NIST Handbook
NIST HB 44-2023

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

as adopted by the
107th National Conference on Weights and Measures

Tina G. Butcher
Richard A. Harshman
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NIST Handbook 44

2023 Edition

Supersedes NIST Handbook 44, 2022 Edition

NIST OFFICE OF WEIGHTS AND MEASURES

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November 2022

U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Institute of Standards and Technology
Laurie E. Locascio, NIST Director and Under Secretary of Commerce for Standards and Technology

Certain commercial entities, equipment, or materials may be identified in this document in order to describe an experimental procedure or concept adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the entities, materials, or equipment are necessarily the best available for the purpose.

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.

Publication History

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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 2023 edition includes amendments made through the Committee on Specifications and Tolerances of the National Conference 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 107th Annual Meeting in July 2022.

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.

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 Conference on Weights and Measures (NCWM). This handbook includes amendments endorsed by the 107th National Conference on Weights and Measures during its Annual Meetings in 2022.

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/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.

Author Contributions

Elizabeth J. Benham: Writing - Original Draft, Writing - Reviewing and Editing; **Tina G. Butcher**: Data Curation, Writing - Original Draft, Writing - Reviewing and Editing; **Richard A. Harshman**: Data Curation, Writing - Original Draft, Writing - Reviewing and Editing; **Jan Konijnenburg**: Data Curation, Writing - Reviewing and Editing; **G. Diane Lee**: Writing - Original Draft, Data Curation, Writing - Reviewing and Editing; **Juana S. Williams**: Data Curation, Writing - Original Draft, Writing - Reviewing and Editing; **Lisa Warfield**: Writing - Reviewing and Editing; **Shelby L. Bowers**: Writing - Reviewing and Editing; **Katrice A. Lippa**: Supervision.

Acknowledgments

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Table of Contents

Table of Contents (continued)

2022 Amendments

The following table lists the codes, paragraphs, and pages in which the 107th National Conference 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 2022" or "Amended 2022."

Section	Code	S&T Item No.	Paragraph	Action	Page
1.10.	General	GEN-22.1	G-A.1.	Amended	1-3
3.30.	Liquid-Measuring Devices	LMD-21.1	Table S.2.2.	Amended	3-13
		LMD-22.1	Table T.2.	Amended	3-21
3.32.	Liquified Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices	LPG-22.1	A.1.	Amended	3-47
3.37.	Mass Flow Meters	MFM-22.1	Table T.2.	Amended	3-119
3.40.	Electric Vehicle Fueling Systems	EVF-22.1 (Priority Item Added to Committee Agenda June 24, 2022)	Entire Code	Code upgraded from tentative to permanent and preamble modified	3-151 to 3-164
		EVF-20.1	S.1.3.1., S.1.3.2.	Amended	3-154
		EVF-22.1 (Priority Item Added to Committee Agenda June 24, 2022)	S.2.7., N.5.2., and T.2.1.	Amended	3-156, 3-160, 3-161
5.54.	Taximeters	TXI-22.1	Table S.5.	Amended	5-32
Appendix D	Definitions	EVF-22.1 (Priority	alternating current (AC);	Added	D-6 to D-34

		Item Added to Committee Agenda June 24, 2022)	ampere; creep; current; direct current (DC); electric vehicle, plug-in; electric vehicle supply equipment (EVSE); electricity as vehicle fuel; energy; energy flow; EVSE field reference standard; hertz (Hz); kilowatt (kW); kilowatt-hour (kWh); load, full; load, light; master meter, electric; megajoule (MJ); meter, electricity; metrological components; nationally recognized testing laboratory (NRTL); ohm (Ω); percent registration; power factor; serving utility; starting load; submeter; test accuracy – in-service; test amperes (TA); thermal overload protector; vehicle connector;		

			vehicle coupler; vehicle inlet; volt; watt; watthour (Wh)		
			audit trail; calibration parameter; configuration parameter; equipment, commercial; event counter; event logger; face; minimum measured quantity (MMQ); non-resettable totalizer; primary indicating element or recording element; remote configuration capability; retail device; unit price	Amended by adding "3.40" to the list of applicable codes to which the definition applies	D-7 to D-32
			recorded representation; and recording element	Added new definitions applicable to Section 3.40	D-27
		OTH-22.2	face	Amended	D-15
		LPG-22.1	liquefied petroleum gas retail motor-fuel device	Added	D-18
		LPG-22.1	motor-fuel device or motor-fuel dispenser or retail motor-fuel device	Amended	D-21

2022 Editorial Changes

SECTION	CODE	PARAGRAPH	ACTION	PAGE
1.10	General Code	G-S.5.6.1. Indicated and Recorded Representation of Units. – Appropriate abbreviations.	**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 ~~**Weights and Measures**~~ "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.	1-8
2.20	Scales	Table 1M. Minimum Travel of Weighbeam of Beam Scale Between Limiting Stops	≤ 30 ~~**or less**~~ > 30~~+~~ to 50~~**, inclusive**~~ > 50~~+~~ to 100~~**, inclusive**~~ > ~~**Over**~~ 100	2-10
		Table 1. Minimum Travel of Weighbeam of Beam Scale Between Limiting Stops	≤ 12 ~~**or less**~~ > 12~~+~~ to 20~~**, inclusive**~~ > 20~~+~~ to 40~~**, inclusive**~~ > ~~**Over**~~ 40	2-10
		Table 4. Minimum Test Weights and Test Loads	≥ 20 001 ~~**kg+**~~ ≥ 40 001 ~~**lb+**~~	2-35
		Table 5. Maintenance and Acceptance Tolerances for Unmarked Postal and Parcel Post Scales	0 to 4~~**, inclusive**~~* > ~~**over**~~ 4* 0 to 1~~**, inclusive**~~ > ~~**over**~~ 1 0 to 7~~**, inclusive**~~ > 7~~+~~ to 24~~**, inclusive**~~ > 24~~+~~ to 30~~**, inclusive**~~ > ~~**over**~~ 30	2-41
3.33	Hydrocarbon Gas Vapor-Measuring Devices	UR.2.3. Correction for Elevation.	The appropriate altitude correction factor from Table 2M. Corrections for Altitude, Metric Units or Table 2. Corrections for Altitude, U.S. Customary Units shall be used. (The table is modified from ~~**NIST Handbook 117**~~ **NBS Handbook 117, Examination of Vapor-**	3-71

			Measuring Devices for Liquefied Petroleum Gas.)	
3.39	Hydrogen Gas-Measuring Devices	Headers	Remove the word "Code" from the headers to be consistent with other codes in NIST Handbook 44.	3-139 to 3-150
		A. Application	(a) Devices used for dispensing a hydrogen gas with a hydrogen fuel index lower than 99.97 % and concentrations of specified impurities that exceed level limits in the latest version of SAE International J2719 **"Hydrogen Fuel Quality for Fuel Cell Vehicles."**	3-141
Appendix B	Units and Systems of Measurement – Their Origin, Development, and Present Status	Multiple	• Several references and citations were updated to provide URL links to NIST publications, Federal Register Notices, and federal statutes and code of regulations. • Clarified that the BIPM Consultative Committees of Units publish practical methods, known as *Mise en Pratique*, to realize the seven SI base units. • Added additional examples of derived units. • Additional information was added to fully describe the retirement of the U.S. survey foot. • Clarified it is incorrect to describe traditional units used in the United States as "Imperial" or "British" and that "U.S. customary" is the correct term. • Removed several unnecessary pronouns and replaced with specific nouns. • Added references to NIST online calibration service resources. • Aligned content for length, mass, and capacity to better reflect current NIST and State Laboratory Program participant laboratories calibration services.	B-6 to B-14

Appendix C	General Tables of Units		• Information was expanded to fully describe the retirement of the U.S. survey foot, including 3 new tables that present U.S. survey unit conversion factors in terms of the International foot. Section 2 surveying length and area tables were reformatted to align with the U.S. survey foot retirement FRN. • Several NIST publications, Federal Register Notices, and federal statutes and code of regulations references were updated in the footnotes. Website URLs were verified and updated. • Unit symbols and abbreviations were added to the "starting units" column to improve usability. • Removed the ångström unit to align with the latest edition of the BIPM SI Brochure and NIST SP 330, as it was eliminated in 2019. • Added footnote guidance for users to consult federal/state laws and regulations and industry documentary standards to confirm the barrel quantity used for a specific application.	C-1 to C-30

Introduction

A. Source

The specifications, tolerances and other technical requirements in this handbook comprise all of those adopted by the National Conference on Weights and Measures, Inc. (NCWM). Contact NCWM at:

1135 M Street, Suite 100	Phone: (402) 434-4880	E-mail: **info@ncwm.com**
Lincoln, NE 68508	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 is culminated at the NCWM Annual Meeting in July. After passing through one or more of the regional associations the 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 development by the committee the amendment may be presented to the membership for a vote at the annual NCWM meeting in July. NCWM policy provides for exceptions to the process to accommodate urgent or priority items. NIST staff provides 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)

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 Division 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.

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)

National Conference 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, 2022.

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**.

GENERAL INFORMATION			
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:

Submit Form via Email to: don.onwiler@ncwm.com
1135 M Street, Suite 110 / Lincoln, Nebraska 68508
P. 402.434.4880 **W.** www.ncwm.com

Revised: January 2022

Table of Contents

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.

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 Conference 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]

(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)

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. (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.

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)

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 printed digitally. In applications where recorded representations are required, the customer may be given the option of not receiving the recorded representation. 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 and 2014)

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)

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.

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-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-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

(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 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)

Section 2

Table of Contents

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Table of Contents

Section 2.20. Scales

A. Application

A.1. General. – This code applies to all types of weighing devices other than automatic bulk-weighing systems, belt-conveyor scales, and automatic weighing systems. The code comprises requirements that generally apply to all weighing devices, and specific requirements that are applicable only to certain types of weighing devices.

(Amended 1972 and 1983)

A.2. Wheel-Load Weighers, Portable Axle-Load Weighers, and Axle-Load Scales. – The requirements for wheel-load weighers, portable axle-load weighers, and axle-load scales apply only to such scales in official use for the enforcement of traffic and highway laws or for the collection of statistical information by government agencies.

A.3. Additional Code Requirements. – In addition to the requirements of this code, devices covered by the Scales code 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. Zero Indication.

(a) On a scale equipped with indicating or recording elements, provision shall be made to either indicate or record a zero-balance condition.

(b) On an automatic-indicating scale or balance indicator, provision shall be made to indicate or record an out-of-balance condition on both sides of zero.

(c) A zero-balance condition may be indicated by other than a continuous digital zero indication, provided that an effective automatic means is provided to inhibit a weighing operation or to return to a continuous digital indication when the scale is in an out-of-balance condition.

(Added 1987) (Amended 1993)

(Amended 1987)

S.1.1.1. Digital Indicating Elements.

(a) A digital zero indication shall represent a balance condition that is within ± ½ the value of the scale division.

(b) A digital indicating device shall either automatically maintain a "center-of-zero" condition to ± ¼ scale division or less, or have an auxiliary or supplemental "center-of-zero" indicator that defines a zero-balance condition to ± ¼ of a scale division or less. A "center-of-zero" indication may operate when zero is indicated for gross and/or net mode(s).
[Nonretroactive as of January 1, 1993]

(c) For electronic cash registers (ECRs) and point-of-sale systems (POS systems) the display of measurement units shall be a minimum of 9.5 mm (3/8 inch) in height.
[Nonretroactive as of January 1, 2021]

(Added 2019)

(Amended 1992, 2008, and 2019)

S.1.1.2. No-Load Reference Value. – On a single draft manually operated receiving hopper scale installed below grade, used to receive grain, and utilizing a no-load reference value, provision shall be made to indicate and record the no-load reference value prior to the gross load value.

(Added 1983)

S.1.2. Value of Scale Division Units. *– Except for batching scales and weighing systems used exclusively for weighing in predetermined amounts, the value of a scale division "d" expressed in a unit of weight shall be equal to:*

(a) 1, 2, or 5; or

(b) a decimal multiple or submultiple of 1, 2, or 5; or

Examples: scale divisions may be 10, 20, 50, 100; or 0.01, 0.02, 0.05; or 0.1, 0.2, 0.5, etc.

(c) a binary submultiple of a specific unit of weight.

Examples: scale divisions may be ½, ¼, 1/8, 1/16, etc.

