NIST OFFICE OF WEIGHTS AND MEASURES

Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

as adopted by the 110th National Council on Weights and Measures

NIST Handbook 44

2026

NIST Handbook
NIST HB 44-2026

Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

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110th National Council on Weights and Measures

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U.S. Department of Commerce
Howard Lutnick, Secretary

National Institute of Standards and Technology
Craig Burkhardt, Acting Under Secretary of Commerce for Standards and Technology and Acting NIST Director

NIST OFFICE OF WEIGHTS AND MEASURES

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This handbook conforms to the concept of primary use of SI (metric) measurements recommended in the Omnibus Trade and Competitiveness Act of 1988 by citing SI units before U.S. customary units where both units appear together and placing separate sections containing requirements in SI units before corresponding sections containing requirements in U.S. customary units. In some cases, however, trade practice is currently restricted to the use of U.S. customary units; therefore, some requirements in this handbook will continue to specify only U.S. customary units until a broad consensus is achieved on the permitted SI units.

In accord with NIST policy, the "meter" and "liter" spellings are used in this document. However, the "metre" and "litre" spellings are acceptable.

It should be noted that a space has been inserted instead of commas in all numerical values having four digits or more in this document. This follows a growing practice, originating in tabular work, to use spaces to separate large numbers into groups of three digits. This avoids conflict with the practice in many countries to use the comma as a decimal marker.

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Abstract

NIST Handbook 44 includes specifications, tolerances, and other technical requirements for weighing and measuring devices. These requirements are intended to encourage the design, installation, testing, and use of weighing and measuring devices that provide for accurate, repeatable measurements; facilitate clear and transparent transactions for buyer and seller; and do not facilitate fraud.

NIST Handbook 44 is adopted by many state, local, and some federal weights and measures authorities to apply to commercial weighing and measuring equipment and associated equipment and for use in applications for law enforcement and the collection of statistical information by government agencies.

NIST has a statutory responsibility for "cooperation with the states in securing uniformity of weights and measures laws and methods of inspection" and publishes this and other NIST Handbooks in partial fulfillment of this responsibility. NIST Handbook 44 was first published in 1949, having been preceded by similar handbooks of various designations and in several forms, beginning in 1918; the handbook is now typically published on an annual basis.

This 2026 edition includes amendments made through the Committee on Specifications and Tolerances of the National Council on Weights and Measures (NCWM) with technical guidance from the Office of Weights and Measures (OWM) of the National Institute of Standards and Technology (NIST) and input from weights and measures officials and industry representatives. These amendments were adopted by the NCWM at its 110th Annual Meeting in July 2025.

Keywords

devices; dry measures; electric vehicle fueling systems; grain analyzers; grain moisture meters; hydrogen gas-measuring devices; liquid-measuring devices; LPG and anhydrous ammonia liquid-measuring; mass flow meters; measure-containers; measuring; measuring systems; meters; multiple dimension measuring devices; odometers; scales; taximeters; timing devices; transportation network measuring systems; vehicle tanks; weighing; weighing systems.

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Foreword

NIST Handbook 44 was first published in 1949, having been preceded by similar handbooks of various designations and in several forms, beginning in 1918.

NIST Handbook 44 is typically published in its entirety each year following the Annual Meeting of the National Council on Weights and Measures (NCWM) formerly the National Conference on Weights and Measures. This handbook includes amendments endorsed by the 110th National Council on Weights and Measures during its Annual Meetings in 2025.

This handbook conforms to the concept of primary use of SI (metric) measurements recommended in the Omnibus Trade and Competitiveness Act of 1988 by citing SI units before U.S. customary units where both units appear together and placing separate sections containing requirements in SI units before corresponding sections containing requirements in U.S. customary units. In some cases, however, trade practice is currently restricted to the use of U.S. customary units; therefore, some requirements in this handbook will continue to specify only U.S. customary units until a broad consensus is achieved on the permitted SI units.

In accordance with NIST policy, the meter/liter spellings are used in this document. However, the metre/litre spellings are acceptable and are preferred.

It should be noted that a space has been inserted instead of commas in all numerical values greater than 999 in this document, following a growing practice, originating in tabular work, to use spaces to separate large numbers into groups of three digits. This avoids conflict with the practice in many countries to use the comma as a decimal marker.

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Isabel Chavez Baucom: Data curation, Writing - Reviewing and Editing; **Elizabeth Jane Benham**: Data curation, Writing - Reviewing and Editing; **Jan Konijnenburg**: Data curation, Writing - Reviewing and Editing; **G. Diane Lee**: Writing - Original Draft preparation, Data curation, Writing - Reviewing and Editing; **Katrice A. Lippa**: Supervision; **John T. McGuire**: Data Curation, Writing - Reviewing and Editing; **Loren B. Minnich**: Data curation, Writing - Original Draft preparation, Writing - Reviewing and Editing; **Juana S. Williams**: Data curation, Writing - Original Draft preparation, Writing - Reviewing and Editing.

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2025 Amendments

The following table lists the codes, paragraphs, and pages in which the 110th National Council on Weights and Measures adopted amendments. In the column headed "Action," changes are noted as "added," "amended," "deleted," or "renumbered." Each code, section, or paragraph that has been changed will be noted as "Added 2025" or "Amended 2025."

Section	Code	S&T Item No.	Paragraph	Action	Page
2.20.	Scales	SCL-25.4	S.1.2.2.2. Class III, III L, and IIII Scales	Amended	2-9
			S.1.2.2.2.2. Weight Classifiers	Amended	2-9
			Table S.6.3.b. Notes for Table S.6.3.a. Marking Requirements, Note 4. (b)	Amended	2-25
		SCL-25.2	Table S.6.3.a. Marking Requirements, Minimum Verification Scale Division (e_{min})	Amended	2-24
		SCL-25.5	T.N.2.4. Multi-Interval and Multiple Range (Variable Division-Value) Scales	Amended	2-44
2.24	Automatic Weighing Systems Code	AWS-24.1	N.1.5. Test Loads	Amended	2-111
			N.1.5.1. Initial Verification	Added	2-111
			Table N.1.5. Test Loads	Amended	2-111
			N.1.5.2. Subsequent Verification	Added	2-112
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			N.2.1.3. Shift Test	Amended	2-112
			N.2.2.1. Tests Non-Automatic	Amended	2-112
			N.2.2.2. Automatic Tests	Amended	2-112
			N.3. Test Procedures -Automatic Checkweigher	Deleted	2-113
			Table N.3.2. Number of Sample Weights per Test for Automatic Checkweighers	Amended	2-113
Appendix D.	Definitions	SCL-25.4	weight classifier	Amended	D-38
		SCL-25.2	e_{min} (minimum verification scale division)	Amended	D-15
			e_{min} (minimum verification scale Interval)	Added	D-15

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2025 Editorial Changes

Section	Code	Paragraph	Action	Page
2.20.	Scales	S.1.11.1. Devices and Systems Adjusted Using a Removable Digital Storage Device.	Added a designation after the paragraph "(added 2019)" to identify the date it was added to the handbook.	2-14
		Table 3. Parameters for Accuracy Classes	Corrected footnote references for Class III and III L devices under the U.S. Customary Units section of the table. The footnote reference for Class III was changed to "4" from "5". The footnote reference for Class III L was changed to "2" from "3".	2-22
		UR.2.10. Primary Indicating Elements Provided by the User.	Changed the title font of UR.2.10. from upright roman type to italic type and corrected the reference to the sub-paragraph of S.1.1.1. from "(c)" to "(d)".	2-54
2.23.	Weights	S.2.1. Surface.	Removed the second "or" in the second sentence of the paragraph to make the sentence grammatically correct and to read as: "A weight of more than 2 grams or 30 grains shall not have sharp edges, points, or corners.	2-95
3.31.	Vehicle-Tank Meters	Table 1. Accuracy Classes and Tolerances for Vehicle-Tank Meters Other Than Vehicle-Mounted Milk Meters	Reformatted the overregistration tolerance for Accuracy Class 1.5 Water to be consistent with the other cells in the table.	3-41
Appendix A: Fundamental Considerations	4. Inspection of Commercial Equipment	4.1. Inspection Versus Testing.	Added the word "the" between the words "of" and "value" in the second-to-last sentence to read: "The term testing may then be limited to those operations carried out to determine the accuracy of the value or performance of the equipment under examination by comparison with the actual physical standards of the official."	A-6

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Section	Code	Paragraph	Action	Page
Appendix C: General Tables of Units of Measurement	1. Tables of Metric Units of Measurement		Added terms and numbers to further describe the prefixes for multiples and subdivisions in the first paragraph of "1. Tables of Metric Units of Measurement".	C-3
			Added four new SI prefixes. Two for forming multiples: ronna and quetta. Two for forming submultiples: ronto and quecto.	C-3
	Entire Appendix C.		Nonbreaking spaces inserted, following the SP 811 SI symbol writing style.	C-3
			Formatting updated following NIST SP 811 section 10.5.3 grouping digits style.	C-3

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Introduction

A. Source

The specifications, tolerances, and other technical requirements in this handbook comprise all of those adopted by the National Council on Weights and Measures, Inc. (NCWM). Effective August 13, 2024, the National Conference on Weights and Measures (NCWM) changed its corporate name to the National Council on Weights and Measures (NCWM). Every effort has been made to incorporate this name change into the NIST Handbooks and other relevant publications. In some instances, the reference will remain as the National Conference on Weights and Measures, indicating that the change was not yet effective. For more information, please visit the **NCWM History** page (**www.ncwm.com/history**).

Contact NCWM at:

9011 South 83rd Street	Phone: (402) 434-4880	E-mail: **info@ncwm.com**
Lincoln, NE 68516	Fax: (402) 434-4878	URL: **www.ncwm.com**

The NCWM is supported by the National Institute of Standards and Technology (NIST), which provides its Executive Secretary and publishes some of its documents. NIST also develops technical publications for use by weights and measures agencies; these publications may subsequently be endorsed or adopted by NCWM or its members.

All of the specifications, tolerances, and other technical requirements given herein are recommended by NCWM for official promulgation in and use by the states in exercising their control of commercial weighing and measuring apparatus. A similar recommendation is made with respect to the local jurisdictions within a state in the absence of the promulgation of specifications, tolerances, and other technical requirements at the state level.

(Amended 2015)

B. Purpose

The purpose of these technical requirements is to eliminate from use, weights and measures and weighing and measuring devices that give readings that are false, that are of such construction that they are faulty (that is, that are not reasonably permanent in their adjustment or will not repeat their indications correctly), or that facilitate the perpetration of fraud, without prejudice to apparatus that conforms as closely as practicable to the official standards.

C. Amendments

Proposed amendments to NIST Handbook 44 are deliberated and developed by NCWM's Committee on Specifications and Tolerances before presentation to the general membership for a vote. In some instances, amendments that significantly affect other NIST Handbooks may be processed jointly by two or more committees.

Amendments to the handbooks are made in accordance with NCWM procedures and policies. The process begins at the regional weights and measures association meetings in the fall of each year and culminates at the NCWM Annual Meeting in July. After passing through one or more of the regional associations a proposed amendment is placed on the agenda of the appropriate NCWM committee for consideration at NCWM's Interim Meeting in January, and after final deliberation and possibly further development by the committee, the amendment may be presented to the membership for a vote at the NCWM Annual Meeting in July. NCWM policy provides for exceptions to the process to accommodate urgent or priority items. NIST staff provide technical assistance and advice throughout the process.

The policy is available on the NCWM website at **www.ncwm.com**. For information on the regional weights and measures associations, visit **www.ncwm.com/meetings**.

(Amended 2015)

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D. System of Paragraph Designation

In order that technical requirements of a similar nature, or those directed to a single characteristic, may be grouped together in an orderly fashion, and to facilitate the location of individual requirements, the paragraphs of each code are divided into sections. Each section is designated by a letter and a name, and each subsection is given a letter-number designation and a side title.

The letter that appears first in a paragraph designation has a specific meaning, as follows:

G. The letter G is a prefix and indicates that the requirement is part of the General Code.

A. Application. These paragraphs pertain to the application of the requirements of a code.

S. Specification. These paragraphs relate to the design of equipment. Specification paragraphs are directed particularly to manufacturers of devices.

N. Note. These paragraphs apply to the official testing of devices.

T. Tolerance. Tolerances are performance requirements. They fix the limit of allowable error or departure from true performance or value.

Sensitivity. The sensitivity requirements, applicable only to nonautomatic-indicating scales, are performance requirements and are lettered with a "T."

UR. User Requirement. These paragraphs are directed particularly to the owner and operator of a device. User requirements apply to the selection, installation, use, and maintenance of devices.

D. Definitions of Terms. A definitions section appears in Appendix D to provide the definition of the terms having a special meaning.

The numerical designation after a letter follows the decimal system of paragraph identification that fixes both the relationship and the limitation of the requirements of the paragraph. For example, in the Scales Code, under Specifications, the following numerical designations occur:

S. Specifications

S.1. Design of Indicating and Recording Elements and of Recorded Representations.

S.1.1. Zero Indication.
  S.1.1.1. Digital Indicating Elements.
  S.1.1.2. No-Load Reference Value.
S.1.2. Value of Scale Units.
  S.1.2.1. Digital Indicating Scales.
S.1.3. Graduations.
  S.1.3.1. Length.
  S.1.3.2. Width.
  S.1.3.3. Clear Space Between Graduations.

In this example, paragraphs S.1.1., S.1.2., and S.1.3. are directed and limited to paragraph S.1., which pertains to the design of indicating and recording elements and of recorded representations. Paragraphs S.1.1.1. and S.1.1.2. are directly related to each other, but they are limited to the design of zero indication. Likewise, paragraphs S.1.3.1., S.1.3.2., and S.1.3.3. are directly related to each other, but they are limited to the design of graduations.

This handbook conforms to the concept of primary use of SI (metric) measurements recommended in the Omnibus Trade and Competitiveness Act of 1988 by citing SI metric units before U.S. customary units where both units appear together and placing separate sections containing requirements for metric units before corresponding sections containing requirements for customary units. Occasionally, a paragraph or table carries the suffix "M" because the requirement in SI units is shown as a separate statement, rather than combined with the U.S. customary units. In these few instances, separate requirements were judged to be more easily understood than attempting to combine SI and U.S. customary units in a single paragraph or table. In some cases, however, trade practice is currently restricted to the use of customary units; therefore, some requirements in this handbook will continue to specify only customary units until the Conference achieves a broad consensus on the permitted metric units.

E. Classification of Requirements

The classification of requirements into "retroactive" and "nonretroactive" status is made in order that the requirements may be put into force and effect without unnecessary hardship and without wholesale condemnation of apparatus. Retroactive requirements are enforceable with respect to all equipment and are printed in upright roman type. Nonretroactive requirements are those that, while clearly desirable, are not so vital that they should at once be enforced with respect to all apparatus. Nonretroactive requirements are printed in ***italic type.***

It is not expected that, after their promulgation in a given jurisdiction, nonretroactive requirements will always remain nonretroactive. It is entirely proper that a weights and measures official, following a careful analysis of existing conditions, fix reasonable periods for the continuance of the nonretroactive application of particular requirements, after which such requirements will become retroactive. These periods should be long enough to avoid undue hardship to the owners or operators of apparatus and, in the case of some requirements, should approximate the average useful life of the apparatus in question.

In order that all interested parties may have timely and ample notice of impending changes in the status of requirements, the following procedure is suggested for the official who plans to change the classification of requirements. If sufficient data are available to make such action feasible, publish in combination with the codes themselves the date or dates at which nonretroactive requirements are to become retroactive. In other cases, give equally effective notice at the earliest practicable date.

A nonretroactive requirement, in italic type, will indicate the year from which it should be enforced and, in some cases, the date the requirement shall be changed to retroactive status. For example, *[Nonretroactive as of 1978 and to become retroactive on January 1, 1985].* As a general rule, each nonretroactive requirement is reviewed after it has been in effect for 10 years to determine the appropriateness of its nonretroactive status.

F. Using the Handbook

Handbook 44 is designed to be a working tool for federal, state, and local weights and measures officials, the equipment manufacturers, installers, and service agencies/agents. As noted in Section 1.10. General Code paragraph G-A.1. Commercial and Law-Enforcement Equipment, applicable portions of Handbook 44 may be used by the weights and measures official to test noncommercial weighing and measuring equipment upon request. Additionally, applicable language in Handbook 44 may be cited as a standard in noncommercial applications, for example, when the handbook is referenced or cited as part of a quality system or in multiple-party contract agreements where noncommercial weighing or measuring equipment is used.

The section on Fundamental Considerations (Appendix A) should be studied until its contents are well known. The General Code, with general requirements pertaining to all devices, obviously must be well known to a user of the handbook. The makeup of the specific codes, the order of paragraph presentation, and particularly paragraph designation are worthy of careful study. It is not deemed advisable for a user to attempt to commit to memory tolerances or tolerance tables, even though these are used frequently. For the handbook to serve its purpose, it should be available when any of its requirements are to be applied. Direct reference is the only sure way to apply a requirement properly and to check whether other requirements may be applicable.

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This handbook supplies criteria which enable the user to determine the suitability, accuracy, and repetitive consistency of a weighing or measuring device, both in the laboratory and in the field. However, not all code sections can be appropriately applied in both settings. Since some sections are designed to be applied specifically to tests performed under laboratory conditions, it would be impractical or unrealistic to apply them to field tests. Not all tests described in the "Notes" section of the handbook are required to be performed in the field as an official test. An inspector may officially approve or reject a device which has been tested in accordance with those sections applicable to the type of test being conducted.

(Paragraph added 1996)

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National Council on Weights and Measures / National Type Evaluation Program

Form 15: Proposal to Amend NIST Handbooks, Guidance Documents, NCWM Bylaws or NCWM Publication 14

Email proposals in Microsoft Word format to info@ncwm.com by August 15.

Each regional association will hold hearings on proposals in the fall. See meeting dates at **www.ncwm.com/meetings**. If any region deems that the item has merit, the region will forward the item to NCWM for national consideration. For more information on the Form 15 process, visit **www.ncwm.com/standards-dev**.

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1. Proposal to:			
__ Laws & Regulations __ Specifications & Tolerances __ Professional Development __ Board of Directors __ NTEP Committee			
2. Submitter's Name:		**3. Date:**	
4. Submitter's Organization:		**5. Address:**	
6. City:	**7. State:**	**8. Zip Code:**	**9. Country:**
10. Phone Number:	**11. Fax Number:**	**12. Email Address:**	

PROPOSAL INFORMATION
13. Purpose: Concise statement as to the intent or purpose of this proposal, such as problem being fixed. **(Do not include justification here.)**
14. Document to be Amended:
__ Handbook 44 __ Handbook 130 __ Handbook 133 __ NCWM Guidance Document __ NCWM Bylaws __ NTEP Administrative Policy
15. Cite portion to be Amended: Submit a separate Form 15 for each code, model law or regulation to be amended.
Section: Paragraph:
16. Proposal: Use ~~**strikeout**~~ to show words to be deleted and **underline** to show new words. **(Do not use track changes.)**
17. For Handbook 44 proposals, indicate one of the following:
☐ **Retroactive** (Enforceable with respect to all devices) ☐ **Nonretroactive** (Enforceable on or after the effective date for devices a) manufactured within a state after the effective date, b) both new and used equipment brought into a state after the effective date, c) used in noncommercial applications which are placed into commercial use after the effective date, ad d) undergoing type evaluation including devices that have been modified to the extent that a new NTEP Certificate of Conformance is required.)
18. Justification: Include national importance, background on the issue, and reference to supporting data or documents.
19. Possible Opposing Argument's: Demonstrate that you are aware and have considered possible opposition.
20. Requested Action if Considered for NCWM Agenda:
__ Voting Item __ Developing Item __ Informational Item __ Other (Please Describe):
21. List of Attachments:

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Section 1.10. General Code

G-A. Application

G-A.1. Commercial and Law-Enforcement Equipment. – These specifications, tolerances, and other technical requirements apply as follows:

1. To commercial weighing and measuring equipment; that is:

   (a) To weights and measures and weighing and measuring devices used or employed:

   (1) in establishing the size, quantity, extent, area, composition (limited to meat and poultry), constituent values (limited to grain), or measurement of quantities, things, produce, or articles for distribution or consumption, purchased, offered, or submitted for sale, hire, or award;

   (2) when assessing a fee for the use of the equipment to determine a weight or measure;

   (3) in determining the basis of an award using count, weight, or measure; or

   (4) in computing any basic charge or payment for services rendered on the basis of weight or measure. (Amended 2008 and 2022)

   (b) To any accessory attached to or used in connection with a commercial weighing or measuring device when such accessory is so designed that its operation affects the accuracy of the device.

2. To weighing and measuring equipment in official use for the enforcement of law or the collection of statistical information by government agencies.

(These requirements should be used as a guide by the weights and measures official when, upon request, courtesy examinations of noncommercial equipment are made.)
(Amended 2022)

G-A.2. Code Application. – This General Code shall apply to all classes of devices as covered in the specific codes. The specific code requirements supersede General Code requirements in all cases of conflict.
(Amended 1972)

G-A.3. Special and Unclassified Equipment. – Insofar as they are clearly appropriate, the requirements and provisions of the General Code and of specific codes apply to equipment failing, by reason of special design or otherwise, to fall clearly within one of the particular equipment classes for which separate codes have been established. With respect to such equipment, code requirements and provisions shall be applied with due regard to the design, intended purpose, and conditions of use of the equipment.

G-A.4. Metric Equipment. – Employment of the weights and measures of the metric system is lawful throughout the United States. These specifications, tolerances, and other requirements shall not be understood or construed as in any way prohibiting the manufacture, sale, or use of equipment designed to give results in terms of metric units. The specific provisions of these requirements and the principles upon which the requirements are based shall be applied to metric equipment insofar as appropriate and practicable. The tolerances on metric equipment, when not specified herein, shall be equivalent to those specified for similar equipment constructed or graduated in the U.S. customary system.

G-A.5. Retroactive Requirements. – "Retroactive" requirements are enforceable with respect to all equipment. Retroactive requirements are printed herein in upright roman type.

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G-A.6. Nonretroactive Requirements. – "Nonretroactive" requirements are enforceable on or after the effective date for devices:

(a) manufactured within a state after the effective date;

(b) both new and used, brought into a state after the effective date;

(c) used in noncommercial applications which are placed into commercial use after the effective date; and

(d) undergoing type evaluation, including devices that have been modified to the extent that a new NTEP Certificate of Conformance (CC) is required.

Nonretroactive requirements are not enforceable with respect to devices that are in commercial service in the state as of the effective date or to new equipment in the stock of a manufacturer or a dealer in the state as of the effective date.

[Nonretroactive requirements are printed in italic type.]

(Amended 1989 and 2011)

G-A.7. Effective Enforcement Dates of Code Requirements. – Unless otherwise specified, each new or amended code requirement shall not be subject to enforcement prior to January 1 of the year following the adoption by the National Council on Weights and Measures and publication by the National Institute of Standards and Technology.

G-S. Specifications

G-S.1. Identification. – All equipment, except weights and separate parts necessary to the measurement process but not having any metrological effect, shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the manufacturer or distributor;

(b) a model identifier that positively identifies the pattern or design of the device;

(1) The model identifier shall be prefaced by the word "Model," "Type," or "Pattern." These terms may be followed by the word "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.). The abbreviation for the word "Model" shall be "Mod" or "Mod." Prefix lettering may be initial capitals, all capitals, or all lower case.

[Nonretroactive as of January 1, 2003]

(Added 2000) (Amended 2001)

(c) a nonrepetitive serial number, except for equipment with no moving or electronic component parts and software;
[Nonretroactive as of January 1, 1968]
(Amended 2003 and 2016)

(1) The serial number shall be prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required serial number.

[Nonretroactive as of January 1, 1986]

(2) Abbreviations for the word "Serial" shall, as a minimum, begin with the letter "S," and abbreviations for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., S/N, SN, Ser. No., and S. No.).

[Nonretroactive as of January 1, 2001]

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(d) the current software version or revision identifier for not-built-for-purpose, software-based devices manufactured as of January 1, 2004, and all software-based devices (or equipment) manufactured as of January 1, 2022;

(Added 2003) (Amended 2016)

(1) The version or revision identifier shall be:

i. prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required version or revision.

[Nonretroactive as of January 1, 2007]

(Added 2006)

Note: *If the equipment is capable of displaying the version or revision identifier, but is unable to meet the formatting requirements, through the NTEP type evaluation process, other options may be deemed acceptable and described in the CC.*

(Added 2016)

ii. continuously displayed or be accessible via the display. Instructions for displaying the version or revision identifier shall be described in the CC. As an alternative, permanently marking the version or revision identifier shall be acceptable providing the device does not always have an integral interface to communicate the version or revision identifier.

[Nonretroactive as of January 1, 2022]

(Added 2016)

(2) Abbreviations for the word "Version" shall, as a minimum, begin with the letter "V" and may be followed by the word "Number." Abbreviations for the word "Revision" shall, as a minimum, begin with the letter "R" and may be followed by the word "Number." The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.). Prefix lettering may be initial capitals, all capitals, or all lowercase.

[Nonretroactive as of January 1, 2007]

(Added 2006) (Amended 2016)

(e) a National Type Evaluation Program (NTEP) Certificate of Conformance (CC) number or a corresponding CC Addendum Number for devices that have a CC.

[Nonretroactive as of January 1, 2003]

(Added 2001) (Amended 2016)

(1) The CC Number or a corresponding CC Addendum Number shall be prefaced by the terms "NTEP CC," "CC," or "Approval." These terms may be followed by the word "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.).

[Nonretroactive as of January 1, 2003]

(Added 2001) (Amended 2016)

The required information shall be so located that it is readily observable without the necessity of the disassembly of a part requiring the use of any means separate from the device.

(Amended 1985, 1991, 1999, 2000, 2001, 2003, 2006, and 2016)

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G-S.1.1. Location of Marking Information for Not-Built-For-Purpose, Software-Based Devices. *– For not-built-for-purpose, software-based devices either:*

(a) The required information in G-S.1. Identification. (a), (b), (d), and (e) shall be permanently marked or continuously displayed on the device; or

(b) The Certificate of Conformance (CC) Number shall be:

(1) permanently marked on the device;

(2) continuously displayed; or

(3) accessible through an easily recognized menu and, if necessary, a submenu. Examples of menu and submenu identification include, but are not limited to, "Help," "System Identification," "G-S.1. Identification," or "Weights and Measures Identification."

Note: *For (b), clear instructions for accessing the information required in G-S.1. Identification, (a), (b), and (d) shall be listed on the CC, including information necessary to identify that the software in the device is the same type that was evaluated.*

[Nonretroactive as of January 1, 2004]

(Added 2003) (Amended 2006)

G-S.1.2. Devices and Main Elements Remanufactured as of January 1, 2002. – All devices and main elements remanufactured as of January 1, 2002, shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the last remanufacturer or distributor; and

(b) the remanufacturer's or distributor's model designation, if different than the original model designation.

(Added 2001) (Amended 2011)

Note: Definitions for "manufactured device," "repaired device," and "repaired element" are included (along with definitions for "remanufactured device" and "remanufactured element") in Appendix D, Definitions.

G-S.2. Facilitation of Fraud. – All equipment and all mechanisms, software, and devices attached to or used in conjunction therewith shall be so designed, constructed, assembled, and installed for use such that they do not facilitate the perpetration of fraud.

(Amended 2007)

G-S.3. Permanence. – All equipment shall be of such materials, design, and construction as to make it probable that, under normal service conditions:

(a) accuracy will be maintained;

(b) operating parts will continue to function as intended; and

(c) adjustments will remain reasonably permanent.

Undue stresses, deflections, or distortions of parts shall not occur to the extent that accuracy or permanence is detrimentally affected.

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G-S.4. Interchange or Reversal of Parts. – Parts of a device that may readily be interchanged or reversed in the course of field assembly or of normal usage shall be:

(a) so constructed that their interchange or reversal will not affect the performance of the device; or

(b) so marked as to show their proper positions.

G-S.5. Indicating and Recording Elements.

G-S.5.1. General. – All weighing and measuring devices shall be provided with indicating or recording elements appropriate in design and adequate in amount. Primary indications and recorded representations shall be clear, definite, accurate, and easily read under any conditions of normal operation of the device.

G-S.5.2. Graduations, Indications, and Recorded Representations.

G-S.5.2.1. Analog Indication and Representation. – Graduations and a suitable indicator shall be provided in connection with indications designed to advance continuously.

G-S.5.2.2. Digital Indication and Representation. – Digital elements shall be so designed that:

(a) All digital values of like value in a system agree with one another.

(b) A digital value coincides with its associated analog value to the nearest minimum graduation.

(c) A digital value "rounds off" to the nearest minimum unit that can be indicated or recorded.

(d) A digital zero indication includes the display of a zero for all places that are displayed to the right of the decimal point and at least one place to the left. When no decimal values are displayed, a zero shall be displayed for each place of the displayed scale division.

