall be used to compute the tolerance applicable to the device under test:

Increased MPE = (2/3 x MPE + U)

with an upper limit of U_{MAX} = 2/3 MPE

Where MPE is the basic tolerance that applies when using a basic reference standard; and

U = uncertainty associated with the Type 2 transfer standard.

The increase in the applied tolerance when using a Type 2 transfer standard applies only to the basic tolerances for devices as defined in Handbook 44; that is acceptance, maintenance and minimum tolerances. Note that the repeatability tolerance and the special test tolerances are NOT increased.

Codes 5.56.(a) Grain Moisture Meters, 5.56.(b) Grain Moisture Meters, and 5.57. Near-Infrared Grain Analyzers are exempt from this requirement because NIST Handbook 159 has requirements for monitoring and retesting grain samples to ensure adequate stability and the tolerances for the devices under test already incorporate the uncertainty associated with the use of grain samples as transfer standards. The code 2.21. Belt-Conveyor Scale Systems Code is also exempt because relative and absolute tolerances are included in the code.

Amend Handbook 44 Appendix D – Definitions as follows.

Standard, Field. – A physical artifact, static or dynamic measurement device or a reference material that (a) meets the requirements of the Fundamental Considerations, Section 3.2., (b) is stable (accurate and repeatable) over an extended period of time (typically one year), (c) is valid (corrections that may be used) over the range of environmental and operational parameters in which the commercial measuring devices are used, and (d) is traceable to the reference or working standards through comparisons, using acceptable laboratory procedures. [3.34, 3.38, 3.39, x.xx, x.xx…]

(Added 202X)

~~transfer~~ standard~~. – A measurement system designed for use in proving and testing cryogenic liquid-measuring devices. [3.38]~~

Standard, Transfer, Type 1 and Type 2. − A physical artifact, static or dynamic measurement device or a reference material that is proven to be stable (accurate and repeatable) for a short time under the limited environmental and operational conditions during which the transfer standard is used. A Type 1 transfer standard is a transfer standard that meets the one-third accuracy requirement for a short time over a limited range of environmental conditions and/or a limited range of operating conditions in which it is used. A Type 2 transfer standard is one that does not meet the one-third requirement and may not be stable or valid over an extended time period or over wide ranges of environmental or operating conditions. (3.34, 3.38, 3.39, x.xx, x.xx…]

(Added 202X)

Amend Handbook 44, Appendix A: Fundamental Considerations as shown below. Delete Footnote 2 referenced in Section 3. Testing Apparatus of NIST Handbook 44 Appendix A, Fundamental Considerations, moving portions of the footnote into Section 3.1 as part of the proposed changes to Section 3.1 shown above. Note that no changes are proposed to Footnote 1.

~~[2] Recommendations regarding the specifications and tolerances for suitable field standards may be obtained from the Office of Weights and Measures of the National Institute of Standards and Technology. Standards will meet the specifications of the National Institute of Standards and Technology Handbook 105-Series standards (or other suitable and designated standards). This section shall not preclude the use of additional field standards and/or equipment, as approved by the Director, for uniform evaluation of device performance.~~

3.1. Adequacy.~~[2]~~ – Tests can be made properly only if, among other things, adequate testing apparatus is available. Testing apparatus may be considered adequate only when it is properly designed for its intended use, when it is so constructed that it will retain its characteristics for a reasonable period under conditions of normal use, when it is available in denominations appropriate for a proper determination of the value or performance of the commercial equipment under test, and when it is accurately calibrated.

3.1.1. Essential Elements of Traceability. To ensure that field test standards and test methods provide for measurements that are traceable to the International System of Units (SI), through NIST or other National Metrology Institutes, they must satisfy the "Essential Elements of Traceability." As explained in NIST IR6969 GMP-13 Good Measurement Practice for Ensuring Metrological Traceability, these elements include the following.

- **Realization of SI Units**
- **Unbroken Chain of Comparisons**
- **Documented Calibration Program**
- **Documented Measurement Uncertainty**
- **Documented Measurement Procedure**
- **Accredited Technical Competence**
- **Measurement Assurance**

3.1.2. Specifications for Standards. Standards will meet the specifications of the National Institute of Standards and Technology Handbook 105-Series standards or other appropriate designated documentary standards (e.g., ASTM, ASME, etc.). Recommendations regarding the specifications and tolerances for suitable field standards may be obtained from the Office of Weights and Measures of the National Institute of Standards and Technology.