[Nonretroactive as of January 1, 1986]

S.1.2.1. Digital Indicating Scales, Units. *– Except for postal scales, a digital-indicating scale shall indicate weight values using only a single unit of measure. Weight values shall be presented in a decimal format with the value of the scale division expressed as 1, 2, or 5, or a decimal multiple or submultiple of 1, 2, or 5.*

The requirement that the value of the scale division be expressed only as 1, 2, or 5, or a decimal multiple or submultiple of only 1, 2, or 5 does not apply to net weight indications and recorded representations that are calculated from gross and tare weight indications where the scale division of the gross weight is different from the scale division of the tare weight(s) on multi-interval or multiple range scales. For example, a multiple range or multi-interval scale may indicate and record tare weights in a lower weighing range (WR) or weighing segment (WS), gross weights in the higher weighing range or weighing segment, and net weights as follows:

55 kg	*Gross Weight*	*(WR2 d = 5 kg)*	*10.05 lb*	*Gross Weight*	*(WS2 d = 0.05 lb)*
– 4 kg	*Tare Weight*	*(WR1 d = 2 kg)*	*– 0.06 lb*	*Tare Weight*	*(WS1 d = 0.02 lb)*
= 51 kg	*Net Weight*	*(Mathematically Correct)*	*= 9.99 lb*	*Net Weight*	*(Mathematically Correct)*

[Nonretroactive as of January 1, 1989]

(Added 1987) (Amended 2008)

S.1.2.2. Verification Scale Interval.

S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales. – If e ≠ d, the verification scale interval "e" shall be determined by the expression:

$$d < e \leq 10\ d$$

If the displayed division (d) is less than the verification division (e), then the verification division shall be less than or equal to 10 times the displayed division.

The value of e must satisfy the relationship, $e = 10^k$ of the unit of measure, where k is a positive or negative whole number or zero. This requirement does not apply to a Class I device with d < 1 mg where e = 1 mg. If e ≠ d, the value of "d" shall be a decimal submultiple of "e," and the ratio shall not be more than 10:1. If e ≠ d, and both "e" and "d" are continuously displayed during normal operation, then "d" shall be differentiated from "e" by size, shape, color, etc. throughout the range of weights displayed as "d."

(Added 1999)

S.1.2.2.2. Class III and IIII Scales. The value of "e" is specified by the manufacturer as marked on the device. Except for dynamic monorail scales, "e" must be less than or equal to "d."

(Added 1999)

(Amended 2021)

S.1.2.3. Prescription Scale with a Counting Feature. – A Class I or Class II prescription scale with an operational counting feature shall not calculate a piece weight or total count unless the sample used to determine the individual piece weight meets the following conditions:

(a) minimum individual piece weight is greater than or equal to 3 e; and

(b) minimum sample piece count is greater than or equal to 10 pieces.

(Added 2003)

S.1.3. Graduations.

S.1.3.1. Length. – Graduations shall be so varied in length that they may be conveniently read.

S.1.3.2. Width. – In any series of graduations, the width of a graduation shall in no case be greater than the width of the clear space between graduations. The width of main graduations shall be not more than 50 % greater than the width of subordinate graduations. Graduations shall be not less than 0.2 mm (0.008 in) wide.

S.1.3.3. Clear Space Between Graduations. – The clear space between graduations shall be not less than 0.5 mm (0.02 in) for graduations representing money-values, and not less than 0.75 mm (0.03 in) for other graduations. 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.1.4. Indicators.

S.1.4.1. Symmetry. – The index of an indicator shall be of the same shape as the graduations, at least throughout that portion of its length associated with the graduations.

S.1.4.2. 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 the graduations, shall be not more than 1.0 mm (0.04 in).

S.1.4.3. 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;
[Nonretroactive as of January 1, 2002]

(b) the width of the clear space between weight graduations; and

(c) three-fourths of the width of the clear space between money-value 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.1.4.4. 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.1.4.5. Parallax. – Parallax effects shall be reduced to the practicable minimum.

S.1.5. Weighbeams.

S.1.5.1. Normal Balance Position. – The normal balance position of the weighbeam of a beam scale shall be horizontal.

S.1.5.2. Travel. – The weighbeam of a beam scale shall have equal travel above and below the horizontal. The total travel of the weighbeam of a beam scale in a trig loop or between other limiting stops near the weighbeam tip shall be not less than the minimum travel shown in Tables 1M and 1. When such limiting stops are not provided, the total travel at the weighbeam tip shall be not less than 8 % of the distance from the weighbeam fulcrum to the weighbeam tip.

Table 1M.
Minimum Travel of Weighbeam of Beam Scale Between Limiting Stops

Distance from Weighbeam Fulcrum to Limiting Stops (centimeters)	Minimum Travel Between Limiting Stops (millimeter)
≤ 30	10
> 30 to 50	13
> 50 to 100	18
> 100	23

Table 1.
Minimum Travel of Weighbeam of Beam Scale Between Limiting Stops

Distance from Weighbeam Fulcrum to Limiting Stops (inches)	Minimum Travel Between Limiting Stops (inch)
≤ 12	0.4
> 12 to 20	0.5
> 20 to 40	0.7
> 40	0.9

S.1.5.3. Subdivision. – A subdivided weighbeam bar shall be subdivided by scale division graduations, notches, or a combination of both. Graduations on a particular bar shall be of uniform width and perpendicular to the top edge of the bar. Notches on a particular bar shall be uniform in shape and dimensions and perpendicular to the face of the bar. When a combination of graduations and notches is employed, the graduations shall be positioned in relation to the notches to indicate notch values clearly and accurately.

S.1.5.4. Readability. – A subdivided weighbeam bar shall be so subdivided and marked, and a weighbeam poise shall be so constructed, that the weight corresponding to any normal poise position can easily and accurately be read directly from the beam, whether or not provision is made for the optional recording of representations of weight.

S.1.5.5. Capacity. – On an automatic-indicating scale having a nominal capacity of 15 kg (30 lb) or less and used for direct sales to retail customers:

(a) the capacity of any weighbeam bar shall be a multiple of the reading-face capacity;

(b) each bar shall be subdivided throughout or shall be subdivided into notched intervals, each equal to the reading-face capacity; and

(c) the value of any turnover poise shall be equal to the reading-face capacity.

S.1.5.6. Poise Stop. – Except on a steelyard with no zero graduation, a shoulder or stop shall be provided on each weighbeam bar to prevent a poise from traveling and remaining back of the zero graduation.

S.1.6. Poises.

S.1.6.1. General. – No part of a poise shall be readily detachable. A locking screw shall be perpendicular to the longitudinal axis of the weighbeam and shall not be removable. Except on a steelyard with no zero graduation, the poise shall not be readily removable from a weighbeam. The knife-edge of a hanging poise shall be hard and sharp and so constructed as to allow the poise to swing freely on the bearing surfaces in the weighbeam notches.

S.1.6.2. Adjusting Material. – The adjusting material in a poise shall be securely enclosed and firmly fixed in position; if softer than brass, it shall not be in contact with the weighbeam.

S.1.6.3. Pawl. – A poise, other than a hanging poise, on a notched weighbeam bar shall have a pawl that will seat the poise in a definite and correct position in any notch, wherever in the notch the pawl is placed, and hold it there firmly and without appreciable movement. The dimension of the tip of the pawl that is transverse to the longitudinal axis of the weighbeam shall be at least equal to the corresponding dimension of the notches.

S.1.6.4. Reading Edge or Indicator. – The reading edge or indicator of a poise shall be sharply defined, and a reading edge shall be parallel to the graduations on the weighbeam.

S.1.7. Capacity Indication, Weight Ranges, and Unit Weights.

(a) **Gross Capacity.** – An indicating or recording element shall not display nor record any values when the gross load (not counting the initial dead load that has been canceled by an initial zero-setting mechanism) is in excess of 105 % of scale capacity.

(b) ***Capacity Indication.*** *– Electronic computing scales (excluding postal scales and weight classifiers) shall neither display nor record a gross or net weight in excess of scale capacity plus 9 d.*
[Nonretroactive as of January 1, 1993]

The total value of weight ranges and of unit weights in effect or in place at any time shall automatically be accounted for on the reading face and on any recorded representation.

This requirement does not apply to: (1) single-revolution dial scales, (2) multi-revolution dial scales not equipped with unit weights, (3) scales equipped with two or more weighbeams, nor (4) devices that indicate mathematically derived totalized values.
(Amended 1990, 1992, and 1995)

S.1.8. Computing Scales.

S.1.8.1. Money-Value Graduations, Metric Unit Prices. – The value of the graduated intervals representing money-values on a computing scale with analog indications shall not exceed:

(a) 1 cent at all unit prices of 55 cents per kilogram and less;

(b) 2 cents at unit prices of 56 cents per kilogram through $2.75 per kilogram (special graduations defining 5-cent intervals may be employed but not in the spaces between regular graduations);

(c) 5 cents at unit prices of $2.76 per kilogram through $7.50 per kilogram; or

(d) 10 cents at unit prices above $7.50 per kilogram.

Value figures and graduations shall not be duplicated in any column or row on the graduated chart. (Also see S.1.8.2. Money-Value Computation.)

S.1.8.2. Money-Value Graduations, U.S. Customary Unit Prices. – The value of the graduated intervals representing money-values on a computing scale with analog indications shall not exceed:

(a) 1 cent at all unit prices of 25 cents per pound and less;

(b) 2 cents at unit prices of 26 cents per pound through $1.25 per pound (special graduations defining 5-cent intervals may be employed but not in the spaces between regular graduations);

(c) 5 cents at unit prices of $ 1.26 per pound through $3.40 per pound; or

(d) 10 cents at unit prices above $3.40 per pound.

Value figures and graduations shall not be duplicated in any column or row on the graduated chart. (Also see S.1.8.2. Money-Value Computation.)

S.1.8.3. Money-Value Computation. – A computing scale with analog quantity indications used in retail trade may compute and present digital money-values to the nearest quantity graduation when the value of the minimum graduated interval is 0.005 kg (0.01 lb) or less. (Also see Sec. 1.10. General Code G-S.5.5. Money-Values, Mathematical Agreement.)

S.1.8.4. Customer's Indications. – Weight indications shall be shown on the customer's side of computing scales when these are used for direct sales to retail customers. Computing scales equipped on the operator's side with digital indications, such as the net weight, unit price, or total price, shall be similarly equipped on the customer's side. Unit price displays visible to the customer shall be in terms of single whole units of weight and not in common or decimal fractions of the unit. Scales indicating in metric units may indicate price per 100 g.

(Amended 1985 and 1995)

S.1.8.4.1. *Scales that will function as either a normal round off scale or as a weight classifier shall be provided with a sealable means for selecting the mode of operation and shall have a clear indication (annunciator), adjacent to the weight display on both the operator's and customer's side whenever the scale is operating as a weight classifier.*
[Nonretroactive as of January 1, 2001]

(Added 1999)

S.1.8.5. Recorded Representations, Point-of-Sale Systems. – The sales information recorded by cash registers when interfaced with a weighing element shall contain the following information for items weighed at the checkout stand:

(a) the net weight;

(b) the unit price;

(c) the total price;

(d) the product class or, in a system equipped with price look-up capability, the product name or code number; and

(e) the tare weight.
[Nonretroactive as of January 1, 2025]

Weight values shall be identified as tare and net, or gross if applicable. The unit of weight shall be identified as kilograms, kg, grams, g, ounces, oz, pounds, or lb.

For devices interfaced with scales indicating in metric units, the unit price may be expressed in price per 100 grams.

(Amended 1995, 2005, and 2021)

S.1.9. Prepackaging Scales.

S.1.9.1. Value of the Scale Division. – On a prepackaging scale, the value of the intervals representing weight values shall be uniform throughout the entire reading face. The recorded weight values shall be identical with those on the indicator.

S.1.9.2. Label Printer. – A prepackaging scale or a device that produces a printed ticket to be used as the label for a package shall print all values digitally and of such size, style of type, and color as to be clear and conspicuous on the label.

S.1.10. Adjustable Components. – An adjustable component such as a pendulum, spring, or potentiometer shall be held securely in adjustment and, except for a zero-load balance mechanism, shall be located within the housing of the element.

(Added 1986)

S.1.11. Provision for Sealing.

S.1.11.1. Devices and Systems Adjusted Using a Removable Digital Storage Device. – For devices and systems in which the calibration or configuration parameters, as defined in Appendix D, 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.

S.1.11.2. All Other Devices. *– Except on Class I scales and devices specified in S.1.11.1., the following provisions for sealing apply:*

(a) Except on Class I scales, provision shall be made for applying a security seal in a manner that requires the security seal to be broken before an adjustment can be made to any component affecting the performance of an electronic device.
[Nonretroactive as of January 1, 1979]

(b) Except on Class I scales, 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]

(c) Except on Class I scales, audit trails shall use the format set forth in Table S.1.11. Categories of Device and Methods of Sealing.
[Nonretroactive as of January 1, 1995]

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.