[Nonretroactive as of January 1, 1986]

(Amended 1973 and 1985)

G-S.5.2.3. Size and Character. – In any series of graduations, indications, or recorded representations, corresponding graduations and units shall be uniform in size and character. Graduations, indications, or recorded representations that are subordinate to, or of a lesser value than others with which they are associated, shall be appropriately portrayed or designated.

[Made retroactive as of January 1, 1975]

G-S.5.2.4. Values. – If graduations, indications, or recorded representations are intended to have specific values, these shall be adequately defined by a sufficient number of figures, words, symbols, or combinations thereof, uniformly placed with reference to the graduations, indications, or recorded representations and as close thereto as practicable, but not so positioned as to interfere with the accuracy of reading.

G-S.5.2.5. Permanence. – Graduations, indications, or recorded representations and their defining figures, words, and symbols shall be of such character that they will not tend easily to become obliterated or illegible.

G-S.5.3. Values of Graduated Intervals or Increments. – In any series of graduations, indications, or recorded representations, the values of the graduated intervals or increments shall be uniform throughout the series.

G-S.5.3.1. On Devices That Indicate or Record in More Than One Unit. – On devices designed to indicate or record in more than one unit of measurement, the values indicated and recorded shall be identified with an appropriate word, symbol, or abbreviation.

(Amended 1978 and 1986)

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G-S.5.4. Repeatability of Indications. – A device shall be capable of repeating, within prescribed tolerances, its indications and recorded representations. This requirement shall be met irrespective of repeated manipulation of any element of the device in a manner approximating normal usage (including displacement of the indicating elements to the full extent allowed by the construction of the device and repeated operation of a locking or relieving mechanism) and of the repeated performance of steps or operations that are embraced in the testing procedure.

G-S.5.5. Money Values, Mathematical Agreement. – Any recorded money value and any digital money-value indication on a computing-type weighing or measuring device used in retail trade shall be in mathematical agreement with its associated quantity representation or indication to the nearest 1 cent of money value. This does not apply to auxiliary digital indications intended for the operator's use only, when these indications are obtained from existing analog customer indications that meet this requirement.

(Amended 1973)

G-S.5.6. Recorded Representations. – Insofar as they are appropriate, the requirements for indicating and recording elements shall also apply to recorded representations. All recorded values shall be presented digitally. In applications where recorded representations are required by a specific code, the customer may be given the option of not receiving the recorded representation. Recorded representations referenced in specific codes shall be made available to the customer in hard copy form, unless otherwise specified by the customer. For systems equipped with the capability of issuing an electronic receipt, ticket, or other recorded representation, the customer may be given the option to receive any required information electronically (e.g., via cell phone, computer, etc.) in lieu of or in addition to a hard copy.

(Amended 1975, 2014, and 2023)

G-S.5.6.1. Indicated and Recorded Representation of Units. – Appropriate abbreviations.

(a) For equipment manufactured on or after January 1, 2008, the appropriate defining symbols are shown in NIST Special Publication SP 811 "Guide for the Use of International System of Units (SI)" and Handbook 44 Appendix C – General Tables of Units of Measurement.

Note: SP 811 can be viewed or downloaded at **www.nist.gov/pml/special-publication-811** or by going to **www.nist.gov/pml/owm** and selecting "Publications," then selecting "NIST Special Publications," and then clicking on the link below "**NIST SP 811: Guide for the Use of the International System of Units (SI)**" showing the year of the current edition.

(Added 2007)

(b) The appropriate defining symbols on equipment manufactured prior to January 1, 2008, with limited character sets are shown in Table 1. Representation of SI Units on Equipment Manufactured Prior to January 1, 2008, with Limited Character Sets.

(Added 1977) (Amended 2007)

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Table 1.
Representation of SI Units on Equipment Manufactured Prior to January 1, 2008, with Limited Character Sets

Name of Unit	International Symbol (common use symbol)	Representation		
		Form I	Form II	
		(double case)	(single case lower)	(single case upper)
Base SI Units				
meter	m	m	m	M
kilogram	kg	kg	kg	KG
Derived SI Units				
newton	N	N	n	N
pascal	Pa	Pa	pa	PA
watt	W	W	w	W
volt	V	V	v	V
degree Celsius	°C	°C	°c	°C
Other Units				
liter	l or L	L	l	L
gram	g	g	g	G
metric ton	t	t	tne	TNE
bar	bar	bar	bar	BAR

(Table Amended 2007)

G-S.5.7. Magnified Graduations and Indications. – All requirements for graduations and indications apply to a series of graduations and an indicator magnified by an optical system or as magnified and projected on a screen.

G-S.6. Marking Operational Controls, Indications, and Features. *– All operational controls, indications, and features, including switches, lights, displays, push buttons, and other means, shall be clearly and definitely identified. The use of approved pictograms or symbols shall be acceptable.*

[Nonretroactive as of January 1, 1977]

(Amended 1978 and 1995)

G-S.7. Lettering. – All required markings and instructions shall be distinct and easily readable and shall be of such character that they will not tend to become obliterated or illegible.

G-S.8. Provision for Sealing Electronic Adjustable Components. *– A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism.*

[Nonretroactive as of January 1, 1990]

A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.

(Added 1985) (Amended 1989 and 1993)

G-S.8.1. Multiple Weighing or Measuring Elements that Share a Common Provision for Sealing. *– A change to any metrological parameter (calibration or configuration) of any weighing or measuring element shall be individually identified.*

[Nonretroactive as of January 1, 2010]

Note: For devices that utilize an electronic form of sealing, in addition to the requirements in G-S.8.1., any appropriate audit trail requirements in an applicable specific device code also apply. Examples of identification of a change to the metrological parameters of a weighing or measuring element include, but are not limited to:

(1) a broken, missing, or replaced physical seal on an individual weighing, measuring, or indicating element or active junction box;

(2) a change in a calibration factor or configuration setting for each weighing or measuring element;

(3) a display of the date of calibration or configuration event for each weighing or measuring element; or

(4) counters indicating the number of calibration and/or configuration events for each weighing or measuring element.

(Added 2007)

G-S.8.2. Devices and Systems Adjusted Using Removable Digital Storage Device. – For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device*, such as a secure digital (SD) card, USB flash drive, etc., security shall be provided for those parameters using either:

(1) an event logger in the device; or

(2) a physical seal that must be broken in order to remove the digital storage device from the device (or system). If security is provided using an event logger, the event logger shall include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter. A printed copy of the information must be available on demand through the device or through another on-site device. In addition to providing a printed copy of the information, the information may be made available electronically. The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1000 records are required. (Note: Does not require 1000 changes to be stored for each parameter.)

* Applies only to removable digital storage devices that must remain in the device or system for it to be operational.

(Added 2019)

G-S.9. Metrologically Significant Software Updates. – A software update that changes the metrologically significant software shall be considered a sealable event.

(Added 2016)

G-N. Notes

G-N.1. Conflict of Laws and Regulations. – If any particular provisions of these specifications, tolerances, and other requirements are found to conflict with existing state laws, or with existing regulations or local ordinances relating to health, safety, or fire prevention, the enforcement of such provisions shall be suspended until conflicting requirements can be harmonized. Such suspension shall not affect the validity or enforcement of the remaining provisions of these specifications, tolerances, and other requirements.

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G-N.2. Testing With Nonassociated Equipment. – Tests to determine conditions, such as radio frequency interference (RFI) that may adversely affect the performance of a device shall be conducted with equipment and under conditions that are usual and customary with respect to the location and use of the device.

(Added 1976)

G-N.3. Test Methods. – Permissible test methods for verifying compliance of commercial weighing and measuring systems with the provisions of the General Code and Specific Codes include, but are not limited to, test methods and apparatus that have been approved by the Director as outlined in Appendix A - Fundamental Considerations, Section 3. Testing Apparatus.

(Added 2023)

G-T. Tolerances

G-T.1. Acceptance Tolerances. – Acceptance tolerances shall apply to equipment:

(a) to be put into commercial use for the first time;

(b) that has been placed in commercial service within the preceding 30 days and is being officially tested for the first time;

(c) that has been returned to commercial service following official rejection for failure to conform to performance requirements and is being officially tested for the first time within 30 days after corrective service;

(d) that is being officially tested for the first time within 30 days after major reconditioning or overhaul; and

(e) undergoing type evaluation.

(Amended 1989)

G-T.2. Maintenance Tolerances. – Maintenance tolerances shall apply to equipment in actual use, except as provided in G-T.1. Acceptance Tolerances.

G-T.3. Application. – Tolerances "in excess" and tolerances "in deficiency" shall apply to errors in excess and to errors in deficiency, respectively. Tolerances "on overregistration" and tolerances "on underregistration" shall apply to errors in the direction of overregistration and of underregistration, respectively. (Also see Appendix D, Definitions.)

G-T.4. For Intermediate Values. – For a capacity, indication, load, value, etc., intermediate between two capacities, indications, loads, values, etc., listed in a table of tolerances, the tolerances prescribed for the lower capacity, indication, load, value, etc., shall be applied.

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 maximum permissible error (mpe) = $(2/3 \times \text{mpe} + U)$

With an upper limit of U_{max} = 2/3 mpe, where mpe is the basic tolerance that applies when using a basic reference standard.

mpe = maximum permissible error
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 NIST Handbook 44; that is acceptance, maintenance, and minimum tolerances. Note that the repeatability tolerance and the special test tolerances are NOT increased.

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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, Examination of Grain Moisture Meters Using Air-Oven Reference Method Transfer Standards 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. Section 2.21. Belt-Conveyor Scale Systems Code is also exempt because relative and absolute tolerances are included in the code.

(Added 2023)

G-UR. User Requirements

G-UR.1. Selection Requirements.

G-UR.1.1. Suitability of Equipment. – Commercial equipment shall be suitable for the service in which it is used with respect to elements of its design, including but not limited to its weighing capacity (for weighing devices), its computing capability (for computing devices), its rate of flow (for liquid-measuring devices), the character, number, size, and location of its indicating or recording elements, and the value of its smallest unit and unit prices.

(Amended 1974)

G-UR.1.2. Environment. – Equipment shall be suitable for the environment in which it is used including, but not limited to, the effects of wind, weather, and RFI.

(Added 1976)

G-UR.1.3. Liquid-Measuring Devices. – To be suitable for its application, the minimum delivery for liquid-measuring devices shall be no less than 100 divisions, except that the minimum delivery for retail analog devices shall be no less than 10 divisions. Maximum division values and tolerances are stated in the specific codes.

(Added 1995)

G-UR.2. Installation Requirements.

G-UR.2.1. Installation. – A device shall be installed in accordance with the manufacturer's instructions, including any instructions marked on the device. A device installed in a fixed location shall be installed so that neither its operation nor its performance will be adversely affected by any characteristic of the foundation, supports, or any other detail of the installation.

G-UR.2.1.1. Visibility of Identification. – Equipment shall be installed in such a manner that all required markings are readily observable.

(Added 1978)

G-UR.2.2. Installation of Indicating or Recording Element. – A device shall be so installed that there is no obstruction between a primary indicating or recording element and the weighing or measuring element; otherwise there shall be convenient and permanently installed means for direct communication, oral or visual, between an individual located at a primary indicating or recording element and an individual located at the weighing or measuring element. (Also see G-UR.3.3. Position of Equipment.)

G-UR.2.3. Accessibility for Inspection, Testing, and Sealing Purposes. – A device shall be located, or such facilities for normal access thereto shall be provided, to permit:

(a) inspecting and testing the device;

(b) inspecting and applying security seals to the device; and

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(c) readily bringing the testing equipment of the weights and measures official to the device by customary means and in the amount and size deemed necessary by such official for the proper conduct of the test.

Otherwise, it shall be the responsibility of the device owner or operator to supply such special facilities, including such labor as may be needed to inspect, test, and seal the device, and to transport the testing equipment to and from the device, as required by the weights and measures official.

(Amended 1991)

G-UR.3. Use Requirements.

G-UR.3.1. Method of Operation. – Equipment shall be operated only in the manner that is obviously indicated by its construction or that is indicated by instructions on the equipment.

G-UR.3.2. Associated and Nonassociated Equipment. – A device shall meet all performance requirements when associated or nonassociated equipment is operated in its usual and customary manner and location.

(Added 1976)

G-UR.3.3. Position of Equipment. – A device or system equipped with a primary indicating element and used in direct sales, except for prescription scales, shall be positioned so that its indications may be accurately read and the weighing or measuring operation may be observed from some reasonable "customer" and "operator" position. The permissible distance between the equipment and a reasonable customer and operator position shall be determined in each case upon the basis of the individual circumstances, particularly the size and character of the indicating element.

(Amended 1974 and 1998)

G-UR.3.4. Responsibility, Money-Operated Devices. – Money-operated devices, other than parking meters, shall have clearly and conspicuously displayed thereon, or immediately adjacent thereto, adequate information detailing the method for the return of monies paid when the product or service cannot be obtained. This information shall include the name, address, and phone number of the local responsible party for the device. This requirement does not apply to devices at locations where employees are present and responsible for resolving any monetary discrepancies for the customer.

(Amended 1977 and 1993)

G-UR.4. Maintenance Requirements.

G-UR.4.1. Maintenance of Equipment. – All equipment in service and all mechanisms and devices attached thereto or used in connection therewith shall be continuously maintained in proper operating condition throughout the period of such service. Equipment in service at a single place of business shall not be considered "maintained in a proper operating condition" if:

(a) predominantly, equipment of all types or applications are found to be in error in a direction favorable to the device user; or

(b) predominantly, equipment of the same type or application is found to be in error in a direction favorable to the device user.

(Amended 1973, 1991, and 2015)

G-UR.4.2. Abnormal Performance. – Unstable indications or other abnormal equipment performance observed during operation shall be corrected and, if necessary, brought to the attention of competent service personnel.

(Added 1976)

G-UR.4.3. Use of Adjustments. – Weighing elements and measuring elements that are adjustable shall be adjusted only to correct those conditions that such elements are designed to control, and shall not be adjusted to

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compensate for defective or abnormal installation or accessories or for badly worn or otherwise defective parts of the assembly. Any faulty installation conditions shall be corrected, and any defective parts shall be renewed or suitably repaired, before adjustments are undertaken. Whenever equipment is adjusted, the adjustments shall be so made as to bring performance errors as close as practicable to zero value.

G-UR.4.4. Assistance in Testing Operations. – If the design, construction, or location of any device is such as to require a testing procedure involving special equipment or accessories or an abnormal amount of labor, such equipment, accessories, and labor shall be supplied by the owner or operator of the device as required by the weights and measures official.

G-UR.4.5. Security Seal. – A security seal shall be appropriately affixed to any adjustment mechanism designed to be sealed.

G-UR.4.6. Testing Devices at a Central Location.

(a) When devices in commercial service require special test facilities, or must be removed from service for testing, or are routinely transported for the purpose of use (e.g., vehicle-mounted devices and devices used in multiple locations), the official with statutory authority may require that the devices be brought to a central location for testing. The dealer or owner of these devices shall provide transportation of the devices to and from the test location.

(b) When the request for removal and delivery to a central test location involves devices used in submetering (e.g., electric, hydrocarbon vapor, or water meters), the owner or operator shall not interrupt the utility service to the customer or tenant except for the removal and replacement of the device. Provisions shall be made by the owner or operator to minimize inconvenience to the customer or tenant. All replacement or temporary meters shall be tested and sealed by a weights and measures official or bear a current, valid approval seal prior to use.

(Added 1994)

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Note: In this section of Handbook 44, the reference temperature for the temperature compensation of refined petroleum products is shown as “15 °C (60 °F).” Although these values are not exact equivalents, they reflect industry usage when the SI and U.S. customary units are used in measurements.

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Section 3.32. Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices

A. Application

A.1. General. – This code applies to devices used for the measurement of liquefied petroleum gas and anhydrous ammonia in the liquid state, whether such devices are installed in a permanent location or mounted on a vehicle. For retail motor-fuel devices, see Appendix D, definition of "liquefied petroleum gas retail motor-fuel device."

(Amended 2022)

A.2. Devices Used to Measure Other Liquid Products not Covered in Specific Codes. – Insofar as they are clearly appropriate, the requirements and provisions of the code may be applied to devices used for the measurement of other liquids that do not remain in a liquid state at atmospheric pressures and temperatures.

A.3. Exceptions. – This code does not apply to mass flow meters. (Also see Section 3.37. Code for Mass Flow Meters.)

(Added 1994)

A.4. Additional Code Requirements. – In addition to the requirements of this code, LPG and Anhydrous Ammonia Liquid-Measuring Devices shall meet the requirements of Section 1.10. General Code.

S. Specifications

S.1. Design of Indicating and Recording Elements and of Recorded Representations.

S.1.1. Primary Elements.

S.1.1.1. General. – A device shall be equipped with a primary indicating element and may also be equipped with a primary recording element.

Note: Vehicle-mounted metering systems shall be equipped with a primary recording element as required by paragraph UR.2.6. Recorded Representations.

(Amended 2023)

S.1.1.2. Units. – A device shall indicate, and record if the device is equipped to record, its deliveries in terms of liters, gallons, quarts, pints, or binary-submultiple or decimal subdivisions of the liter or gallon.

(Amended 1987)

S.1.1.3. Value of Smallest Unit. – The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed the equivalent of:

(a) 0.5 L (1 pt) on retail devices; or

(b) 5 L (1 gal) on wholesale devices.

(Amended 1987)

S.1.1.4. Advancement of Indicating and Recording Elements. – Primary indicating and recording elements shall be susceptible to advancement only by the mechanical operation of the device. However, a device may be cleared by advancing its elements to zero, but only if:

(a) the advancing movement, once started, cannot be stopped until zero is reached; or

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(b) in the case of indicating elements only, such elements are automatically obscured until the elements reach the correct zero position.

S.1.1.5. Money-Values, Mathematical Agreement. – Any digital money-value indication and any recorded money-value on a computing-type device shall be in mathematical agreement with its associated quantity indication or representation to within 1 cent of money-value; except that a stationary retail computing-type device must compute and indicate to the nearest 1 cent of money-value. (Also see Section 1.10. General Code, G-S.5.5. Money-Values, Mathematical Agreement.)

(Amended 1984 and 1988)

S.1.1.6. Recorded Representations. – Any recorded representation created by a device of the computing type which includes the total computed price, shall also include thereon the total volume of the delivery in terms of liters or gallons, and the appropriate decimal fraction of the liter or gallon, and the corresponding price per liter or gallon.

(Added 1979) (Amended 1987 and 2023)

S.1.2. Graduations.

S.1.2.1. Length. – Graduations shall be so varied in length that they may be conveniently read.

S.1.2.2. Width. – In any series of graduations:

(a) the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations;

(b) the width of main graduations shall be not more than 50 % greater than the width of subordinate graduations; and

(c) graduations shall in no case be less than 0.2 mm (0.008 in) in width.

S.1.2.3. Clear Interval between Graduations. – The clear interval shall be not less than 1.0 mm (0.04 in). If the graduations are not parallel, the measurement shall be made:

(a) along the line of relative movement between the graduations at the end of the indicator; or

(b) if the indicator is continuous, at the point of widest separation of the graduations.

S.1.3. Indicators.

S.1.3.1. Symmetry. – The index of an indicator shall be symmetrical with respect to the graduations, at least throughout that portion of its length associated with the graduations.

S.1.3.2. Length. – The index of an indicator shall reach to the finest graduations with which it is used, unless the indicator and the graduations are in the same plane, in which case the distance between the end of the indicator and the ends of the graduations, measured along the line of graduations, shall be not more than 1.0 mm (0.04 in).

S.1.3.3. Width. – The width of the index of an indicator in relation to the series of graduations with which it is used shall be not greater than:

(a) *the width of the narrowest graduation;** and

*[*Nonretroactive as of January 1, 2002]*

(Amended 2001)

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(b) the width of the minimum clear interval between graduations.

When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width throughout the length of the index that coincides with the graduation.

S.1.3.4. Clearance. – The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm (0.06 in).

S.1.3.5. Parallax. – Parallax effects shall be reduced to the practicable minimum.

S.1.4. For Retail Devices Only.

S.1.4.1. Indication of Delivery. – A retail device shall automatically show on its face the initial zero condition and the quantity delivered up to the nominal capacity of the device. However, the following requirements shall apply:

(a) For electronic devices manufactured prior to January 1, 2006, the first 0.03 L (or 0.009 gal) of a delivery and its associated total sales price need not be indicated.

(b) For electronic devices manufactured on or after January 1, 2006, the measurement, indication of delivered quantity, and the indication of total sales price shall be inhibited until the fueling position reaches conditions necessary to ensure that the delivery starts at zero.

[Nonretroactive as of January 1, 2006]

(Amended 2016)

S.1.4.2. Return to Zero.

(a) Primary indicating elements shall be readily returnable to a definite zero indication.

(b) Primary recording elements on a stationary retail device shall be readily returnable to a definite zero indication if the device is equipped to record.

(c) Means shall be provided to prevent the return of primary indicating elements and of primary recording elements if these are returnable to zero, beyond their correct zero position.

(d) Primary indicating elements shall not be resettable to zero during a delivery.

(Amended 1990 and 2016)

S.1.5. For Stationary Retail Devices Only.

S.1.5.1. Display of Unit Price and Product Identity. – A device of the computing type shall display on each face the unit price at which the device is set to compute or to deliver, and there shall be conspicuously displayed on each side of the device the identity of the product that is being dispensed.

Except for dispensers used exclusively for fleet sales and other price contract sales, all of the unit prices at which that product is offered for sales shall meet the following conditions:

(a) *For a system that applies a discount prior to the delivery, all unit prices shall be displayed or shall be capable of being displayed on the dispenser through a deliberate action of the purchaser prior to the delivery of the product. It is not necessary that all of the unit prices be simultaneously displayed prior to the delivery of the product.*

[Nonretroactive as of January 1, 2016]

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(b) For a system that offers post-delivery discounts on fuel sales, display of pre-delivery unit price information is exempt from (a) above, provided the system complies with S.1.5.5. Recorded Representations for Transactions Where a Post-Delivery Discount(s) is Provided.

Note: When a product is offered at more than one unit price, display of the unit price information may be through the deliberate action of the customer: 1) using controls on the device; 2) through the customer's use of personal or vehicle-mounted electronic equipment communicating with the system; or 3) verbal instructions by the customer.

(Amended 2016)

S.1.5.2. Money-Value Computations. – A computing device shall compute the total sales price at any single-purchase unit price (excluding fleet sales and other price contract sales) for which the product is offered for sale at any delivery possible within either the measurement range of the device or the range of the computing elements, whichever is less. The analog money-value indication shall not differ from the mathematically computed money-value (quantity × unit price = sales price), for any delivered quantity, by an amount greater than the values shown in Table 1. Money-Value Divisions and Maximum Allowable Variations for Money-Value Computations on Mechanical Analog Computers.

(Amended 1995)

Table 1.
Money-Value Divisions and
Maximum Allowable Variations for Money-Value
Computations on Mechanical Analog Computers

Unit Price		Money-Value Division	Maximum Allowable Variation	
From	To and Including		Design Test	Field Test
0	\$0.25/liter or \$1.00/gallon	1¢	± 1¢	± 1¢
\$0.25/liter or \$1.00/gallon	\$0.75/liter or \$3.00/gallon	1¢ or 2¢	± 1¢	± 2¢
\$0.75/liter or \$3.00/gallon	\$2.50/liter or \$10.00/gallon	1¢ or 2¢	± 1¢	± 2¢
		5¢	± 2½¢	± 5¢

S.1.5.2.1. Money-Value Divisions, Analog. – The value of the graduated intervals representing money-values on a computing-type device with analog indications shall be as follows:

(a) Not more than 1 cent at all unit prices up to and including \$0.25 per liter or \$1.00 per gallon.

(b) Not more than 2 cents at unit prices greater than \$0.25 per liter or \$1.00 per gallon up to and including \$0.75 per liter or \$3.00 per gallon.

(c) Not more than 5 cents at all unit prices greater than \$0.75 per liter or \$3.00 per gallon.

(Amended 1984)

S.1.5.2.2. Money-Value Divisions, Digital. – A computing-type device with digital indications shall comply with the requirements of paragraph G.-S.5.5. Money-Values, Mathematical Agreement, and the total price computation shall be based on quantities not exceeding 0.01 gal intervals for devices indicating in U.S. customary units and 0.05 L for devices indicating in metric units.

S.1.5.2.3. Money-Value Divisions, Auxiliary Indications. *– In a system equipped with auxiliary indications, all indicated money-value divisions shall be identical.*

[Nonretroactive as of January 1, 1985.]

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S.1.5.3. Agreement Between Indications.

(a) When a quantity value indicated or recorded by an auxiliary element is a derived or computed value based on data received from a device, the value may differ from the quantity value displayed on the dispenser, provided that the following conditions are met:

(1) All total values for an individual sale that are indicated or recorded by the system agree, and

(2) Within each element, the values indicated or recorded meet the formula (quantity × unit price = total sale price) to the closest cent.

(b) When a system applies a post-delivery discount(s) to a fuel's unit price through an auxiliary element, the total volume of the delivery shall be in agreement between all elements in the system.

[Nonretroactive as of January 1, 2016]

(Added 2016)

S.1.5.4. Recorded Representations. – Except for fleet sales and other price contract sales and for transactions where a post-delivery discount is provided, a receipt providing the following information shall be available through a built-in or separate recording element for all transactions conducted with point-of-sale systems or devices activated by debit cards, credit cards, and/or cash:

(a) the total volume of the delivery;

(b) the unit price;

(c) the total computed price; and

(d) the product identity by name, symbol, abbreviation, or code number.

(Added 2014) (Amended 2016)

S.1.5.5. Recorded Representations for Transactions Where a Post-Delivery Discount(s) is Provided. – Except for fleet sales and other price contract sales, a recorded representation providing the following information shall be available through a built-in or separate recording element that is part of the system for transactions involving a post-delivery discount:

(a) the product identity by name, symbol, abbreviation, or code number;

(b) transaction information as shown on the dispenser at the end of the delivery and prior to any post-delivery discount(s), including the:

(1) total volume of the delivery;

(2) unit price; and

(3) total computed price of the fuel sale.

(c) an itemization of the post-delivery discounts to the unit price; and

(d) the final total price of the fuel sale after all post-delivery discounts are applied.

(Added 2016) (Amended 2023)

S.1.5.6. Transaction Information, Power Loss. *– In the event of a power loss, the information needed to complete any transaction in progress at the time of the power loss (such as the quantity and unit price, or*

sales price) shall be determinable for at least 15 minutes at the device or another on-site device accessible to the customer.

[Nonretroactive as of January 1, 2017]

(Added 2016)

S.1.5.7. Totalizers for Retail Motor-Fuel Dispensers. *– Retail motor-fuel dispensers shall be equipped with a nonresettable totalizer for the quantity delivered through the metering device.*

[Nonretroactive as of January 1, 2017]

(Added 2016)

S.1.6. For Wholesale Devices Only.

S.1.6.1. Travel of Indicator. – A wholesale device shall be readily operable to deliver accurately any quantity from 180 L (50 gal) to the capacity of the device. If the most sensitive element of the indicating system uses an indicator and graduations, the relative movement of these parts corresponding to a delivery of 4 L (1 gal) shall be not less than 5 mm (0.20 in).

(Amended 1987)

S.2. Design of Measuring Elements.

S.2.1. Air/Vapor Elimination. – A measuring system shall be equipped with an effective air/vapor eliminator or other automatic means to prevent the passage of air/vapor through the meter. Vent lines from the air/vapor eliminator shall be made of appropriate non-collapsible material.

(Amended 2016 and 2018)

S.2.2. Provision for Sealing. – For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device, security shall be provided for those parameters as specified in G-S.8.2. Devices and Systems Adjusted Using Removable Digital Storage Devices. For parameters adjusted using other means, the following applies.

Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or for physically applying a security seal in such a manner that requires the security seal to be broken before an adjustment or interchange can be made of:

(a) any measuring or indicating element;

(b) any adjustable element for controlling delivery rate, when such rate tends to affect the accuracy of deliveries; and

(c) any metrological parameter that will affect the metrological integrity of the device or system.

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

*Audit trails shall use the format set forth in Table S.2.2. Categories of Device and Methods of Sealing.**

*[*Nonretroactive as of January 1, 1995]*

(Amended 2006 and 2019)

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Table S.2.2. ***Categories of Device and Methods of Sealing***	
Categories of Device	***Methods of Sealing***
Category 1: *No remote configuration capability.*	*Seal by physical seal or two event counters: one for calibration parameters and one for configuration parameters.*
Category 2: *Remote configuration capability, but access is controlled by physical hardware.* *The device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode or shall not operate while in this mode.*	*The hardware enabling access for remote communication must be on-site. The hardware must be sealed using a physical seal or an event counter for calibration parameters and an event counter for configuration parameters. The event counters may be located either at the individual measuring device or at the system controller; however, an adequate number of counters must be provided to monitor the calibration and configuration parameters of the individual devices at a location. If the counters are located in the system controller rather than at the individual device, means must be provided to generate a hard copy of the information through an on-site device.*
Category 3: *Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).* *The device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode or shall not operate while in this mode.*	*An event logger is required in the device; it must include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter. A printed copy of the information must be available on demand through the device or through another on-site device. The information may also be available electronically. The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1 000 records are required. (**Note:** Does not require 1 000 changes to be stored for each parameter.)*

[Nonretroactive as of January 1, 1995]

(Table Added 2006) (Amended 2016)

S.2.3. Directional Flow Valves. – A measuring system shall be equipped with a valve or other effective means, automatic in operation and installed in or adjacent to the measuring element, to prevent reversal of flow of the product being measured.