3.1.3. Authority for Approving Field Test Standards and/or Equipment. This section shall not preclude the use of additional field standards and/or equipment, as approved by the Director, for uniform evaluation of device performance. Specific types of field test standards are not required to be identified in a NIST Handbook 44 code in order to be considered suitable. Provided the standards meet the "Essential Elements of Traceability" (described in Section 3.1.1. above) that help ensure the standards are suitable and capable of supporting measurements traceable through NIST or other National Metrology Institutes, they need only be approved by the Director.

3.2. Tolerances for Standards. – Except for work of relatively high precision, it is recommended that the accuracy of **field** standards used in testing commercial weighing and measuring equipment be established and maintained so that the use of corrections is not necessary. When the **field** standard is used without correction, its combined error and uncertainty must be less than one-third of the applicable device tolerance.

Device testing is complicated to some degree when corrections to standards are applied. When using a correction for a standard, the uncertainty associated with the corrected value must be less than one-third of the applicable device tolerance. The reason for this requirement is to give the device being tested as nearly as practicable the full benefit of its own tolerance.

Whenever possible and practical, field standards should be used to test commercial devices. However, where it is impractical or unduly cumbersome to use field standards, transfer standards may be used. There are two categories of transfer standards. The critical criteria that distinguish between these standards are: (1) the accuracy and uncertainty of the standard; (2) the stability as a standard over an extended period; and (3) proven validity or performance of the standard over the range of environmental and operational conditions in which the standard may be used.

A "field standard" is one that meets the one-third requirement mentioned earlier in this section. Additionally, the field standard maintains its validity or stability as a standard over an extended period (defined based on data of the standard's stability by an authorized metrology lab or as specified by the Director) and is known to maintain its value as a standard over the full range of environmental conditions and the range of operating conditions in which the standard may be used to test commercial weighing and measuring devices. Corrections, as documented by an authorized metrology laboratory, may be used.

Commented [BTG(1]: We might want to avoid a specific time of "1 year" since some jurisdictions specify other timelines and might raise this as a concern. This would allow the jurisdiction to define the timeline according to their data or their laws/regulations.

Transfer standards do not meet one or more of these critical criteria. One category of transfer standards, which is referred to here as a "Type 1 transfer standard," is a transfer standard that meets the one-third accuracy requirement for a short time, under a limited range of environmental conditions and/or a limited range of operating conditions. The accuracy of a Type 1 transfer standard may have to be verified through

testing each time it is used to verify that the desired accuracy and performance can be achieved when the Type 1 transfer standard is used under the limited environmental and operating conditions. When a Type 1 transfer standard is used, the basic tolerances specified for the commercial measuring devices are applied as specified in the applicable codes.

The second category of transfer standard, which is referred to here as a "Type 2 transfer standard," is one that does not meet the one-third requirement. The Type 2 transfer standard must be stable and valid under the environmental or operating conditions in which it is used. The performance characteristics must be confirmed with sufficient data to properly characterize the uncertainty associated with the Type 2 transfer standard. When a Type 2 transfer standard is used, the tolerances applicable to the commercial weighing and measuring device must be increased to recognize the large uncertainty or corrections associated with the Type 2 transfer standard. When commercial meters are tested using a Type 2 transfer standard, the tolerance applied to the meter under test shall be determined as specified in the General Code.

(Added 202X)

3.3. Accuracy of Field Standards. – Prior to the official use of testing apparatus, its accuracy should invariably be verified. Field standards should be calibrated as often as circumstances require. By their nature, metal volumetric field standards are more susceptible to damage in handling than are standards of some other types. A field standard should be calibrated whenever damage is known or suspected to have occurred or significant repairs have been made. In addition, field standards, particularly volumetric standards, should be calibrated with sufficient frequency to affirm their continued accuracy, so that the official may always be in an unassailable position with respect to the accuracy of his testing apparatus. Secondary field standards, such as special fabric testing tapes, should be verified much more frequently than such basic standards as steel tapes or volumetric provers to demonstrate their constancy of value or performance.