(Amended 1989, 1991, 1993, and 2019)

Table S.1.11. ***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.*	*The hardware enabling access for remote communication must be at the device and sealed using a physical seal or two event counters: one for calibration parameters and one for configuration parameters.*
Category 3: *Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).*	*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 through the device or through another on-site device. 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.)*

[Nonretroactive as of January 1, 1995]

(Table added 1993)

S.1.12. Manual Weight Entries. *– A device when being used for direct sale shall accept an entry of a manual gross or net weight value only when the scale gross or net* weight indication is at zero. Recorded manual weight entries, except those on labels generated for packages of standard weights, shall identify the weight value as a manual weight entry by one of the following terms: "Manual Weight," "Manual Wt," or "MAN WT." The use of a symbol to identify multiple manual weight entries on a single document is permitted, provided that the symbol is defined on the same page on which the manual weight entries appear and the definition of the symbol is automatically printed by the recording element as part of the document.*
*[Nonretroactive as of January 1, 1993] [*Nonretroactive as of January 1, 2005]*

(Added 1992) (Amended 2004)

S.1.13. Vehicle On-Board Weighing Systems: Vehicle in Motion. – When the vehicle is in motion, a vehicle on-board weighing system shall either:

(a) be accurate; or

(b) inhibit the weighing operation.

(Added 1993)

S.1.14. Weigh-in-Motion (WIM) Vehicle Scales.

S.1.14.1. Identification of a Fault. – Fault conditions shall be presented to the customer and the operator in a clear and unambiguous manner. No weight values shall be indicated or recorded when a fault condition is detected. The following fault conditions shall be identified, if applicable:

(a) Vehicle speed was below the minimum or above the maximum speed as specified by the manufacturer.

(b) A change in vehicle speed greater than that specified by the manufacturer was detected.

(c) Vehicle direction of travel was not valid for the installation.

(d) The amount of time all vehicle axles were simultaneously on the scale was below the minimum data acquisition time.

(e) Vehicle path of travel was outside the lateral side edges of the load-receiving element.

S.1.14.2. Information to be Recorded. – In addition to the information that is normally recorded for vehicle scales, the following shall also be printed and/or stored electronically for each vehicle weighment, if applicable:

(a) Scale identification if more than one lane at the site has the ability to weigh a vehicle in motion.

(b) Vehicle direction of travel if the weigh-in-motion vehicle scale is bi-directional.

(Added 2021)

S.2. Design of Balance, Tare, Level, Damping, and Arresting Mechanisms.

S.2.1. Zero-Load Adjustment.

S.2.1.1. General. – A scale shall be equipped with means by which the zero-load balance may be adjusted. Any loose material used for this purpose shall be enclosed so that it cannot shift in position and alter the balance condition of the scale.

Except for an initial zero-setting mechanism, an automatic zero adjustment outside the limits specified in S.2.1.3. Scales Equipped with an Automatic Zero-Tracking Mechanism is prohibited.

(Amended 2010)

S.2.1.2. Scales used in Direct Sales. – A manual zero-setting mechanism (except on a digital scale with an analog zero-adjustment mechanism with a range of not greater than one scale division) shall be operable or accessible only by a tool outside of and entirely separate from this mechanism, or it shall be enclosed in a cabinet. Except on Class I or II scales, a balance ball shall either meet this requirement or not itself be rotatable.

A semiautomatic zero-setting mechanism shall be operable or accessible only by a tool outside of and separate from this mechanism or it shall be enclosed in a cabinet, or it shall be operable only when the indication is stable within plus or minus:

(a) 3.0 scale divisions for scales of more than 2000 kg (5000 lb) capacity in service prior to January 1, 1981, and for all axle-load, railway track, and vehicle scales; or

(b) 1.0 scale division for all other scales.

S.2.1.3. Scales Equipped with an Automatic Zero-Tracking Mechanism.

S.2.1.3.1. Automatic Zero-Tracking Mechanism for Scales Manufactured Between January 1, 1981, and January 1, 2007. – The maximum load that can be "rezeroed," when either placed on or removed from the platform all at once under normal operating conditions, shall be for:

(a) bench, counter, and livestock scales: 0.6 scale division;

(b) vehicle, axle-load, and railway track scales: 3.0 scale divisions; and

(c) all other scales: 1.0 scale division.

(Amended 2005)

S.2.1.3.2. Automatic Zero-Tracking Mechanism for Scales Manufactured on or after January 1, 2007. – The maximum load that can be "rezeroed," when either placed on or removed from the platform all at once under normal operating conditions, shall be:

(a) for vehicle, axle-load, and railway track scales: 3.0 scale division; and

(b) for all other scales: 0.5 scale division.

(Added 2005)

S.2.1.3.3. Means to Disable Automatic Zero-Tracking Mechanism on Class III L Devices. *– Class III L devices equipped with an automatic zero-tracking mechanism shall be designed with a sealable means that would allow zero tracking to be disabled during the inspection and test of the device. [Nonretroactive as of January 1, 2001]*

(Added 1999) (Amended 2005)

S.2.1.4. Monorail Scales. – On a static monorail scale equipped with digital indications, means shall be provided for setting the zero-load balance to within 0.02 % of scale capacity. On a dynamic monorail weighing system, means shall be provided to automatically maintain these conditions.

(Amended 1999)

S.2.1.5. Initial Zero-Setting Mechanism. – Scales of accuracy Classes I, II, and III may be equipped with an initial zero-setting device.

(a) For weighing, load-receiving, and indicating elements in the same housing or covered on the same CC, an initial zero-setting mechanism shall not zero a load in excess of 20 % of the maximum capacity of the scale unless tests show that the scale meets all applicable tolerances for any amount of initial load compensated by this device within the specified range.

(b) For indicating elements not permanently attached to weighing and load-receiving elements covered on a separate CC, the maximum initial zero-setting mechanism range of electronic indicators shall not exceed 20 % of the configured capacity.
[Nonretroactive as of January 1, 2009]

(Added 2008)

(Added 1990) (Amended 2008)

S.2.1.6. Combined Zero-Tare ("0/T") Key. – Scales not intended to be used in direct sales applications may be equipped with a combined zero and tare function key, provided that the device is clearly marked as to how the key functions. The device must also be clearly marked on or adjacent to the weight display with the statement "Not for Direct Sales."

(Added 1998)

S.2.2. Balance Indicator. – On a balance indicator consisting of two indicating edges, lines, or points, the ends of the indicators shall be sharply defined. When the scale is in balance, the ends shall be separated by not more than 1.0 mm (0.04 in).

S.2.2.1. Dairy-Product Test, Grain-Test, Prescription, and Class I and II Scales. – Except on digital indicating devices, a dairy-product test, grain-test, prescription, or Class I or II scale shall be equipped with a balance indicator. If an indicator and a graduated scale are not in the same plane, the clearance between the indicator and the graduations shall be not more than 1.0 mm (0.04 in).

S.2.2.2. Equal-Arm Scale. *– An equal-arm scale shall be equipped with a balance indicator. If the indicator and balance graduation are not in the same plane, the clearance between the indicator and the balance graduation shall be not more than 1.0 mm (0.04 in).*
[Nonretroactive as of January 1, 1989]

(Added 1988)

S.2.3. Tare. – *On any scale (except a monorail scale equipped with digital indications and multi-interval scales or multiple range scales when the value of tare is determined in a lower weighing range or weighing segment), the value of the tare division shall be equal to the value of the scale division.** The tare mechanism shall operate only in a backward direction (that is, in a direction of underregistration) with respect to the zero-load balance condition of the scale. *A device designed to automatically clear any tare value shall also be designed to prevent the automatic clearing of tare until a complete transaction has been indicated. **
*[*Nonretroactive as of January 1, 1983]*

(Amended 1985 and 2008)

***Note**: On a computing scale, this requires the input of a unit price, the display of the unit price, and a computed positive total price at a readable equilibrium. Other devices require a complete weighing operation, including tare, net, and gross weight determination.**
*[*Nonretroactive as of January 1, 1983]*

S.2.3.1. Monorail Scales Equipped with Digital Indications. – On a static monorail weighing system equipped with digital indications, means shall be provided for setting any tare value of less than 5 % of the scale capacity to within 0.02 % of scale capacity. On a dynamic monorail weighing system, means shall be provided to automatically maintain this condition.

(Amended 1999)

S.2.4. Level-Indicating Means. – Except for portable wheel-load weighers and portable axle-load scales a portable scale shall be equipped with level -indicating means if its weighing performance is changed by an amount greater than the appropriate acceptance tolerance when it is tilted up to and including 5 % rise over run in any direction from a level position and rebalanced. The level-indicating means shall be readable without removing any scale parts requiring a tool.

[This requirement is nonretroactive as of January 1, 1986, for prescription, jewelers', and dairy-product test scales and scales marked Class I and II.]

Note: Portable wheel-load weighers and portable axle-load scales shall be accurate when tilted up to and including 5 % rise over run in any direction from a level position and rebalanced.

(Amended 1991 and 2008)

S.2.4.1. Vehicle On-Board Weighing Systems. – A vehicle on-board weighing system shall operate within tolerance when the weighing system is tilted up to and including 5 % rise over run in any direction from a level position and rebalanced. If the accuracy of the system is affected by out-of-level conditions normal to the use of the device, the system shall be equipped with an out-of-level sensor that inhibits the weighing operation when the system is out of level to the extent that the accuracy limits are exceeded.

(Added 1992) (Amended 2008)

S.2.5. Damping Means. – An automatic-indicating scale and a balance indicator shall be equipped with effective means to damp oscillations and to bring the indicating elements quickly to rest.

S.2.5.1. Digital Indicating Elements. – Digital indicating elements equipped with recording elements shall be equipped with effective means to permit the recording of weight values only when the indication is stable within plus or minus:

(a) 3.0 scale divisions for scales of more than 2000 kg (5000 lb) capacity in service prior to January 1, 1981, hopper (other than grain hopper) scales with a capacity exceeding 22 000 kg (50 000 lb), and for all vehicle, axle-load, livestock, and railway track scales; and

(b) 1.0 scale division for all other scales.

The values recorded shall be within applicable tolerances.

(Amended 1995)

S.2.5.2. Jewelers', Prescription, and Class I, and Class II Scales. – A jewelers', prescription, Class I, or Class II scales shall be equipped with appropriate means for arresting the oscillation of the mechanism.

S.2.5.3. Class I and Class II Prescription Scales with a Counting Feature. – A Class I or Class II prescription scale shall indicate to the operator when the piece weight computation is complete by a stable display of the quantity placed on the load-receiving element.

(Added 2003)

S.3. Design of Load-Receiving Elements.

S.3.1. Travel of Pans of Equal-Arm Scale. – The travel between limiting stops of the pans of a nonautomatic-indicating equal-arm scale not equipped with a balance indicator shall be not less than the minimum travel shown in Table 2M. and Table 2.

Table 2M.
Minimum Travel of Pans of Nonautomatic Indicating Equal-Arm Scale without Balance Indicator

Nominal Capacity (kilograms)	Minimum Travel of Pans (millimeters)
2 or less	9
2+ to 5, inclusive	13
5+ to 12, inclusive	19
Over 12	25

Table 2.
Minimum Travel of Pans of Nonautomatic Indicating Equal-Arm Scale without Balance Indicator

Nominal Capacity (pounds)	Minimum Travel of Pans (inch)
4 or less	0.35
4+ to 12, inclusive	0.5
12+ to 26, inclusive	0.75
Over 26	1.0

S.3.2. Drainage. – A load-receiving element intended to receive wet commodities shall be so constructed as to drain effectively.

S.3.3. Scoop Counterbalance. – A scoop on a scale used for direct sales to retail customers shall not be counterbalanced by a removable weight. A permanently attached scoop-counterbalance shall indicate clearly on both the operator's and customer's sides of the scale whether it is positioned for the scoop to be on or off the scale.

S.3.4. Length of Weigh-In-Motion Vehicle Scales. – The load-receiving element shall be of sufficient length to allow the weighment of any vehicle intended to be weighed on the scale in a single draft (i.e., all axles of the vehicle are on the load-receiving element simultaneously during the weighment).

(Added 2021)

S.4. Design of Weighing Elements.

S.4.1. Antifriction Means. – Frictional effects shall be reduced to a minimum by suitable antifriction elements. Opposing surfaces and points shall be properly shaped, finished, and hardened. A platform scale having a frame around the platform shall be equipped with means to prevent interference between platform and frame.