(Amended 1982)

S.2.4. Maintenance of Liquid State. – A device shall be so designed and installed that the product being measured will remain in a liquid state during the passage through the meter.

S.2.5. Zero-Set-Back Interlock.

S.2.5.1. Zero-Set-Back Interlock, Electronic Stationary Meters (Other than Electronic Stationary Retail Motor-Fuel Dispensers) and Electronic Vehicle-Mounted Meters. – *A device shall be constructed so that after an individual delivery or multiple deliveries at one location have been completed, an automatic interlock system shall engage to prevent a subsequent delivery until the indicating element and, if equipped, recording element have been returned to their zero positions.*

[Nonretroactive as January 1, 2021]

(Added 2019) (Amended 2021 and 2024)

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S.2.5.2. Zero-Set-Back Interlock for Electronic Stationary Retail Motor-Fuel Devices. *– A device shall be constructed so that:*

(a) after a delivery cycle has been completed by moving the starting lever to any position that shuts off the device, an automatic interlock prevents a subsequent delivery until the indicating elements and recording elements, if the device is equipped and activated to record, have been returned to their zero positions;

(b) the discharge nozzle cannot be returned to its designed hanging position (that is, any position where the tip of the nozzle is placed in its designed receptacle and the lock can be inserted) until the starting lever is in its designed shut-off position and the zero-set-back interlock has been engaged; and

(c) in a system with more than one dispenser supplied by a single pump, an effective automatic control valve in each dispenser prevents product from being delivered until the indicating elements on that dispenser are in a correct zero position.

[Nonretroactive as of January 1, 2017]

(Added 2016) (Amended 2024)

S.2.6. Automatic Timeout.

S.2.6.1. Electronic Stationary (Other than Stationary Retail Motor-Fuel Dispensers). *– For individual deliveries, if there is no product flow for three minutes the transaction must be completed before additional product flow is allowed. The three-minute timeout shall be a sealable feature on an indicator.*

[Nonretroactive as of January 1, 2021]

(Added 2021) (Amended 2023)

S.2.6.2. Automatic Timeout Pay-at-Pump Retail Motor-Fuel Devices. *– Once a device has been authorized, it must deauthorize within three minutes if not activated. Reauthorization of the device must be performed before any product can be dispensed. If the time limit to deauthorize the device is programmable, it shall not accept an entry greater than three minutes.*

[Nonretroactive as of January 1, 2022]

(Added 2021)

S.2.6.3. Electronic Vehicle-Mounted Meters. – For individual deliveries, if there is no product flow for five minutes the transaction must be completed before additional product flow is allowed. The five-minute timeout shall be a sealable feature on the indicator.

(Added 2023)

S.2.7. Thermometer Well. – For test purposes, means shall be provided to determine the temperature of the liquid either:

(a) in the liquid chamber of the meter; or

(b) in the meter inlet or discharge line and immediately adjacent to the meter.

(Amended 1987)

S.2.8. Automatic Temperature Compensation. – A device may be equipped with an adjustable automatic means for adjusting the indication and registration of the measured volume of product to the volume at 15 °C (60 °F).

S.2.8.1. Provision for Deactivating. – On a device equipped with an automatic temperature-compensating mechanism that will indicate or record only in terms of liters or gallons adjusted to 15 °C (60 °F), provision

shall be made to facilitate the deactivation of the automatic temperature-compensating mechanism so that the meter may indicate, and record if it is equipped to record, in terms of the uncompensated volume.
(Amended 1972)

S.2.8.2. Provision for Sealing. – Provision shall be made for applying security seals in such a manner that an automatic temperature-compensating system cannot be disconnected and that no adjustment may be made to the system.

S.3. Design of Discharge Lines and Discharge Line Valves.

S.3.1. Diversion of Measured Liquid. – No means shall be provided by which any measured liquid can be diverted from the measuring chamber of the meter or the discharge line therefrom. However, two or more delivery outlets may be permanently installed if means are provided to ensure that:

(a) liquid can flow from only one such outlet at one time; and

(b) the direction of flow for which the mechanism may be set at any time is definitely and conspicuously indicated.

In addition, a manually controlled outlet that may be opened for the purpose of emptying a portion of the system to allow for repair and maintenance operations shall be permitted. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the device and to indicate clearly and unmistakably when the valve controls are so set as to permit passage of liquid through such outlet.
(Amended 1975)

S.3.2. Delivery Hose. – The delivery hose of a retail device shall be of the wet-hose type with a shutoff valve at its outlet end.

S.4. Marking Requirements.

S.4.1. Limitation of Use. – If a device is intended to measure accurately only products having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately only when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently stated on the device.

S.4.2. Discharge Rates. – A device shall be marked to show its designed maximum and minimum discharge rates. The marked minimum discharge rate shall not exceed:

(a) 20 L (5 gal) per minute for stationary retail devices; or

(b) 20 % of the marked maximum discharge rate for other retail devices and for wholesale devices.
(Amended 1987)

Note: Also see example in Section 3.30. Liquid-Measuring Devices Code, paragraph S.4.4.1. Discharge Rates.
(Added 2003)

S.4.3. Location of Marking Information; Retail Motor-Fuel Dispensers. *– The marking information required in General Code, paragraph G-S.1. Identification shall appear as follows:*

(a) within 60 cm (24 in) to 150 cm (60 in) from the base of the dispenser;

(b) either internally and/or externally provided the information is permanent and easily read; and

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(c) on a portion of the device that cannot be readily removed or interchanged (i.e., not on a service access panel).

The use of a dispenser key or tool to access internal marking information is permitted for retail motor-fuel dispensers.

[Nonretroactive as of January 1, 2003]

(Added 2006)

S.4.4. Temperature Compensation. – If a device is equipped with an automatic temperature compensator, the primary indicating elements, recording elements, and recorded representation shall be clearly and conspicuously marked to show that the volume delivered has been adjusted to the volume at 15 °C (60 °F).

N. Notes

N.1. Test Liquid. – A device shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics.

N.2. Vaporization and Volume Change. – Care shall be exercised to reduce to a minimum, vaporization and volume changes.

N.3. Test Drafts.

N.3.1. Minimum Test. – Test drafts shall be equal to at least the amount delivered by the device in one minute at its normal discharge rate.

(Amended 2023)

N.3.2. Transfer Standard Meter Test. – When comparing a meter with a calibrated transfer standard meter, the minimum quantity for any test draft shall be equal to or greater than the amount delivered in one minute at the flow rate being tested.

(Added 2023) (Amended 2024)

(Amended 1982, 2023, and 2024)

N.4. Testing Procedures.

N.4.1. Normal Tests. – The "normal" test of a device shall be made at the maximum discharge flow rate developed under the conditions of the installation. Any additional tests conducted at flow rates down to and including one-half the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered normal tests.

(Amended 1998)

N.4.1.1. Automatic Temperature Compensation. – On devices equipped with automatic temperature-compensating systems, normal tests shall be conducted as follows:

(a) by comparing the compensated volume indicated or recorded to the actual delivered volume adjusted to 15 °C (60 °F); and

(b) with the temperature-compensating system deactivated, comparing the uncompensated volume indicated or recorded to the actual delivered volume.

The first test shall be performed with the automatic temperature-compensating system operating in the "as found" condition. On devices that indicate or record both the compensated and uncompensated volume for each delivery, the tests in (a) and (b) may be performed as a single test.

(Amended 1987)

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N.4.2. Special Tests. – "Special" tests shall be made to develop the operating characteristics of a device and any special elements and accessories attached to or associated with the device. Any test except as set forth in N.4.1. Normal Tests shall be considered a special test.

N.4.2.1. For Motor-Fuel Devices. – A motor-fuel device shall be so tested at a minimum discharge rate of:

(a) 20 L (5 gal) per minute; or

(b) the minimum discharge rate marked on the device, whichever is less.

N.4.2.2. For Other Retail Devices. – A retail device other than a motor-fuel device shall be tested at a minimum discharge rate of the:

(a) minimum discharge rate that can be developed under the conditions of installation; or

(b) minimum discharge rate marked on the device, whichever is greater.

(Amended 1973)

N.4.2.3. For Wholesale Devices. – "Special" tests on a wholesale device shall include a test at, or slightly above, the minimum discharge rate marked on the device. In no case shall the test be performed at a flow rate less than the minimum discharge rate marked on the device.

(Amended 1987 and 2017)

N.4.3. Money-Value Computation Tests.

N.4.3.1. Laboratory Design Evaluation Tests. – In the conduct of laboratory design evaluation tests, compliance with paragraph S.1.5.2. Money-Value Computations shall be determined by using the cone gear as a reference for the total quantity delivered. The indicated delivered quantity shall agree with the cone gear representation with the index of the indicator within the width of the graduation. The maximum allowable variation of the indicated sales price shall be as shown in Table 1. Money-Value Divisions and Maximum Allowable Variations for Money-Value Computations on Mechanical Analog Computers.

N.4.3.2. Field Tests. – In the conduct of field tests to determine compliance with paragraph S.1.5.2. Money-Value Computations the maximum allowable variation in the indicated sales price shall be as shown in Table 1. Money-Value Divisions and Maximum Allowable Variations for Money-Value Computations on Mechanical Analog Computers.

(Added 1984)

N.4.4. Repeatability Tests. – Tests for repeatability should include a minimum of three consecutive test drafts of approximately the same size and be conducted under controlled conditions where variations in factors such as temperature, pressure, and flow rate are reduced to the extent that they will not affect the results obtained. When conducting the tests, the discharge rates shall be within the minimum and maximum discharge rates as marked by the manufacturer. For devices equipped with an automatic temperature compensator, results shall be based on the uncompensated (gross) volume (e.g., with the temperature compensator deactivated).

(Amended 2019)

N.5. Temperature Correction. – Adjustments shall be made for any changes in volume resulting from the differences in liquid temperatures between time of passage through the meter and time of volumetric determination in the prover. When adjustments are necessary, appropriate petroleum measurement tables should be used.

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T. Tolerances

T.1. Application.

T.1.1. To Underregistration and to Overregistration. – The tolerances hereinafter prescribed shall be applied to errors of underregistration and errors of overregistration, whether or not a device is equipped with an automatic temperature compensator.

T.2. Tolerance Values. – The maintenance and acceptance tolerances for normal and special tests shall be as shown in Table T.2. Accuracy Classes and Tolerances for LPG and Anhydrous Ammonia Liquid-Measuring Devices.
(Amended 2003)

Table T.2.
Accuracy Classes and Tolerances for LPG and Anhydrous Ammonia Liquid-Measuring Devices

Accuracy Class	Application	Acceptance Tolerance	Maintenance Tolerance	Special Test Tolerance
1.0	Anhydrous ammonia, LPG (including vehicle-mounted meters)	0.6 %	1.0 %	1.0 %

(Added 2003)

T.3. Repeatability. – When multiple tests are conducted at approximately the same flow rate and draft size, the range of the test results for the flow rate shall not exceed 40 % of the absolute value of the maintenance tolerance and the results of each test shall be within applicable tolerance. (Also see N.4.4. Repeatability Tests)
(Added 1992) (Amended 1997, 2001, and 2019)

T.4. Automatic Temperature-Compensating Systems. – The difference between the meter errors (expressed as a percentage) determined with and without the automatic temperature-compensating system activated shall not exceed:

(a) 1.0 % for mechanical automatic temperature-compensating systems; and

(b) 0.5 % for electronic automatic temperature-compensating systems.

The delivered quantities for each test shall be approximately the same size. The results of each test shall be within the applicable acceptance or maintenance tolerance.
(Added 1991) (Amended 1992, 1996, and 1997)

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Discharge Rate. – A device shall be so installed that the actual maximum discharge rate will not exceed the rated maximum discharge rate. If necessary, means for flow regulation shall be incorporated in the installation, in which case this shall be fully effective and automatic in operation.

UR.1.2. Length of Discharge Hose. – The length of the discharge hose on a stationary motor-fuel device shall not exceed 5.5 m (18 ft), measured from the outside of the housing of the device to the inlet end of the discharge nozzle, unless it can be demonstrated that a longer hose is essential to permit deliveries to be made to receiving vehicles or vessels. Unnecessarily remote location of a device shall not be accepted as justification for an abnormally long hose.
(Amended 1991)

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UR.2. Use Requirements.

UR.2.1. Return of Indication and Recording Elements to Zero. – The primary indicating elements (visual), and the primary recording elements when these are returnable to zero, shall be returned to zero before each delivery.

UR.2.2. Condition of Fill of Discharge Hose. – The discharge hose shall be completely filled with liquid before the "zero" condition is established prior to the start of a commercial delivery, whether this condition is established by resetting the primary indicating elements to zero indication or by recording the indications of the primary indicating elements. (Also see UR.2.1. Return of Indication and Recording Elements to Zero.)

UR.2.3. Vapor-Return Line. – During any metered delivery of liquefied petroleum gas from a supplier's tank to a receiving container, a vapor-return line from the receiving container to the supplier's tank is prohibited except:

(a) in the case of any receiving container to which normal deliveries cannot be made without the use of such vapor-return line; or

(b) in the case of any top spray-fill receiving container when the ambient temperature is at or above 32 °C (90 °F).

(Amended 2016)

UR.2.4. Temperature Compensation.

UR.2.4.1. Use of Automatic Temperature Compensators. – If a device is equipped with an automatic temperature compensator, this shall be connected, operable, and in use at all times. Such automatic temperature compensator may not be removed, nor may a compensated device be replaced with an uncompensated device, without the written approval of the weights and measures authority having jurisdiction over the device.

UR.2.4.2. Temperature Compensated Sale. – All sales of liquefied petroleum gas in a liquid state, when the quantity is determined by an approved measuring system equipped with a temperature-compensating mechanism, or by weight and converted to liters or gallons, or by a calibrated container, shall be in terms of liters or the U.S. gallon of 231 in^3 at 15 °C (60 °F).

(Added 1984)

UR.2.4.3. Invoices. – Any invoice based on a reading of a device that is equipped with an automatic temperature compensator or based on a weight converted to gallons, or based on the volume of a calibrated container, shall have shown thereon that the volume delivered has been adjusted to the volume at 15 °C (60 °F).

(Amended 1984)

UR.2.4.4. Automated Temperature-Compensating Systems. – Means for determining the temperature of measured liquid in an automatic temperature-compensating system shall be so designed and located that, in any "usual and customary" use of the system, the resulting indications and/or recorded representations are within applicable tolerances.

(Added 1987)

UR.2.5. Ticket in Printing Device. – A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a delivery is begun, and in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

UR.2.6. Recorded Representations. – Vehicle-mounted metering systems shall be equipped with a means to record all sales where product is delivered through the meter and shall comply with G-S.5.6. Recorded

Representations. A copy of the recorded representation issued by the device shall be provided to the customer at the time of delivery or as otherwise specified by the customer.

(Added 1992) (Amended 2023)

UR.2.7. For Stationary Retail Computing-Type Systems Only, Installed After January 1, 2017.

UR.2.7.1. Unit Price and Product Identity.

(a) The following information shall be conspicuously displayed or posted on the face of a retail dispenser used in a direct sale:

(1) except for unit prices resulting from any post-delivery discount and dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks), all of the unit prices at which the product is offered for sale; and

(2) in the case of a computing-type device or money-operated type device, the unit price at which the dispenser is set to compute.

Provided that the dispenser complies with S.1.5.1. Display of Unit Price and Product Identity, it is not necessary that all the unit prices be simultaneously displayed or posted.

(b) The following information shall be conspicuously displayed or posted on each side of a retail dispenser used in a direct sale:

(1) The identity of the product in descriptive commercial terms; and

(2) The identity of the grade, brand, blend, or mixture that a multi-product dispenser is set to deliver.

(Added 2016)

UR.2.7.2. Computing Device. – Any computing device used in an application where a product or grade is offered for sale at one or more unit prices shall be used only for sales for which the device computes and displays the sales price for the selected transaction. The following exceptions apply:

(a) Fleet sales and other price contract sales are exempt from this requirement.

(b) A truck stop dispenser used exclusively for refueling trucks is exempt from this requirement, provided that:

(1) all purchases of fuel are accompanied by a recorded representation of the transaction containing the applicable price per unit of measure, the total quantity delivered, and the total price of the sale; and

(2) unless a dispenser complies with S.1.5.1. Display of Unit Price, the price posted on the dispenser and the price at which the dispenser is set to compute shall be the highest price for any transaction which may be conducted.

(c) A dispenser used in an application where a price per unit discount is offered following the delivery is exempt from this requirement, provided the following conditions are satisfied:

(1) the unit price posted on the dispenser and the unit price at which the dispenser is set to compute shall be the highest unit price for any transaction;

(2) all purchases of fuel are accompanied by a receipt recorded by the system for the transaction containing:

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a. the product identity by name, symbol, abbreviation, or code number;

b. transaction information as shown on the dispenser at the end of the delivery and prior to any post-delivery discount including the:

1. total volume of the delivery;

2. unit price; and

3. total computed price of the fuel sale prior to post-delivery discounts being applied.

c. an itemization of the post-delivery discounts to the unit price; and

d. the final total price of the fuel sale after all post-delivery discounts are applied.

(Added 2016) (Amended 2023)

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Appendix A. Fundamental Considerations Associated with the Enforcement of Handbook 44 Codes

1. Uniformity of Requirements

1.1. National Council Codes. – Weights and measures jurisdictions are urged to promulgate and adhere to the National Council codes, to the end that uniform requirements may be in force throughout the country. This action is recommended even though a particular jurisdiction does not wholly agree with every detail of the National Council codes. Uniformity of specifications and tolerances is an important factor in the manufacture of commercial equipment. Deviations from standard designs to meet the special demands of individual weights and measures jurisdictions are expensive, and any increase in costs of manufacture is, of course, passed on to the purchaser of equipment. On the other hand, if designs can be standardized by the manufacturer to conform to a single set of technical requirements, production costs can be kept down, to the ultimate advantage of the general public. Moreover, it seems entirely logical that equipment that is suitable for commercial use in the "specification" states should be equally suitable for such use in other states.

Another consideration supporting the recommendation for uniformity of requirements among weights and measures jurisdictions is the cumulative and regenerative effect of the widespread enforcement of a single standard of design and performance. The enforcement effort in each jurisdiction can then reinforce the enforcement effort in all other jurisdictions. More effective regulatory control can be realized with less individual effort under a system of uniform requirements than under a system in which even minor deviations from standard practice are introduced by independent state action.

Since the National Council codes represent the majority opinion of a large and representative group of experienced regulatory officials, and since these codes are recognized by equipment manufacturers as their basic guide in the design and construction of commercial weighing and measuring equipment, the acceptance and promulgation of these codes by each state are strongly recommended.

1.2. Form of Promulgation. – A convenient and very effective form of promulgation already successfully used in a considerable number of states is promulgation by citation of National Institute of Standards and Technology Handbook 44. It is especially helpful when the citation is so made that, as amendments are adopted from time to time by the National Council on Weights and Measures, these automatically go into effect in the state regulatory authority. For example, the following form of promulgation has been used successfully and is recommended for consideration:

> The specifications, tolerances, and other technical requirements for weighing and measuring devices as recommended by the National Council on Weights and Measures and published in the National Institute of Standards and Technology Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices," and supplements thereto or revisions thereof, shall apply to commercial weighing and measuring devices in the state.

In some states, it is preferred to base technical requirements upon specific action of the state legislature rather than upon an act of promulgation by a state officer. The advantages cited above may be obtained and may yet be surrounded by adequate safeguards to insure proper freedom of action by the state enforcing officer if the legislature adopts the National Council requirements by language somewhat as follows:

> The specifications, tolerances, and other technical requirements for weighing and measuring devices as recommended by the National Council on Weights and Measures shall be the specifications, tolerances, and other technical requirements for weighing and measuring devices of the state except insofar as specifically modified, amended, or rejected by a regulation issued by the state (insert title of enforcing officer).

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2. Tolerances for Commercial Equipment

2.1. Acceptance and Maintenance Tolerances. – The official tolerances prescribed by a weights and measures jurisdiction for commercial equipment are the limits of inaccuracy officially permissible within that jurisdiction. It is recognized that errorless value or performance of mechanical equipment is unattainable. Tolerances are established, therefore, to fix the range of inaccuracy within which equipment will be officially approved for commercial use. In the case of classes of equipment on which the magnitude of the errors of value or performance may be expected to change as a result of use, two sets of tolerances are established: acceptance tolerances and maintenance tolerances.

Acceptance tolerances are applied to new or newly reconditioned equipment; equipment returned to service following official rejection for failure to conform to performance requirements; or equipment undergoing NTEP evaluation, and are smaller than (usually one-half of) the maintenance tolerances. Maintenance tolerances thus provide an additional range of inaccuracy within which equipment will be approved on subsequent tests, permitting a limited amount of deterioration before the equipment will be officially rejected for inaccuracy and before reconditioning or adjustment will be required. In effect, there is assured a reasonable period of use for equipment after it is placed in service before reconditioning will be officially required. The foregoing comments do not apply, of course, when only a single set of tolerance values is established, as is the case with equipment such as glass milk bottles and graduates, which maintain their original accuracy regardless of use, and measure-containers, which are used only once.

2.2. Theory of Tolerances. – Tolerance values are so fixed that the permissible errors are sufficiently small that there is no serious injury to either the buyer or the seller of commodities, yet not so small as to make manufacturing or maintenance costs of equipment disproportionately high. Obviously, the manufacturer must know what tolerances his equipment is required to meet, so that he can manufacture economically. His equipment must be good enough to satisfy commercial needs but should not be subject to such stringent tolerance values as to make it unreasonably costly, complicated, or delicate.

2.3. Tolerances and Adjustments. – Tolerances are primarily accuracy criteria for use by the regulatory official. However, when equipment is being adjusted for accuracy, either initially or following repair or official rejection, the objective should be to adjust as closely as practicable to zero error. Equipment owners should not take advantage of tolerances by deliberately adjusting their equipment to have a value, or to give performance, at or close to the tolerance limit. Nor should the repair or service personnel bring equipment merely within tolerance range when it is possible to adjust closer to zero error.[1]

3. Testing Apparatus

3.1. Adequacy. – 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.

(Amended 2023)

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

[1] See General Code, Section 1.10.; User Requirement G-UR.4.3. Use of Adjustments.

- Documented Measurement Uncertainty
- Documented Measurement Procedure
- Accredited Technical Competence
- Measurement Assurance

3.1.2. Specifications for Standards. – Standards shall 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 to the International System of Units (SI) through NIST or other National Metrology Institutes, they need only be approved by the Director.

(Added 2023)

3.2. Tolerances for Standards. – Except for work of relatively high precision, it is recommended that the accuracy of standards used in testing commercial weighing and measuring equipment be established and maintained so that the use of corrections is not necessary. When the 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 field standard or a transfer 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 weighing and measuring 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 a designated period of time (as determined by the Director); and (3) demonstrated validity or performance of the standard over the range of environmental and operational conditions in which the standard can be reasonably anticipated to 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 designated period of time (defined based on data of the standard's stability by an authorized metrology lab or as specified by the Director) and can be demonstrated to maintain its value as a standard over the range of environmental conditions and the range of operating conditions in which the standard can be reasonably anticipated to be used to test commercial weighing and measuring devices.

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 limited time of use, 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 weighing and 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 can be reasonably anticipated to be used. The performance characteristics must be

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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 associated with the Type 2 transfer standard. When commercial weighing and measuring devices are tested using a Type 2 transfer standard, the tolerance applied to the commercial weighing and measuring devices meter under test shall be determined as specified in Section 1.10. General Code, G-T.5. Tolerances on Tests When Type 2 Transfer Standards Are Used.

(Added 2023)

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. 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 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.

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.

(Amended 2023)

4. Inspection of Commercial Equipment

4.1. Inspection Versus Testing. – A distinction may be made between the inspection and the testing of commercial equipment that should be useful in differentiating between the two principal groups of official requirements; i.e., specifications and performance requirements. Although the term inspection is frequently loosely used to include everything that the official has to do in connection with commercial equipment, it is useful to limit the scope of that term primarily to examinations made to determine compliance with design, maintenance, and user requirements. The term testing may then be limited to those operations carried out to determine the accuracy of the value or performance of the equipment under examination by comparison with the actual physical standards of the official. These two terms will be used herein in the limited senses defined.

4.2. Necessity for Inspection. – It is not enough merely to determine that the errors of equipment do not exceed the appropriate tolerances. Specification and user requirements are as important as tolerance requirements and should be enforced. Inspection is particularly important and should be carried out with unusual thoroughness whenever the official examines a type of equipment not previously encountered.

This is the way the official learns whether or not the design and construction of the device conform to the specification requirements. But even a device of a type with which the official is thoroughly familiar and that he has previously found to meet specification requirements should not be accepted entirely on faith. Some part may have become damaged, or some detail of design may have been changed by the manufacturer, or the owner or operator may have removed an essential element or made an objectionable addition. Such conditions may be learned only by inspection. Some degree of inspection is therefore an essential part of the official examination of every piece of weighing or measuring equipment.

4.3. Specification Requirements. – A thorough knowledge by the official of the specification requirements is a prerequisite to competent inspection of equipment. The inexperienced official should have his specifications before him when making an inspection and should check the requirements one by one against the equipment itself. Otherwise, some important requirement may be overlooked. As experience is gained, the official will become progressively less dependent on the handbook, until finally observance of faulty conditions becomes almost automatic and the time and effort required to do the inspecting are reduced to a minimum. The printed specifications, however, should always be available for reference to refresh the official's memory or to be displayed to support his decisions, and they are an essential item of his kit.

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Specification requirements for a particular class of equipment are not all to be found in the separate code for that class. The requirements of the General Code apply, in general, to all classes of equipment, and these must always be considered in combination with the requirements of the appropriate separate code to arrive at the total of the requirements applicable to a piece of commercial equipment.

4.4. General Considerations. – The simpler the commercial device, the fewer are the specification requirements affecting it, and the more easily and quickly can adequate inspection be made. As mechanical complexity increases, however, inspection becomes increasingly important and more time consuming, because the opportunities for the existence of faulty conditions are multiplied. It is on the relatively complex device, too, that the official must be on the alert to discover any modification that may have been made by an operator that might adversely affect the proper functioning of the device.

It is essential for the officials to familiarize themselves with the design and operating characteristics of the devices that he inspects and tests. Such knowledge can be obtained from the catalogs and advertising literature of device manufacturers, from trained service persons and plant engineers, from observation of the operations performed by service persons when reconditioning equipment in the field, and from a study of the devices themselves.

Inspection should include any auxiliary equipment and general conditions external to the device that may affect its performance characteristics. In order to prolong the life of the equipment and forestall rejection, inspection should also include observation of the general maintenance of the device and of the proper functioning of all required elements. The official should look for worn or weakened mechanical parts, leaks in volumetric equipment, or elements in need of cleaning.

4.5. Misuse of Equipment. – Inspection, coupled with judicious inquiry, will sometimes disclose that equipment is being improperly used, either through ignorance of the proper method of operation or because some other method is preferred by the operator. Equipment should be operated only in the manner that is obviously indicated by its construction or that is indicated by instructions on the equipment, and operation in any other manner should be prohibited.

4.6. Recommendations. – A comprehensive knowledge of each installation will enable the official to make constructive recommendations to the equipment owner regarding proper maintenance of his weighing and measuring devices and the suitability of his equipment for the purposes for which it is being used or for which it is proposed that it be used. Such recommendations are always in order and may be very helpful to an owner. The official will, of course, carefully avoid partiality toward or against equipment of specific makes and will confine his recommendations to points upon which he is qualified, by knowledge and experience, to make suggestions of practical merit.

4.7. Accurate and Correct Equipment. – Finally, the weights and measures official is reminded that commercial equipment may be accurate without being correct. A piece of equipment is accurate when its performance or value (that is, its indications, its deliveries, its recorded representations, or its capacity or actual value, etc., as determined by tests made with suitable standards) conforms to the standard within the applicable tolerances and other performance requirements. Equipment that fails so to conform is inaccurate. A piece of equipment is correct when, in addition to being accurate, it meets all applicable specification requirements. Equipment that fails to meet any of the requirements for correct equipment is incorrect. Only equipment that is correct should be sealed and approved for commercial use.[2]

5. Correction of Commercial Equipment

5.1. Adjustable Elements. – Many types of weighing and measuring instruments are not susceptible to adjustment for accuracy by means of adjustable elements. Linear measures, liquid measures, graduates, measure-containers, milk and lubricating-oil bottles, farm milk tanks, dry measures, and some of the more simple types of scales are in this category. Other types (for example, taximeters and odometers and some metering devices) may be adjusted in the field, but only by changing certain parts such as gears in gear trains.