Accurate and dependable results cannot be obtained with faulty or inadequate field standards. If either the service person or official is poorly equipped, their results cannot be expected to check consistently. Disagreements can be avoided and the servicing of commercial equipment can be expedited and improved if service persons and officials give equal attention to the adequacy and maintenance of their testing apparatus.

Background and Discussion:
Item GEN-19.1 was assigned to the original submitter, Seraphin, for further development. As noted at the beginning of this item Seraphin has worked with NIST OWM to revise and combine the original proposals of GEN-19.1 and OTH-22.1. Consequently, NIST OWM has asked that OTH-22.1 be combined with GEN-19.1. For more information or to provide comment, please contact:

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The submitter of the original GEN 19.1 provided the following:

Over the last several years, there have been, and still are, proposals to recognize some types of meters as either transfer standards or as field standards. Handbook 44 already recognizes the use of many different types of master meters, other reference materials, or devices as transfer standards. This proposal is based upon the existing recognition and permitted use of transfer standards that are already in Handbook 44.

However, there is no common understanding among industry and weights and measures officials as to what distinguishes a field standard from a transfer standard. Consequently, changes are proposed to the Fundamental Considerations Section 3.2. and definitions are proposed for field standards and transfer standards to highlight the critical differences between these two types of standards. Any artifact, reference material or measuring device that meets the requirements of accuracy and repeatability as specified in Section 3.2. of the Handbook 44 Fundamental Considerations qualifies as a field standard. However, what has not been clearly understood is that **the field standard must meet Section 3.2. over the environmental and operational parameters in which the commercial measuring devices under test are used.** The ranges for these environmental and operational parameters may be very large and include:

- The range of flow rates at which the commercial meters under test operate (from the minimum to maximum flow rates for the meters);
- The range of air temperatures over which meters are used (perhaps 10° F to 105° F);
- The range of product temperatures over which meters are used (perhaps 10° F to 105° F, especially applicable for above ground storage tanks);
- The range of temperature differences that may exist between the product, the standard and the air over which meters are used (perhaps up to 50° F, especially for cold fuel in underground tanks and hot air temperatures);
- The range of pressures at which the pumping systems operate at different times and locations;
- The different products measured by similar meters; and
- Tests of multiple "standards" of the same type when used in different test system configurations (and "standards" of different sizes) to verify that the results agree and are consistent.

A range of environmental and operational parameters over which a transfer standard must meet the accuracy and repeatability requirements are more limited, that is, a transfer standard need only be accurate and repeatable over the conditions that exist for the "short" time that the transfer standard is used. Transfer standards may be tested before and after use to verify a commercial measuring device, so the range of conditions in which accuracy and repeatability may be relatively small. The transfer standard is only required to be accurate and repeatable during the time it is in use, which might be to test only one commercial device. For example:

- The range of flow rates at which the meters under test operate **at the time of the test**;
- The range of air temperatures that exist **at the time of the test**;
- The range of product temperatures that exist **at the time of the test**;
- The range of temperature differences that may exist between the product, the standard and the air **at the time of the test**;
- The range of pressures at which the pumping systems operate **at the time of the test**; and
- The product being measured by the meter **at the time of the test**.

A critical issue that has not be adequately addressed and defined is, "How long must a field standard remain valid (i.e., accurate and repeatable)?" Common sense dictates that the field standard must remain valid over an extended period of time. Transfer standards need only remain valid during their "short" period of use. Because (1) there are some many different types of field standards used to test commercial measuring devices, (2) there are so many transfer standards recognized in Handbook 44, and (3) the applications vary greatly, it isn't clear that a common minimum time period for field standards or for transfer standards can be established. Nevertheless, field standards must be valid and stable over long time periods and wide ranges of environmental and operational parameters as compared to transfer standards.

Additionally, transfer standards do not have to meet the one-third requirement for the uncertainty associated with its performance. Consequently, Handbook 44 typically specifies that the basic tolerances to be applied to the device under test be increased by two times the standard deviation of the transfer standard. This presumes that the transfer standard has been adjusted to have "zero error" or corrections are used to address any significant systematic errors in the transfer standard. This also applies when field standards are used. "The reason for this requirement is to give the device being tested as nearly as practicable the full benefit of its own tolerance."[1]

The submitter also provided the following possible opposing arguments:

[1] Handbook 44, Fundamental Considerations, Section 3.2.