S.4.2. Adjustable Components. – An adjustable component such as a nose-iron or potentiometer shall be held securely in adjustment. The position of a nose-iron on a scale of more than 1000 kg (2000 lb) capacity, as determined by the factory adjustment, shall be accurately, clearly, and permanently defined.

(Amended 1986)

S.4.3. Multiple Load-Receiving Elements. – Except for mechanical bench and counter scales, a scale with a single indicating or recording element, or a combination indicating-recording element, that is coupled to two or more load-receiving elements with independent weighing systems, shall be provided with means to prohibit the activation of any load-receiving element (or elements) not in use, and shall be provided with automatic means to indicate clearly and definitely which load-receiving element (or elements) is in use.

S.5. Design of Weighing Devices, Accuracy Class.

S.5.1. Designation of Accuracy Class. *– Weighing devices are divided into accuracy classes and shall be designated as I, II, III, III L, or IIII.*
[Nonretroactive as of January 1, 1986]

S.5.2. Parameters for Accuracy Class. *– The accuracy class of a weighing device is designated by the manufacturer and shall comply with parameters shown in Table 3.*
[Nonretroactive as of January 1, 1986]

S.5.3. Multi-Interval and Multiple Range Scales, Division Value. – On a multi-interval scale and multiple range scale, the value of "e" shall be equal to the value of "d."[1]

(Added 1986) (Amended 1995)

S.5.4. Relationship of Minimum Load Cell Verification Interval Value to the Scale Division. *– The relationship of the value for the minimum load cell verification scale interval, v_{min}, to the scale division, d, for a specific scale using National Type Evaluation Program (NTEP) certified load cells shall comply with the following formulae where N is the number of load cells in a single independent[1] weighing/load-receiving element (such as hopper, railroad track, or vehicle scale weighing/load-receiving elements):*

(a) $v_{\min} \leq \frac{d*}{\sqrt{N}}$ *for scales without lever systems; and*

(b) $v_{\min} \leq \frac{d*}{\sqrt{N} \times (scale\,multiple)}$ *for scales with lever systems.*

[1] "Independent" means with a weighing/load-receiving element not attached to adjacent elements and with its own A/D conversion circuitry and displayed weight.

*[*When the value of the scale division, d, is different from the verification scale division, e, for the scale, the value of e must be used in the formulae above.]*

This requirement does not apply to complete weighing/load-receiving elements or scales, which satisfy all the following criteria:

[1] Footnote 1 to Table 3. Parameters for Accuracy Classes.

- *the complete weighing/load-receiving element or scale has been evaluated for compliance with T.N.8.1. Temperature under the NTEP;*

- *the complete weighing/load-receiving element or scale has received an NTEP Certificate of Conformance; and*

- *the complete weighing/load-receiving element or scale is equipped with an automatic zero-tracking mechanism which cannot be made inoperative in the normal weighing mode. (A test mode which permits the disabling of the automatic zero-tracking mechanism is permissible, provided the scale cannot function normally while in this mode.*

[Nonretroactive as of January 1, 1994]

(Added 1993) (Amended 1996 and 2016)

Table 3.
Parameters for Accuracy Classes

Class	***Value of the Verification Scale Division (d or e[1])***	***Number of Scale[4] Divisions (n)***	
		Minimum	***Maximum***
SI Units			
I	*equal to or greater than 1 mg*	*50 000*	*--*
II	*1 to 50 mg, inclusive*	*100*	*100 000*
	equal to or greater than 100 mg	*5 000*	*100 000*
III[2,5]	*0.1 to 2 g, inclusive*	*100*	*10 000*
	equal to or greater than 5 g	*500*	*10 000*
III L[3]	*equal to or greater than 2 kg*	*2 000*	*10 000*
IIII	*equal to or greater than 5 g*	*100*	*1 200*
U.S. Customary Units			
III[5]	*0.0002 lb to 0.005 lb, inclusive*	*100*	*10 000*
	0.005 oz to 0.125 oz, inclusive	*100*	*10 000*
	equal to or greater than 0.01 lb	*500*	*10 000*
	equal to or greater than 0.25 oz	*500*	*10 000*
III L[3]	*equal to or greater than 5 lb*	*2 000*	*10 000*
IIII	*greater than 0.01 lb*	*100*	*1 200*
	greater than 0.25 oz	*100*	*1 200*

[1] *For Class I and II devices equipped with auxiliary reading means (i.e., a rider, a vernier, or a least significant decimal differentiated by size, shape, or color), the value of the verification scale division "e" is the value of the scale division immediately preceding the auxiliary means.*

[2] *A Class III scale marked "For prescription weighing only" may have a verification scale division (e) not less than 0.01 g.*

(Added 1986) (Amended 2003)

[3] *The value of a scale division for crane and hopper (other than grain hopper) scales shall be not less than 0.2 kg (0.5 lb). The minimum number of scale divisions shall be not less than 1000.*

[4] *On a multiple range or multi-interval scale, the number of divisions for each range independently shall not exceed the maximum specified for the accuracy class. The number of scale divisions, n, for each weighing range is determined by dividing the scale capacity for each range by the verification scale division, e, for each range. On a scale system with multiple load-receiving elements and multiple indications, each element considered shall not independently exceed the maximum specified for the accuracy class. If the system has a summing indicator, the n_{max} for the summed indication shall not exceed the maximum specified for the accuracy class.*

(Added 1997)

[5] *The minimum number of scale divisions for a Class III Hopper Scale used for weighing grain shall be 2000.*)

[*Nonretroactive as of January 1, 1986*]

(Amended 1986, 1987, 1997, 1998, 1999, 2003, and 2004)

S.6. Marking Requirements. – (Also see G-S.1. Identification, G-S.4. Interchange or Reversal of Parts, G-S.6. Marking Operational Controls, Indications, and Features, G-S.7. Lettering, G-UR.2.1.1. Visibility of Identification, and UR.3.4.1. Use in Pairs.)

S.6.1. Nominal Capacity; Vehicle and Axle-Load Scales. *– For all vehicle and axle-load scales, the marked nominal capacity shall not exceed the concentrated load capacity (CLC) times the quantity of the number of sections in the scale minus 0.5.*

As a formula, this is stated as:

$$\textit{nominal capacity} \leq CLC \times (N - 0.5)$$

where N = the number of sections in the scale.
[Nonretroactive as of January 1, 1989]

Note: When the device is used in a combination railway track and vehicle weighing application, the above formula shall apply only to the vehicle scale application.

(Added 1988) (Amended 1999 and 2002)

S.6.2. Location of Marking Information. – Scales that are not permanently attached to an indicating element, and for which the load-receiving element is the only part of the weighing/load-receiving element visible after installation, may have the marking information required in Section 1.10. General Code, G-S.1. Identification and Section 2.20. Scales Code, S.6. Marking Requirements located in an area that is accessible only through the use of a tool; provided that the information is easily accessible (e.g., the information may appear on the junction box under an access plate). The identification information for these scales shall be located on the weighbridge (load-receiving element) near the point where the signal leaves the weighing element or beneath the nearest access cover.

(Added 1989)

S.6.3. Scales, Main Elements, and Components of Scales or Weighing Systems. – Scales, main elements of scales when not contained in a single enclosure for the entire scale, load cells for which Certificates of Conformance (CC) have been issued under the National Type Evaluation Program (NTEP), and other equipment necessary to a weighing system, but having no metrological effect on the weighing system, shall be marked as specified in Table S.6.3.a. Marking Requirements and explained in the accompanying notes in Table S.6.3.b. Notes for Table S.6.3.a.

(Added 1990)

Table S.6.3.a.
Marking Requirements

To Be Marked With ⇓	Weighing Equipment				
	Weighing, Load-Receiving, and Indicating Element in Same Housing or Covered on the Same CC[1]	**Indicating Element not Permanently Attached to Weighing and Load-Receiving Element or Covered by a Separate CC**	**Weighing and Load-Receiving Element Not Permanently Attached to Indicating Element or Covered by a Separate CC**	**Load Cell with CC (11)**	**Other Equipment or Device (10)**
Manufacturer's ID (1)	X	X	X	X	X
Model Designation and Prefix (1)	X	X	X	X	X
Serial Number and Prefix (2)	X	X	X	X	X (16)
Certificate of Conformance Number (CC) (23)	X	X	X	X	X (23)
Accuracy Class (17)	X	X (8)	X (19)	X	
Nominal Capacity (3)(18)(20)	X	X	X		
Value of Scale Division, "d" (3)	X	X			
Value of "e" (4)	X	X			
Temperature Limits (5)	X	X	X	X	
Concentrated Load Capacity (CLC) (12)(20)(22)		X	X (9)		
Special Application (13)	X	X	X		
Maximum Number of Scale Divisions (n_{max}) (6)		X (8)	X (19)	X	
Minimum Verification Scale Division (e_{min})			X (19)		
"S" or "M" (7)				X	
Direction of Loading (15)				X	
Minimum Dead Load				X	
Maximum Capacity				X	
Minimum and Maximum Speed (25)			X		
Maximum Speed Change (26)			X		
Vehicle Direction Restriction (27)			X		
Safe Load Limit				X	
Load Cell Verification Interval (v_{min}) (21)				X	
Section Capacity and Prefix (14)(20)(22)(24)		X	X		

Table S.6.3.a. Marking Requirements
Note: For applicable notes, Table S.6.3.b. [1] Weighing/load-receiving elements and indicators which are in the same housing or which are permanently attached will generally appear on the same CC. If not in the same housing, elements shall be hard-wired together or sealed with a physical seal or an electronic link. This requirement does not apply to peripheral equipment that has no input or effect on device calibrations or configurations. (Added 2001)

(Added 1990) (Amended 1992, 1999, 2000, 2001, 2002, 2004, and 2021)

Table S.6.3.b.
Notes for Table S.6.3.a. Marking Requirements

1. Manufacturer's identification and model designation and *model designation prefix.**
   *[*Nonretroactive as of January 1, 2003*]
   (Also see G-S.1. Identification.) *[Prefix lettering may be initial capitals, all capitals or all lower case]*
   (Amended 2000)

2. *Serial number [Nonretroactive as of January 1, 1968] and prefix [Nonretroactive as of January 1, 1986].* (Also see G-S.1. Identification.)

3. The device shall be marked with the nominal capacity. *The nominal capacity shall be shown together with the value of the scale division (e.g., 15 × 0.005 kg, 30 × 0.01 lb, or capacity = 15 kg, d = 0.005 kg) in a clear and conspicuous manner and be readily apparent when viewing the reading face of the scale indicator unless already apparent by the design of the device. Each scale division value or weight unit shall be marked on multiple range or multi-interval scales.*
   [Nonretroactive as of January 1, 1983]
   (Amended 2005)

4. *Required only if different from "d."*
   [Nonretroactive as of January 1, 1986]

5. *Required only on Class III, III L, and IIII devices if the temperature range on the NTEP CC is narrower than and within − 10 °C to 40 °C (14 °F to 104 °F). [Nonretroactive as of January 1, 1986]*
   (Amended 1999)

6. *This value may be stated on load cells in units of 1000; e.g., n: 10 is 10 000 divisions.*
   [Nonretroactive as of January 1, 1988]

7. *Denotes compliance for single or multiple load cell applications. It is acceptable to use a load cell with the "S" or Single Cell designation in multiple load cell applications as long as all other parameters meet applicable requirements. A load cell with the "M" or Multiple Cell designation can be used only in multiple load cell applications.*
   [Nonretroactive as of January 1, 1988]
   (Amended 1999)

8. *An indicating element not permanently attached to a weighing element shall be clearly and permanently marked with the accuracy Class of I, II, III, III L, or IIII, as appropriate, and the maximum number of scale divisions,* n_{max}, *for which the indicator complies with the applicable requirement. Indicating elements that qualify for use in both Class III and III L applications may be marked III/III L and shall be marked with the maximum number of scale divisions for which the device complies with the applicable requirements for each accuracy class.*
   [Nonretroactive as of January 1, 1988]

9. *For vehicle and axle-load scales only. The CLC shall be added to the load-receiving element of any such scale not previously marked at the time of modification.*
[Nonretroactive as of January 1, 1989]

(Amended 2002)

10. Necessary to the weighing system but having no metrological effect, e.g., auxiliary remote display, keyboard, etc.

11. *The markings may be either on the load cell or in an accompanying document; except that, if an accompanying document is provided, the serial number shall appear both on the load cell and in the document. [Nonretroactive as of January 1, 1988] The manufacturer's name or trademark, the model designation, and identifying symbols for the model and serial numbers as required by paragraph G-S.1. Identification shall also be marked both on the load cell and in any accompanying document.*
[Nonretroactive as of January 1, 1991]

12. Required on the indicating element *and the load-receiving element* of vehicle and axle-load scales. *Such marking shall be identified as "concentrated load capacity" or by the abbreviation "CLC."**
*[*Nonretroactive as of January 1, 1989]*

(Amended 2002)

13. *A scale designed for a special application rather than general use shall be conspicuously marked with suitable words, visible to the operator and to the customer, restricting its use to that application, e.g., postal scale, prepack scale, weight classifier, etc.** When a scale is installed with an operational counting feature, the scale shall be marked on both the operator and customer sides with the statement "The counting feature is not legal for trade," except when a Class I or Class II prescription scale complies with all Handbook 44 requirements applicable to counting features.
*[*Nonretroactive as of 1986]*

(Amended 1994 and 2003)

14. Required on *livestock** and railway track scales. When marked on vehicle and axle-load scales manufactured before January 1, 1989, it may be used as the CLC. For livestock scales manufactured between January 1, 1989, and January 1, 2003, required markings may be either CLC or section capacity.
*[*Nonretroactive as of January 1, 2003]*

(Amended 2002)

15. *Required if the direction of loading the load cell is not obvious.*
[Nonretroactive as of January 1, 1988]

16. *Serial number [Nonretroactive as of January 1, 1968] and prefix [Nonretroactive as of January 1, 1986].* (Also see G-S.1. Identification.) Modules without "intelligence" on a modular system (e.g., printer, keyboard module, cash drawer, and secondary display in a point-of-sale system) are not required to have serial numbers.