[2] See Section 1.10. General Code and Appendix D. Definitions.

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Some types, of which fabric-measuring devices and cordage-measuring devices are examples, are not intended to be adjusted in the field and require reconditioning in shop or factory if inaccurate. Liquid-measuring devices and most scales are equipped with adjustable elements, and some vehicle-tank compartments have adjustable indicators. Field adjustments may readily be made on such equipment. In the discussion that follows, the principles pointed out and the recommendations made apply to adjustments on any commercial equipment, by whatever means accomplished.

5.2. When Corrections Should Be Made. – One of the primary duties of a weights and measures official is to determine whether equipment is suitable for commercial use. If a device conforms to all legal requirements, the official "marks" or "seals" it to indicate approval. If it does not conform to all official requirements, the official is required to take action to ensure that the device is corrected within a reasonable period of time. Devices with performance errors that could result in serious economic injury to either party in a transaction should be prohibited from use immediately and not allowed to be returned to service until necessary corrections have been made. The official should consider the most appropriate action, based on all available information and economic factors.

Some officials contend that it is justifiable for the official to make minor corrections and adjustments if there is no service agency nearby or if the owner or operator depends on this single device and would be "out of business" if the use of the device were prohibited until repairs could be made. Before adjustments are made at the request of the owner or the owner's representative, the official should be confident that the problem is not due to faulty installation or a defective part, and that the adjustment will correct the problem. The official should never undertake major repairs, or even minor corrections, if services of commercial agencies are readily available. The official should always be mindful of conflicts of interest before attempting to perform any services other than normal device examination and testing duties.

(Amended 1995)

5.3. Gauging. – In the majority of cases, when the weights and measures official tests commercial equipment, he is verifying the accuracy of a value or the accuracy of the performance as previously established either by himself or by someone else. There are times, however, when the test of the official is the initial test on the basis of which the calibration of the device is first determined or its performance first established. The most common example of such gauging is in connection with vehicle tanks the compartments of which are used as measures. Frequently the official makes the first determination on the capacities of the compartments of a vehicle tank, and his test results are used to determine the proper settings of the compartment indicators for the exact compartment capacities desired. Adjustments of the position of an indicator under these circumstances are clearly not the kind of adjustments discussed in the preceding paragraph.

6. Rejection of Commercial Equipment

6.1. Rejection and Condemnation. – The Uniform Weights and Measures Law contains a provision stating that the director shall reject and order to be corrected such physical weights and measures or devices found to be incorrect. Weights and measures and devices that have been rejected, may be seized if not corrected within a reasonable time or if used or disposed of in a manner not specifically authorized. The director shall remove from service and may seize weights and measures found to be incorrect that are not capable of being made correct.

These broad powers should be used by the official with discretion. The director should always keep in mind the property rights of an equipment owner and cooperate in working out arrangements whereby an owner can realize at least something from equipment that has been rejected. In cases of doubt, the official should initially reject rather than condemn outright. Destruction and confiscation of equipment are harsh procedures. Power to seize and destroy is necessary for adequate control of extreme situations, but seizure and destruction should be resorted to only when clearly justified.

On the other hand, rejection is clearly inappropriate for many items of measuring equipment. This is true for most linear measures, many liquid and dry measures, graduates, measure-containers, milk bottles, lubricating-oil bottles, and some scales. When such equipment is "incorrect," it is either impractical or impossible to adjust or repair it, and the official has no alternative to outright condemnation. When only a few such items are involved, immediate destruction or confiscation is probably the best procedure. If a considerable number of items are involved (as, for example, a stock of measures in the hands of a dealer or a large shipment of bottles), return of these to the manufacturer

for credit or replacement should ordinarily be permitted provided that the official is assured that they will not get into commercial use. In rare instances, confiscation and destruction are justified as a method of control when less harsh methods have failed.

In the case of incorrect mechanisms such as fabric-measuring devices, taximeters, liquid-measuring devices, and most scales, repair of the equipment is usually possible, so rejection is the customary procedure. Seizure may occasionally be justified, but in the large majority of instances this should be unnecessary. Even in the case of worn-out equipment, some salvage is usually possible, and this should be permitted under proper controls.

(Amended 1995)

7. Tagging of Equipment

7.1. Rejected and Condemned. – It will ordinarily be practicable to tag or mark as rejected each item of equipment found to be incorrect and considered susceptible of proper reconditioning. However, it can be considered justifiable not to mark as rejected incorrect devices capable of meeting acceptable performance requirements if they are to be allowed to remain in service for a reasonable time until minor problems are corrected, since marks of rejection may tend to be misleading about a device's ability to produce accurate measurements during the correction period. The tagging of equipment as condemned, or with a similar label to indicate that it is permanently out of service, is not recommended if there is any other way in which the equipment can definitely be put out of service. Equipment that cannot successfully be repaired should be dismantled, removed from the premises, or confiscated by the official rather than merely being tagged as "condemned."

(Amended 1995)

7.2. Nonsealed and Noncommercial. – Rejection is not appropriate if measuring equipment cannot be tested by the official at the time of his regular visit–for example, when there is no gasoline in the supply tank of a gasoline-dispensing device. Some officials affix to such equipment a nonsealed tag stating that the device has not been tested and sealed and that it must not be used commercially until it has been officially tested and approved. This is recommended whenever considerable time will elapse before the device can be tested.

Where the official finds in the same establishment, equipment that is in commercial use and also equipment suitable for commercial use that is not presently in service, but which may be put into service at some future time, he may treat the latter equipment in any of the following ways:

(a) Test and approve the same as commercial equipment in use.

(b) Refrain from testing it and remove it from the premises to preclude its use for commercial purposes.

(c) Mark the equipment nonsealed.

Where the official finds commercial equipment and noncommercial equipment installed or used in close proximity, he may treat the noncommercial equipment in any of the following ways:

(a) Test and approve the same as commercial equipment.

(b) Physically separate the two groups of equipment so that misuse of the noncommercial equipment will be prevented.

(c) Tag it to show that it has not been officially tested and is not to be used commercially.

8. Records of Equipment

8.1. Records, General. - The official will be well advised to keep careful records of equipment that is rejected, so that he may follow up to ensure that the necessary repairs have been made. As soon as practicable following

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completion of repairs, the equipment should be retested. Complete records should also be kept of equipment that has been tagged as nonsealed or noncommercial. Such records may be invaluable should it subsequently become necessary to take disciplinary steps because of improper use of such equipment.

9. Sealing of Equipment

9.1. Types of Seals and Their Locations. – Most weights and measures jurisdictions require that all equipment officially approved for commercial use (with certain exceptions to be pointed out later) be suitably marked or sealed to show approval. This is done primarily for the benefit of the public to show that such equipment has been officially examined and approved. The seal of approval should be as conspicuous as circumstances permit and should be of such a character and so applied that it will be reasonably permanent. Uniformity of position of the seal on similar types of equipment is also desirable as a further aid to the public.

The official will need more than one form of seal to meet the requirements of different kinds of equipment. Good quality, weather-resistant, water-adhesive, or pressure-sensitive seals or decalcomania seals are recommended for fabric-measuring devices, liquid-measuring devices, taximeters, and most scales, because of their permanence and good appearance. Steel stamps are most suitable for liquid and dry measures, for some types of linear measures, and for weights. An etched seal, applied with suitable etching ink, is excellent for steel tapes, and greatly preferable to a seal applied with a steel stamp. The only practicable seal for a graduate is one marked with a diamond or carbide pencil, or one etched with glass-marking ink. For a vehicle tank, the official may wish to devise a relatively large seal, perhaps of metal, with provision for stamping data relative to compartment capacities, the whole to be welded or otherwise permanently attached to the shell of the tank. In general, the lead-and-wire seal is not suitable as an approval seal.

9.2. Exceptions. – Commercial equipment such as measure-containers, milk bottles, and lubricating-oil bottles are not tested individually because of the time element involved. Because manufacturing processes for these items are closely controlled, an essentially uniform product is produced by each manufacturer. The official normally tests samples of these items prior to their sale within his jurisdiction and subsequently makes spot checks by testing samples selected at random from new stocks.

Another exception to the general rule for sealing approved equipment is found in certain very small weights whose size precludes satisfactory stamping with a steel die.

10. Rounding Off Numerical Values

10.1. Definition. – To round off or round a numerical value is to change the value of recorded digits to some other value considered more desirable for the purpose at hand by dropping or changing certain figures. For example, if a computed, observed, or accumulated value is 4738, this can be rounded off to the nearest thousand, hundred, or ten, as desired. Such rounded-off values would be, respectively, 5000, 4700, and 4740. Similarly, a value such as 47.382 can be rounded off to two decimal places, to one decimal place, or to the units place. The rounded-off figures in this example would be, respectively, 47.38, 47.4, and 47.

10.2. General Rules. – The general rules for rounding off may be stated briefly as follows:

(a) When the figure next beyond the last figure or place to be retained is less than 5, the figure in the last place retained is to be kept unchanged. When rounding off 4738 to the nearest hundred, it is noted that the figure 3 (next beyond the last figure to be retained) is less than 5. Thus, the rounded-off value would be 4700. Likewise, 47.382 rounded to two decimal places becomes 47.38.

(b) When the figure next beyond the last figure or place to be retained is greater than 5, the figure in the last place retained is to be increased by 1. When rounding off 4738 to the nearest thousand, it is noted that the figure 7 (next beyond the last figure to be retained) is greater than 5. Thus, the rounded-off value would be 5000. Likewise, 47.382 rounded to one decimal place becomes 47.4.

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(c) When the figure next beyond the last figure to be retained is 5 followed by any figures other than zero(s), treat as in (b) above; that is, the figure in the last place retained is to be increased by 1. When rounding off 4501 to the nearest thousand, 1 is added to the thousands figure and the result becomes 5000.

(d) When the figure next beyond the last figure to be retained is 5 and there are no figures, or only zeros, beyond this 5, the figure in the last place to be retained is to be left unchanged if it is even (0, 2, 4, 6, or 8) and is to be increased by 1 if it is odd (1, 3, 5, 7, or 9). This is the odd and even rule, and may be stated as follows: "If odd, then add." Thus, rounding off to the first decimal place, 47.25 would become 47.2 and 47.15 would become 47.2. Also, rounded to the nearest thousand, 4500 would become 4000 and 1500 would become 2000.

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It is important to remember that, when there are two or more figures to the right of the place where the last significant figure of the final result is to be, the entire series of such figures must be rounded off in one step and not in two or more successive rounding steps. [Expressed differently, when two or more such figures are involved, these are not to be rounded off individually, but are to be rounded off as a group.] Thus, when rounding off 47.3499 to the first decimal place, the result becomes 47.3. In arriving at this result, the figures "499" are treated as a group. Since the 4 next beyond the last figure to be retained is less than 5, the "499" is dropped (see subparagraph (a) above). It would be incorrect to round off these figures successively to the left so that 47.3499 would become 47.350 and then 47.35 and then 47.4.

10.3. Rules for Reading of Indications. – An important aspect of rounding off values is the application of these rules to the reading of indications of an indicator-and-graduated-scale combination (where the majority of the indications may be expected to lie somewhere between two graduations) if it is desired to read or record values only to the nearest graduation. Consider a vertical graduated scale and an indicator. Obviously, if the indicator is between two graduations but is closer to one graduation than it is to the other adjacent graduation, the value of the closer graduation is the one to be read or recorded.

In the case where, as nearly as can be determined, the indicator is midway between two graduations, the odd-and-even rule is invoked, and the value to be read or recorded is that of the graduation whose value is even. For example, if the indicator lies exactly midway between two graduations having values of 471 and 472, respectively, the indication should be read or recorded as 472, this being an even value. If midway between graduations having values of 474 and 475, the even value 474 should be read or recorded. Similarly, if the two graduations involved had values of 470 and 475, the even value of 470 should be read or recorded.

A special case not covered by the foregoing paragraph is that of a graduated scale in which successive graduations are numbered by twos, all graduations thus having even values; for example, 470, 472, 474, etc. When, in this case, an indication lies midway between two graduations, the recommended procedure is to depart from the practice of reading or recording only to the value of the nearest graduation and to read or record the intermediate odd value. For example, an indication midway between 470 and 472 should be read as 471.

10.4. Rules for Common Fractions. – When applying the rounding-off rules to common fractions, the principles are to be applied to the numerators of the fractions that have, if necessary, been reduced to a common denominator. The principle of "5s" is changed to the one-half principle; that is, add if more than one-half, drop if less than one-half, and apply the odd-and even rule if exactly one-half.

For example, a series of values might be $1\frac{1}{32}$, $1\frac{2}{32}$, $1\frac{3}{32}$, $1\frac{4}{32}$, $1\frac{5}{32}$, $1\frac{6}{32}$, $1\frac{7}{32}$, $1\frac{8}{32}$, $1\frac{9}{32}$. Assume that these values are to be rounded off to the nearest eighth ($\frac{4}{32}$). Then,

$1\frac{1}{32}$ becomes 1. ($\frac{1}{32}$ is less than half of $\frac{4}{32}$ and accordingly is dropped.)

$1\frac{2}{32}$ becomes 1. ($\frac{2}{32}$ is exactly one-half of $\frac{4}{32}$; it is dropped because it is rounded (down) to the "even" eighth, which in this instance is $\frac{0}{8}$.)

$1\frac{3}{32}$ becomes $1\frac{4}{32}$ or $1\frac{1}{8}$. ($\frac{3}{32}$ is more than half of $\frac{4}{32}$, and accordingly is rounded "up" to $\frac{4}{32}$ or $\frac{1}{8}$).

$1\frac{4}{32}$ remains unchanged, being an exact eighth ($1\frac{1}{8}$).

$1^{5}/_{32}$ becomes $1^{4}/_{32}$ or $1^{1}/_{8}$. ($^{5}/_{32}$ is $^{1}/_{32}$ more than an exact $^{1}/_{8}$; $^{1}/_{32}$ is less than half of $^{4}/_{32}$ and accordingly is dropped.)

$1^{6}/_{32}$ becomes $1^{2}/_{8}$ or $1^{1}/_{4}$. ($^{6}/_{32}$ is $^{2}/_{32}$ more than an exact $^{1}/_{8}$; $^{2}/_{32}$ is exactly one-half of $^{4}/_{32}$, and the final fraction is rounded (up) to the "even" eighth, which in this instance is $^{2}/_{8}$.)

$1^{7}/_{32}$ becomes $1^{2}/_{8}$ or $1^{1}/_{4}$. ($^{7}/_{32}$ is $^{3}/_{32}$ more than an exact $^{1}/_{8}$; $^{3}/_{32}$ is more than one-half of $^{4}/_{32}$ and accordingly the final fraction is rounded (up) to $^{2}/_{8}$ or $^{1}/_{4}$.)

$1^{8}/_{32}$ remains unchanged, being an exact eighth ($1^{2}/_{8}$ or $1^{1}/_{4}$.)

$1^{9}/_{32}$ becomes $1^{2}/_{8}$ or $1^{1}/_{4}$. ($^{9}/_{32}$ is $^{1}/_{32}$ more than an exact $^{1}/_{8}$; $^{1}/_{32}$ is less than half of $^{4}/_{32}$ and accordingly is dropped.)

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Appendix C. General Tables of Units of Measurement

These tables have been prepared for the benefit of those requiring tables of units for occasional ready reference. In Section 4 of this Appendix, the tables are carried out to a large number of decimal places and exact values are indicated by underlining. In most of the other tables, only a limited number of decimal places are given, therefore, making the tables better adapted to the average user.

1. Tables of Metric Units of Measurement

In the International System of Units (SI), commonly known as the metric system of measurement, designations of multiples and subdivisions of any unit may be arrived at by combining the unit symbol with the prefixes deka, hecto, and kilo meaning, respectively, ten (10), one hundred (100), and one thousand (1 000), and deci, centi, and milli, meaning, respectively, one-tenth (0.1), one-hundredth (0.01), and one-thousandth (0.001). In some of the following metric tables, some such multiples and subdivisions have not been included for the reason that these have limited usage.

In certain cases, particularly in scientific usage, it becomes convenient to provide for multiples larger than one thousand (1 000) and for subdivisions smaller than one-thousandth (0.001). The following prefixes are recognized for this purpose[1]:

quetta,	(Q),	meaning 10^{30}	deci,	(d),	meaning 10^{-1}
ronna,	(R),	meaning 10^{27}	centi,	(c),	meaning 10^{-2}
yotta,	(Y),	meaning 10^{24}	milli,	(m),	meaning 10^{-3}
zetta,	(Z),	meaning 10^{21}	micro,	(μ),	meaning 10^{-6}
exa,	(E),	meaning 10^{18}	nano,	(n),	meaning 10^{-9}
peta,	(P),	meaning 10^{15}	pico,	(p),	meaning 10^{-12}
tera,	(T),	meaning 10^{12}	femto,	(f),	meaning 10^{-15}
giga,	(G),	meaning 10^{9}	atto,	(a),	meaning 10^{-18}
mega,	(M),	meaning 10^{6}	zepto,	(z),	meaning 10^{-21}
kilo,	(k),	meaning 10^{3}	yocto,	(y),	meaning 10^{-24}
hecto,	(h),	meaning 10^{2}	ronto,	(r),	meaning 10^{-27}
deka,	(da),	meaning 10^{1}	quecto,	(q),	meaning 10^{-30}

For example, a kilometer is 1 000 meters and a millimeter is 0.001 meter.

[1] By action of the 27th General Conference on Weights and Measures (2022), the number of International System of Units (SI) prefixes was expanded from 20 to 24 with the addition of ronna, ronto, quetta, and quecto. The International Bureau of Weights and Measures (BIPM) implemented the update in The International System of Units [Brochure], 9th Edition, version 2.01. For more information see https://doi.org/10.59161/AUE.

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Units of Length

10 millimeters (mm)	= 1 centimeter (cm)
10 centimeters	= 1 decimeter (dm) = 100 millimeters
10 decimeters	= 1 meter (m) = 1 000 millimeters
10 meters	= 1 dekameter (dam)
10 dekameters	= 1 hectometer (hm) = 100 meters
10 hectometers	= 1 kilometer (km) = 1 000 meters

Units of Area

100 square millimeters (mm^2)	= 1 square centimeter (cm^2)
100 square centimeters	= 1 square decimeter (dm^2)
100 square decimeters	= 1 square meter (m^2)
100 square meters	= 1 square dekameter (dam^2) = 1 are
100 square dekameters	= 1 square hectometer (hm^2) = 1 hectare (ha)
100 square hectometers	= 1 square kilometer (km^2)

Units of Volume

10 milliliters (mL)	= 1 centiliter (cL)
10 centiliters	= 1 deciliter (dL) = 100 milliliters
10 deciliters	= 1 liter[2] (L) = 1 000 milliliters
10 liters	= 1 dekaliter (daL)
10 dekaliters	= 1 hectoliter (hL) = 100 liters
10 hectoliters	= 1 kiloliter (kL) = 1 000 liters
1 000 cubic millimeters (mm^3)	= 1 cubic centimeter (cm^3)
1 000 cubic centimeters	= 1 cubic decimeter (dm^3)
	= 1 000 000 cubic millimeters
1 000 cubic decimeters	= 1 cubic meter (m^3)
	= 1 000 000 cubic centimeters
	= 1 000 000 000 cubic millimeters

Units of Mass

10 milligrams (mg)	= 1 centigram (cg)
10 centigrams	= 1 decigram (dg) = 100 milligrams
10 decigrams	= 1 gram (g) = 1 000 milligrams
10 grams	= 1 dekagram (dag)
10 dekagrams	= 1 hectogram (hg) = 100 grams
10 hectograms	= 1 kilogram (kg) = 1 000 grams
1 000 kilograms	= 1 megagram (Mg) or 1 metric ton (t)

[2] By action of the 12th General Conference on Weights and Measures (1964), the liter is a special name for the cubic decimeter (dm^3).

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2. Tables of U.S. Customary Units of Measurement[3, 4]

Units of Length

12 inches (in)	= 1 foot (ft)
3 feet	= 1 yard (yd)
16½ feet	= 1 rod (rd), pole, or perch
40 rods	= 1 furlong (fur) = 660 feet
8 furlongs	= 1 mile (mi)[5] = 5 280 feet
1 852 meters (m)	= 6 076.115 49 feet (approximately)
	= 1 international nautical mile

Gunter's or Surveyors Chain Units of Measurement

1 link (li)	= 0.66 foot (ft) = 0.04 rod (rd) = 0.01 chain (ch)
1 fathom	= 6 feet
1 rod, perch, or pole	= 25 links = 16.5 feet = 0.25 chain
1 chain	= 66 feet = 4 rods = 100 links
1 furlong (fur)	= 660 feet = 10 chains = 40 rods
1 cable's length	= 720 feet = 120 fathoms
1 mile (mi)	= 5 280 feet = 8 furlongs = 80 chains = 320 rods
1 league	= 15 840 feet = 3 miles

[3] This section lists units of measurement traditionally used in the United States. In keeping with the Metric Conversion Act of 1975 (15 U.S.C. 205a et seq.) as amended by Omnibus Trade and Competitiveness Act of 1988, the ultimate objective is to make the International System of Units (SI) the primary measurement system used in the United States.

[4] *Federal Register*, July 1, 1959, Vol. 24, No. 128, p. 5348. NOTICE: In collaboration, National Oceanic and Atmospheric Administration (NOAA) and NIST have taken action to provide national uniformity in the measurement of length. The final decision to retire the U.S. survey foot was published in the *Federal Register*, announcing the deprecation date of December 31, 2022. Beginning on January 1, 2023, the U.S. survey foot should be avoided, except for historic and legacy applications and will be superseded by the international foot definition (i.e., 1 foot = 0.3048 meter exactly) in all applications. Prior to this date, except for the mile and square mile, the cable's length, chain, fathom, furlong, league, link, rod, pole, perch, acre, and acre-foot were previously only defined in terms of the U.S. survey foot. With this update, relationships are available in terms of the international foot, which can simply be referred as the "foot." Either the term "foot" or "international foot" may be used, as required for clarity in technical applications. This is particularly the case for surveying and mapping applications, although over time "foot" will become more prevalent. The preferred measurement unit of length in the United States is the meter (m) and surveyors, map makers, and engineers are encouraged to adopt the SI for their work. For more information see *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698) available at **https://www.govinfo.gov/content/pkg/FR-2020-10-05/pdf/2020-21902.pdf**.

[5] Originally referred to as the "statute mile," when Queen Elizabeth I changed the definition of the mile from the Roman mile of 5 000 feet to the statute mile of 5 280 feet. Although the U.S. statute mile was originally based on the U.S. survey foot (1 200/393 7 meter), its definition is now based the international foot (0.304 8 meter), per Federal Register (October 5, 2020, 85 FR 62698, p. 62698), which states that definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications. The mile based on the international foot is about 3 millimeters shorter that the mile based on the U.S. survey foot, although both are defined as being equal to 5 280 feet.

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Units of Area[6]

1 square foot (ft^2)	=144 square inches (in^2)
1 square yard (yd^2)	= 9 square feet = 1 296 square inches
1 square rod (rd^2), square pole, or square perch	= 272.25 square feet = 0.062 5 square chain (ch^2)
1 square chain	= 4 356 square feet = 16 square rods = 0.1 acre
1 acre (ac)	= 43 560 square feet = 160 square rods = 10 square chains
1 square mile (mi^2)	= 27 878 400 square feet = 640 acres
1 square mile (mi^2)	= 27 878 400 square feet = 640 acres

Units of Volume

1 728 cubic inches (in^3)	= 1 cubic foot (ft^3)
27 cubic feet	= 1 cubic yard (yd^3)

Units of Liquid Volume[7]

4 gills (gi)	= 1 pint (pt) = 28.875 cubic inches (in^3)
2 pints	= 1 quart (qt) = 57.75 cubic inches
4 quarts	= 1 gallon (gal) = 231 cubic inches = 8 pints = 32 gills

Apothecaries Units of Liquid Volume

60 minims	= 1 fluid dram (fl dr or $f\,\mathfrak{Z}$) = 0.225 6 cubic inch (in^3)
8 fluid drams	= 1 fluid ounce (fl oz or $f\,\bar{\mathfrak{z}}$) = 1.804 7 cubic inches
16 fluid ounces	= 1 pint (pt) = 28.875 cubic inches = 128 fluid drams
2 pints	= 1 quart (qt) = 57.75 cubic inches = 32 fluid ounces = 256 fluid drams
4 quarts	= 1 gallon (gal) = 231 cubic inches = 128 fluid ounces = 1 024 fluid drams

Units of Dry Volume[8]

2 pints (pt)	= 1 quart (qt) = 67.200 6 cubic inches (in^3)
8 quarts	= 1 peck (pk) = 537.605 cubic inches = 16 pints
4 pecks	= 1 bushel (bu) = 2 150.42 cubic inches = 32 quarts

[6] Squares and cubes of U.S. customary but not of SI units are sometimes expressed by the use of abbreviations rather than symbols. For example, sq ft is an abbreviation that represents square foot, and cu ft is an abbreviation that represents cubic foot.

[7] When necessary to distinguish units of liquid measure such as the fluid ounce, liquid pint, or liquid quart from dry measures, the word "liquid" or "fluid," or the abbreviations "liq" or "fl," should be used in combination with the unit name or abbreviation.

[8] When necessary to distinguish dry pint or quart from the liquid pint or quart, the word "dry" should be used in combination with the name or abbreviation of the dry unit.

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Avoirdupois Units of Mass[9]

[The "grain" is an equivalent quantity in avoirdupois, troy, and apothecaries units of mass.]

1 µlb	= 0.000 001 pound (lb)
$27^{11}/_{32}$ grains (gr)	= 1 dram (dr)
16 drams	= 1 ounce (oz)
	= 437½ grains
16 ounces	= 1 pound (lb)
	= 256 drams
	= 7 000 grains
100 pounds	= 1 hundredweight (cwt)[10]
20 hundredweights	= 1 ton (tn)[11]
	= 2 000 pounds[9]

In "gross" or "long" measure, the following values are recognized:

112 pounds (lb)	= 1 gross (or long) hundredweight (cwt)[9]
20 gross (or long) hundredweights	= 1 gross (or long) ton
	= 2 240 pounds[9]

Troy Units of Mass

[The "grain" is an equivalent quantity in avoirdupois, troy, and apothecaries units of mass.]

24 grains (gr)	= 1 pennyweight (dwt)
20 pennyweights	= 1 ounce troy (oz t) = 480 grains
12 ounces troy	= 1 pound troy (lb t)
	= 240 pennyweights = 5 760 grains

[8] Use the measurement system name or the abbreviation when necessary to distinguish the avoirdupois dram from the apothecaries dram, or to distinguish the avoirdupois dram or ounce from the fluid dram or ounce, or to distinguish the avoirdupois ounce or pound from the troy or apothecaries ounce or pound. When necessary, the word "avoirdupois" or the abbreviation "avdp" should be used in combination with, following the name or abbreviation of the avoirdupois unit. However, if the term "avoirdupois" or "avdp" does not specifically appear in association with a measurement expressed in drams, ounces, or pounds, the value it is understood to represent the avoirdupois unit. The word "troy" or the abbreviation "t" should be used in combination with, following the name or abbreviation of the troy unit. The word "apothecaries" or the abbreviation "ap" should be used in combination with, following the name or abbreviation of the apothecaries unit. For example, "1 pound apothecaries (lb ap)," not "1 apothecaries pound (ap lb)."

[10] When the terms "hundredweight" and "ton" are used unmodified, they are commonly understood to mean the 100-pound hundredweight and the 2000-pound ton, respectively; these units may be designated "net" or "short" when necessary to distinguish them from the corresponding units in gross or long measure.

[11] As of January 1, 2014, "tn" is the required abbreviation for "short ton." Devices manufactured between January 1, 2008, and December 31, 2013, may use an abbreviation other than "tn" to specify "short ton."

(Added 2013)

Apothecaries Units of Mass

[The "grain" is an equivalent quantity in avoirdupois, troy, and apothecaries units of mass.]

