

Examples of Transfer Standards
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The following definitions are proposed for adoption in S&T Item Block 8, GEN-19.1. Examples of the different types of transfer standards begin on the next page.

Standard, Field. – A physical artifact, static or dynamic measurement devices, such as scales, meters, etc., or a reference material that (a) meets the requirements of the Fundamental Considerations, Section 3.2., (b) is stable (accurate and repeatable) over a designated period of time of use (as determined by the Director), (c) is valid (with corrections that may be applied) over the range of environmental and operational parameters in which the commercial measuring devices to be tested can be reasonably anticipated to be used, and (d) is traceable to the reference or working standards through comparisons, using acceptable laboratory procedures. [1.10]

Standard, Transfer, Type 1 and Type 2. – A physical artifact, static or dynamic measurement devices, such as scales, meters, etc., or a reference material that is demonstrated to be stable (accurate and repeatable) under the limited environmental and operational conditions and time during which the transfer standard is used. A Type 1 transfer standard is a transfer standard that meets the one-third accuracy requirement over a limited range of environmental conditions and/or a limited range of operating conditions and time 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. [1.10]

Examples of Transfer Standards

Handbook 44 allows for the use of both field standards and transfer standards. Field standards are any standard that has an accuracy and uncertainty less than one-third of the applicable tolerance that applies to the device being tested.¹ It is expected that the field standard will retain its characteristics for a reasonable period under conditions of normal use.² Consequently, the accuracy and repeatability over time of the standard used to test a device must be considered to determine if the standard meets the requires as field standard or if there are factors that limit the use of the standard in terms of (1) accuracy and uncertainty or (3) the period of time that it maintains its accuracy and uncertainty over time. This may include the transportation and setup of the standard from one location to another.

Some examples of transfer standards are provided below. Some factors that must be considered when assessing the use of transfer standards are provided for the initial examples to illustrate the thought process that goes into the evaluation and use of transfer standards. Later, other examples of transfer standards are listed, but factors to be evaluated are not listed.

1. Farm Milk Tanks Code 4.42: Master Meters, Type 2 transfer standard
 - a. The maintenance and acceptance tolerances for farm milk tanks is 0.2%. One-third of the tolerance is 0.067%.
 - b. Neck-type provers may be used as field standards, because the tolerance for neck-type provers stated in NIST Handbook 105-3 is 0.05%.
 - c. When master meters were recognized for use to test farm milk tanks, it was believed that, due to repeatability considerations, they could not meet the accuracy and uncertainty requirement of 0.067%. Consequently, the tolerances for farm milk tanks when master meters are used was set at 0.4% (See paragraph T.4.).
 - d. Additionally, there was a concern that master meters could potentially change accuracy during transport from one location to another and even during the time it is used to check a milk tank. Hence, test note N.5.1. states that a master meter must be tested before and after the gauging process. Additionally, the accuracy of the master meter must be re-verified at least every quarter of the tank capacity, or every 500 gal, whichever is greater.

2. Cryogenic Liquid-Measuring Devices Code 3.34, Carbon Dioxide Liquid-Measuring Devices Code 3.38, and Hydrogen Gas-Measuring Devices Code 3.39, Type 2 transfer standards
 - a. Each of these codes recognizes the use of transfer standards to test commercial devices.
 - b. The tolerances for cryogenic and carbon dioxide meters are 1.5% acceptance and 2.5% maintenance. For hydrogen gas-measuring devices, the tolerances are 5.0% and 7.0% for acceptance and maintenance tolerances, respectively.
 - c. Each of these codes has test notes recognizing the possible use of transfer standards or master meters to test commercial meters.
 - d. Each of the codes recognize that the transfer standards or master meters may not meet the accuracy and repeatability requirements for a field standard. Hence, each code

¹ Handbook 44, 2023 Edition, Fundamental Considerations, Section 3.2.

² Handbook 44, 2023 Edition, Fundamental Considerations, Section 3.1.