17. *The accuracy class of a device shall be marked on the device with the appropriate designation as I, II, III, III L, or IIII.*
[Nonretroactive as of January 1, 1986]

18. The nominal capacity shall be conspicuously marked as follows:

    (a) on any scale equipped with unit weights or weight ranges;
    (b) on any scale with which counterpoise or equal-arm weights are intended to be used;
    (c) on any automatic-indicating or recording scale so constructed that the capacity of the indicating or recording element, or elements, is not immediately apparent;
    (d) on any scale with a nominal capacity less than the sum of the reading elements; and

Table S.6.3.b.
Notes for Table S.6.3.a. Marking Requirements

*(e) on the load-receiving element (weighbridge) of vehicle, axle-load, and livestock scales.**
*[*Nonretroactive as of January 1, 1989]*

(Amended 1992)

19. *For weighing and load-receiving elements not permanently attached to indicating element or covered by a separate CC.*
[Nonretroactive as of January 1, 1988]

(Amended 1992)

20. *Combination vehicle/railway track scales must be marked with both the nominal capacity and CLC for vehicle weighing and the nominal capacity and section capacity for railway weighing. All other requirements relating to these markings will apply.*
[Nonretroactive as of January 1, 2000]

(Added 1999)

21. *The value of the load cell verification interval (v_{min}) must be stated in mass units. In addition to this information, a device may be marked with supplemental representations of v_{min}.*
[Nonretroactive as of January 1, 2001]

(Added 1999)

22. *Combination vehicle/livestock scales must be marked with both the CLC for vehicle weighing and the section capacity for livestock weighing. All other requirements relative to these markings will apply.*
[Nonretroactive as of January 1, 2003]

(Added 2002) (Amended 2003)

Note*: The marked section capacity for livestock weighing may be less than the marked CLC for vehicle weighing.*

(Amended 2003)

23. *Required only if a CC has been issued for the device or equipment.*
[Nonretroactive as of January 1, 2003]

(G-S.1. Identification (e) Added 2001)

24. *The section capacity shall be prefaced by the words "Section Capacity" or an abbreviation of that term. Abbreviations shall be "Sec Cap" or "Sec C." All capital letters and periods may be used.*
[Nonretroactive as of January 1, 2005]

(Added 2004)

25. Weigh-in-motion vehicle scales must be marked with minimum and maximum vehicle speed limitations.

(Added 2021)

26. Weigh-in-motion vehicle scales must be marked with the maximum vehicle speed change allowed during the weighment.

(Added 2021)

27. Weigh-in-motion vehicle scales must be marked as "uni-directional" if the travel direction is restricted.

(Added 2021)

S.6.4. Railway Track Scales. – A railway track scale shall be marked with the maximum capacity of each section of the load-receiving element of the scale. Such marking shall be accurately and conspicuously presented on, or adjacent to, the identification or nomenclature plate that is attached to the indicating element of the scale. The nominal capacity marking shall satisfy the following:

(a) For scales manufactured from January 1, 2002, through December 31, 2013:

(1) the nominal capacity of a scale with more than two sections shall not exceed twice its rated section capacity; and

(2) the nominal capacity of a two-section scale shall not exceed its rated section capacity.

(b) For scales manufactured on or after January 1, 2014, the nominal scale capacity shall not exceed the lesser of:

(1) the sum of the Weigh Module Capacities as shown in Table S.6.4.M. and Table S.6.4.; or

(2) the Rated Section Capacity (RSC) multiplied by the Number of Sections (Ns) minus the Number of Dead Spaces (Nd) minus 0.5. As a formula this is stated as:

$$RSC \times (Ns - Nd - 0.5)$$

;or

(3) 290 300 kg (640 000 lb).

(Amended 1988, 2001, 2002, and 2013)

Table S.6.4.M.
Railway Track Scale – Weigh Module Capacity

Weigh Module Length (meters)	Weigh Module Capacity (kilograms)
< 1.5	36 300
1.5 to < 3.0	72 600
3.0 to < 4.5	108 900
4.5 to < 7.0	145 100
7.0 to < 9.0	168 700
9.0 to < 10.5	192 300
10.5 to < 12.0	234 100
12.0 to < 17.0	257 600

Note: The capacity of a particular module is based on its length as shown above. To determine the "sum of the weigh module capacities" referenced in paragraph S.6.4.(b)(1): (1) determine the length of each individual weigh module in the scale; (2) find its corresponding "weigh module capacity" in the table above; and (3) add all of the individual weigh module capacities."

(Table Added 2013)

Table S.6.4.
Railway Track Scale – Weigh Module Capacity

Weigh Module Length (feet)	Weigh Module Capacity (pounds)
< 5	80 000
5 to < 10	160 000
10 to < 15	240 000
15 to < 23	320 000
23 to < 29	372 000
29 to < 35	424 000
35 to < 40	516 000
40 to < 56	568 000
Note: The capacity of a particular module is based on its length as shown above. To determine the "sum of the weigh module capacities" referenced in paragraph S.6.4.(b)(1): (1) determine the length of each individual weigh module in the scale; (2) find its corresponding "weigh module capacity" in the table above; and (3) add all of the individual weigh module capacities."	

(Table Added 2013)

S.6.5. Livestock Scales. – A livestock scale manufactured prior to January 1, 1989, or after January 1, 2003, shall be marked with the maximum capacity of each section of the load-receiving element of the scale. Livestock scales manufactured between January 1, 1989, and January 1, 2003, shall be marked with either the Concentrated Load Capacity (CLC) or the Section Capacity. Such marking shall be accurately and conspicuously presented on, or adjacent to the identification or nomenclature plate that is attached to the indicating element of the scale. *The nominal capacity of a scale with more than two sections shall not exceed twice its rated section capacity. The nominal capacity of a two-section scale shall not exceed its rated section capacity.**
*[*Nonretroactive as of January 1, 2003]*
(Added 2002)

Also see Note 14 in Table S.6.3.b. Notes for Table S.6.3.a.

S.6.6. Counting Feature, Minimum Individual Piece Weight, and Minimum Sample Piece Count. – A Class I or Class II prescription scale with an operational counting feature shall be marked with the minimum individual piece weight and minimum number of pieces used in the sample to establish an individual piece weight.
(Added 2003)

N. Notes

N.1. Test Procedures.

N.1.1. Increasing-Load Test. – The increasing-load test shall be conducted on all scales with the test loads approximately centered on the load-receiving element of the scale, except on a scale having a nominal capacity greater than the total available known test load. When the total test load is less than the nominal capacity, the test load is used to greatest advantage by concentrating it, within prescribed load limits, over the main load supports of the scale.

N.1.2. Decreasing-Load Test (Automatic Indicating Scales). – The decreasing-load test shall be conducted with the test load approximately centered on the load-receiving element of the scale.

N.1.2.1. Scales Marked I, II, III, or IIII. – Except for portable wheel load weighers, decreasing-load tests shall be conducted on scales marked I, II, III or IIII and with "n" equal to or greater than 1000 with test loads equal to the maximum test load at each tolerance value. For example, on a Class III scale, at test loads equal to 4000 d, 2000 d, and 500 d; for scales with n less than 1000, the test load shall be equal to one-half of the maximum load applied in the increasing-load test. (Also see Table 6. Maintenance Tolerances.)

(Amended 1998)

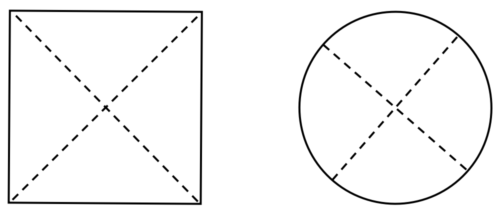
N.1.2.2. All Other Scales. – On all other scales, except for portable wheel load weighers, the decreasing-load test shall be conducted with a test load equal to one-half of the maximum load applied in the increasing-load test.

(Amended 1998)

N.1.3. Shift Test.

N.1.3.1. Dairy-Product Test Scales. – A shift test shall be conducted with a test load of 18 g successively positioned at all points on which a weight might reasonably be placed in the course of normal use of the scale.

N.1.3.2. Equal-Arm Scales. – A shift test shall be conducted with a half-capacity test load centered successively at four points positioned equidistance between the center and the front, left, back, and right edges of each pan as shown in the diagrams below. An equal test load shall be centered on the other pan.



N.1.3.3. Vehicle Scales, Axle-Load Scales, and Livestock Scales.

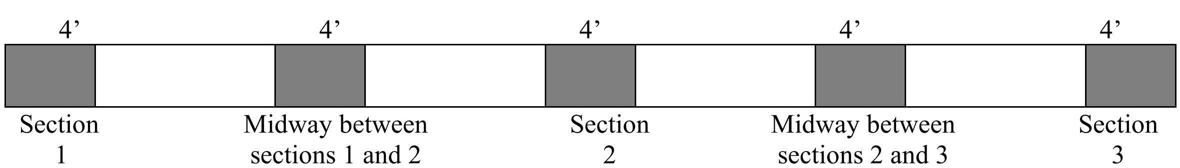
N.1.3.3.1. Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales.

(a) **Minimum Shift Test.** – At least one shift test shall be conducted with a minimum test load of 12.5 % of scale capacity, which may be performed anywhere on the load-receiving element using the prescribed test patterns and maximum test loads specified below. (Combination Vehicle/Livestock Scales shall also be tested consistent with N.1.3.3.2. Prescribed Test Pattern and Test Loads for Livestock Scales with More Than Two Sections and Combination Vehicle/Livestock Scales.)

(Amended 1991, 2000, and 2003)

(b) **Prescribed Test Pattern and Loading for Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales.** – The normal prescribed test pattern shall be an area of 1.2 m (4 ft) in length and 3.0 m (10 ft) in width or the width of the scale platform, whichever is less. Multiple test patterns may be utilized when loaded in accordance with paragraph (c), (d), or (e) as applicable. An example of a possible test pattern is shown in the diagram below.

(Amended 1997, 2001, and 2003)



(c) **Loading Precautions for Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales.** – When loading the scale for testing, one side of the test pattern shall be loaded to no more than half of the concentrated load capacity or test load before loading the other side. The area covered by the test load may be less than 1.2 m (4 ft) × 3.0 m (10 ft) or the width of the scale platform, whichever is less; for test patterns less than 1.2 m (4 ft) in length the maximum loading shall meet the formula: [(wheel base of test cart or length of test load divided by 48 in) × 0.9 × CLC]. The maximum test load applied to each test pattern shall not exceed the concentrated load capacity of the scale. When the test pattern exceeds 1.2 m (4 ft), the maximum test load applied shall not exceed the concentrated load capacity times the largest "r" factor in Table UR.3.2.1. Span Maximum Load for the length of the area covered by the test load. For load-receiving elements installed prior to January 1, 1989, the rated section capacity may be substituted for concentrated load capacity to determine maximum loading. An example of a possible test pattern is shown above.