20 grains (gr)	= 1 scruple (s ap or ℈)
3 scruples	= 1 dram apothecaries (dr ap or ʒ)
	= 60 grains
8 drams apothecaries	= 1 ounce apothecaries (oz ap or ℥)
	= 24 scruples = 480 grains
12 ounces apothecaries	= 1 pound apothecaries (lb ap)
	= 96 drams apothecaries
	= 288 scruples = 5 760 grains

3. Notes on British Units of Measurement

In Great Britain, the yard, the avoirdupois pound, the troy pound, and the apothecaries pound relationships are identical with the units of the same names used in the United States. The tables of British linear measure, troy mass, and apothecaries mass are the same as the corresponding United States tables, except for the British spelling "drachm" in the table of apothecaries mass. The table of British avoirdupois mass is the same as the United States table up to 1 pound; above that point the table reads:

14 pounds	= 1 stone
2 stones	= 1 quarter = 28 pounds
4 quarters	= 1 hundredweight = 112 pounds
20 hundredweight	= 1 ton = 2 240 pounds

The present British gallon and bushel – known as the "Imperial gallon" and "Imperial bushel" – are, respectively, about 20 % and 3 % larger than the United States gallon and bushel. The Imperial gallon is defined as the volume of 10 avoirdupois pounds of water under specified conditions, and the Imperial bushel is defined as 8 Imperial gallons. Also, the subdivision of the Imperial gallon as presented in the table of British apothecaries fluid measure differs in two important respects from the corresponding United States subdivision, in that the Imperial gallon is divided into 160 fluid ounces (whereas the United States gallon is divided into 128 fluid ounces), and a "fluid scruple" is included. The full table of British measures of capacity (which are used alike for liquid and for dry commodities) is as follows:

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon
2 gallons	= 1 peck
8 gallons (4 pecks)	= 1 bushel
8 bushels	= 1 quarter

The full table of British apothecaries measure is as follows:

20 minims	= 1 fluid scruple
3 fluid scruples	= 1 fluid drachm
	= 60 minims
8 fluid drachms	= 1 fluid ounce
20 fluid ounces	= 1 pint
8 pints	= 1 gallon (160 fluid ounces)

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4. Tables of Units of Measurement

Unit conversion is a multi-step process that involves multiplication or division by a numerical factor; selection of the correct number of significant digits; and rounding. Accurate unit conversions are obtained by selecting an appropriate conversion factor (a ratio which converts one unit of measure into another without changing the quantity), which are supplied in these tables.

Some unit conversions may be exact, without increasing or decreasing the precision of the original quantity. Exact unit conversion factors are underlined in these tables. It is good practice to keep all the digits, especially if other mathematical operations or conversions will follow. Rounding should be the last step of the conversion process and should be performed only once.

To convert a value from one unit of measurement to different unit of measurement follow the steps below.

- Find the table corresponding to the general category of measurement; for example, the table titled "Units of Volume" includes conversion factors for volume measurements.
- Locate the "starting unit" of measurement in the far, left column.
- Proceed horizontally to the right on the same row until you reach the column with the heading of the appropriate "ending unit" of measurement.
- The unit conversion factor is located at the intersection of the row and column.
- Multiply the quantity value of the starting unit of measurement by the conversion factor.
- The result is the equivalent quantity value in the ending unit of measurement.

Units of Length[12]
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:					
	Inches	**Feet**	**Yards**	**Miles**	**Centimeters**	**Meters**
1 inch (in) =	1	0.083 333 33	0.027 777 78	0.000 015 782 83	2.54	0.025 4
1 foot (ft) =	12	1	0.333 333 3	0.000 189 393 9	30.48	0.304 8
1 yard (yd) =	36	3	1	0.000 568 181 8	91.44	0.914 4
1 mile (mi) =	63 360	5 280	1 760	1	160 934.4	1 609.344
1 centimeter (cm) =	0.393 700 8	0.032 808 40	0.010 936 13	0.000 006 213 712	1	0.01
1 meter (m) =	39.370 08	3.280 840	1.093 613	0.000 621 371 2	100	1

NOTE: Per Federal Register, July 1, 1959, Vol. 24, No. 128, p. 5348, the following are exact mathematical relationships:
1 U.S. survey foot = 1 200/393 7 meter (exactly)
1 international foot = 12 × 0.025 4 meter = 0.304 8 (exactly)
1 international foot = 0.999 998 survey foot (exactly)
1 international foot = 0.025 4 × 39.37 U.S. survey foot (exactly)
1 international mile = 0.999 998 survey mile (exactly)

[12] *See Footnote 3.*

Units of Length – International Foot and Survey Equivalent Measurements[13]

(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:	
	International foot metric equivalent	U.S. survey foot metric equivalent
	Meters	Meters
1 foot =	0.304 8	0.304 800 609 601
1 cable's length =	219.456	219.456 438 913
1 chain (ch) =	20.116 8	20.116 840 234
1 fathom =	1.828 8	1.828 803 658
1 furlong (fur) =	201.168	201.168 402 337
1 league =	4 828.032	4 828.041 656 083
1 link (li) =	0.201 168	0.201 168 402
1 mile =	1 609.344	1 609.347 218 694
1 rod (rd), perch, or pole =	5.029 2	5.029 210 058

Units of Length – Survey Measure

(All underlined figures are exact; conversions to meters based on international foot.[14])

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:					
	Links	Feet	Rods	Chains	Miles	Meters
1 link (li) =	1	0.66	0.04	0.01	0.000 125	0.201 168
1 foot (ft) =	1.515 151 5	1	0.060 606 06	0.015 151 5	0.000 189 393 9	0.304 8
1 rod (rd), pole, or perch =	25	16.5	1	0.25	0.003 125	5.029 2
1 chain (ch) =	100	66	4	1	0.0125	20.116 8
1 mile (mi) =	8 000	5 280	320	80	1	1 609.344
1 meter (m) =	4.970 970	3.280 840	0.198 838 8	0.049 709 70	0.000 621 371 2	1

[13] *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Units in this table were historically defined using the U.S. survey foot. They may now be defined using either the international definition of the foot or U.S. survey foot. Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

[14] See Footnote 3.

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Units of Length – Thickness Measurement
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:		
	Inches	**Millimeters**	**Micrometers**
1 mil =	0.001	0.025 4	25.4
NOTE: The unit "mil" is a unit traditionally used by some U.S. industry sectors for the measurement of thickness.			

Units of Area[15]
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Square Inches	**Square Feet**	**Square Yards**
1 square inch (in^2) =	1	0.006 944 444	0.000 771 604 9
1 square foot (ft^2) =	144	1	0.111 111 1
1 square yard (yd^2) =	1 296	9	1
1 square mile (mi^2) =	4 014 489 600	27 878 400	3 097 600
1 square centimeter (cm^2) =	0.155 000 3	0.001 076 391	0.000 119 599 0
1 square meter (m^2) =	1 550.003	10.763 91	1.195 990

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Square Miles	**Square Centimeters**	**Square Meters**
1 square inch (in^2) =	0.000 000 000 249 097 7	6.451 6	0.000 645 16
1 square foot (ft^2) =	0.000 000 035 870 06	929.030 4	0.092 903 04
1 square yard (yd^2) =	0.000 000 322 830 6	8 361.273 6	0.836 127 36
1 square mile (mi^2) =	1	25 899 881 103.36	2 589 988.110 336
1 square centimeter (cm^2) =	0.000 000 000 038 610 22	1	0.000 1
1 square meter (m^2) =	0.000 000 386 102 2	10 000	1

[15] Area measurements are applied to both regular (e.g., regular polygons such as the square, rectangle, or equilateral triangle, or circle, ellipse, etc.) and irregular geometric shapes. For example, an acre is not necessarily a regular shape, such as a square or rectangle. If an acre is a square, then the length of one side is approximately equal to $\sqrt{43560\ \text{ft}^2} = 208.710$ ft.

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Units of Area – International Foot and Survey Equivalent Measurements[16]

(All underlined figures are exact.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:	
		International foot metric equivalent	U.S. survey foot metric equivalent
		Square Meters	Square Meters
1 square rod (rd^2), square pole, or square perch	=	25.292 852 64	25.292 953 812
1 square chain (ch^2)	=	404.685 642 24	404.687 260 987
1 acre (ac)	=	4 046.856 422 4	4 046.872 609 874
1 square mile (mi^2)	=	2 589 988.110 336	2 589 998.470 319 521

Units of Area – Survey Measure [16]

(All underlined figures are exact; SI equivalents based on the international foot.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:			
		Square Feet	Square Rods	Square Chains	Acres
1 square foot (ft^2)	=	1	0.003 673 095	0.000 229 568 4	0.000 022 956 84
1 square rod (rd^2), square pole, or square perch	=	272.25	1	0.062 5	0.006 25
1 square chain (ch^2)	=	4 356	16	1	0.1
1 acre (ac)	=	43 560	160	10	1
1 square mile (mi^2)	=	27 878 400	102 400	6 400	640
1 square meter (m^2)	=	10.763 91	0.039 536 86	0.002 471 054	0.000 247 105 4
1 hectare (ha)	=	107 639.1	395.368 6	24.710 54	2.471 054

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:		
		Square Miles	Square Meters	Hectares
1 square foot (ft^2)	=	0.000 000 035 870 06	0.092 903 04	0.000 009 290 304
1 square rod (rd^2), square pole, square perch	=	0.000 009 765 625	25.292 852 64	0.002 529 285 264
1 square chain (ch^2)	=	0.000 156 25	404.685 642 24	0.040 468 564 224
1 acre (ac)	=	0.001 562 5	4 046.856 422 4	0.404 685 642 24
1 square mile (mi^2)	=	1	2 589 988.110 336	258.998 811 033 6
1 square meter (m^2)	=	0.000 000 386 102 2	1	0.000 1
1 hectare (ha)	=	0.003 861 022	10 000	1

[16] *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

Units of Volume[17]

(All underlined figures are exact.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:		
		Cubic Inches	**Cubic Feet**	**Cubic Yards**
1 cubic inch (in^3)	=	1	0.000 578 703 7	0.000 021 433 47
1 cubic foot (ft^3)	=	1 728	1	0.037 037 04
1 cubic yard (yd^3)	=	46 656	27	1
1 cubic centimeter (cm^3)	=	0.061 023 74	0.000 035 314 67	0.000 001 307 951
1 cubic decimeter (dm^3)	=	61.023 74	0.035 314 67	0.001 307 951
1 cubic meter (m^3)	=	61 023.74	35.314 67	1.307 951

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:		
		Milliliters (Cubic Centimeters)	**Liters (Cubic Decimeters)**	**Cubic Meters**
1 cubic inch (in^3)	=	16.387 064	0.016 387 064	0.000 016 387 064
1 cubic foot (ft^3)	=	28 316.846 592	28.316 846 592	0.028 316 846 592
1 cubic yard (yd^3)	=	764 554.857 984	764.554 857 984	0.764 554 857 984
1 cubic centimeter (cm^3)	=	1	0.001	0.000 001
1 cubic decimeter (dm^3)	=	1 000	1	0.001
1 cubic meter (m^3)	=	1 000 000	1 000	1

[17] Volume or capacity measurement units are applied to both regular (e.g., cube, rectangular prism, cylinder, cone, pyramid, sphere, etc.) and irregular geometric objects.

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Units of Capacity or Volume – Dry Volume Measure
(All underlined figures are exact.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:			
		Dry Pints	**Dry Quarts**	**Pecks**	**Bushels**
1 dry pint (pt)	=	1	0.5	0.062 5	0.015 625
1 dry quart (qt)	=	2	1	0.125	0.031 25
1 peck (pk)	=	16	8	1	0.25
1 bushel (bu)	=	64	32	4	1
1 cubic inch (in^3)	=	0.029 761 6	0.014 880 8	0.001 860 10	0.000 465 025
1 cubic foot (ft^3)	=	51.428 09	25.714 05	3.214 256	0.803 563 95
1 liter (L)	=	1.816 166	0.908 083 0	0.113 510 4	0.028 377 59
1 cubic meter (m^3)	=	1 816.166	908.083 0	113.510 4	28.377 59

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:			
		Cubic Inches	**Cubic Feet**	**Liters**	**Cubic Meters**
1 dry pint (pt)	=	33.600 312 5	0.019 444 63	0.550 610 5	0.000 550 610 5
1 dry quart (qt)	=	67.200 625	0.038 889 25	1.101 221	0.001 101 221
1 peck (pk)	=	537.605	0.311 114	8.809 768	0.008 809 768
1 bushel (bu)	=	2 150.42	1.244 456	35.239 070 166 88	0.035 239 070 166 88
1 cubic inch (in^3)	=	1	0.000 578 703 7	0.016 387 064	0.000 016 387 064
1 cubic foot (ft^3)	=	1 728	1	28.316 846 592	0.028 316 846 592
1 liter (L)	=	61.023 74	0.035 314 67	1	0.001
1 cubic meter (m^3)	=	61 023.74	35.314 67	1 000	1

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Units of Capacity or Volume – Liquid Volume Measure

(All underlined figures are exact.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:			
		Minims	**Fluid Drams**	**Fluid Ounces**	**Gills**
1 minim	=	1	0.016 666 67	0.002 083 333	0.000 520 833 3
1 fluid dram (fl dr)	=	60	1	0.125	0.031 25
1 fluid ounce (fl oz)	=	480	8	1	0.25
1 gill (gi)	=	1 920	32	4	1
1 liquid pint (pt)	=	7 680	128	16	4
1 liquid quart (qt)	=	15 360	256	32	8
1 gallon (gal)	=	61 440	1 024	128	32
1 cubic inch (in3)	=	265.974 0	4.432 900	0.554 112 6	0.138 528 1
1 cubic foot (ft3)	=	459 603.1	7 660.052	957.506 5	239.376 6
1 milliliter (mL)	=	16.230 73	0.270 512 2	0.033 814 02	0.008 453 506
1 liter (L)	=	16 230.73	270.512 2	33.814 02	8.453 506

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:			
		Liquid Pints	**Liquid Quarts**	**Gallons**	**Cubic Inches**
1 minim	=	0.000 130 208 3	0.000 065 104 17	0.000 016 276 04	0.003 759 766
1 fluid dram (fl dr)	=	0.007 812 5	0.003 906 25	0.000 976 562 5	0.225 585 94
1 fluid ounce (fl oz)	=	0.062 5	0.031 25	0.007 812 5	1.804 687 5
1 gill (gi)	=	0.25	0.125	0.031 25	7.218 75
1 liquid pint (pt)	=	1	0.5	0.125	28.875
1 liquid quart (qt)	=	2	1	0.25	57.75
1 gallon (gal)	=	8	4	1	231
1 cubic inch (in^3)	=	0.034 632 03	0.017 316 02	0.004 329 004	1
1 cubic foot (ft^3)	=	59.844 16	29.922 08	7.480 519	1 728
1 milliliter (mL)	=	0.002 113 376	0.001 056 688	0.000 264 172 1	0.061 023 74
1 liter (L)	=	2.113 376	1.056 688	0.264 172 1	61.023 74

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Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:		
		Cubic Feet	Milliliters	Liters
1 minim	=	0.000 002 175 790	0.061 611 52	0.000 061 611 52
1 fluid dram (fl dr)	=	0.000 130 547 4	3.696 691	0.003 696 691
1 fluid ounce (fl oz)	=	0.001 044 379	29.573 53	0.029 573 53
1 gill (gi)	=	0.004 177 517	118.294 1	0.118 294 1
1 liquid pint (pt)	=	0.016 710 07	473.176 5	0.473 176 5
1 liquid quart (qt)	=	0.033 420 14	946.352 9	0.946 352 9
1 gallon (gal)	=	0.133 680 6	3 785.411 784	3.785 411 784
1 cubic inch (in^3)	=	0.000 578 703 7	16.387 06	0.016 387 06
1 cubic foot (ft^3)	=	1	28 316.85	28.316 85
1 milliliter (mL)	=	0.000 035 314 67	1	0.001
1 liter (L)	=	0.035 314 67	1 000	1

Units of Volume – International Foot and Survey Equivalent Measurements[18]
(All underlined figures are exact.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:	
		International foot metric equivalent	U.S. survey foot metric equivalent
		Cubic Meters	Cubic Meters
acre-foot	=	1 233.481 837 547 52	1 233.489 238 468 149

[18] *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Units in this table were historically defined using the U.S. survey foot. They may now be defined using either the international definition of the foot or U.S. survey foot. Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

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Units of Mass Not Less Than Avoirdupois Ounces
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Avoirdupois Ounces	**Avoirdupois Pounds**	**Short Hundredweights**	**Short Tons**
1 avoirdupois ounce (oz) =	1	0.062 5	0.000 625	0.000 031 25
1 avoirdupois pound (lb) =	16	1	0.01	0.000 5
1 short hundredweight (ctw) =	1 600	100	1	0.05
1 short ton (tn) =	32 000	2 000	20	1
1 long ton =	35 840	2 240	22.4	1.12
1 kilogram (kg) =	35.273 96	2.204 623	0.022 046 23	0.001 102 311
1 metric ton (t) =	35 273.96	2 204.623	22.046 23	1.102 311

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Long Tons	**Kilograms**	**Metric Tons**
1 avoirdupois ounce (oz) =	0.000 027 901 79	0.028 349 523 125	0.000 028 349 523 125
1 avoirdupois pound (lb) =	0.000 446 428 6	0.453 592 37	0.000 453 592 37
1 short hundredweight (ctw) =	0.044 642 86	45.359 237	0.045 359 237
1 short ton (tn) =	0.892 857 1	907.184 74	0.907 184 74
1 long ton =	1	1 016.046 908 8	1.016 046 908 8
1 kilogram (kg) =	0.000 984 206 5	1	0.001
1 metric ton (t) =	0.984 206 5	1 000	1

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Units of Mass Not Greater Than Pounds and Kilograms

(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Grains	**Apothecaries Scruples**	**Pennyweights**	**Avoirdupois Drams**
1 grain (gr) =	1	0.05	0.041 666 67	0.036 571 43
1 apothecaries scruple (dr ap) =	20	1	0.833 333 3	0.731 428 6
1 pennyweight (dwt) =	24	1.2	1	0.877 714 3
1 avoirdupois dram (dr) =	27.343 75	1.367 187 5	1.139 323	1
1 apothecaries dram (dr ap) =	60	3	2.5	2.194 286
1 avoirdupois ounce (oz) =	437.5	21.875	18.229 17	16
1 apothecaries ounce (oz) =	480	24	20	17.554 29
1 troy ounce (oz t) =	480	24	20	17.554 29
1 apothecaries pound (lb ap) =	5 760	288	240	210.651 4
1 troy pound (lb t) =	5 760	288	240	210.651 4
1 avoirdupois pound (lb) =	7 000	350	291.666 7	256
1 milligram (mg) =	0.015 432 36	0.000 771 617 9	0.000 643 014 9	0.000 564 383 4
1 gram (g) =	15.432 36	0.771 617 9	0.643 014 9	0.564 383 4
1 kilogram (kg) =	15 432.36	771.617 9	643.014 9	564.383 4

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Apothecaries Drams	**Avoirdupois Ounces**	**Apothecaries or Troy Ounces**	**Apothecaries or Troy Pounds**
1 grain (gr) =	0.016 666 67	0.002 285 714	0.002 083 333	0.000 173 611 1
1 apothecaries scruple (s ap) =	0.333 333 3	0.045 714 29	0.041 666 67	0.003 472 222
1 pennyweight (dwt) =	0.4	0.054 857 14	0.05	0.004 166 667
1 avoirdupois dram (dr) =	0.455 729 2	0.062 5	0.569 661 5	0.004 747 179
1 apothecaries dram (dr ap) =	1	0.137 142 9	0.125	0.010 416 67
1 avoirdupois ounce (oz) =	7.291 667	1	0.911 458 3	0.075 954 86
1 apothecaries ounce (oz) =	8	1.097 143	1	0.083 333 333
1 troy ounce (oz t) =	8	1.097 143	1	0.083 333 333
1 apothecaries pound (lb) =	96	13.165 71	12	1
1 troy pound (lb t) =	96	13.165 71	12	1
1 avoirdupois pound (lb) =	116.666 7	16	14.583 33	1.215 278
1 milligram (mg) =	0.000 257 206 0	0.000 035 273 96	0.000 032 150 75	0.000 002 679 229
1 gram (g) =	0.257 206 0	0.035 273 96	0.032 150 75	0.002 679 229
1 kilogram (kg) =	257.206 0	35.273 96	32.150 75	2.679 229

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:			
		Avoirdupois Pounds	**Milligrams**	**Grams**	**Kilograms**
1 grain (gr)	=	0.000 142 857 1	64.798 91	0.064 798 91	0.000 064 798 91
1 apothecaries scruple (s ap)	=	0.002 857 143	1 295.978 2	1.295 978 2	0.001 295 978 2
1 pennyweight (dwt)	=	0.003 428 571	1 555.173 84	1.555 173 84	0.001 555 173 84
1 avoirdupois dram (dr)	=	0.003 906 25	1 771.845 195 312 5	1.771 845 195 312 5	0.001 771 845 195 312 5
1 apothecaries dram (dr ap)	=	0.008 571 429	3 887.934 6	3.887 934 6	0.003 887 934 6
1 avoirdupois ounce (oz)	=	0.062 5	28 349.523 125	28.349 523 125	0.028 349 523 125
1 apothecaries ounce (oz ap)	=	0.068 571 43	31 103.476 8	31.103 476 8	0.031 103 476 8
1 troy ounce (oz t)	=	0.068 571 43	31 103.476 8	31.103 476 8	0.031 103 476 8
1 apothecaries pound (lb ap)	=	0.822 857 1	373 241.721 6	373.241 721 6	0.373 241 721 6
1 troy pound (lb t)	=	0.822 857 1	373 241.721 6	373.241 721 6	0.373 241 721 6
1 avoirdupois pound (lb)	=	1	453 592.37	453.592 37	0.453 592 37
1 milligram (mg)	=	0.000 002 204 623	1	0.001	0.000 001
1 gram (g)	=	0.002 204 623	1 000	1	0.001
1 kilogram (kg)	=	2.204 623	1 000 000	1 000	1

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Units of Pressure
(All underlined figures are exact.)

Starting Unit ↓		Multiply by the Ending Unit Conversion Factor:					
		Pascal (Pa)	**Kilopascal (kPa)**	**Megapascal (MPa)**	**Pound-force per square inch (psi) (lbf/in^2)**	**Millimeter of mercury (mm Hg [0 °C])**	**Inch of water (in H_2O [4 °C])**
1 Pa	=	1	0.001	0.000 001	0.000 145 037 74	0.007 500 615	0.004 014 742 13
1 kPa	=	1 000.0	1	0.001	0.145 037 744	7.500 615 05	4.014 742 133
1 MPa	=	1 000 000	1 000	1	145.037 744	7 500.615 05	4 014.742 13
1 psi (lbf/in^2)	=	6 894.757	6.894 757	0.006 894 757	1	51.714 918 1	27.680 671 4
1 mmHg (0 °C)	=	133.322 4	0.133 322 4	0.000 133 322 4	0.019 336 78	1	0.535 255 057
1 inH_2O (4 °C)	=	249.082	0.249 082	0.000 249 082	0.036 126 291	1.868 268 198	1

Conversion Equations for Units of Temperature
(Exact)

Units	**To Degree Fahrenheit ($°F$)**	**To Degree Celsius ($°C$)**	**To Kelvin (K)**
Degree Fahrenheit ($°F$)	$°F$	$\frac{(°F - 32)}{1.8}$	$\frac{(°F - 32)}{1.8} + 273.15$
Degree Celsius ($°C$)	$(°C \times 1.8) + 32$	$°C$	$(°C) + 273.15$
Kelvin (K)	$(K - 273.15) * 1.8 + 32$	$K - 273.15$	K

Instructions for the Conversion Equations for Temperature:

Start at the left column of the table until you reach the row labeled with the starting unit. Then proceed horizontally to the right along that row until you reach the column of the desired unit. The unit conversion factor is located at the intersection of the row and column.

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5. Tables of Equivalents[19]

In these tables, all SI equivalents that use the foot (or other U.S. Customary units derived from the foot) are based on the international foot.

When the name of a unit is enclosed in brackets (thus, [1 hand] . . .), this indicates (1) that the unit is not in general current use in the United States, or (2) that the unit is believed to be based on "custom and usage" rather than on formal authoritative definition.

Equivalents involving decimals are, in most instances, rounded off to the third decimal place except where they are exact, in which cases these exact equivalents are so designated. The equivalents of the imprecise units "tablespoon" and "teaspoon" are rounded to the nearest milliliter.

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Units of Length (all SI equivalents that use the foot are based on the international foot definition, 1 foot = 0.3 048 m exactly) (All underlined figures are exact.)	
1 cable's length	120 fathoms 720 feet 219.456 meters
1 centimeter (cm)	0.01 meter 0.393 7 inch
1 chain (ch) (Gunter's or surveyor's)	66 feet 20.116 8 meters
1 decimeter (dm)	0.1 meter (exactly) 3.937 inches
1 dekameter (dam)	10 meters (exactly) 32.808 feet
1 fathom	6 feet (exactly) 1.828 8 meters (exactly)
1 foot (ft)	12 inches (exactly) 0.304 8 meter (exactly)
1 furlong (fur)	10 chains (exactly) 660 feet (exactly) 1/8 mile (exactly) 201.168 meters (exactly)
[1 hand]	4 inches
1 inch (in)	2.54 centimeters (exactly)
1 kilometer (km)	1 000 meters (exactly) 0.621 mile
1 league (land)	3 miles (exactly) 4.828 032 kilometers (exactly)

[19] *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

Units of Length (all SI equivalents that use the foot are based on the international foot definition, 1 foot = 0.3 048 m exactly) (All underlined figures are exact.)	
1 link (li) (Gunter's or surveyor's)	0.66 foot (exactly) 0.201 168 meter (exactly)
1 meter (m)	0.001 kilometer (exactly) 39.37 inches 1.094 yards
1 mil	0.001 inch (exactly) 0.025 4 millimeter (exactly) 25.4 micrometer (exactly)
1 micrometer (μm)[20]	0.001 millimeter (exactly) 0.000 001 meter (exactly) 0.000 039 37 inch
1 mile (mi)	5 280 feet (exactly) 1.609 344 kilometers (exactly)
1 mile (mi) (international nautical)[21]	1 852 meters (exactly) 1.852 kilometers (exactly) 1.151 miles
1 millimeter (mm)	0.001 meter (exactly) 0.039 370 1 inch (exactly)
1 nanometer (nm)	0.000 000 001 meter (exactly) 0.000 000 039 37 inch
1 point	0.013 837 inch (exactly) 1/72 inch (approximately) 0.351 millimeter ("point" is historically used in typography)
1 rod (rd), pole, or perch	16½ feet (exactly) 5.029 2 meters (exactly)
1 yard (yd)	3 feet (exactly) 0.914 4 meter (exactly)

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[20] The SI symbol for the prefix micro is the Greek letter mu (m).

[21] **NIST SP 447**, *Weights and Measures Standards of the United States, A Brief History* (1975). The international nautical mile of 1 852 meters (6 076.115 49 feet) was adopted by the First International Extraordinary Hydrographic Conference, Monaco, 1929, under the name "International nautical mile." It was later adopted for use in the United States (effective July 1, 1954) by identical directives of the U.S. Department of Commerce and Department of Defense. The value formerly used in the United States was 6 080.20 feet = 1 nautical (geographical or sea) mile.

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Units of Area (All underlined figures are exact.)	
1 acre (ac)	43 560 square feet (exactly) 0.404 685 642 24 hectare (exactly)
1 are (a)	100 square meters (exactly) 119.599 square yards 0.025 acre
1 hectare (ha)	10 000 square meters (exactly) 0.01 square kilometer (exactly) 2.471 acres
[1 section (of land)]	[1 mile square] (approximate)
[1 square (building)]	100 square feet
1 square centimeter (cm^2)	0.000 1 square meter (exactly) 0.155 square inch
1 square decimeter (dm^2)	0.01 square meter (exactly) 15.500 square inches
1 square foot (ft^2)	144 square inches (exactly) 929.030 4 square centimeters (exactly)
1 square inch (in^2)	0.006 944 444 square feet 6 451 6 square centimeters (exactly)
1 square kilometer (km^2)	1 000 000 square meters (exactly) 247.104 acres 0.386 square mile
1 square meter (m^2)	0.000 001 square kilometer (exactly) 1 000 000 square millimeters (exactly) 1.196 square yards 10.764 square feet
1 square mile (mi^2)	2.589 99 square kilometers 258.999 hectares
1 square millimeter (mm^2)	0.000 001 square meter (exactly) 0.002 square inch
1 square rod (rd^2), square pole, or square perch	25.292 852 64 square meters (exactly)
1 square yard (yd^2)	0.836 127 36 square meter (exactly) 9 square feet (exactly) 1 296 square inches (exactly)
[1 township]	[6 miles square] (approximate) [36 sections (of land)] 36 square miles (approximate)

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Units of Capacity or Volume (All underlined figures are exact.)	
1 barrel (bbl), liquid	31 to 42 gallons[22]
1 barrel (bbl), standard for fruits, vegetables, and other dry commodities, except cranberries	7 056 cubic inches 105 dry quarts 3.281 bushels, struck measure
1 barrel (bbl), standard, cranberry	5 826 cubic inches $86\frac{45}{64}$ dry quarts 2.709 bushels, struck measure
1 bushel (bu) (U.S.) struck measure	2 150.42 cubic inches (exactly) 35.238 liters
[1 bushel, heaped (U.S.)]	2 747.715 cubic inches 1.278 bushels, struck measure[23]
[1 bushel (bu) (British Imperial) (struck measure)]	1.032 U.S. bushels, struck measure 2 219.36 cubic inches
1 cord (cd) (firewood)	128 cubic feet (exactly)
1 cubic centimeter (cm^3)	0.001 cubic decimeter (exactly) 0.001 liter (exactly) 1 milliliter (exactly) 0.061 cubic inch
1 cubic decimeter (dm^3)	1 000 cubic centimeters (exactly) 1 000 milliliters (exactly) 1 liter (exactly) 61.024 cubic inches
1 cubic foot (ft^3)	7.481 gallons 28.316 cubic decimeters (liters)
1 cubic inch (in^3)	0.554 fluid ounce (fl oz) (or $f\,\bar{3}$) 4.433 fluid drams (fl dr) (or $f\,3$) 16.387 cubic centimeters
1 cubic meter (m^3)	1 000 cubic decimeters 1 000 liters 1.308 cubic yards
1 cubic yard (yd^3)	0.765 cubic meter 27 cubic feet (exactly)

[22] A variety of "barrels" are established by law or industry usage. Consult federal laws and regulations, state laws and regulations, and documentary standards for the industry application to ensure the use of the appropriate barrel definition. For example, federal taxes on fermented liquors are based on a barrel of 31 gallons; many state laws fix the "barrel for liquids" as 31½ gallons; a 36-gallon barrel has been used for cistern measurement; federal law recognizes a 40-gallon barrel for "proof spirits;" and by custom, 42 gallons comprise a barrel of crude oil or petroleum products for statistical purposes, and this equivalent is recognized "for liquids" by some states.