I. There are several proposals before the S&T Committee to recognize some meters as field standards and field standard reference meters. These proposals have not specified how the proposed field standards are to be tested to demonstrate compliance with the Fundamental Considerations requirements of Section. 3.2. It is possible that some companies will push for the recognition of meters as field standards without submitting data to support their claims of performance as field standards.

II. It is very difficult, time consuming and expensive to test meters that are proposed for use as field standards, especially to test using different fuels over the range of temperatures that exist for commercial applications and for temperature differences between the fuel and the air. It is possible that some will object to having to prove meter performance over the range of environmental and operational parameters.

III. It is possible that some companies will want to use performance data collected under laboratory conditions as being indicative of the expected performance of the meters under field conditions.

IV. Laboratory calibration procedures may not reflect the performance of the proposed field standard under field conditions.

V. Some companies may object to the cost of collecting data for transfer standards (meters) of different sizes and with different flow rate ranges to prove that the results for the different sized transfer standards (metering systems) will produce consistent test results on the same commercial meters.

VI. Establishing a reasonably good estimate of the standard deviation associated with a transfer standard (to be added to the basic tolerances for the devices under test) may require significant time, effort and cost.

VII. Some companies may want to modify the device under test to be able to test the commercial measuring device, rather than testing the device as used.

The submitter states that these items are fully developed and requested that this be a Voting Item in 2022.

Background and Discussion for Item OTH-22.1 originally submitted by NIST Office of Weights and Measures.

Source:
NIST, Office of Weights and Measures

Previous Action:
New

Original Justification:
Footnote 2 of Handbook 44, Appendix A, Fundamental Considerations, Section 3. Testing Apparatus was added to:

(1) specify recommendations for suitable field test standards;
(2) require that field test standards meet specifications in Handbook 105 Series or other appropriate documentary standards; and
(3) note that guidance may be obtained from NIST OWM regarding appropriate specifications, tolerances, and other criteria for assessing the suitability of a field test standard for use in inspecting and testing commercial weighing and measuring equipment.

Footnote 2 also recognizes that the Director has the authority to approve additional field test standards and/or equipment beyond those recommended by NIST or specified in a Handbook 105 or other documentary standard. NIST OWM periodically receives inquiries regarding the use of various types of test equipment and test methods. OWM has worked with state weights and measures programs and industry to develop standards and procedures and recommendations on the use of such equipment/methods and, in some cases this has resulted in a specific recommendation or Handbook 105. However, as recognized, in Footnote 2, this does not preclude the Director from approving equipment for which a specific Handbook 105 or other documentary standard does not exist.

In order to be considered suitable for use in official testing of a commercial weighing or measuring device, field test standards and procedures need to meet a list of what is often referred to as the "Essential Elements of Traceability." This list includes elements outlined in NIST IR6969 GMP-13 Good Measurement Practice for Ensuring Metrological Traceability shown above in the proposed Section 3.1.1. Essential Elements of Traceability. Provided steps are taken to ensure that a given field test standard has been demonstrated to meet the requirements in these elements, it is appropriate for that field test standard to be used in the official inspection and testing of a commercial weighing or measuring device or for use by a service company in testing and placing a device back into service after service work.

While Footnote 2 already provides a statement regarding the authority of the Director to approve such equipment, OWM believes including additional information regarding the essential elements of traceability and a reference to specific measurement practices would be helpful to both emphasize that authority and provide guidance to Directors and industry regarding the selection of appropriate field test standards.

NIST OWM recommends the guidance originally included in Footnote 2 along with the additional references to the "Essential Elements" described above are best included in the body of Section 3 for clarity and ease of use. Consequently, OWM recommends deleting the existing Footnote 2 and incorporating its contents into the body of Section 3.

OWM also believes that some may erroneously believe that field test standards must be specifically listed within a NIST Handbook 44 code in order to be used in the inspection and testing of devices covered by that code. Providing a clear statement that this is not the case along with a reference to the required criteria may help alleviate this misunderstanding.

The submitter acknowledges that Footnote 2 already provides a clear statement that the Director has authority to approve standards which are not addressed by a NIST Handbook 105 Series handbook. Some might argue that the proposed inclusion of additional information and guidance is not necessary.