(Amended 1997 and 2003)

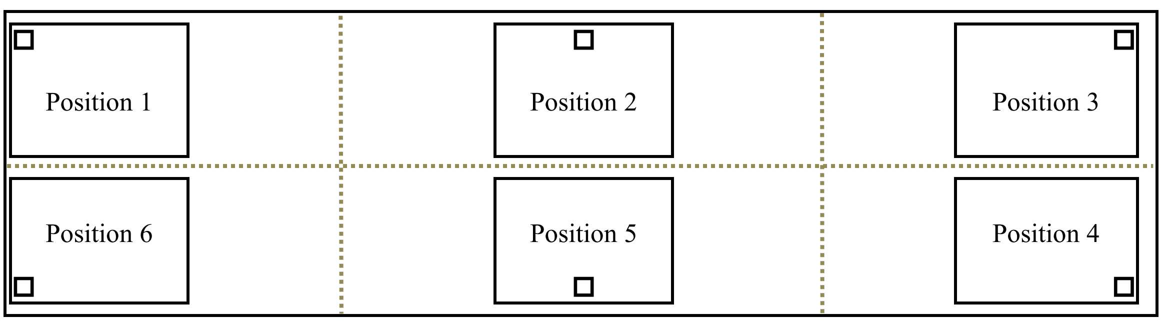
(d) **Multiple Pattern Loading.** – To test to the nominal capacity, multiple patterns may be simultaneously loaded in a manner consistent with the method of use.

(e) **Other Designs.** – Special design scales and those that are wider than 3.7 m (12 ft) shall be tested in a manner consistent with the method of use but following the principles described above.

(Amended 1988, 1991, 1997, 2000, 2001, and 2003)

(Amended 2003)

N.1.3.3.2. Prescribed Test Pattern and Test Loads for Livestock Scales with More Than Two Sections and Combination Vehicle/Livestock Scales. – A minimum test load of 5 000 kg (10 000 lb) or one-half of the rated section capacity, whichever is less, shall be placed, as nearly as possible, successively over each main load support as shown in the diagram below. For livestock scales manufactured between January 1, 1989, and January 1, 2003, the required loading shall be no greater than one-half CLC.



□ = Load Bearing Point

(Added 2003) (Amended 2016)

N.1.3.3.3. Prescribed Test Patterns and Test Loads for Two-Section Livestock Scales. – A shift test shall be conducted using the following prescribed test loads and test patterns: 1) When a single field standard weight is used, the prescribed test load shall be applied centrally in the prescribed test pattern; or 2) When multiple field standard weights are used as the prescribed test load, the load shall be applied in a consistent pattern in the shift test positions throughout the test and applied in a manner that does not concentrate the load in a test pattern that is less than when the same load is a single field standard weights on the load-receiving element.

The shift test load shall not exceed one-half the rated section capacity or one-half the rated concentrated load capacity whichever is applicable, using either:

(a) A one-half nominal capacity test load centered as nearly as possible, successively at the center of each quarter of the load-receiving element as shown in N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers Figure 1; or

(b) A one-quarter nominal capacity test load centered as nearly as possible, successively over each main load support as shown in N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers Figure 2.

(Added 2007) (Amended 2016)

N.1.3.4. Railway Track Scales Weighing Individual Cars in Single Drafts. – A shift test shall be conducted with at least two different test loads, if available, distributed over, to the right and left of, each pair of main levers or other weighing elements supporting each section of the scale.

N.1.3.5. Monorail Scales, Static Test. – A shift test shall be conducted with a test load equal to the largest load that can be anticipated to be weighed in a given installation, but never less than one-half scale capacity. The load shall be placed successively on the right end, the left end, and the center of the live rail.

(Added 1985)

N.1.3.5.1. Dynamic Monorail Weighing Systems. – Dynamic tests with livestock carcasses or portions of carcasses shall be conducted during normal plant production. No less than 20 test loads using carcasses or portions of carcasses of the type normally weighed shall be used in the dynamic test. If the plant conveyor chain does not space or prevent the carcasses or portions of carcasses from touching one another, dynamic tests shall not be conducted until this condition has been corrected.

All carcasses or portions of carcasses shall be individually weighed statically on either the same scale being tested dynamically or another monorail scale with the same or smaller divisions and in close proximity. (The scale selected for static weighing of the carcasses or portions of carcasses shall first be tested statically with certified test weights that have been properly protected from the harsh environment of the packing plant to ensure they maintain accuracy.)

If the scale being tested is used for weighing freshly slaughtered animals (often referred to as a "hot scale"), care must be taken to get a static weighment as quickly as possible before or following the dynamic weighment to avoid loss due to shrink. If multiple dynamic tests are conducted using the same carcasses or portions of carcasses, static weights shall be obtained before and after multiple dynamic tests. If the carcass or portion of a carcass changes weight between static tests, the amount of weight change shall be taken into account, or the carcass or portion of a carcass shall be disregarded for tolerance purposes.

Note: For a dynamic monorail test, the reference scale shall comply with the principles in Appendix A, Fundamental Considerations, paragraph 3.2. Tolerances for Standards.

(Added 1996) (Amended 1999 and 2007)

N.1.3.6. Vehicle On-Board Weighing Systems. – The shift test for a vehicle on-board weighing system shall be conducted in a manner consistent with its normal use. For systems that weigh as part of the lifting cycle, the center of gravity of the load may be shifted in the vertical direction as well as from side to side. In other cases, the center of gravity may be moved to the extremes of the load-receiving element using loads of a magnitude that reflect normal use (i.e., the load for the shift test may exceed one-half scale capacity), and may, in some cases, be equal to the capacity of the scale. The shift test may be conducted when the weighing system is out of level to the extent that the weighing system remains operational.

(Added 1992)

N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers. – A shift test shall be conducted using the following prescribed test loads and test patterns. A single field standard weight used as the prescribed test load shall be applied centrally in the prescribed test pattern. When multiple field standard weights are used as the prescribed test load, the load shall be applied in a consistent pattern in the shift test positions throughout the test and applied in a manner that does not concentrate the load in a test pattern that is less than when that same load is a single field standard weight on the load-receiving element.

(a) For scales with a nominal capacity of 500 kg (1000 lb) or less, a shift test shall be conducted using a one-third nominal capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible at the center of each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1.

(b) For scales with a nominal capacity greater than 500 kg (1000 lb), a shift test may be conducted by either using a one-third nominal capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible at the center of each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1, or by using a one-quarter nominal capacity test load centered as nearly as possible, successively, over each corner of the load-receiving element using the prescribed test pattern as shown in Figure 2.

Figure 1

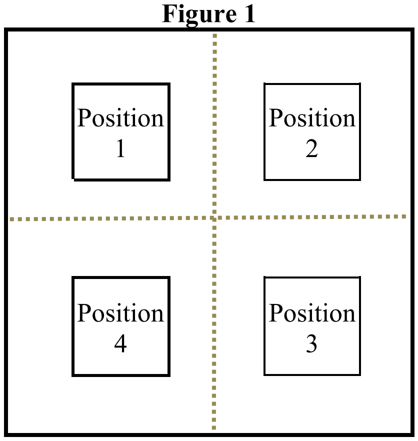
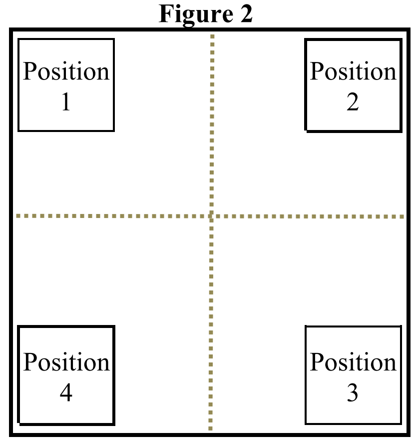


Figure 2



(Added 2003)

(Amended 1987, 2003, and 2007)

N.1.4. Sensitivity Test. – A sensitivity test shall be conducted on nonautomatic-indicating (weighbeam) scales only, with the weighing device in equilibrium at zero-load and at maximum test load. The test shall be conducted by increasing or decreasing the test load in an amount equal to the applicable value specified in T.2. Sensitivity Requirement (SR) or T.N.6. Sensitivity.

N.1.5. Discrimination Test. *– Except for digital electronic scales designated Accuracy Class I or II in which the value of e = d and is less than 5 mg, a discrimination test shall be conducted on all automatic indicating scales with the weighing device in equilibrium at or near zero load and at or near maximum test load, and under controlled conditions in which environmental factors are reduced to the extent that they will not affect the results obtained. For scales equipped with an Automatic Zero-Tracking Mechanism (AZT), the discrimination test may be conducted at a range outside of the AZT range.*
[Nonretroactive as of January 1, 1986]

(Added 1985) (Amended 2004 and 2021)

N.1.5.1. Digital Device. – On a digital device, this test is conducted from just below the lower edge of the zone of uncertainty for increasing load tests, or from just above the upper edge of the zone of uncertainty for decreasing-load tests.

N.1.6. RFI Susceptibility Tests, Field Evaluation. – An RFI test shall be conducted at a given installation when the presence of RFI has been verified and characterized if those conditions are considered "usual and customary."

(Added 1986)

N.1.7. Ratio Test. – A ratio test shall be conducted on all scales employing counterpoise weights and on nonautomatic-indicating equal-arm scales.

N.1.8. Material Tests. – A material test shall be conducted on all customer-operated bulk weighing systems for recycled materials using bulk material for which the device is used. Insert into the device, in a normal manner, several accurately pre-weighed samples (free of foreign material) in varying amounts approximating average drafts.

N.1.9. Zero-Load Balance Change. – A zero-load balance change test shall be conducted on all scales after the removal of any test load. The zero-load balance should not change by more than the minimum tolerance applicable. (Also see G-UR.4.2. Abnormal Performance.)

N.1.10. Counting Feature Test. – A test of the counting function shall be conducted on all Class I and Class II prescription scales having an active counting feature used in "legal for trade" applications. The test should verify that the scale will not accept a sample with less than either the minimum sample piece count or the minimum sample weight of 30 e. Counting feature accuracy should be verified at a minimum of two test loads. Verification of the count calculations shall be based upon the weight indication of the test load.

Note:

(1) The minimum sample weight is equal to the marked minimum individual piece weight times the marked minimum sample piece count.

(2) Test load as used in this section refers to actual calibration test weights selected from an appropriate test weight class.

(Added 2003)

N.1.11. Substitution Test. – In the substitution test procedure, material or objects are substituted for known test weights, or a combination of known test weights and previously quantified material or objects, using the scale under test as a comparator. Additional test weights or other known test loads may be added to the known test load to evaluate higher weight ranges on the scale.

(Added 2003)

N.1.12. Strain-Load Test. – In the strain-load test procedure, an unknown quantity of material or objects are used to establish a reference load or tare to which test weights or substitution test loads are added.

(Added 2003)

N.2. Verification (Testing) Standards. – Field standard weights used in verifying weighing devices shall comply with requirements of NIST Handbook 105-Series standards (or other suitable and designated standards) or the tolerances expressed in Appendix A, Fundamental Considerations, paragraph 3.2. Tolerances for Standards (i.e., one-third of the smallest tolerance applied).

(Amended 1986)

N.3. Minimum Test Weights and Test Loads. – The minimum test weights and test loads for in-service tests (except railway track scales) are shown in Table 4. (Also see Footnote 2 in Table 4. Minimum Test Weights and Test Loads.)

(Added 1984) (Amended 1988)

N.3.1. Minimum Test-Weight Load and Tests for Railway Track Scales.

(Amended 1990 and 2012)

N.3.1.1. Initial and Subsequent Tests. – The test-weight load shall be not less than 35 000 kg (80 000 lb). A strain-load test conducted up to the used capacity of the weighing system is recommended.

(Added 1990) (Amended 2012)

N.3.1.2. Interim Test. – An Interim Test may be used to return a railway track scale into temporary service following repairs that could affect the accuracy of the weighing system providing all of the following conditions are met:

(a) a test weight load of not less than 13 500 kg (30 000 lb) shall be used;

(b) a shift (section) test shall be conducted using a test-weight load of not less than 13 500 kg (30 000 lb);

(c) a strain-load test shall be conducted up to at least 25 % of scale capacity;

(d) all test results shall be within applicable tolerances; and

(e) the official with statutory authority shall be immediately notified when scales are repaired and placed in temporary service with an Interim Test. The length of temporary service following repair is at the discretion of the official with statutory authority.