[23] Frequently recognized as 1¼ bushels, struck measure.

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Units of Capacity or Volume (All underlined figures are exact.)	
1 cup, measuring	8 fluid ounces (exactly) 237 milliliters ½ liquid pint (exactly)
1 dekaliter (daL)	10 liters (exactly) 2.642 gallons 1.135 pecks
1 dram, fluid (or liquid) (fl dr) (or ƒ ʒ) (U.S.)	⅛ fluid ounce (exactly) 0.226 cubic inch 3.697 milliliters 1.041 British fluid drachms
[1 drachm, fluid (fl dr) (British)]	0.961 U.S. fluid dram 0.217 cubic inch 3.552 milliliters
1 gallon (gal) (U.S.)	231 cubic inches (exactly) 3.785 liters 0.833 British gallon 128 U.S. fluid ounces (exactly)
[1 gallon (gal) (British Imperial)]	277.42 cubic inches 1.201 U.S. gallons 4.546 liters 160 British fluid ounces (exactly)
1 gill (gi)	7.219 cubic inches 4 fluid ounces (exactly) 0.118 liter
1 hectoliter (hL)	100 liters 26.418 gallons 2.838 bushels
1 liter (L)	1 cubic decimeter (exactly) 1 000 milliliters (exactly) 1.057 liquid quarts 0.908 dry quart 61.024 cubic inches
1 milliliter (mL)	0.001 cubic decimeter (exactly) 0.001 liter (exactly) 0.271 fluid dram 16.231 minims 0.061 cubic inch
1 ounce, fluid (or liquid) (fl oz) (or ƒ ℥) (U.S.)	1.805 cubic inches 29.573 milliliters 1.041 British fluid ounces

Units of Capacity or Volume (All underlined figures are exact.)	
[1 ounce, fluid (fl oz) (British)]	0.961 U.S. fluid ounce 1.734 cubic inches 28.412 milliliters
1 peck (pk)	8.810 liters
1 pint (pt), dry	33.600 cubic inches 0.551 liter
1 pint (pt), liquid	28.875 cubic inches (exactly) 0.473 liter
1 quart (qt), dry (U.S.)	67.201 cubic inches 1.101 liters 0.969 British quart
1 quart (qt), liquid (U.S.)	57.75 cubic inches (exactly) 0.946 liter 0.833 British quart
[1 quart (qt) (British)]	69.354 cubic inches 1.032 U.S. dry quarts 1.201 U.S. liquid quarts
1 tablespoon, measuring	3 teaspoons (exactly) 15 milliliters 4 fluid drams ½ fluid ounce (exactly)
1 teaspoon, measuring	⅓ tablespoon (exactly) 5 milliliters 1⅓ fluid drams[24]
1 water ton (English)	270.91 U.S. gallons 224 British Imperial gallons (exactly)

[24] The equivalent "1 teaspoon = 1⅓ fluid drams" has been found by NIST to correspond more closely with the actual capacities of "measuring" and silver teaspoons than the equivalent "1 teaspoon = 1 fluid dram," which is given by a number of dictionaries.

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Units of Mass (All underlined figures are exact.)	
1 assay ton (AT)[25]	29.167 grams
1 carat (c)[26]	200 milligrams (exactly) 3.086 grains
1 dram apothecaries (dr ap or ʒ)	60 grains (exactly) 3.888 grams
1 dram avoirdupois (dr)	$27^{11}/_{32}$ (= 27.344) grains 1.772 grams
1 gamma (γ)	1 microgram (exactly)
1 grain (gr)	64.798 91 milligrams (exactly)
1 gram (g)	0.001 kilogram (exactly) 15.432 grains 0.035 ounce, avoirdupois
1 hundredweight, gross or long[27] (gross cwt)	112 pounds (exactly) 50.802 kilograms
1 hundredweight, gross or short (cwt or net cwt)	100 pounds (exactly) 45.359 kilograms
1 kilogram (kg)	1 000 grams (exactly) 2.205 pounds
1 microgram (µg)[28]	0.000 001 gram (exactly)
1 milligram (mg)	0.001 gram (exactly) 0.015 grain 0.005 carat (exactly)
1 ounce, avoirdupois (oz)	437.5 grains (exactly) 0.911 troy or apothecaries ounce 28.350 grams
1 ounce, troy or apothecaries (oz t or oz ap or ℥)	480 grains (exactly) 1.097 avoirdupois ounces 31.103 grams
1 ounce, troy (oz t)	480 grains (exactly) 1.097 avoirdupois ounces 31.103 grams

[25] Used in assaying. The assay ton bears the same relation to the milligram that a ton of 2000 pounds avoirdupois bears to the troy ounce; hence the mass in milligrams of precious metal obtained from one assay ton of ore gives directly the number of troy ounces to the net ton.

[26] NIST Circular 43 (1913) The Metric Carat. As of July 1, 1913, the international metric carat was recognized as 200 milligrams for diamonds and other precious stones and expressed as decimal fractions. A carat is further divided where 1 carat equals 100 points. Available at **https://nvlpubs.nist.gov/nistpubs/Legacy/circ/nbscircular43.pdf**.

[27] The gross or long ton and hundredweight are used commercially in the United States to only a very limited extent, usually in restricted industrial fields. The units are the same as the British "ton" and the "hundredweights."

[28] The SI symbol for the prefix micro is the Greek letter mu (µ).

Units of Mass (All underlined figures are exact.)	
1 ounce, apothecaries (oz ap or ℥)	480 grains (exactly) 1.097 avoirdupois ounces 31.103 grams
1 pennyweight (dwt)	1.555 grams
1 point	0.01 carat (exactly) 2 milligrams (exactly) ("point" is historically used in the jewelry industry to describe gemstones)
1 pound, avoirdupois (lb)	7 000 grains (exactly) 1.215 troy or apothecaries pounds 453.592 37 grams (exactly)
1 micropound (µlb)[29]	0.000 001 pound (exactly)
1 pound, troy (lb t)	5 760 grains (exactly) 0.823 avoirdupois pound 373.242 grams
1 pound, apothecaries (lb ap)	5 760 grains (exactly) 0.823 avoirdupois pound 373.242 grams
1 scruple (s ap or ℈)	20 grains (exactly) 1.296 grams
1 ton, gross or long[29]	2 240 pounds (exactly) 1.12 net tons (exactly) 1.016 metric tons
1 ton, metric (t)	2 204.623 pounds 0.984 gross ton 1.102 net tons
1 ton, net or short (tn)[30]	2 000 pounds (exactly) 0.893 gross ton 0.907 metric ton

[29] The SI symbol for the prefix micro is the Greek letter mu (µ). This is an example where SI writing style is applied to a non-SI unit abbreviation. The Greek letter mu prefix is used in combination with the abbreviation for pound (lb).

[30] As of January 1, 2014, "tn" is the required abbreviation for "short ton." Devices manufactured between January 1, 2008, and December 31, 2013, may use an abbreviation other than "tn" to specify "short ton."
(Added 2013)

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Appendix D. Definitions

The specific code to which the definition applies is shown in [brackets] at the end of the definition. Definitions for the General Code [1.10] apply to all codes in Handbook 44.

A

absolute value. – The absolute value of a number is the magnitude of that number without considering the positive or negative sign. [2.20]

acceptance test. – The first official test of a farm milk tank, at a particular location, in which the tank is accepted as correct. This test applies to newly constructed tanks, relocated used tanks, and recalibrated tanks. [4.42]

accurate. – A piece of equipment is "accurate" when its performance or value – that is, its indications, its deliveries, its recorded representations, or its capacity or actual value, etc., as determined by tests made with suitable standards - conforms to the standard within the applicable tolerances and other performance requirements. Equipment that fails so to conform is "inaccurate." (Also see "correct.") [Appendix A]

all-class. – A description of a multi-class calibration that includes all the classes of a grain type. [5.56(a), 5.57]
(Added 2007)

alternating current (AC). – An electric current that reverses direction in a circuit at regular intervals. [3.40]
(Added 2022)

ampere. – The practical unit of electric current. It is the quantity of current caused to flow by a potential difference of one volt through a resistance of one ohm. One ampere (A) is equal to the flow of one coulomb of charge per second. One coulomb (C) is the unit of electric charge equal in magnitude to the charge of 6.24×10^{18} electrons. [3.40]
(Added 2022)

analog or digital recorder. – An element used with a belt-conveyor scale that continuously records the rate-of-flow of bulk material over the scale (formerly referred to as a chart recorder). [2.21]
(Amended 1989)

analog type. – A system of indication or recording in which values are presented as a series of graduations in combination with an indicator, or in which the most sensitive element of an indicating system moves continuously during the operation of the device. [1.10]

animal scale. – A scale designed for weighing single heads of livestock. [2.20]
(Amended 1987)

apparent mass versus 8.0 g/cm^3. – The apparent mass of an object versus 8.0 g/cm^3 is the mass of material of density 8.0 g/cm^3 that produces exactly the same balance reading as the object when the comparison is made in air with a density of 1.2 mg/cm^3 at 20 °C. [3.37]

approval seal. – A label, tag, stamped or etched impression, or the like, indicating official approval of a device. (Also see "security seal.") [1.10]

assumed atmospheric pressure. – The average atmospheric pressure agreed to exist at the meter at various ranges of elevation, irrespective of variations in atmospheric pressure from time to time. [3.33]

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audit trail. – An electronic count and/or information record of the changes to the values of the calibration or configuration parameters of a device. [1.10, 2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 5.54, 5.56(a), 5.58]

(Added 1993) (Amended 2019 and 2022)

automatic bulk weighing system. – A weighing system adapted to the automatic weighing of bulk commodities in successive drafts of predetermined amounts, automatically recording the no-load and loaded weight values and accumulating the net weight of each draft. [2.22]

automatic checkweigher. – An automatic weighing system that does not require the intervention of an operator during the weighing process and used to subdivide items of different weights into one or more subgroups, such as identifying packages that have acceptable or unacceptable fill levels according to the value of the difference between their weight and a pre-determined set point. These systems may be used to fill standard packages for compliance with net weight requirements. [2.24]

(Amended 2004)

automatic gravimetric filling machine (instrument). – A filling machine or instrument that fills containers or packages with predetermined and virtually constant mass of product from bulk by automatic weighing, and which comprises essentially an automatic feeding device or devices associated with one or more weighing unit and the appropriate discharge devices. [2.24]

(Added 2004)

automatic-indicating scale. – One on which the weights of applied loads of various magnitudes are automatically indicated throughout all or a portion of the weighing range of the scale. (A scale that automatically weighs out commodity in predetermined drafts, such as an automatic hopper scale, a packaging scale, and the like, is not an "automatic-indicating" scale.) [2.20. 2.22]

automatic temperature or density compensation. – The use of integrated or ancillary equipment to obtain from the output of a volumetric meter an equivalent mass, or an equivalent liquid volume at the assigned reference temperature below and a pressure of 14.696 lb/in^2 absolute.

Cryogenic liquids	21 °C (70 °F) [3.34]
Hydrocarbon gas vapor	15 °C (60 °F) [3.33]
Hydrogen gas	21 °C (70 °F) [3.39]
Liquid carbon dioxide	21 °C (70 °F) [3.38]
Liquefied petroleum gas (LPG) and Anhydrous ammonia	15 °C (60 °F) [3.32]
Petroleum liquid fuels and lubricants	15 °C (60 °F) [3.30]

(Amended 2019)

automatic weighing system (AWS). – An automatic weighing system is a weighing device that, in combination with other hardware and/or software components, automatically weighs discrete items and that does not require the intervention of an operator during the weighing process. Examples include, but are not limited to, weigh-labelers and checkweighers. [2.24]

(Amended 2004)

automatic zero-setting mechanism (AZSM). – See "automatic zero-setting mechanism" under "zero-setting mechanism." [2.22]

(Amended 2010)

automatic zero-setting mechanism (belt-conveyor scale). – A zero setting device that operates automatically without intervention of the operator after the belt has been running empty. [2.21]

(Added 2002)

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automatic zero-tracking (AZT) mechanism. – Automatic means provided to maintain the zero-balance indication, within specified limits, without the intervention of an operator. [2.20, 2.22, 2.24]
(Amended 2010)

auxiliary indication. – a means to increase the displayed resolution of a weighing device, such as a rider or vernier on an analog device, or a differentiated least significant digit to the right of the decimal point on a digital device. [2.20]
(Added 2024)

auxiliary indicator. – Any indicator other than the master weight totalizer that indicates the weight of material determined by the scale. [2.21]

axle-load scale. – A scale permanently installed in a fixed location, having a load-receiving element specially adapted to determine the combined load of all wheels (1) on a single axle or (2) on a tandem axle of a highway vehicle. [2.20]

B

badge. – A metal plate affixed to the meter by the manufacturer showing the manufacturer's name, serial number and model number of the meter, and its rated capacity. [3.33]

balance, zero-load. – See "zero-load balance." [2.20]

balance indicator. – A combination of elements, one or both of which will oscillate with respect to the other, for indicating the balance condition of a nonautomatic indicating scale. The combination may consist of two indicating edges, lines, or points, or a single edge, line, or point and a graduated scale. [2.20]

balancing mechanism. – A mechanism (including a balance ball) that is designed for adjusting a scale to an accurate zero-load balance condition. [2.20]

base pressure. – The absolute pressure used in defining the gas measurement unit to be used, and is the gauge pressure at the meter plus an agreed atmospheric pressure. [3.33]

basic distance rate. – The charge for distance for all intervals except the initial interval. [5.54]

basic time rate. – The charge for time for all intervals except the initial interval. [5.54]

basic tolerances. – Tolerances on under-registration and on over-registration, 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]

batching system. – One in which raw materials are proportioned in pre-determined quantities by weight and/or liquid measure for inclusion in a finished product. [2.22, 3.36]
(Added 2018)

batching meter. – A device used for the purpose of measuring quantities of water to be used in a batching operation. [3.36]

beam. – See "weighbeam." [2.20]

beam scale. – One on which the weights of loads of various magnitudes are indicated solely by means of one or more weighbeam bars either alone or in combination with counterpoise weights. [2.20]

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bell prover. – A calibrated cylindrical metal tank of the annular type with a scale thereon that, in the downward travel in a surrounding tank containing a sealing medium, displaces air through the meter being proved or calibrated. [3.33]

belt-conveyor. – An endless moving belt for transporting material from place to place. [2.21]

belt-conveyor scale. – A device that employs a weighing element in contact with a belt to sense the weight of the material being conveyed and the speed (travel) of the material, and integrates these values to produce total delivered weight. [2.21]

belt-conveyor scale systems area. – The scale system area refers to the scale suspension, weigh idlers attached to the scale suspension, 5 approach (−) idlers, and 5 retreat (+) idlers. [2.21]
(Added 2001)

belt load. – The weight of the material carried by the conveyor belt, expressed in terms of weight units per unit of length (e.g., pounds per foot, kilograms per meter). Also called “belt loading.” [2.21]
(Added 2013)

belt revolution. – The amount of conveyor belt movement or travel that is equivalent to the total length of the conveyor belt. Also referred to as "belt circuit." [2.21]
(Added 2013)

billed weight. – The weight used in the computation of the freight, postal, or storage charge, whether actual weight or dimensional weight. [5.58]

binary submultiples. – Fractional parts obtained by successively dividing by the number two. Thus, one-half, one-fourth, one-eighth, one-sixteenth, and so on, are binary submultiples. [1.10]

built-for-purpose device. – Any main device or element which was manufactured with the intent that it be used as, or part of, a weighing or measuring device or system. [1.10]
(Added 2003)

C

calibration parameter. – Any adjustable parameter that can affect measurement or performance accuracy and, due to its nature, needs to be updated on an ongoing basis to maintain device accuracy (e.g., span adjustments, linearization factors, and coarse zero adjustments). [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 5.54, 5.56(a), 5.58.]
(Added 1993) (Amended 2016, 2019, and 2022)

carbon dioxide liquid-measuring device. – A system including a mechanism or machine of (a) the meter or (b) a weighing type of device mounted on a vehicle designed to measure and deliver liquid carbon dioxide. Means may be provided to indicate automatically, for one of a series of unit prices, the total money value of the quantity measured. [3.38]

car-wash timer. – A timer used in conjunction with a coin-operated device to measure the time during which car-wash water, cleaning solutions, or waxing solutions are dispensed. [5.55]

center-reading tank. – One so designed that the gauge rod or surface gauge, when properly positioned for use, will be approximately in the vertical axis of the tank, centrally positioned with respect to the tank walls. [4.43]

cereal grain and oil seeds. – Agricultural commodities including, but not limited to, corn, wheat, oats, barley, flax, rice, sorghum, soybeans, peanuts, dry beans, safflower, sunflower, fescue seed, etc. [5.56(a), 5.56(b)]

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Certificate of Conformance (CC), Active. – A document issued based on testing by a Participating Laboratory, which the certificate holder maintains in active status under the National Type Evaluation Program (NTEP). The document constitutes evidence of conformance of a type with the requirements of this document, NIST Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices," and the test procedures contained in NCWM Publication 14. By maintaining the Certificate in active status, the Certificate holder declares the intent to continue to manufacture or remanufacture the device consistent with the type and in conformance with the applicable requirements. A device is traceable to an active CC if: (a) it is of the same type identified on the Certificate, and (b) it was manufactured during the period that the Certificate was maintained in active status. For manufacturers of grain moisture meters, maintenance of active status also involves annual participation in the NTEP Laboratory On-going Calibration Program, OCP (Phase II).
(Added 2024)

Certificate of Conformance (CC), Inactive. – A document issued based on testing by a Participating Laboratory, which was previously active, but the device, measurement system, instrument or element is no longer being manufactured for commercial applications. However, devices, measurement systems, instruments or elements already manufactured, installed or in inventory may be used, sold, repaired, and resold under inactive CCs.
(Added 2024)

chart recorder. – See analog or digital recorder.
(Amended 1989)

check rate. – A rate of flow usually 20 % of the capacity rate. [3.33]

checkweighing scale. – One used to verify predetermined weight within prescribed limits. [2.24]

class of grain. – Hard Red Winter Wheat as distinguished from Hard Red Spring Wheat as distinguished from Soft Red Winter Wheat, etc. [5.56(a), 5.56(b), 5.57]

clear interval between graduations. – The distance between adjacent edges of successive graduations in a series of graduations. If the graduations are "staggered," the interval shall be measured, if necessary, between a graduation and an extension of the adjacent graduation. (Also see "minimum clear interval.") [1.10]

cleared. – A taximeter is "cleared" when it is inoperative with respect to all fare indication, when no indication of fare or extras is shown and when all parts are in those positions in which they are designed to be when the vehicle on which the taximeter is installed is not engaged by a passenger. [5.54]

cold-tire pressure. – The pressure in a tire at ambient temperature. [5.53, 5.54]

commercial equipment. – See "equipment."
(Added 2008)

computing scale. – One that indicates the money values of amounts of commodity weighed, at predetermined unit prices, throughout all or part of the weighing range of the scale. [2.20]

computing type or computing type device. – A device designed to indicate, in addition to weight or measure, the total money value of product weighed or measured, for one of a series of unit prices. [1.10]

concave curve. – A change in the angle of inclination of a belt conveyor where the center of the curve is above the conveyor. [2.21]

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concentrated load capacity (CLC) (also referred to as Dual Tandem Axle Capacity [DTAC]). – A capacity rating of a vehicle or axle-load scale, specified by the manufacturer, defining the maximum load applied by a group of two axles with a centerline spaced four feet apart and an axle width of eight feet for which the weighbridge is designed. The concentrated load capacity rating is for both test and use. [2.20]

(Added 1988) (Amended 1991, 1994, and 2003)

configuration parameter. – Any adjustable or selectable parameter for a device feature that can affect the accuracy of a transaction or can significantly increase the potential for fraudulent use of the device and, due to its nature, needs to be updated only during device installation or upon replacement of a component (e.g., division value (increment), sensor range, and units of measurement). [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3,34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 5.54, 5.56(a), 5.58]

(Added 1993) (Amended 2019 and 2022)

consecutive-car test train. – A train consisting of cars weighed on a reference scale, then coupled consecutively and run over the coupled-in-motion railway track scale under test. [2.20]

(Added 1990)

construction materials hopper scale. – A scale adapted to weighing construction materials such as sand, gravel, cement, and hot oil. [2.20]

contract sale. – A sale where a written agreement exists, prior to the point of sale, in which both buyer and seller have accepted pricing conditions of the sale. Examples include, but are not limited to: e-commerce, club sales, or pre-purchase agreements. Any devices used in the determination of quantity must comply with NIST Handbook 44. [3.30, 3.32, 3.37]

(Added 1993) (Amended 2002)

conventional scale. – If the use of conversion tables is necessary to obtain a moisture content value, the moisture meter indicating scale is called "conventional scale." The values indicated by the scale are dimensionless. [5.56(b)]

conversion table. – Any table, graph, slide rule, or other external device used to determine the moisture content from the value indicated by the moisture meter. [5.56(b)]

convex curve. – A change in the angle of inclination of a belt conveyor where the center of the curve is below the conveyor. [2.21]

conveyor stringers. – Support members for the conveyor on which the scale and idlers are mounted. [2.21]

correct. – A piece of equipment is "correct" when, in addition to being accurate, it meets all applicable specification requirements. Equipment that fails to meet any of the requirements for correct equipment is "incorrect." (Also see "accurate.") [Appendix A]

correction table. – Any table, graph, slide rule, or other external device used to determine the moisture content from the value indicated by the moisture meter when the indicated value is altered by a parameter not automatically corrected for in the moisture meter (for example, temperature or test weight). [5.56(b)]

counterbalance weight(s). – One intended for application near the butt of a weighbeam for zero-load balancing purposes. [2.20]

counterpoise weight(s). – A slotted or "hanger" weight intended for application near the tip of the weighbeam of a scale having a multiple greater than one. [2.20]

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coupled-in-motion railroad weighing system. – A device and related installation characteristics consisting of (1) the associated approach trackage, (2) the scale (i.e., the weighing element, the load-receiving element, and the indicating element with its software), and (3) the exit trackage, which permit the weighing of railroad cars coupled in motion. [2.20, 2.23]

(Added 1992)

crane scale. – One with a nominal capacity of 5 000 pounds or more designed to weigh loads while they are suspended freely from an overhead, track-mounted crane. [2.20]

creep. – A continuous apparent measurement of energy indicated by a system with operating voltage applied and no power consumed (load terminals open circuited). [3.40]

(Added 2022)

cryogenic liquid-measuring device. – A system including a liquid-measuring element designed to measure and deliver cryogenic liquids in the liquid state. [3.34]

(Amended 1986 and 2003)

cryogenic liquids. – Fluids whose normal boiling point is below 120 kelvin (− 243 °F). [3.34]

cubic foot, gas. – The amount of a cryogenic liquid in the gaseous state at a temperature of 70 °F and under a pressure of 14.696 lb/in^2 absolute that occupies one cubic foot (1 ft^3). (See NTP.) [3.34]

current. – The rate of the flow of electrical charge past any one point in a circuit. The unit of measurement is amperes (A) or coulombs (C) per second. [3.40]

(Added 2022)

D

"d," dimension division value. – The smallest increment that the device displays for any axis and length of object in that axis. [5.58]

d, value scale division. – See "scale division, value of (d)." [2.20, 2.22]

D_{max} (maximum load of the measuring range). – Largest value of a quantity (mass) which is applied to a load cell during test or use. This value shall not be greater than E_{max}. [2.20]

(Added 2005)

D_{min} (minimum load of the measuring range). – Smallest value of a quantity (mass) which is applied to a load cell during test or use. This value shall not be less than E_{min}. [2.20]

(Added 2006)

data acquisition time (DAT). – The total time an object is completely on a load-receiving element while it is being weighed in motion. An object is completely on a load-receiving element from the time the trailing edge of an object to be weighed first moves onto the load-receiving element up to the time the leading edge of the object first moves off the load-receiving element. This time duration is affected by the length of the load-receiving element, speed of the object to be weighed, and the length of the object to be weighed. [2.20]

(Added 2021)

dairy-product-test scale. – A scale used in determining the moisture content of butter and/or cheese or in determining the butterfat content of milk, cream, or butter. [2.20]

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decimal submultiples. – Parts obtained by successively dividing by the number 10. Thus 0.1, 0.01, 0.001, and so on are decimal submultiples. [1.10]

decreasing-load test. – A test for automatic-indicating scales only, wherein the performance of the scale is tested as the load is reduced. [2.20, 2.22]

(Amended 1987)

deficiency. – See "excess and deficiency." [1.10]

diesel gallon equivalent (DGE). – Diesel gallon equivalent (DGE) means 6.384 pounds of compressed natural gas or 6.059 pounds of liquefied natural gas. [3.37]

(Added 2016)

digital type. – A system of indication or recording of the selector type or one that advances intermittently in which all values are presented digitally, or in numbers. In a digital indicating or recording element, or in digital representation, there are no graduations. [1.10]

dimensional offset. – The effect of eliminating the conveyance material on a measurement made by a multiple dimension measuring device resulting in only the object intended to be measured being measured. [5.58.]