The submitter states that these items are fully developed and requested that this be a Voting Item in 2022.

Additional Justification for the Formula in the Proposed G-T.5.

Assessment of the 2/3 Formula and the OIML "Reduced MPE" Formula

The 2/3 Formula: Increased MPE = (2/3 x MPE + U) with an upper limit of U_{MAX} = 2/3 MPE

OIML Formula: Reduced MPE = (4/3 × MPE – *U*)

Note: The general term "standard" is used in this paper to address both field standards and transfer standards. The specific terms "field standard" and "Type 2 transfer standard" (T2TS) distinguish between these two types of standards according to the proposed definitions submitted to the NCWM by Seraphin. Type 1 transfer standards (T1TS) are not addressed in this paper.

Based on the results of a discussion between one of the submitters (Seraphin) and Marc Buttler, Emerson - Micro Motion, the submitters agreed to recommend the 2/3 formula for use rather than the OIML formula. However, it is essential that an upper limit be established on the uncertainty associated with a Type 2 transfer standard (abbreviated as T2TS). The submitters agreed to recommend this upper limit not exceed 2/3 of the MPE of the commercial device under test. The same limit should be used if the OIML formula is used.

Commented [BTG(2]: Wanted to provide some explanation of why we feel it is acceptable to deviate from the OIML formula with the condition of establishing the upper limit.

The OIML formula and the 2/3 formula are similar, but they take different approaches to establish the tolerances for the device under test. The 2/3 formula is more logical, more technically consistent with the Handbook 44 concept of Type 2 transfer standards, and it is easier to understand. The 2/3 formula combines the tolerance that remains to be used by the commercial device with the growing uncertainty of the T2TS into one total tolerance value, whereas the OIML Reduced MPE calculates only the tolerance applied to test of the commercial meter under test. When Type 2 transfer standards are used in the field, the uncertainties associated with the T2TS should be recorded on the report form or a copy of the calibration certificate should be left with the test report, so the uncertainty values are available on site and can be used in an analysis should the tests with another T2TS generate different results.

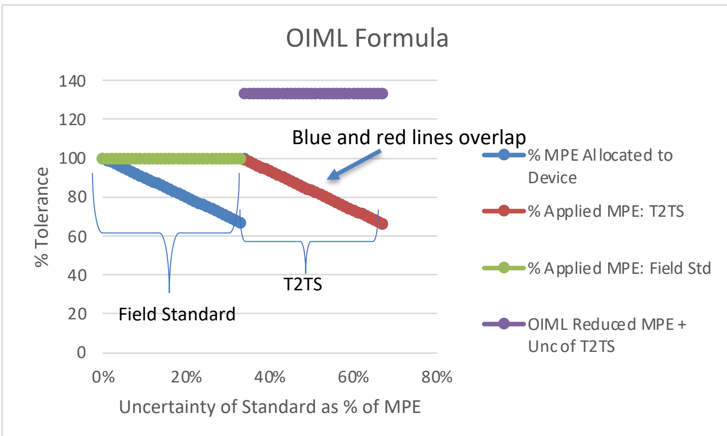
The most accurate reference standard that is available should always be used for any field test. However, when the only practical option for a field test that is available is a Type 2 transfer standard, the 2/3 formula will err in favor of the commercial device to avoid failing a device that should have passed. Conversely, the OIML Reduced MPE might result in failing a commercial device that would have passed had a more accurate (e.g., Type 1 transfer or field) reference standard been available to use for the test.