(Added 1990) (Amended 2012)

N.3.1.3. Enforcement Action for Inaccuracy. – To take enforcement action on a scale that is found to be inaccurate, a minimum test load of 13 500 kg (30 000 lb) must be used.

(Added 1990)

Table 4.
Minimum Test Weights and Test Loads[1]

Devices in Metric Units			Devices in U.S. Customary Units		
Device Capacity (kg)	Minimums (in terms of device capacity)		Device Capacity (lb)	Minimums (in terms of device capacity)	
	Test Weights (greater of)	Test Loads[2]		Test Weights (greater of)	Test Loads[2]
0 to 150	100 %		0 to 300	100 %	
151 to 1 500	25 % or 150 kg	75 %	301 to 3 000	25 % or 300 lb	75 %
1 501 to 20 000	12.5 % or 500 kg	50 %	3001 to 40 000	12.5 % or 1 000 lb	50 %
≥ 20 001	12.5 % or 5 000 kg	25 %[3]	≥ 40 001	12.5 % or 10 000 lb	25 %[3]

Where practicable:

- Test weights to dial face capacity, 1000 d, or test load to used capacity, if greater than minimums specified.
- During initial verification, a scale should be tested to capacity.

[1] If the amount of test weight in Table 4 combined with the load on the scale would result in an unsafe condition, then the appropriate load will be determined by the official with statutory authority.

[2] The term "test load" means 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. Not more than three substitutions shall be used during substitution testing, after which the tolerances for strain load tests shall be applied to each set of test loads.

[3] The scale shall be tested from zero to at least 12.5 % of scale capacity using known test weights and then to at least 25 % of scale capacity using either a substitution or strain load test that utilizes known test weights of at least 12.5 % of scale capacity. Whenever practical, a strain load test should be conducted to the used capacity of the scale. When a strain load test is conducted, the tolerances apply only to the test weights or substitution test loads.

(Amended 1988, 1989, 1994, and 2003)

Note: GIPSA requires devices subject to their inspection to be tested to at least "used capacity," which is calculated based on the platform area of the scale and a weight factor assigned to the species of animal weighed on the scale. "Used capacity" is calculated using the formula:

Used Scale Capacity = Scale Platform Area × Species Weight Factor

Where species weight factor = 540 kg/m^2 (110 lb/ft^2) for cattle, 340 kg/m^2 (70 lb/ft^2) for calves and hogs, and 240 kg/m^2 (50 lb/ft^2) for sheep and lambs.

N.3.2. Field Standard Weight Carts. – Field Standard Weight Carts that comply with the tolerances expressed in Appendix A, Fundamental Considerations, paragraph 3.2. Tolerances for Standards (i.e., one-third of the smallest tolerance applied) may be included as part of the minimum required test load (Also see Table 4. Minimum Test Weights and Test Loads.) for shift tests and other test procedures.

(Added 2004)

N.4. Coupled-in-Motion Railroad Weighing Systems.[2]

N.4.1. Weighing Systems Used to Weigh Trains of Less Than Ten Cars. – These weighing systems shall be tested using a consecutive-car test train consisting of the number of cars weighed in the normal operation run over the weighing system a minimum of five times in each mode of operation following the final calibration.
(Added 1990) (Amended 1992)

N.4.2. Weighing Systems Placed in Service Prior to January 1, 1991, and Used to Weigh Trains of Ten or More Cars. – The minimum test train shall be a consecutive-car test train of no less than ten cars run over the scale a minimum of five times in each mode of operation following final calibration.
(Added 1990) (Amended 1992)

N.4.3. Weighing Systems Placed in Service on or After January 1, 1991, and Used to Weigh Trains of Ten or More Cars.

(a) These weighing systems shall be tested using a consecutive-car test train of no less than ten cars run over the scale a minimum of five times in each mode of operation following final calibration; or

(b) if the official with statutory authority determines it necessary, the As-Used Test Procedures outlined in N.4.3.1. shall be used.
(Added 1990) (Amended 1992)

N.4.3.1. As-Used Test Procedures. – A weighing system shall be tested in a manner that represents the normal method of operation and length(s) of trains normally weighed. The weighing systems may be tested using either a:

(a) consecutive-car test train of a length typical of train(s) normally weighed; or

(b) distributed-car test train of a length typical of train(s) normally weighed.

However, a consecutive-car test train of a shorter length may be used, provided that initial verification test results for the shorter consecutive-car test train agree with the test results for the distributed-car or full-length consecutive-car test train as specified in N.4.3.1.1. Initial Verification.

The official with statutory authority shall be responsible for determining the minimum test train length to be used on subsequent tests.
(Added 1990) (Amended 1992)

N.4.3.1.1. Initial Verification. – Initial verification tests should be performed on any new weighing system and whenever either the track structure or the operating procedure changes. If a consecutive-car test train of length shorter than trains normally weighed is to be used for subsequent verification, the shorter consecutive-car test train results shall be compared either to a distributed-car or to a consecutive-car test train of length(s) typical of train(s) normally weighed.

The difference between the total train weight of the train(s) representing the normal method of operation and the weight of the shorter consecutive-car test train shall not exceed 0.15 %. If the difference in test results exceeds 0.15 %, the length of the shorter consecutive-car test train shall be increased until agreement within 0.15 % is achieved. Any adjustments to the weighing system based upon the use of a

[2] A test weight car that is representative of one of the types of cars typically weighed on the scale under test may be used wherever reference weight cars are specified.
(Added 1991)

shorter consecutive-car test train shall be offset to correct the bias that was observed between the full-length train test and the shorter consecutive-car test train.

(Added 1990) (Amended 1992 and 1993)

N.4.3.1.2. Subsequent Verification. – The test train may consist of either a consecutive-car test train with a length not less than that used in initial verification, or a distributed-car test train representing the number of cars used in the normal operation.

(Added 1990)

N.4.3.1.3. Distributed-Car Test Trains.

(a) The length of the train shall be typical of trains that are normally weighed.

(b) The reference weight cars shall be split into three groups, each group consisting of ten cars or 10 % of the train length, whichever is less.
(Amended 1991)

(c) The test groups shall be placed near the front, around the middle, and near the end of the train.

(d) Following the final adjustment, the distributed-car test train shall be run over the scale at least three times or shall produce 50 weight values, whichever is greater.

(e) The weighing system shall be tested in each mode of operation.

(Added 1990) (Amended 1992)

N.4.3.1.4. Consecutive-Car Test Trains.

(a) A consecutive-car test train shall consist of at least ten cars.

(b) If the consecutive-car test train consists of between ten and twenty cars, inclusive, it shall be run over the scale a minimum of five times in each mode of operation following the final calibration.

(c) If the consecutive-car test train consists of more than twenty cars, it shall be run over the scale a minimum of three times in each mode of operation.

(Added 1990) (Amended 1992)

N.5. Uncoupled-in-Motion Railroad Weighing System. – An uncoupled-in-motion scale shall be tested statically before being tested in motion by passing railroad reference weight cars over the scale. When an uncoupled-in-motion railroad weighing system is tested, the car speed and the direction of travel shall be the same as when the scale is in normal use. The minimum in-motion test shall be three reference weight cars passed over the scale three times. The cars shall be selected to cover the range of weights that are normally weighed on the system and to reflect the types of cars normally weighed.

(Added 1993)

N.6. Nominal Capacity of Prescription Scales. – The nominal capacity of a prescription scale shall be assumed to be one-half apothecary ounce, unless otherwise marked. (Applicable only to scales not marked with an accuracy class.)

N.7. Weigh-in-Motion Vehicle Scales Test Procedures.

N.7.1. Reference Scale. – A static scale as approved by the local jurisdiction shall be used to establish the weight of reference vehicles used in this procedure.

N.7.1.1. Dimension. – The reference scale shall be of such dimension and spacing as to weigh reference vehicles in a single draft.

N.7.1.2. Location. – The reference scale should be located near the weigh-in-motion vehicle scale to minimize the effect of vehicle fuel consumption. The reference scale and the weigh-in-motion vehicle scale may be the same scale.

N.7.1.3. Timing. – The reference scale shall be tested immediately prior to using it to establish reference vehicle weights. A subsequent test of the reference scale may be performed immediately following the establishment of the reference vehicle weights to ensure its repeatability.

N.7.1.4. Qualification. – The reference scale shall comply with the principles in Appendix A, Fundamental Considerations, Paragraph 3.2. Tolerances for Standards.

N.7.2. Reference Vehicle. – One or more reference vehicles shall be used to provide varying weight conditions for testing. Reference vehicles should be representative of vehicles that are customarily weighed on the weigh-in-motion vehicle scale during normal operation. A motorized field standard weight cart with tests weights and a driver may be used as an additional reference vehicle.

N.7.2.1. Weight Conditions. – Reference vehicle(s) shall be selected to provide at least a high and a low weight condition. Different types of vehicles may be used.

N.7.2.2. Load Position. – Loads on the reference vehicle should be positioned equally side-to-side.

N.7.2.3. Static Weight. – Reference vehicle(s) shall be statically weighed on a reference scale as defined in N.7.1 Reference Scale immediately before being used to conduct the weigh-in-motion vehicle scale tests.

N.7.2.3.1. Rounding. – Error weights may be added to the reference vehicle to increase its weight to a whole scale division to minimize rounding errors.

N.7.2.3.2. Re-Weighing. – Reference vehicles may be re-weighed at the discretion of the testing authority.

N.7.3. Test Speeds. – The speed of the reference vehicle shall be maintained within the parameters as specified by the manufacturer during each test (see also paragraphs S.1.14.1.(a) Identification of a Fault, Vehicle Speed and S.1.14.1.(b) Identification of a Fault, Change in Vehicle Speed)**.**

N.7.3.1. Range. – Various speeds of the reference vehicle shall be used between the minimum and maximum operating speeds specified for the weigh-in-motion vehicle scale. The minimum speed capability of the reference vehicle may be used as the minimum speed.

N.7.4. Static Tests for Weigh-in-Motion Vehicle Scales. – The weigh-in-motion vehicle scale shall comply with applicable vehicle scale tests defined in N.1. Test Procedures when tested statically.

N.7.5. Dynamic Tests for Weigh-in-Motion Vehicle Scales. – Test procedures shall simulate the normal intended use as closely as possible (i.e., test as used).

N.7.5.1. Vehicles. – The tests shall be performed using the reference vehicle(s) defined in N.7.2. Reference Vehicle.

N.7.5.2. Weighments. – Each reference vehicle shall have a minimum of five weighments at the speeds defined in N.7.3. Test Speeds.

N.7.5.3. Vehicle Position. – Reference vehicle(s) must stay within the defined roadway along the load-receiving element (see also S.1.14.1.(e) Identification of a Fault, Vehicle Path of Travel).

N.7.5.4. Travel Directions. – The tests shall be performed in both directions of travel unless travel direction is restricted by the marking.

N.7.5.5. Results. – At the conclusion of the weigh-in-motion tests, there shall be a minimum of 10 total weight readings for the reference vehicle(s) for each applicable direction of travel. The tolerance for each weight reading shall be based on the gross vehicle weight and the applicable tolerance values for Class III L.

(Added 2021)

T. Tolerances Applicable to Devices not Marked I, II, III, III L, or IIII

T.1. Tolerance Values.

T.1.1. General. – The tolerances applicable to devices not marked with an accuracy class shall have the tolerances applied as specified in Table T.1.1. Tolerances for Unmarked Scales.

(Amended 1990)

T.1.2. Postal and Parcel Post Scales. – The tolerances for postal and parcel post scales are given in Table T.1.1. Tolerances for Unmarked Scales and Table 5. Maintenance and Acceptance Tolerances for Unmarked Postal and Parcel Post Scales.