(Added 2021)

dimensional weight (or dim, weight). – A value computed by dividing the object's volume by a conversion factor; it may be used for the calculation of charges when the value is greater than the actual weight. [5.58]

(Added 2004)

direct current (DC). – An electric current that flows in one direction. [3.40]

(Added 2022)

direct sale. – A sale in which both parties in the transaction are present when the quantity is being determined. An unattended automated or customer-operated weighing or measuring system is considered to represent the device/business owner in transactions involving an unattended device. [1.10]

(Amended 1993)

discharge hose. – A flexible hose connected to the discharge outlet of a measuring device or its discharge line. [3.30, 3.31, 3.32, 3.34, 3.37, 3.38, 3.39]

(Added 1987) (Amended 2019)

discharge line. – A rigid pipe connected to the outlet of a measuring device. [3.30, 3.31, 3.32, 3.34, 3.37, 3.39]

(Added 1987) (Amended 2019)

discrimination (of an automatic-indicating scale). – The value of the test load on the load-receiving element of the scale that will produce a specified minimum change of the indicated or recorded value on the scale. [2.20, 2.22]

dispenser. – See motor-fuel device. [3.30, 3.37]

distributed-car test train. – A train consisting of cars weighed first on a reference scale, cars coupled consecutively in groups at different locations within the train, then run over the coupled-in-motion railway track scale under test. The groups are typically placed at the front, middle, and rear of the train. [2.20]

(Added 1990)

dry hose. – A discharge hose intended to be completely drained at the end of each delivery of product. (Also see "dry-hose type.") [3.30, 3.31]

(Amended 2002)

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dry-hose type. – A type of device in which it is intended that the discharge hose be completely drained following the mechanical operations involved in each delivery. (Also see "dry hose.") [3.30, 3.31, 3.34, 3.35]

dynamic monorail weighing system. – A weighing system which employs hardware or software to compensate for dynamic effects from the load or the system that do not exist in static weighing, in order to provide a stable indication. Dynamic factors may include shock or impact loading, system vibrations, oscillations, etc., and can occur even when the load is not moving across the load-receiving element. [2.20]

(Added 1999)

E

e, value of verification scale interval. – See "verification scale interval, value of (e)." [2.20]

E_{max} (maximum capacity). – Largest value of a quantity (mass) which may be applied to a load cell without exceeding the mpe. [2.20]

(Added 2005)

E_{min} (minimum dead load). – Smallest value of a quantity (mass) which may be applied to a load cell during test or use without exceeding the mpe. [2.20]

(Added 2006)

e_{min} (minimum verification scale division). – The smallest scale division for which a weighing element complies with the applicable requirements. [2.24]

(Added 1997) (Amended 2025)

e_{min} (minimum verification scale interval). – The smallest verification scale interval for which a weighing element complies with the applicable requirements. [2.20]

(Added 2025)

electric vehicle, plug-in. – A vehicle that employs electrical energy as a primary or secondary mode of propulsion. Plug-in electric vehicles may be all-electric vehicles (EVs) or plug-in hybrid electric vehicles (PHEVs). All-electric vehicles are powered by an electric motor and battery at all times. All-electric vehicles may also be called battery-electric vehicles (BEVs). Plug-in hybrid electric vehicles employ both an electric motor and an internal combustion engine that consumes either conventional or alternative fuel or a fuel cell. In a parallel type hybrid-electric vehicle, either the electric motor or the engine may propel the vehicle. In a series type hybrid-electric vehicle, the engine or fuel cell generates electricity that is then used by the electric motor to propel the vehicle. EVs, BEVs, and PHEVs are capable of receiving and storing electricity via connection to an external electrical supply. Not all hybrid-electric vehicles are of the plug-in type. Hybrid-electric vehicles that do not have the capability to receive electrical energy from an external supply (HEVs) generate electrical energy onboard with the internal combustion engine, regenerative braking, or both. [3.40]

(Added 2022)

electric vehicle supply equipment (EVSE). – A device or system designed and used specifically to transfer electrical energy to an electric vehicle, either as charge transferred via physical or wireless connection, by loading a fully charged battery, or by other means. [3.40]

(Added 2022)

electricity as vehicle fuel. – Electrical energy transferred to and/or stored onboard an electric vehicle primarily for the purpose of propulsion. [3.40]

(Added 2022)

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electronic link. – An electronic connection between the weighing/load-receiving or other sensing element and indicating element where one recognizes the other and neither can be replaced without calibration. [2.20]
(Added 2001)

element. – A portion of a weighing or measuring device or system which performs a specific function and can be separated, evaluated separately, and is subject to specified full or partial error limits.
(Added 2002)

energy. – The integral of active power with respect to time. [3.40]
(Added 2022)

energy flow. – The flow of energy between line and load terminals (conductors) of an electricity system. Flow from the line to the load terminals is considered energy delivered. Energy flowing in the opposite direction (i.e., from the load to line terminals) is considered as energy received. [3.40]
(Added 2022)

equal-arm scale. – A scale having only a single lever with equal arms (that is, with a multiple of one), equipped with two similar or dissimilar load-receiving elements (pan, plate, platter, scoop, or the like), one intended to receive material being weighed and the other intended to receive weights. There may or may not be a weighbeam. [2.20]

equipment, commercial. – Weights, measures, and weighing and measuring devices, instruments, elements, and systems or portion thereof, used or employed in establishing the measurement or in computing any basic charge or payment for services rendered on the basis of weight or measure. As used in this definition, measurement includes the determination of size, quantity, value, extent, area, composition (limited to meat and poultry), constituent value (for grain), or measurement of quantities, things, produce, or articles for distribution or consumption, purchased, offered, or submitted for sale, hire, or award. [1.10, 2.20, 2.21, 2.22, 2.24, 3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 4.40, 5.51, 5.56.(a), 5.56.(b), 5.57, 5.58, 5.59]
(Added 2008) (Amended 2019 and 2022)

event counter. – A non-resettable counter that increments once each time the mode that permits changes to sealable parameters is entered and one or more changes are made to sealable calibration or configuration parameters of a device. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 5.54, 5.56(a), 5.56(b), 5.57, 5.58]
(Added 1993) (Amended 2019 and 2022)

event logger. – A form of audit trail containing a series of records where each record contains the number from the event counter corresponding to the change to a sealable parameter, the identification of the parameter that was changed, the time and date when the parameter was changed, and the new value of the parameter. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 5.54, 5.56(a), 5.56(b), 5.57, 5.58]
(Added 1993) (Amended 2019 and 2022)

EVSE field reference standard. – A portable apparatus that is traceable to NIST and is used as a standard to test EVSEs in commercial applications. This instrument is also known as a portable standard or working standard. [3.40]
(Added 2022)

excess and deficiency. – When an instrument or device is of such a character that it has a value of its own that can be determined, its error is said to be "in excess" or "in deficiency," depending upon whether its actual value is, respectively, greater or less than its nominal value. (Also see "nominal.") Examples of instruments having errors "in excess" are: a linear measure that is too long; a liquid measure that is too large; and a weight that is "heavy." Examples

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of instruments having errors "in deficiency" are: a lubricating-oil bottle that is too small; a vehicle tank compartment that is too small; and a weight that is "light." [1.10]

extended display mode. – A means to temporarily change the scale division (d) to a value less than the verification scale interval (e), following a manual command. [2.20]

(Added 2024)

extras. – Charges to be paid by a passenger in addition to the fare, including any charge at a flat rate for the transportation of passengers in excess of a stated number and any charge for the transportation of baggage. [5.54]

F

face. – That side of a taximeter on which passenger charges are indicated. [5.54]

face. – That portion of a computing-type pump or dispenser which displays the actual computation of price per unit, delivered quantity, and total sale price. In the case of some electronic displays, this may not be an integral part of the pump or dispenser. [3.30, 3.32, 3.37, 3.39, and 3.40]

(Added 1987) (Amended 2022)

fare. – That portion of the charge for the hire of a vehicle that is automatically calculated by a taximeter through the operation of the distance and/or time mechanism. [5.54]

farm milk tank. – A unit for measuring milk or other fluid dairy product, comprising a combination of (1) a stationary or portable tank, whether or not equipped with means for cooling its contents, (2) means for reading the level of liquid in the tank, such as a removable gauge rod or a surface gauge, and (3) a chart for converting level-of-liquid readings to volume; or such a unit in which readings are made on a gauge rod or surface gauge directly in terms of volume. Each compartment of a subdivided tank shall, for purposes of this code, be construed to be a "farm milk tank." [4.43]

feeding mechanism. – The means for depositing material to be weighed on the belt conveyor. [2.21]

ft^3/h. – Cubic feet per hour. [3.33]

fifth wheel. – A commercially-available distance-measuring device which, after calibration, is recommended for use as a field transfer standard for testing the accuracy of taximeters and odometers on rented vehicles. [5.53, 5.54]

fifth-wheel test. – A distance test similar to a road test, except that the distance traveled by the vehicle under test is determined by a mechanism known as a "fifth wheel" that is attached to the vehicle and that independently measures and indicates the distance. [5.53, 5.54]

flat rate. – A rate selection that when applied results in the indication of a fixed (non-incrementing) amount for passenger charges. This rate shall be included on the statement of established rates that is required to be posted in the vehicle. [5.54.]

(Added 2016)

fractional bar. – A weighbeam bar of relatively small capacity for obtaining indications intermediate between notches or graduations on a main or tare bar. [2.20]

G

gasoline gallon equivalent (GGE). – Gasoline gallon equivalent (GGE) means 5.660 pounds of compressed natural gas. [3.37]

(Added 1994) (Amended 2016)

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gauge pressure. – The difference between the pressure at the meter and the atmospheric pressure (psi). [3.33]

gauge rod. – A graduated, "dip-stick" type of measuring rod designed to be partially immersed in the liquid and to be read at the point where the liquid surface crosses the rod. [4.42]

gauging. – The process of determining and assigning volumetric values to specific graduations on the gauge or gauge rod that serve as the basis for the tank volume chart. [4.42]

graduated interval. – The distance from the center of one graduation to the center of the next graduation in a series of graduations. (Also see "value of minimum graduated interval.") [1.10]

graduation. – A defining line or one of the lines defining the subdivisions of a graduated series. The term includes such special forms as raised or indented or scored reference "lines" and special characters such as dots. (Also see "main graduation" and "subordinate graduation.") [1.10]

grain class. – Different grains within the same grain type. For example, there are six classes for the grain type "wheat:" Durum Wheat, Hard Red Spring Wheat, Hard Red Winter Wheat, Soft Red Winter Wheat, Hard White Wheat, and Soft White Wheat. [5.56(a), 5.57]
(Added 2007)

grain hopper scale. – One adapted to the weighing of individual loads of varying amounts of grain. [2.20]

grain moisture meter. – Any device indicating either directly or through conversion tables and/or correction tables the moisture content of cereal grains and oil seeds. Also termed "moisture meter." [5.56(a), 5.56(b)]

grain sample. – That portion of grain or seed taken from a bulk quantity of grain or seed to be bought or sold and used to determine the moisture content of the bulk. [5.56(a), 5.56(b)]

grain-test scale. – A scale adapted to weighing grain samples used in determining moisture content, dockage, weight per unit volume, etc. [2.20]

grain type. – See "kind of grain." [5.56(a), 5.57]
(Added 2007)

gravity discharge. – A type of device designed for discharge by gravity. [3.30, 3.31]

H

head pulley. – The pulley at the discharge end of the belt conveyor. The power drive to drive the belt is generally applied to the head pulley. [2.21]

hertz (Hz). – Frequency or cycles per second. One cycle of an alternating current or voltage is one complete set of positive and negative values of the current or voltage. [3.40]
(Added 2022)

hexahedron. – A geometric solid (i.e., box) with six rectangular or square plane surfaces. [5.58]
(Added 2008)

hired. – A taximeter is "hired" when it is operative with respect to all applicable indications of fare or extras. The indications of fare include time and distance where applicable unless qualified by another indication of "Time Not Recording" or an equivalent expression. [5.54]

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hopper scale. – A scale designed for weighing bulk commodities whose load-receiving element is a tank, box, or hopper mounted on a weighing element. (Also see "automatic hopper scale," "grain hopper scale," and "construction materials hopper scale.") [2.20]

I

idlers or idler rollers. – Freely turning cylinders mounted on a frame to support the conveyor belt. For a flat belt, the idlers consist of one or more horizontal cylinders transverse to the direction of belt travel. For a troughed belt, the idlers consist of one or more horizontal cylinders and one or more cylinders at an angle to the horizontal to lift the sides of the belt to form a trough. [2.21]

idler space. – The center-to-center distance between idler rollers measured parallel to the belt. [2.21]

increasing-load test. – The normal basic performance test for a scale in which observations are made as increments of test load are successively added to the load-receiving element of the scale. [2.20, 2.22]

increment. – The value of the smallest change in value that can be indicated or recorded by a digital device in normal operation. [1.10]

index of an indicator. – The particular portion of an indicator that is directly utilized in making a reading. [1.10]

indicating element. – An element incorporated in a weighing or measuring device by means of which its performance relative to quantity or money value is "read" from the device itself as, for example, an index-and-graduated-scale combination, a weighbeam-and-poise combination, a digital indicator, and the like. (Also see "primary indicating or recording element.") [1.10]

indicator, balance. – See "balance indicator." [2.20]

initial distance or time interval. – The interval corresponding to the initial money drop. [5.54]

initial zero-setting mechanism. – See "initial zero-setting mechanism" under "zero-setting mechanism." [2.20] (Added 1990)

in-service light indicator. – A light used to indicate that a timing device is in operation. [5.55]

integrator. – A device used with a belt-conveyor scale that combines conveyor belt load (e.g., lb/ft) and belt travel (e.g., feet) to produce a total weight of material passing over the belt-conveyor scale. An integrator may be a separate, detached mechanism or may be a component within a totalizing device. (Also see "master weight totalizer.") [2.21] (Added 2013)

interval, clear, between graduations. – See "clear interval between graduations." [1.10]

interval, graduated. – See "graduated interval." [1.10]

irregularly-shaped object. – Any object that is not a hexahedron shape. [5.58] (Added 2008)

J

jewelers' scale. – One adapted to weighing gems and precious metals. [2.20]

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K

kilowatt (kW). – A unit of power equal to 1 000 watts (W). [3.40]
(Added 2022)

kilowatt-hour (kWh). – A unit of energy equal to 1 000 watthours (Wh). [3.40]
(Added 2022)

kind of grain. – Corn as distinguished from soybeans as distinguished from wheat, etc. [5.56(a), 5.56(b)]

L

label. – A printed ticket, to be attached to a package, produced by a printer that is a part of a prepackaging scale or that is an auxiliary device. [2.20]

large-delivery device. – Devices used primarily for single deliveries greater than 200 gallons, 2 000 liters, 20 000 cubic feet, 2 000 kilograms, or 2 000 pounds. [3.34, 3.38]

laundry-drier timer. – A timer used in conjunction with a coin-operated device to measure the period of time that a laundry drier is in operation. [5.55]

liquefied petroleum gas. – A petroleum product composed predominantly of any of the following hydrocarbons or mixtures thereof: propane, propylene, butanes (normal butane or isobutane), and butylenes. [3.31, 3.32, 3.33, 3.34, 3.37]

liquefied petroleum gas liquid-measuring device. – A system including a mechanism or machine of the meter type designed to measure and deliver liquefied petroleum gas in the liquid state by a definite quantity, whether installed in a permanent location or mounted on a vehicle. Means may or may not be provided to indicate automatically, for one of a series of unit prices, the total money value of the liquid measured. [3.32]
(Amended 1987)

liquefied petroleum gas retail motor-fuel device. – A device designed for the measurement and delivery of liquefied petroleum gas used as a fuel for internal combustion engines in vehicles bearing a state or federal license plate for use on public roads. The term means the same as "retail motor-fuel dispenser" and "retail motor-fuel device" as it appears in section 3.32 LPG and Anhydrous Ammonia Liquid-Measuring Devices. [3.32]
(Added 2022)

liquefied petroleum gas vapor-measuring device. – A system including a mechanism or device of the meter type, equipped with a totalizing index, designed to measure and deliver liquefied petroleum gas in the vapor state by definite volumes, and generally installed in a permanent location. The meters are similar in construction and operation to the conventional natural- and manufactured-gas meters. [3.33]

liquid fuel. – Any liquid used for fuel purposes, that is, as a fuel, including motor-fuel. [3.30, 3.31]

liquid-fuel device. – A device designed for the measurement and delivery of liquid fuels. [3.30]

liquid-measuring device. – A mechanism or machine designed to measure and deliver liquid by definite volume. Means may or may not be provided to indicate automatically, for one of a series of unit prices, the total money value of the liquid measured, or to make deliveries corresponding to specific money values at a definite unit price. [3.30]

liquid volume correction factor. – A correction factor used to adjust the liquid volume of a cryogenic product at the time of measurement to the liquid volume at NBP. [3.34]

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livestock scale. – A scale equipped with stock racks and gates and adapted to weighing livestock standing on the scale platform. [2.20]
(Amended 1989)

load, full. – A test condition with rated voltage, current at 100 % of test amps level, and power factor of 1.0. [3.40]
(Added 2022)

load, light. – A test condition with rated voltage, current at 10 % of test amps level, and power factor of 1.0. [3.40]
(Added 2022)

load cell. – A device, whether electric, hydraulic, or pneumatic, that produces a signal (change in output) proportional to the load applied. [2.20, 2.21, 2.23]

load cell verification interval (v). – The load cell interval, expressed in units of mass, used in the test of the load cell for accuracy classification. [2.20, 2.21]
(Added 1996)

loading point. – A location on a conveyor where the material is received by the belt. The location of the discharge from a hopper, chute, or pre-feed device used to supply material to a conveyor. [2.21]
(Amended 2013)

load-receiving element. – That element of a scale that is designed to receive the load to be weighed; for example, platform, deck, rail, hopper, platter, plate, scoop. [2.20, 2.21, 2.23]

location services. – Any of the various technologies used to determine the geographical location of a receiving unit in or physically attached to a vehicle. These technologies may include but are not limited to: global positioning services; cellular networks; or wi-fi networks. [5.54]
(Added 2017)

low-flame test. – A test simulating extremely low-flow rates such as caused by pilot lights. [3.33]

lubricant device. – A device designed for the measurement and delivery of liquid lubricants, including, but not limited to, heavy gear lubricants and automatic transmission fluids (automotive). [3.30]

M

m^3/h. – Cubic meters per hour. [3.33]

main bar. – A principal weighbeam bar, usually of relatively large capacity as compared with other bars of the same weighbeam. (On an automatic-indicating scale equipped with a weighbeam, the main weighbeam bar is frequently called the "capacity bar.") [2.20]

main graduation. – A graduation defining the primary or principal subdivisions of a graduated series. (Also see "graduation.") [1.10]

main-weighbeam elements. – The combination of a main bar and its fractional bar, or a main bar alone if no fractional bar is associated with it. [2.20]

manual zero-setting mechanism. – See "manual zero-setting mechanism" under "zero-setting mechanism." [2.20]

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manufactured device. – Any commercial weighing or measuring device shipped as new from the original equipment manufacturer. [1.10]

(Amended 2001)

mass flow meter. – A device that measures the mass of a product flowing through the system. The mass measurement may be determined directly from the effects of mass on the sensing unit or may be inferred by measuring the properties of the product, such as the volume, density, temperature, or pressure, and displaying the quantity in mass units. [3.37]

master meter, electric. – An electric watthour meter owned, maintained, and used for commercial billing purposes by the serving utility. All the electric energy served to a submetered service system is recorded by the master meter. [3.40]

(Added 2022)

master meter test method. – A method of testing milk tanks that utilizes an approved master meter system for measuring test liquid removed from or introduced into the tank. [4.42]

master weight totalizer. – A primary indicating element used with a belt-conveyor scale that incorporates the function of an integrator to indicate the totalized weight of material passed over the scale. (Also see "integrator.") [2.21]

(Amended 2013)

material test. – The test of a belt-conveyor scale using material (preferably that for which the device is normally used) that has been weighed to an accuracy of 0.1 %. [2.21]

(Amended 1989)

maximum capacity. – The largest load that may be accurately weighed. [2.20, 2.24]

(Added 1999)

maximum cargo load. – The maximum cargo load for trucks is the difference between the manufacturer's rated gross vehicle weight and the actual weight of the vehicle having no cargo load. [5.53]

maximum current deliverable (MCD). – The maximum current that the EVSE can deliver as installed under optimum conditions. [3.40]

(Added 2024)

maximum deliverable amperage (MDA). – The maximum current available from the EVSE at the time of the test as determined by the Control Pilot Pulse Width Modulation signal or via digital communication between the EVSE and EV or test equipment. [3.40]

(Added 2024)

measurement field. – A region of space or the measurement pattern produced by the measuring instrument in which objects are placed or passed through, either singly or in groups, when being measured by a single device. [5.58]

measuring element. – That portion of a complete multiple dimension measuring device that does not include the indicating element. [5.58]

meter, electricity. – An electric watthour meter. [3.40]

(Added 2022)

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meter register. – An observation index for the cumulative reading of the gas flow through the meter. In addition, there are one or two proving circles in which one revolution of the test hand represents ½, 1, 2, 5, or 10 cubic feet, or 0.025, 0.05, 0.1, 0.2, or 0.25 cubic meter, depending on meter size. If two proving circles are present, the circle representing the smallest volume per revolution is referred to as the "leak-test circle." [3.33]

metrological components. – Elements or features of a measurement device or system that perform the measurement process or that may affect the final quantity determination or resulting price determinations. This includes accessories that can affect the validity of transactions based upon the measurement process. The measurement process includes determination of quantities; the transmission, processing, storage, or other corrections or adjustments of measurement data or values; and the indication or recording of measurement values or other derived values such as price or worth or charges. [3.40]

(Added 2022)

metrological integrity (of a device). – The design, features, operation, installation, or use of a device that facilitates (1) the accuracy and validity of a measurement or transaction, (2) compliance of the device with weights and measures requirements, or (3) the suitability of the device for a given application. [1.10, 2.20]

(Added 1993)

minimum capacity. – The smallest load that may be accurately weighed. The weighing results may be subject to excessive error if used below this value. [2.20, 2.24]

(Added 1999)

minimum clear interval. – The shortest distance between adjacent graduations when the graduations are not parallel. (Also see "clear interval.") [3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36, 3.38, 5.50, 5.51, 5.56(b)]

minimum delivery. – The least amount of weight that is to be delivered as a single weighment by a belt-conveyor scale system in normal use. [2.21]

minimum load cell verification interval. – *See* v_{min}

minimum measured quantity (MMQ). – The smallest quantity delivered for which the measurement is to within the applicable tolerances for that system. [3.37, 3.39, 3.40]

(Added 2019) (Amended 2022)

minimum tolerance. – Minimum tolerances are the smallest tolerance values that can be applied to a scale. Minimum tolerances are determined on the basis of the value of the minimum graduated interval or the nominal or reading face capacity of the scale. (Also see definition for basic tolerances.) [2.20, 2.22, 2.24]

minimum totalized load. – The least amount of weight for which the scale is considered to be performing accurately. [2.21]

moisture content (wet basis). – The mass of water in a grain or seed sample (determined by the reference method) divided by the mass of the grain or seed sample expressed as a percentage (%). [5.56(a), 5.56(b)]

money drop. – An increment of fare indication. The "initial money drop" is the first increment of fare indication following activation of the taximeter. [5.54]

money-operated type. – A device designed to be released for service by the insertion of money, or to be actuated by the insertion of money to make deliveries of product. [1.10]

motor-fuel. – Liquid used as fuel for internal-combustion engines. [3.30]

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motor-fuel device or motor-fuel dispenser or retail motor-fuel device. – A device designed for the measurement and delivery of liquids used as fuel for internal-combustion engines. The term "motor-fuel dispenser" means the same as "motor-fuel device;" the term "retail motor-fuel device" applies to a unique category of device. (Also see definitions of "retail device" and "liquefied petroleum gas retail motor-fuel device.") [3.30 and 3.37]

(Amended 2022)

multi-class. – A description of a grouping of grain classes, from the same grain type, in one calibration. A multi-class grain calibration may include (1) all the classes of a grain type (all-class calibration), or (2) some of the classes of a grain type within the calibration. [5.56(a), 5.57.]

(Added 2007)

multi-interval scale. – A scale having one weighing range which is divided into partial weighing ranges (segments), each with different scale intervals, with each partial weighing range (segment) determined automatically according to the load applied, both on increasing and decreasing loads. [2.20]

(Added 1995)

multi-jet water meter. – A water meter in which the moving element takes the form of a multiblade rotor mounted on a vertical spindle within a cylindrical measuring chamber. The liquid enters the measuring chamber through several tangential orifices around the circumference and leaves the measuring chamber through another set of tangential orifices placed at a different level in the measuring chamber. These meters register by recording the revolutions of a rotor set in motion by the force of flowing water striking the blades. [3.36]

(Added 2003)

multiple. – An integral multiple; that is, a result obtained by multiplying by a whole number. (Also see "multiple of a scale.") [1.10]

multiple cell application load cell. – A load cell intended for use in a weighing system which incorporates more than one load cell. A multiple cell application load cell is designated with the letter "M" or the term "Multiple." (Also see "single cell application load cell.") [2.20]

(Added 1999)

multiple range scale. – A scale having two or more weighing ranges with different maximum capacities and different scale intervals for the same load receptor, each range extending from zero to its maximum capacity. [2.20]

(Added 1995)

multiple of a scale. – In general, the multiplying power of the entire system of levers or other basic weighing elements. (On a beam scale, the multiple of the scale is the number of pounds on the load-receiving element that will be counterpoised by one pound applied to the tip pivot of the weighbeam.) [2.20]

multi-revolution scale. – An automatic-indicating scale having a nominal capacity that is a multiple of the reading-face capacity and that is achieved by more than one complete revolution of the indicator. [2.20]

multiple-tariff taximeter. – One that may be set to calculate fares at any one of two or more rates. [5.54]

N

nationally recognized testing laboratory (NRTL). – A laboratory that conducts testing and certification that is recognized by the Occupational Safety and Health Administration (OSHA). [3.40]

(Added 2022)

National Type Evaluation Program (NTEP). – A program administered by NCWM. It is a program of cooperation between the NCWM, NIST, other federal agencies, the states, and the private sector for determining, on a uniform

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basis, conformance of a type with the relevant provisions of NIST Handbook 44 "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices," and NCWM, Publication 14, "National Type Evaluation Program, Technical Policy, Checklists, and Test Procedures."

(Added 2024)

NBP. – Normal Boiling Point of a cryogenic liquid at 14.696 lb/in^2 absolute. [3.34]

NTP. – Normal Temperature and Pressure of a cryogen at a temperature of 21 °C (70 °F) and a pressure of 101.325 kPa (14.696 lb/in^2 absolute). [3.34]

NTP density and volume correction factor. – A correction factor used to adjust the liquid volume of a cryogenic product at the time of measurement to the gas equivalent at NTP. [3.34]

natural gas. – A gaseous fuel, composed primarily of methane, that is suitable for compression and dispensing into a fuel storage container(s) for use as an engine fuel. [3.37]

(Added 1994)

negotiated rate. – A rate selection that, when applied, results in a fixed (non-incrementing) amount for passenger charges and is based on a value that has been agreed upon by the operator and passenger. [5.54]

(Added 2016)

n_{max} (maximum number of scale divisions). – The maximum number of scale divisions for which a main element or load cell complies with the applicable requirements. The maximum number of scale divisions permitted for an installation is limited to the lowest n_{max} marked on the scale indicating element, weighing element, or load cell. [2.21, 2.24]

(Added 1997) (Amended 2024)

n_{max} (maximum number of verification scale intervals). – The maximum number of verification scale intervals for which a main element or load cell complies with the applicable requirements. The maximum number of verification scale intervals permitted for an installation is limited to the lowest n_{max} marked on the scale indicating element, weighing element, or load cell. [2.20]

(Added 2024)

no-load reference value. – A positive weight value indication with no load in the load-receiving element (hopper) of the scale. (Used with automatic bulk-weighing systems and certain single-draft, manually-operated receiving hopper scales installed below grade and used to receive grain.) [2.20]

nominal. – Refers to "intended" or "named" or "stated," as opposed to "actual." For example, the "nominal" value of something is the value that it is supposed or intended to have, the value that it is claimed or stated to have, or the value by which it is commonly known. Thus, "1-pound weight," "1-gallon measure," "1-yard indication," and "500-pound scale" are statements of nominal values; corresponding actual values may be greater or lesser. (Also see nominal capacity of a scale.) [1.10]

nominal capacity. – The nominal capacity of a scale is (a) the largest weight indication that can be obtained by the use of all of the reading or recording elements in combination, including the amount represented by any removable weights furnished or ordinarily furnished with the scale, but excluding the amount represented by any extra removable weights not ordinarily furnished with the scale, and excluding also the capacity of any auxiliary weighing attachment not contemplated by the original design of the scale, and excluding any fractional bar with a capacity less than 2½ % of the sum of the capacities of the remaining reading elements, or (b) the capacity marked on the scale by the manufacturer, whichever is less. (Also see "nominal capacity, batching scale"; "nominal capacity, hopper scale.") [2.20]

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nominal capacity, batching scale. – The nominal capacity of a batching scale is the capacity as marked on the scale by the scale manufacturer, or the sum of the products of the volume of each of the individual hoppers, in terms of cubic feet, times the weight per cubic foot of the heaviest material weighed in each hopper, whichever is less. [2.20]

nominal capacity, hopper scale. – The nominal capacity of a hopper scale is the capacity as marked on the scale by the scale manufacturer, or the product of the volume of the hopper in bushels or cubic feet times the maximum weight per bushel or cubic foot, as the case may be, of the commodity normally weighed, whichever is less. [2.20]

non-automatic checkweigher. – A weighing instrument that requires the intervention of an operator during the weighing process, used to subdivide items of different weights into one or more subgroups, such as identifying packages that have acceptable or unacceptable fill levels according to the value of the difference between their weight and a pre-determined set point. [2.24]

Notes: Determining the weighing result includes any intelligent action of the operator that affects the result, such as deciding and taking an action when an indication is stable or adjusting the weight of the weighed load.

Deciding the weighing result is acceptable means making a decision regarding the acceptance of each weighing result on observing the indication or releasing a print-out. The weighing process allows the operator to take an action which influences the weighing result in the case where the weighing result is not acceptable.

(Added 2004)

non-automatic weighing instrument. – A weighing instrument or system that requires the intervention of an operator during the weighing process to determine the weighing result or to decide that it is acceptable. [2.20, 2.24]

Notes: Determining the weighing result includes any intelligent action of the operator that affects the result, such as deciding and taking an action when an indication is stable or adjusting the weight of the weighed load.

Deciding the weighing result is acceptable means making a decision regarding the acceptance of each weighing result on observing the indication or releasing a print-out. The weighing process allows the operator to take an action which influences the weighing result in the case where the weighing result is not acceptable.

(Added 2004) (Amended 2005)

non-resettable totalizer. – An element interfaced with the measuring or weighing element that indicates the cumulative registration of the measured quantity with no means to return to zero. [3.30, 3.37, 3.39, 3.40]

(Added 2019) (Amended 2022)

nonretroactive. – "Nonretroactive" requirements are enforceable after the effective date for:

1. D-devices manufactured within a state after the effective date;

2. D-both new and used devices brought into a state after the effective date; and

3. D-devices used in noncommercial applications which are placed into commercial use after the effective date.

Nonretroactive requirements are not enforceable with respect to devices that are in commercial service in the state as of the effective date or to new equipment in the stock of a manufacturer or a dealer in the state as of the effective date. *(Nonretroactive requirements are printed in italic type.)* [1.10]

(Amended 1989)

nose-iron. – A slide-mounted, manually-adjustable pivot assembly for changing the multiple of a lever. [2.20]

notes. – A section included in each of a number of codes, containing instructions, pertinent directives, and other specific information pertaining to the testing of devices. Notes are primarily directed to weights and measures officials.