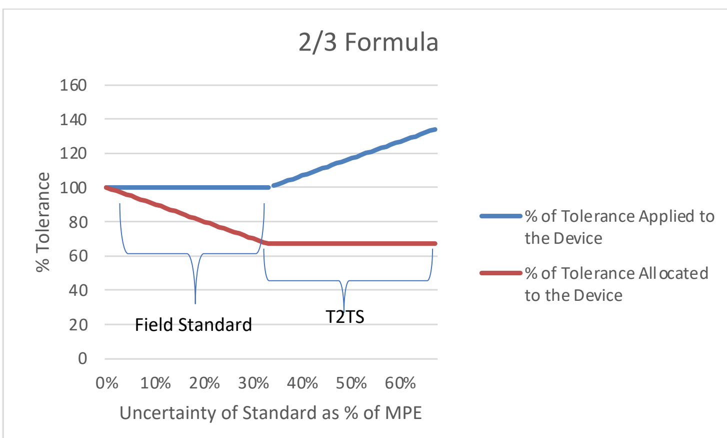
Conclusion

Field standards are intended to have an error and uncertainty less than or equal to 1/3 of the tolerance applied to the commercial device under test. When a Type 2 transfer standard has an uncertainty slightly greater than 1/3 of the tolerance, then, using the 2/3 formula, the total tolerance applied to the device under test increases above the H44 tolerance by the amount that the uncertainty associated with the Type 2 transfer standard exceeds the 1/3 limit, thereby establishing a total tolerance slightly greater than the H44 tolerances specified in the applicable codes and keeping the portion of the tolerance that remains allocated to the device under test at a constant level equal to 2/3 of the H44 tolerance. When the uncertainty for the Type 2 transfer standard exceeds 1/3 of the MPE, the OIML formula resets the "Reduced MPE" (applied tolerance) to 100% of the MPE. As the uncertainty of the Type 2 transfer standard gets larger and larger, the tolerance allocated to the device under test (e.g., a meter since OIML R117 applies to meters) gets smaller and smaller, to the extent that it is not realistic to use a T2TS to test a commercial meter, because the uncertainty of the T2TS uses up most of the device tolerance. The 2/3 formula is consistent with (but actually smaller than) the usual H44 tolerances that state that the basic tolerances are to be increased by two standard deviations when using a T2TS. Note that with a U_{MAX} of 2/3 MPE for the maximum uncertainty of the T2TS, the applied tolerance associated with the field test result using the 2/3 formula never exceeds 1.33 of the original H44 tolerance for the device under test. The submitters note that, while these principles and associated formula were established to apply to metering systems, the concepts can apply equally to other types of commercial weighing and measuring equipment.

Commented [BTG(3]: Referencing the fact that this concept was drawn from R117 which applies to meters, may prompt someone to question whether the entire proposal should be limited to transfer standards for metering systems. We want this proposal to apply more broadly.

The 2/3 formula specifies the total uncertainty as the device tolerance when a T2TS is used. The OIML formula generates only the tolerance applied to the meter under test when a T2TS is used. The OIML formula is designed to keep the **combined** Reduced MPE value plus the uncertainty associated with the T2TS equal to 1.33 MPE. The OIML formula should also have an upper limit for the uncertainty of the T2TS as well, which should be U_{MAX} of 2/3 MPE. Note that when there is an upper limit of 2/3 the MPE, then the OIML formula always has a tolerance (applied MPE or the Reduced MPE) that is greater than or equal to 2/3 of the original MPE. The OIML Reduced MPE is the tolerance applied to the reading of the meter under test compared to the reading of the T2TS. Consequently, the use of the Reduced MPE with a T2TS is a meter-to-meter or device-to-device tolerance.





The error in the device under test is determined as the difference between the indication of the device under test compared with the value represented or measured by the standard (usually presumed to have zero error or corrections are used for any errors in the standard).

The increase in the applied tolerance when using a Type 2 transfer standard applies only to the basic tolerances for devices as defined in Handbook 44, i.e., acceptance, maintenance and minimum tolerances.[2] Note that the repeatability

[2] **basic tolerances.** – Tolerances on underregistration and on overregistration, or in excess and in deficiency, that are established by a particular code for a particular device under all normal tests, whether maintenance or acceptance. Basic tolerances include minimum tolerance values when these are specified. Special tolerances, identified as such and pertaining to special tests, are not basic tolerances. [2.20, 2.22., 3.34, 3.38, 4.42, 5.54]

tolerance and the special test tolerances are NOT increased. [Note that the definition should apply to all codes, not just those listed with the definition, which do not include all codes that refer to basic tolerances.]