- specifies that when a transfer standard is used, then “To the basic tolerance values that would otherwise be applied, there shall be added an amount equal to two times the standard deviation of the applicable transfer standard when compared to a basic reference standard.”
3. Scales Code 2.20: Dynamic Monorail Weighing Systems (N.1.3.5.1.), Type 2 transfer standard
 - a. Dynamic tests with livestock carcasses or portions of carcasses shall be conducted during normal plant production.
 - b. All carcasses or portions of carcasses shall be individually weighed statically on either the same scale being tested dynamically or another monorail scale with the same or smaller divisions and in close proximity.
 - c. If the scale being tested is used for weighing freshly slaughtered animals (often referred to as a “hot scale”), care must be taken to get a static weighment as quickly as possible before or following the dynamic weighment to avoid loss due to shrink. If multiple dynamic tests are conducted using the same carcasses or portions of carcasses, static weights shall be obtained before and after multiple dynamic tests. If the carcass or portion of a carcass changes weight between static tests, the amount of weight change shall be taken into account, or the carcass or portion of a carcass shall be disregarded for tolerance purposes.
 - d. The acceptance and maintenance tolerances are the same and the tolerances are relatively small (see paragraph T.N.3.8.).
 4. Weigh-In-Motion Systems – Tentative Code 2.25, Type 1 transfer standard
 - a. Trucks are used as test vehicles (transfer standards).
 - b. Vehicles are to be weighed on a reference scale (multi-platform vehicle scale) before being used.
 - c. The tolerances for axle loads are $\pm 20\%$; for an axle-load group $\pm 15\%$; for the gross vehicle weight $\pm 10\%$.
 - d. The weights of the reference vehicles and their reference weights must be known within one-third of the tolerances applied to the scale under test. Because of the large tolerances for the WIM system, the weights of the reference vehicles and their axle loads may have relatively large uncertainties associated with their values and still meet the one-third requirement. The weight of the fuel used during the travel from the reference scale and during the time of the tests must be considered and eliminated as a significant source of error relative to the tolerances allowed for the test vehicles.
 5. Odometers and Taximeters Codes 5.53 and 5.54, Type 1 transfer standard
 - a. These two codes allow the use of a fifth wheel to determine the accuracy for distance measurement.
 - b. NBS Handbook 137, “Examination of Distance Measuring Devices,” should be reviewed.
 6. Wire- and Cordage-Measuring Devices 5.51, Type 1 transfer standard
 - a. When not tested with a steel tape, the devices may be tested with a dimensionally stable material appropriately marked and compared at frequent periodic intervals with

- a steel tape in order to assure that any marked interval is not in error by more than $\frac{1}{3}$ of the tolerance of the device at that particular interval.
7. Automatic Weighing Systems 2.24, Type 1 transfer standard
 - a. N.1.2. Accuracy of Test Pucks or Packages. – The error in any test puck or package shall not exceed one-fourth ($\frac{1}{4}$) of the acceptance tolerance. If packages are used to conduct field tests on automatic weighing systems, the package weights shall be determined on a reference scale or balance with an inaccuracy that does not exceed one-fifth ($\frac{1}{5}$) of the smallest tolerance that can be applied to the device under test.
 8. The following example is hypothetical and intended to illustrate how the same (reference) meter, used to test commercial meters in a specific measurement application, could be both a Type 2 transfer standard and a Type 1 transfer standard based upon the tolerances that apply. Suppose that a (reference) meter has been evaluated for use to test vehicle-tank meters (VTMs) measuring gasoline and diesel fuel under the VTM Code. Assume that the performance of the (reference) meter has been found to have zero bias or error over the range of flow rates over which it will be used. Additionally, assume during the evaluation of the performance of the (reference) meter that the (reference) meter has a standard deviation (repeatability) of 0.05%. For simplicity, let two standard deviations represent a 95% confidence level as the uncertainty associated with the (reference) meter when used to test commercial VTMs.

The acceptance tolerance for the VTMs is 0.15% and the maintenance tolerance is 0.3%. If the (reference) meter is used to test a VTM to acceptance tolerance, the uncertainty associated with the (reference) meter is 0.10%, which exceeds the one-third limit required for use as a field standard. Consequently, this hypothetical (reference) meter, when used to test a VTM to acceptance tolerance would be a Type 2 transfer standard. As a result, the tolerance applied to the VTMs would have to be increased by using the formula proposed in S&T item B8: GEN-19.1. The applicable tolerance that would be applied to the VTMs for acceptance testing would be 0.2% when using the (reference) meter.

Now, consider that the same (reference) meter is used to test VTMs to the maintenance tolerance of 0.3%. The uncertainty associated with the (reference) meter is still 0.10%, which is at the one-third limit for the (reference) meter to be used as a Type 1 transfer standard. Consequently, the reference meter would be a Type 1 transfer standard to test VTMs to the maintenance tolerance and no increase in the applied tolerance is necessary.

There are two points of which to be aware concerning example 8.

- The example shows that the same reference meter may be Type 1 and Type 2 in the same measurement application (e.g., VTMs measuring gasoline and diesel fuel) depending upon whether the acceptance or maintenance tolerance applies to the meter under test.
- The reference meter is not considered to be a field standard, because it does not meet the one-third requirement for all the prescribed tests for VTMs in this application (even if the meter is stable over time).