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O

odometer. – A device that automatically indicates the total distance traveled by a vehicle. For the purpose of this code, this definition includes hub odometers, cable-driven odometers, and the distance-indicating or odometer portions of "speedometer" assemblies for automotive vehicles. [5.53]

official grain samples. – Grain or seed used by the official as the official transfer standard from the reference standard method to test the accuracy and precision of grain moisture meters. [5.56(a), 5.56(b)]

official with statutory authority. – The representative of the jurisdiction(s) responsible for certifying the accuracy of the device. [2.20, 2.21, 2.22]

(Added 1991)

ohm (Ω). – The practical unit of electric resistance that allows one ampere of current to flow when the impressed potential is one volt. [3.40]

(Added 2022)

operating tire pressure. – The pressure in a tire immediately after a vehicle has been driven for at least 5 miles or 8 kilometers. [5.53, 5.54]

over-and-under indicator. – An automatic-indicating element incorporated in or attached to a scale and comprising an indicator and a graduated scale with a central or intermediate "zero" graduation and a limited range of weight graduations on either side of the zero graduation, for indicating weights greater than and less than the predetermined values for which other elements of the scale may be set. (A scale having an over-and-under indicator is classed as an automatic-indicating scale.) [2.20]

overregistration and underregistration. – When an instrument or device is of such a character that it indicates or records values as a result of its operation, its error is said to be in the direction of overregistration or underregistration, depending upon whether the indications are, respectively, greater or less than they should be. Examples of devices having errors of "overregistration" are: a fabric-measuring device that indicates more than the true length of material passed through it; and a liquid-measuring device that indicates more than the true amount of the liquid delivered by the device. Examples of devices having errors of "underregistration" are: a meter that indicates less than the true amount of product that it delivers; and a weighing scale that indicates or records less than the true weight of the applied load. [1.10]

P

parallax. – The apparent displacement, or apparent difference in height or width, of a graduation or other object with respect to a fixed reference, as viewed from different points. [1.10]

parking meter. – A coin-operated device for measuring parking time for vehicles. [5.55]

passenger vehicles. – Vehicles such as automobiles, recreational vehicles, limousines, ambulances, and hearses. [5.53]

percent registration. – Percent registration is calculated as follows:

$$Percent\ Registration = \frac{Wh\ measured\ by\ EVSE}{Wh\ measured\ by\ STANDARD} \times 100$$

[3.40]

(Added 2022)

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performance requirements. – Performance requirements include all tolerance requirements and, in the case of nonautomatic-indicating scales, sensitivity requirements (SR). (Also see definitions for "tolerance" and "sensitivity requirement.") [1.10]

point-based railroad weighing systems. – An in-motion-railroad weighing system designed to weigh wheel(s) of a railway car when centered on the load sensor within a weighing zone typically of 2 inches or less. The weight of the wheels are added to obtain the total weight of the cars and train which are used for any transaction. [2.20]

(Added 2021)

point-of-sale system. – An assembly of elements including a weighing or measuring element, an indicating element, and a recording element (and may also be equipped with a "scanner") used to complete a direct sales transaction. The system components, when operated together, must be capable of the following:

1. determining the weight or measure of a product or service offered;

2. calculating a charge for the product or service based on the weight or measure and an established price/rate structure;

3. determining a total cost that includes all associated charges involved with the transaction; and

4. providing a sales receipt.

[2.20, 3.30, 3.32, 3.37, 3.39]

(Added 1986) (Amended 1997, 2015, and 2019)

poise. – A movable weight mounted upon or suspended from a weighbeam bar and used in combination with graduations, and frequently with notches, on the bar to indicate weight values. (A suspended poise is commonly called a "hanging poise.") [2.20]

postal scale. – A scale (usually a computing scale) designed for use to determine shipping weight or delivery charges for letters or parcels delivered by the U.S. Postal Service or private shipping companies. A weight classifier may be used as a postal scale. [2.20]

(Added 1987)

power factor (PF). – The ratio of "active power" to "apparent power" in an AC circuit. It describes the efficient use of available power. [3.40]

(Added 2022)

prepackaging scale. – A computing scale specially designed for putting up packages of random weights in advance of sale. [2.20]

prescription scale. – A scale or balance adapted to weighing the ingredients of medicinal and other formulas prescribed by physicians and others and used or intended to be used in the ordinary trade of pharmacists. [2.20]

pressure type (device). – A type of device designed for operation with the liquid under artificially produced pressure. [3.30, 3.31]

primary indicating or recording elements. – The term "primary" is applied to those principal indicating (visual) elements and recording elements that are designed to, or may, be used by the operator in the normal commercial use of a device. The term "primary" is applied to any element or elements that may be the determining factor in arriving at the sale representation when the device is used commercially. (Examples of primary elements are the visual indicators for meters or scales not equipped with ticket printers or other recording elements and both the visual indicators and the ticket printers or other recording elements for meters or scales so equipped.) The term "primary" is not applied to such auxiliary elements as, for example, the totalizing register or predetermined-stop mechanism on a meter or the means for producing a running record of successive weighing operations, these elements being

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supplementary to those that are the determining factors in sales representations of individual deliveries or weights. (Also see "indicating element" and "recording element.") [1.10, 3.40]

(Amended 2022)

prover method. – A method of testing milk tanks that utilizes approved volumetric prover(s) for measuring the test liquid removed from or introduced into the tank. [4.42]

prover oil. – A light oil of low vapor pressure used as a sealing medium in bell provers, cubic-foot bottles, and portable cubic-foot standards. [3.33]

proving indicator. – The test hand or pointer of the proving or leak-test circle on the meter register or index. [3.33, 3.36.]

R

"r" factor. – A computation for determining the suitability of a vehicle scale for weighing vehicles with varying axle configurations. The factor was derived by dividing the weights in FHWA Federal Highway Bridge Gross Weight Table B by 34 000 lbs. (The resultant factors are contained in Table UR.3.2.1.) [2.20]

radio frequency interference (RFI). – Radio frequency interference is a type of electrical disturbance that, when introduced into electronic and electrical circuits, may cause deviations from the normally expected performance. [1.10]

random error(s). – The sample standard deviation of the error (indicated values) for a number of consecutive automatic weighings of a load, or loads, passed over the load receptor, shall be expressed mathematically as:

$$s = \sqrt{\frac{1}{n-1}\sum\left(x_i - \bar{x}\right)^2} \quad \text{or} \quad s = \sqrt{\frac{1}{n-1}\left(\sum x_i^2 - \frac{\left(\sum x_i\right)^2}{n}\right)}$$

where: x = error of a load indication
n = the number of loads

[2.24]

ranges, weight. – See "weight ranges." [2.20]

rated capacity. – The rate of flow in cubic meters per hour of a hydrocarbon gas vapor-measuring device as recommended by the manufacturer. This rate of flow should cause a pressure drop across the meter not exceeding ½-inch water column. [3.33]

rated scale capacity. – That value representing the weight that can be delivered by the device in one hour. [2.21]

ratio test. – A test to determine the accuracy with which the actual multiple of a scale agrees with its designed multiple. This test is used for scales employing counterpoise weights and is made with standard test weights substituted in all cases for the weights commercially used on the scale. (It is appropriate to use this test for some scales not employing counterpoise weights.) [2.20]

reading face. – That portion of an automatic-indicating weighing or measuring device that gives a visible indication of the quantity weighed or measured. A reading face may include an indicator and a series of graduations or may present values digitally, and may also provide money-value indications. [1.10, 2.20]

(Amended 2005)

reading-face capacity. – The largest value that may be indicated on the reading face, exclusive of the application or addition of any supplemental or accessory elements. [1.10]

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recorded representation. – The printed, embossed, electronic, or other representation that is recorded as a quantity, unit price, total price, product identify, or other information required by a weighing or measuring device. [1.10, 2.20, 2.21, 2.22, 2.24, 2.25, 3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 5.54, 5.55, 5.56(a), 5.56(b), 5.57, 5.58, 5.60]

(Amended 2023)

recorded representation, EVSE. – The printed, electronically recorded, or other representation that retains a copy of the quantity and any other required information generated by a weighing or measuring device. [3.40]

(Added 2022) (Amended 2023)

recording element. – An element incorporated in a weighing or measuring device by means of which the device's performance relative to quantity or money value is permanently recorded on a tape, ticket, card, or the like, in the form of a printed, stamped, punched, or perforated representation or recorded electronically in instances where that option is permitted by specific code. [1.10, 2.20, 2.21, 2.22, 2.24, 2.25, 3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 5.54, 5.55, 5.56(a), 5.56(b), 5.57, 5.58, 5.60]

(Amended 2023)

recording element, EVSE. – An element incorporated, connected to, or associated with a weighing or measuring device by means of which its performance relative to quantity or money value is permanently recorded in a printed or electronic form. [3.40]

(Added 2022) (Amended 2023)

recording scale. – One on which the weights of applied loads may be permanently recorded on a tape, ticket, card, or the like in the form of a printed, stamped, punched, or perforated representation. [2.20]

reference weight car. – A railcar that has been statically weighed for temporary use as a mass standard over a short period of time, typically the time required to test one scale.

Note: A test weight car that is representative of the types of cars typically weighed on the scale under test may be used wherever reference weight cars are specified. [2.20]

(Added 1991) (Amended 2012)

reference vehicle. – A vehicle with an associated load, including the driver, that has been statically weighed for temporary use as a field standard, typically the time required to test on weigh-in-motion vehicle scale. [2.20]

(Added 2021)

remanufactured device. – A device that is disassembled, checked for wear, parts replaced or fixed, reassembled and made to operate like a new device of the same type. [1.10]

(Added 2001)

remanufactured element. – An element that is disassembled, checked for wear, parts replaced or fixed, reassembled and made to operate like a new element of the same type. [1.10]

(Added 2001)

remote configuration capability. – The ability to adjust a weighing or measuring device or change its sealable parameters from or through some other device that is not itself necessary to the operation of the weighing or measuring device or is not a permanent part of that device. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 5.54, 5.56(a), 5.58]

(Added 1993) (Amended 2019 and 2022)

repaired device. – A device to which work is performed that brings the device back into proper operating condition. [1.10]

(Added 2001)

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repaired element. – An element to which work is performed that brings the element back into proper operating condition. [1.10]

(Added 2001)

retail device. – A measuring device primarily used to measure product for the purpose of sale to the end user. [3.30, 3.32, 3.37, 3.39, 3.40]

(Amended 1987, 2004, 2019, and 2022)

retroactive. – "Retroactive" requirements are enforceable with respect to all equipment. Retroactive requirements are printed herein in upright roman type. (Also see "nonretroactive.") [1.10]

road test. – A distance test, over a measured course, of a complete taximeter assembly when installed on a vehicle, the mechanism being actuated as a result of vehicle travel. [5.53, 5.54]

rolling circumference. – The rolling circumference is the straight-line distance traveled per revolution of the wheel (or wheels) that actuates the taximeter or odometer. If more than one wheel actuates the taximeter or odometer, the rolling circumference is the average distance traveled per revolution of the actuating wheels. [5.53, 5.54]

S

scale. – See specific type of scale. [2.20]

scale area, belt-conveyor. – See belt-conveyor scale systems area. [2.21]

(Added 2001)

scale division, number of (n). – See "verification scale interval, number of (n)." [2.20]

(Amended 2024)

scale division, value of (d). – The value of the scale division, expressed in units of mass, is the smallest subdivision of the scale for analog indication or the difference between two consecutively indicated or printed values for digital indication or printing. (Also see "verification scale division.") [2.20, 2.22]

scale section. – A part of a vehicle, axle-load, livestock, or railway track scale consisting of two main load supports, usually transverse to the direction in which the load is applied. [2.20]

seal. – See "approval seal," "security seal." [1.10]

section capacity. – The section capacity of a scale is the maximum live load that may be divided equally on the load pivots or load cells of a section. [2.20]

(Added 2001)

section test. – A shift test in which the test load is applied over individual sections of the scale. This test is conducted to disclose the weighing performance of individual sections, since scale capacity test loads are not always available and loads weighed are not always distributed evenly over all main load supports. [2.20]

security means. – A method used to prevent access by other than qualified personnel, or to indicate that access has been made to certain parts of a scale that affect the performance of the device. [2.21]

security seal. – A uniquely identifiable physical seal, such as a lead-and-wire seal or other type of locking seal, a pressure-sensitive seal sufficiently permanent to reveal its removal, or similar apparatus attached to a weighing or measuring device for protection against or indication of access to adjustment. (Also see "approval seal.") [1.10]

(Amended 1994)

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selector-type. – A system of indication or recording in which the mechanism selects, by means of a ratchet-and-pawl combination or by other means, one or the other of any two successive values that can be indicated or recorded. [1.10]

semi-automatic zero-setting mechanism. – See "semi-automatic zero-setting mechanism" under "zero-setting mechanism." [2.20]

sensitivity (of a nonautomatic-indicating scale). – The value of the test load on the load-receiving element of the scale that will produce a specified minimum change in the position of rest of the indicating element or elements of the scale. [2.20]

sensitivity requirement (SR). – A performance requirement for a non automatic-indicating scale; specifically, the minimum change in the position of rest of the indicating element or elements of the scale in response to the increase or decrease, by a specified amount, of the test load on the load-receiving element of the scale. [2.20]

serving utility. – The utility distribution company that owns the master meter and sells electric energy to the owner of a submeter system. [3.40]
(Added 2022)

shift test. – A test intended to disclose the weighing performance of a scale under off-center loading. [2.20]

side. – That portion of a pump or dispenser which faces the consumer during the normal delivery of product. [3.30]
(Added 1987)

simulated-road test. – A distance test during which the taximeter or odometer may be actuated by some means other than road travel. The distance traveled is either measured by a properly calibrated roller device or computed from rolling circumference and wheel-turn data. [5.53, 5.54]

simulated test. – A test using artificial means of loading the scale to determine the performance of a belt-conveyor scale. [2.21]

single cell application load cell. – A load cell intended for use in a weighing system which incorporates one or more load cells. A single cell application load cell is designated with the letter "S" or the term "Single." (Also see "multiple cell application load cell.") [2.20]
(Added 1999)

single-tariff taximeter. – One that calculates fares at a single rate only. [5.54]

skirting. – Stationary side boards or sections of belt conveyor attached to the conveyor support frame or other stationary support to prevent the bulk material from falling off the side of the belt. [2.21]

slow-flow meter. – A retail device designed for the measurement, at very slow rates (less than 40 L (10 gal) per hour), of liquid fuels at individual domestic installations. [3.30]

small-delivery device. – Any device other than a large-delivery device. [3.34, 3.38]

span (structural). – The distance between adjoining sections of a scale. [2.20]
(Added 1988)

specification. – A requirement usually dealing with the design, construction, or marking of a weighing or measuring device. Specifications are directed primarily to the manufacturers of devices. [1.10]

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

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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]
(Added 2023)

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]
(Added 2023)

starting load. – The minimum load above which the device will indicate energy flow continuously. [3.40]
(Added 2022)

static monorail weighing system. – A weighing system in which the load being applied is stationary during the weighing operation. [2.20]
(Added 1999)

strain-load test. – The test of a scale beginning with the scale under load and applying known test weights to determine accuracy over a portion of the weighing range. The scale errors for a strain-load test are the errors observed for the known test loads only. The tolerances to be applied are based on the known test load used for each error that is determined. [2.20, 2.22]

submeter. – A meter or meter system downstream of the electric master meter. [3.40]
(Added 2022)

subordinate graduation. – Any graduation other than a main graduation. (Also see "graduation.") [1.10]

subsequent distance or time intervals. – The intervals corresponding to money drops following the initial money drop. [5.54]

substitution test. – A scale testing process used to quantify the weight of material or objects for use as a known test load. [2.20]
(Added 2003)

substitution test load. – The sum of the combination of field standard test weights and any other applied load used in the conduct of a test using substitution test methods. [2.20]
(Added 2003)

surface gauge. – A combination of (1) a stationary indicator, and (2) a movable, graduated element designed to be brought into contact with the surface of the liquid from above. [4.42]

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systematic (average) error ($\bar{x}$). – The mean value of the error (of indication) for a number of consecutive automatic weighings of a load, or loads, passed over the load-receiving element (e.g., weigh-table), shall be expressed mathematically as:

$$\bar{x} = \frac{\sum x}{n}$$

where: x = error of a load indication
n = the number of loads

[2.24]

T

tail pulley. – The pulley at the opposite end of the conveyor from the head pulley. [2.21]

take-up. – A device to provide sufficient tension in a conveyor belt so that the belt will be positively driven by the drive pulley. – A counter-weighted take-up consists of a pulley free to move in either the vertical or horizontal direction with dead weights applied to the pulley shaft to provide the tension required. [2.21]

tare mechanism. – A mechanism (including a tare bar) designed for determining or balancing out the weight of packaging material, containers, vehicles, or other materials that are not intended to be included in net weight determinations. [2.20]

tare-weighbeam elements. – The combination of a tare bar and its fractional bar, or a tare bar alone if no fractional bar is associated with it. [2.20]

taximeter. – A device that automatically calculates, at a predetermined rate or rates, and indicates the charge for hire of a vehicle. [5.54]

test accuracy – in-service. – The device accuracy determined by a test made during the period that the system is in service. It may be made on the customer's premises without removing the system from its mounting or by removing the EVSE for testing either on the premises or in a laboratory or shop. [3.40]

(Added 2022)

test amperes (TA). – The full load current (amperage) specified by the EVSE manufacturer for testing and calibration adjustment. (Example: TA 30). [3.40]

(Added 2022)

test chain. – A device used for simulated tests consisting of a series of rollers or wheels linked together in such a manner as to assure uniformity of weight and freedom of motion to reduce wear, with consequent loss of weight, to a minimum. [2.21]

test liquid. – The liquid used during the test of a device. [3.30, 3.31, 3.34, 3.35, 3.36, 3.37, 3.38]

test object. – An object whose dimensions are verified by appropriate reference standards and intended to verify compliance of the device under test with certain metrological requirements. [5.58]

test puck. – A metal, plastic, or other suitable object that remains stable for the duration of the test, used as a test load to simulate a package. Pucks can be made in a variety of dimensions and have different weights to represent a wide range of package sizes. Metal versions may be covered with rubber cushions to eliminate the possibility of damage to weighing and handling equipment. The puck mass is adjusted to an accuracy specified in N.1.2. Accuracy of Test Pucks or Packages. [2.24]

(Amended 2004)

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test train. – A train consisting of or including reference weight cars and used to test coupled-in-motion railway track scales. The reference weight cars may be placed consecutively or distributed in different places within a train. [2.20]

(Added 1990) (Amended 1991)

test weight car. – A railroad car designed to be a stable mass standard to test railway track scales. The test weight car may be one of the following types: a self-contained composite car, a self-propelled car, or a standard rail car. [2.20]

(Added 1991)

testing. – An operation consisting of a series of volumetric determinations made to verify the accuracy of the volume chart that was developed by gauging. [4.42]

thermal overload protector. – A circuit breaker or fuse that automatically limits the maximum current in a circuit. [3.40]

(Added 2022)

time recorder. – A clock-operated mechanism designed to record the time of day. Examples of time recorders are those used in parking garages to record the "in" and "out" time of day for parked vehicles. [5.55]

timing device. – A device used to measure the time during which a particular paid-for service is dispensed. Examples of timing devices are laundry driers, car-wash timers, parking meters, and parking-garage clocks and recorders. [5.55]

tolerance. – A value fixing the limit of allowable error or departure from true performance or value. (Also see "basic tolerances.") [1.10]

training idlers. – Idlers of special design or mounting intended to shift the belt sideways on the conveyor to assure the belt is centered on the conveying idlers. [2.21]

tripper. – A device for unloading a belt conveyor at a point between the loading point and the head pulley. [2.21]

U

uncoupled-in-motion railroad weighing system. – A device and related installation characteristics consisting of (1) the associated approach trackage, (2) the scale (i.e., the weighing element, the load-receiving element, and the indicating element with its software), and (3) the exit trackage, which permit the weighing of railroad cars uncoupled in motion. [2.20]

(Added 1993)

underregistration. – See "overregistration" and "underregistration." [1.10]

unit price. – The price at which the product is being sold and expressed in whole units of measurement. [1.10, 2.20, 3.30, 3.31, 3.32, 3.37, 3.39, 3.40]

(Added 1992) (Amended 2019 and 2022)

unit train. – A unit train is defined as a number of contiguous cars carrying a single commodity from one consignor to one consignee. The number of cars is determined by agreement among the consignor, consignee, and the operating railroad. [2.20]

unit weight. – One contained within the housing of an automatic-indicating scale and mechanically applied to and removed from the mechanism. The application of a unit weight will increase the range of automatic indication, normally in increments equal to the reading-face capacity. [2.20]

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user requirement. – A requirement dealing with the selection, installation, use, or maintenance of a weighing or measuring device. User requirements are directed primarily to the users of devices. (Also see Introduction, Section D.) [1.10]

usual and customary. – Commonly or ordinarily found in practice or in the normal course of events and in accordance with established practices. [1.10]

utility-type water meter. – A device used for the measurement of water, generally applicable to meters installed in residences or business establishments, excluding batching meters. [3.36]

(Added 2011)

V

value of minimum graduated interval. – (1) The value represented by the interval from the center of one graduation to the center of the succeeding graduation. (2) The increment between successive recorded values. (Also see "graduated interval.") [1.10]

vapor equalization credit. – The quantity deducted from the metered quantity of liquid carbon dioxide when a vapor equalizing line is used to facilitate the transfer of liquid during a metered delivery. [3.38]

vapor equalization line. – A hose or pipe connected from the vapor space of the seller's tank to the vapor space of the buyer's tank that is used to equalize the pressure during a delivery. [3.38]

vehicle connector. – A device that by insertion into a vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of providing power and information exchange, with means for attachment of an electric vehicle cable. This device is a part of the vehicle coupler. [3.40]

(Added 2022)

vehicle coupler. – A means enabling the connection, at will, of an electric vehicle cable to the equipment. It consists of a vehicle connector and a vehicle inlet. [3.40]

(Added 2022)

vehicle inlet. – The part incorporated in, or fixed to the vehicle, which receives power from a vehicle connector. [3.40]

(Added 2022)

vehicle on-board weighing system. – A weighing system designed as an integral part of or attached to the frame, chassis, lifting mechanism, or bed of a vehicle, trailer, industrial truck, industrial tractor, or forklift truck. [2.20]

(Amended 1993)

vehicle scale. – A scale (including weigh-in-motion vehicle scales) adapted to weighing highway, farm, or other large industrial vehicles (except railroad freight cars), loaded or unloaded. [2.20]

(Amended 2021)

verification scale interval, value of (e). – A value, expressed in units of weight (mass) and specified by the manufacturer of a device, by which the tolerance values and the accuracy class applicable to the device are determined. The verification scale interval is applied to all scales, in particular to ungraduated devices since they have no graduations. [2.20]

(Amended 2024)

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verification scale interval, number of (n). – The capacity divided by the value of the verification scale interval. [2.20]

$$n = \frac{Capacity}{e}$$

(Added 2024)

visible type. – A type of device in which the measurement takes place in a see-through glass measuring chamber. [3.30]

v_{min} (minimum load cell verification interval). – The smallest load cell verification interval, *expressed in units of mass** into which the load cell measuring range can be divided. [2.20, 2.24]
*[*Nonretroactive as of January 1, 2001]*
(Added 1996) (Amended 1999)

volt. – The practical unit of electromotive force. One volt will cause one ampere to flow when impressed across a resistance of one ohm. [3.40]
(Added 2022)

W

watt (W). – The practical unit of electric power. In an alternating-current (AC) circuit, the power in watts is volts times amperes multiplied by the circuit power factor. [3.40]
(Added 2022)

watthour (Wh). – The practical unit of electric energy that is expended in one hour when the average power consumed during the hour is one watt. [3.40]
(Added 2022)

weighbeam. – An element comprising one or more bars, equipped with movable poises or means for applying counterpoise weights or both. [2.20]

weigh-belt system. – A type of belt-conveyor scale system designed by the manufacturer as a self-contained conveyor system and that is installed as a unit. A unit is comprised of integral components and, at minimum, includes a: conveyor belt; belt drive; conveyor frame; and weighing system. A weigh-belt system may operate at single or multiple flow rates and may use variable-speed belt drives. [2.21]
(Added 2015)

weighing element. – That portion of a scale that supports the load-receiving element and transmits to the indicating element a signal or force resulting from the load applied to the load-receiving element. [2.20, 2.21, 2.22]
(Added 1988)

weigh-in-motion (WIM) vehicle scale. – A vehicle scale adapted to weighing vehicles as they travel across the scale without stopping. [2.20]
(Added 2021)

weigh-labeler. – An automatic weighing system that determines the weight of a package and prints a label or other document bearing a weight declaration for each discrete item (usually a label also includes unit and total price declarations). Weigh-labelers are sometimes used to weigh and label standard and random packages (also called "Prepackaging Scales"). [2.24]
(Amended 2004)

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weigh module. – The portion of a load-receiving element supported by two sections. The length of a module is the distance to which load can be applied. [2.20]
(Added 2013)

weighment. – A single complete weighing operation. [2.20, 2.21]
(Added 1986)

weight, unit. – See "unit weight." [2.20]

weight classifier. – A digital scale that rounds weight values up to the next verification scale interval (e). [2.20]
(Added 1987) (Amended 2024 and 2025)

weight ranges. – Electrical or electro-mechanical elements incorporated in an automatic indicating scale through the application of which the range of automatic indication of the scale is increased, normally in increments equal to the reading-face capacity. [2.20]

wet basis. – See "moisture content (wet basis)." [5.56(a), 5.56(b)]

wet hose. – A discharge hose intended to be full of product at all times. (Also see "wet-hose type.") [3.30, 3.31, 3.38, 3.39]
(Amended 2002 and 2019)

wet-hose type. – A type of device designed to be operated with the discharge hose full of product at all times. (Also see "wet hose.") [3.30, 3.32, 3.34, 3.37, 3.38, 3.39]
(Amended 2002 and 2019)

wheel-load weighers. – Compact, self-contained, portable weighing elements specially adapted to determining the wheel loads or axle loads of vehicles on highways for the enforcement of highway weight laws only. [2.20]

wholesale device. – Any device other than a retail device. (Also see "retail device.") [3.30, 3.32]

wing pulley. – A pulley made of widely spaced metal bars in order to set up a vibration to shake loose material off the underside (return side) of the belt. [2.21]

Z

zero-load balance. – A correct weight indication or representation of zero when there is no load on the load-receiving element. (Also see "zero-load balance for an automatic-indicating scale," "zero-load balance for a nonautomatic-indicating scale," "zero-load balance for a recording scale.") [2.20]

zero-load balance, automatic-indicating scale. – A condition in which the indicator is at rest at, or oscillates through approximately equal arcs on either side of, the zero graduation. [2.20]

zero-load balance, nonautomatic-indicating scale. – A condition in which (a) the weighbeam is at rest at, or oscillates through approximately equal arcs above and below, the center of a trig loop; (b) the weighbeam or lever system is at rest at, or oscillates through approximately equal arcs above and below, a horizontal position or a position midway between limiting stops; or (c) the indicator of a balance indicator is at rest at, or oscillates through approximately equal arcs on either side of, the zero graduation. [2.20]

zero-load balance for a recording scale. – A condition in which the scale will record a representation of zero load. [2.20]

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zero-load reference (belt-conveyor scales). – A zero-load reference value represents no load on a moving conveyor belt. This value can be either; a number representing the electronic load cell output, a percentage of full scale capacity, or other reference value that accurately represents the no load condition of a moving conveyor belt. The no load reference value can only be updated after the completion of a zero load test.[2.21]

(Added 2002)

zero-setting mechanism. – Means provided to attain a zero balance indication with no load on the load-receiving element. The types of zero-setting mechanisms are: [2.20, 2.22, 2.24]

automatic zero-setting mechanism (AZSM). – Automatic means provided to set the zero-balance indication without the intervention of an operator. [2.22]

(Added 2010)

automatic zero-tracking (AZT) mechanism. – See "automatic zero-tracking (AZT) mechanism." (NOTE: AZT maintains zero with specified limits. "Zero-setting sets/establishes zero with limits based on scale capacity.) [2.20, 2.22, 2.24]

initial zero-setting mechanism. – Automatic means provided to set the indication to zero at the time the instrument is switched on and before it is ready for use. [2.20]

(Added 1990)

manual zero-setting mechanism. – Nonautomatic means provided to attain a zero balance indication by the direct operation of a control. [2.20]

semiautomatic zero-setting mechanism. – Automatic means provided to attain a direct zero balance indication requiring a single initiation by an operator. [2.20]

(Amended 2010)

zero-setting mechanism (belt-conveyor scale). – A mechanism enabling zero totalization to be obtained over a whole number of belt revolutions. [2.21, 2.23]

(Added 2002)

zero-tracking mechanism. – See "automatic zero-tracking mechanism" under "zero-setting mechanism." [2.20, 2.22, 2.24]

zone of uncertainty. – The zone between adjacent increments on a digital device in which the value of either of the adjacent increments may be displayed. [2.20]

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