Explanation and Assessment

Field Standards: Uncertainty is Part of the Tolerance

Under the Fundamental Considerations, the correction and uncertainty of field standards are not to exceed 1/3 of the tolerance for the device under test. Under this condition, field standards are considered to be known values and the H44 tolerance is applied to the device under test without any consideration for the uncertainty associated with the field standard. The uncertainty associated with field standards may vary from nearly zero relative to the tolerance for the device under test up to 1/3 of the tolerance for the device under test. Even though the field standard may have an uncertainty as large as 1/3 of the tolerance applied to the device under test, the tolerance specified in H44 for the device is applied without consideration for the uncertainty associated with the field standard. The objective of this limit on the uncertainty associated with field standards "…is to give the device being tested as nearly as practicable the full benefit of its own tolerance."[3] Once the uncertainty associated with a "standard" exceeds the 1/3 limit, the "standard" no longer qualifies as a field standard, but is a Type 2 transfer standard under Seraphin's proposed definitions.

Type 2 Transfer Standards: Uncertainty is Added to the Tolerance

When the uncertainty associated with a T2TS exceeds 1/3 of the tolerance applied to the device under test, the uncertainty of the T2TS is recognized in the field test result by increasing the tolerance that is applied to the device under test. The OIML formula and the 2/3 formula take different approaches to increasing the tolerance for the device under test.

[3] Handbook 44, Fundamental Considerations, Section 3.2

	Field Standard	Field Standard	OIML Formula	OIML Formula	2/3 Formula	2/3 Formula
Uncertainty of Standard (as % of Tolerance)	% of MPE (Tolerance) Applied to the Device	% MPE (Tolerance) Allocated to Device	% of MPE Applied to the Difference in the Test Results Using a T2TS	OIML Reduced MPE and Uncertainty of T2TS (%)	% of Combined Tolerance and Uncertainty Applied to the Device	% of Combined Tolerance and Uncertainty Allocated to the Device
0%	100	100				
10%	100	90				
20%	100	80				
30%	100	70				
33%	100	67				
34%			99	133	101	67
40%			93	133	107	67
50%			83	133	117	67
60%			73	133	127	67
67%			67	133	133	67
70%			63	133	137	67
80%			53	133	147	67
90%			43	133	157	67
100%			33	133	167	67

The OIML formula increases the tolerance applied to the device under test by 1/3 minus the uncertainty of the T2TS as soon as the uncertainty of the Type 2 transfer standard exceeds the 1/3 limit. This increase recognizes the uncertainty that is up to 1/3 of the tolerance for field standards. Hence, the tolerance applied to the device under test plus the uncertainty of the T2TS is 1.33 times the original MPE when the uncertainty of the Type 2 transfer standard exceeds 1/3 of the MPE. As the uncertainty of the Type 2 transfer standard increases, the portion of the MPE allocated to the meter under test for the field test result decreases. If the uncertainty of the Type 2 transfer standard becomes very large, the poor accuracy and/or poor repeatability of Type 2 transfer standard makes its use ineffective.

In the 2/3 approach, the formula starts with 2/3 of the device tolerance (i.e., the MPE) apportioned to the device under test, which is the situation when the uncertainty of a field standard is exactly equal to 1/3 of the device tolerance. Next, the uncertainty associated with the T2TS is added to the 2/3 of the original MPE. Consequently, the tolerance (i.e., the MPE) applied to the field test gradually increases by the same amount as the uncertainty for the Type 2 transfer standard increases above the 1/3 level of the original MPE. An upper limit for the uncertainty of the T2TS is proposed to be 2/3 of the MPE, so that the uncertainty does not increase without limit and become meaningless. Hence, the tolerance applied to the device under test, when a T2TS has an uncertainty at the upper limit of 2/3 the MPE, the total tolerance plus the uncertainty will be 1.33 times the original MPE, which is equal to the maximum allowed by the OIML formula for the Reduced MPE plus the uncertainty of the T2TS when the uncertainty of the T2TS just exceeds the 1/3 limit.

The Impact of Large Uncertainties for Field and Transfer Standards

When different standards are used to test the same commercial devices, there is the possibility that the results will not agree exactly. As the uncertainties associated with the field or Type 2 transfer standards increase, then the probability increases that the field test results will not agree or even agree within tolerance. The concern is that some commercial devices could be tested with one standard and pass (or fail) the field tests, but, when tested with a different standard, some commercial devices would fail (or pass) the field tests. Consequently, it is important to keep the uncertainties associated with the standards used to test commercial devices as small as reasonably possible, so that the probabilities of getting different field test results when using different standards are reduced.