(Amended 1990)

Table T.1.1. Tolerances for Unmarked Scales

Type of Device	Subcategory	Minimum Tolerance	Acceptance Tolerance	Maintenance Tolerance	Decreasing-Load Multiplier[1]	Other Applicable Requirements
Vehicle, axle-load, livestock, railway track (weighing statically), crane, and hopper (other than grain hopper)		Class III L, T.N.3.1 (Table 6) and T.N.3.2.			1.0	T.N.2., T.N.3., T.N.4.1., T.N.4.2., T.N.4.3., T.N.4.4., T.N.5., T.N.7.2., *T.N.8.1.4.*[4], T.N.9.
Grain test scales	n ≤ 10 000 n > 10 000	Class III, T.N.3.1. (Table 6) and T.N.3.2. Class II, T.N.3.1. (Table 6) and T.N.3.2.			1.0	*T.N.8.1.4.*[4], T.N.9.
Railway track scales weighing in motion		T.N.3.6. except that for T.N.3.6.2. (a), no single error shall exceed four times the maintenance tolerance.			1.0	*T.N.8.1.4.*[4], T.N.9.
Monorail scales, in-motion		T.N.3.8.			1.0	*T.N.8.1.4.*[4], T.N.9.
Customer-operated bulk-weighing systems for recycled materials		± 5 % of applied material test load. Average error on 10 or more test loads ≤ 2.5 %.			1.0	*T.N.8.1.4.*[4], T.N.9.
Wheel-load weighers and portable axle-load scales	Tested individually or in pairs[2]	0.5 d or 50 lb, whichever is greater	1 % of test load	2 % of test load	1.5[3]	*T.N.8.1.4.*[4], T.N.9.
Prescription scales		0.1 grain (6 mg)	0.1 % of test load	0.1 % of test load	1.5	*T.N.8.1.4.*[4], T.N.9.
Jewelers' scales	Graduated	0.5 d	0.05 % of test load	0.05 % of test load	1.5	*T.N.8.1.4.*[4], T.N.9.
	Ungraduated	Sensitivity or smallest weight, whichever is less				
Dairy-product test scale	Loads < 18 g 18 g load	0.2 grain 0.2 grain	0.2 grain 0.3 grain	0.2 grain 0.5 grain	1.5	*T.N.8.1.4.*[4], T.N.9.
Postal and parcel post scales designed/used to weigh loads < 2 lb	Loads < 2 lb	15 grain, 1 g, $^{1}/_{32}$ oz, 0.03 oz, or 0.002 lb	15 grain, 1 g, $^{1}/_{32}$ oz, 0.03 oz, or 0.002 lb	15 grain, 1 g, $^{1}/_{32}$ oz, 0.03 oz, or 0.002 lb	1.5	*T.N.8.1.4.*[4], T.N.9.
	Loads ≤ 2 lb	Table 5	Table 5	Table 5		
Other postal and parcel post scales		Table 5	Table 5	Table 5	1.5	*T.N.8.1.4.*[4], T.N.9.
All other scales (including grain hopper)	n > 5000	0.5 d or 0.05 % of scale capacity, whichever is less	0.05 % of test load	0.1 % of test load	1.5	T.N.2.5., T.N.4.1., T.N.4.2., T.N.4.3., T.N.5., T.N.7.2., *T.N.8.1.4.*[4], T.N.9.
	n ≤ 5000	Class III, T.N.3.1., Table 6 and T.N.3.2.			1.0	T.N.2., T.N.3., T.N.4.1., T.N.4.2., T.N.4.3., T.N.5., T.N.7.2., *T.N.8.1.4.*[4], T.N.9.

[1] The decreasing load test applies only to automatic indicating scales.
[2] If marked and tested as a pair, the tolerance shall be applied to the sum of the indication.
[3] The decreasing load test does not apply to portable wheel load weighers.
[4] *T.N.8.1.4. Operating Temperature. is nonretroactive and effective for unmarked devices manufactured as of January 1, 1981.*

(Table Added 1990) (Amended 1992, 1993, and 2012)

Table 5.
Maintenance and Acceptance Tolerances for Unmarked Postal and Parcel Post Scales

Scale Capacity (lb)	Test Loads (lb)	Maintenance Tolerance (±) (oz)	Maintenance Tolerance (±) (lb)	Acceptance Tolerance (±) (oz)	Acceptance Tolerance (±) (lb)
0 to 4*	0 to 1	1/32	0.002	1/32	0.002
	> 1	1/8	0.008	1/16	0.004
> 4*	0 to 7	3/16	0.012	3/16	0.012
	> 7 to 24	3/8	0.024	3/16	0.012
	> 24 to 30	1/2	0.030	1/4	0.015
	> 30	0.1 % of Test Load		0.05 % of Test Load	

*Also see Table T.1.1. Tolerances for Unmarked Scales for scales designed and/or used to weigh loads less than 2 lb.

T.2. Sensitivity Requirement (SR).

T.2.1. Application. – The sensitivity requirement (SR) is applicable to all nonautomatic-indicating scales not marked I, II, III, III L, or IIII, and is the same whether acceptance or maintenance tolerances apply.

T.2.2. General. – Except for scales specified in paragraphs T.2.3. Prescription Scales through T.2.8. Railway Track Scales: 2 d, 0.2 % of the scale capacity, or 40 lb, whichever is least.

T.2.3. Prescription Scales. 6 mg (0.1 grain).

T.2.4. Jewelers' Scales.

T.2.4.1. With One-Half Ounce Capacity or Less. – 6 mg (0.1 grain).

T.2.4.2. With More Than One-Half Ounce Capacity. – 1 d or 0.05 % of the scale capacity, whichever is less.

T.2.5. Dairy-Product Test Scales.

T.2.5.1. Used in Determining Butterfat Content. – 32 mg (0.5 grain).

T.2.5.2. Used in Determining Moisture Content. – 19 mg (0.3 grain).

T.2.6. Grain Test Scales. – The sensitivity shall be as stated in T.N.6. Sensitivity.
(Amended 1987)

T.2.7. Vehicle, Axle-Load, Livestock, and Animal Scales.

T.2.7.1. Equipped With Balance Indicators. – 1 d.

T.2.7.2. Not Equipped With Balance Indicators. – 2 d or 0.2 % of the scale capacity, whichever is less.

T.2.8. Railway Track Scales. – 3 d or 100 lb, whichever is less.

T.3. Sensitivity Requirement, Equilibrium Change Required. – The minimum change in equilibrium with test loads equal to the values specified in T.2. Sensitivity Requirements (SR) shall be as follows:

(a) **Scale with a Trig Loop but without a Balance Indicator.** – The position of rest of the weighbeam shall change from the center of the trig loop to the top or bottom, as the case may be.

(b) **Scale with a Single Balance Indicator and Having a Nominal Capacity of Less Than 250 kg (500 lb).** – The position of rest of the indicator shall change 1.0 mm (0.04 in) or one division on the graduated scale, whichever is greater.

(c) **Scale with a Single Balance Indicator and Having a Nominal Capacity of 250 kg (500 lb) or Greater.** – The position of rest of the indicator shall change 6.4 mm (0.25 in) or one division on the graduated scale or the width of the central target area, whichever is greater. However, the indicator on a batching scale shall change 3.2 mm (0.125 in) or one division on the graduated scale, whichever is greater.

(d) **Scale with Two Opposite-Moving Balance Indicators.** – The position of rest of the two indicators moving in opposite directions shall change 1.0 mm (0.04 in) with respect to each other.

(e) **Scale with Neither a Trig Loop nor a Balance Indicator.** – The position of rest of the weighbeam or lever system shall change from the horizontal, or midway between limiting stops, to either limit of motion.

T.N. Tolerances Applicable to Devices Marked I, II, III, III L, and IIII.

T.N.1. Principles.

T.N.1.1. Design. – The tolerance for a weighing device is a performance requirement independent of the design principle used.

T.N.1.2. Accuracy Classes. – Weighing devices are divided into accuracy classes according to the number of scale divisions (n) and the value of the scale division (d).

T.N.1.3. Scale Division. – The tolerance for a weighing device is related to the value of the scale division (d) or the value of the verification scale division (e) and is generally expressed in terms of d or e.

T.N.2. Tolerance Application.

T.N.2.1. General. – The tolerance values are positive (+) and negative (−) with the weighing device adjusted to zero at no load. When tare is in use, the tolerance values are applied from the tare zero reference (zero net weight indication); the tolerance values apply to the net weight indication for any possible tare load using certified test loads.

(Amended 2008)

T.N.2.2. Type Evaluation Examinations. – For type evaluation examinations, the tolerance values apply to increasing and decreasing load tests within the temperature, power supply, and barometric pressure limits specified in T.N.8.

T.N.2.3. Subsequent Verification Examinations. – For subsequent verification examinations, the tolerance values apply regardless of the influence factors in effect at the time of the conduct of the examination. (Also see G-N.2. Testing with Nonassociated Equipment.)

T.N.2.4. Multi-Interval and Multiple Range (Variable Division-Value) Scales. – For multi-interval and multiple range scales, the tolerance values are based on the value of the scale division of the range in use.

T.N.2.5. Ratio Tests. – For ratio tests, the tolerance values are 0.75 of the applicable tolerances.

T.N.3. Tolerance Values.

T.N.3.1. Maintenance Tolerance Values. – The maintenance tolerance values are as specified in Table 6. Maintenance Tolerances.

T.N.3.2. Acceptance Tolerance Values. – The acceptance tolerance values shall be one-half the maintenance tolerance values.

T.N.3.3. Wheel-Load Weighers and Portable Axle-Load Weighers of Class IIII. – The tolerance values are two times the values specified in T.N.3.1. Maintenance Tolerance Values and T.N.3.2. Acceptance Tolerance Values.

(Amended 1986)

T.N.3.4. Crane and Hopper (Other than Grain Hopper) Scales. – The maintenance and acceptance tolerances shall be as specified in T.N.3.1. Maintenance Tolerance Values and T.N.3.2. Acceptance Tolerance Values for Class III L, except that the tolerance for crane and construction materials hopper scales shall not be less than 1 d or 0.1 % of the scale capacity, whichever is less.

(Amended 1986)

Table 6.
Maintenance Tolerances
(All values in this table are in scale divisions)

	Tolerance in Scale Divisions			
	1	**2**	**3**	**5**
Class	**Test Load**			
I	0 - 50 000	50 001 - 200 000	200 001 +	
II	0 - 5 000	5 001 - 20 000	20 001 +	
III	0 - 500	501 - 2 000	2 001 - 4 000	4 001 +
IIII	0 - 50	51 - 200	201 - 400	401 +
III L	0 - 500	501 - 1 000	(Add 1 d for each additional 500 d or fraction thereof)	

T.N.3.5. Separate Main Elements: Load Transmitting Element, Indicating Element, Etc. – If a main element separate from a complete weighing device is submitted for laboratory type evaluation, the tolerance for the main element is 0.7 that for the complete weighing device. This fraction includes the tolerance attributable to the testing devices used.

(Amended 2015)

T.N.3.6. Coupled-In-Motion Railroad Weighing Systems. – The maintenance and acceptance tolerance values for the group of weight values appropriate to the application must satisfy the following conditions:

(Amended 1990 and 1992)

T.N.3.6.1. – For any group of weight values, the difference in the sum of the individual in-motion car weights of the group as compared to the sum of the individual static weights shall not exceed 0.2 %.

(Amended 1990)

T.N.3.6.2. – If a weighing system is used to weigh trains of five or more cars, and if the individual car weights are used, any single weight value within the group must meet the following criteria:

(a) no single error may exceed three times the static maintenance tolerance;

(b) not more than 5 % of the errors may exceed two times the static maintenance tolerance; and

(c) not more than 35 % of the errors may exceed the static maintenance tolerance.

(Amended 1990 and 1992)

T.N.3.6.3. – For any group of weight values wherein the sole purpose is to determine the sum of the group, T.N.3.6.1. alone applies.

(Amended 1990)

T.N.3.6.4. – For a weighing system used to weigh trains of less than five cars, no single car weight within the group may exceed the static maintenance tolerance.

(Amended 1990 and 1992)

T.N.3.7. Uncoupled-in-Motion Railroad Weighing Systems. – The maintenance and acceptance tolerance values for any single weighment within a group of non-interactive (i.e., uncoupled) loads, the weighment error shall not exceed the static maintenance tolerance.

(Amended 1992)

T.N.3.8. Dynamic Monorail Weighing System. – Acceptance tolerance shall be the same as the maintenance tolerance shown in Table 6. Maintenance Tolerances. On a dynamic test of twenty or more individual test loads, 10 % of the individual test loads may be in error, each not to exceed two times the tolerance. The error on the total of the individual test loads shall not exceed ± 0.2 %. (Also see Note in N.1.3.5.1. Dynamic Monorail Weighing Systems.) *For equipment undergoing type evaluation, a tolerance equal to one-half the maintenance tolerance values shown in Table 6. Maintenance Tolerances shall apply.*
[Nonretroactive January 1, 2002]

(Added 1986) (Amended 1999 and 2001)

T.N.3.9. Materials Test on Customer-Operated Bulk Weighing Systems for Recycled Materials. – The maintenance and acceptance tolerance shall be ± 5 % of the applied materials test load except that the average error on ten or more test materials test loads shall not exceed ± 2.5 %.

(Added 1986)

T.N.3.10. Prescription Scales with a Counting Feature. – In addition to Table 6. Maintenance Tolerances (for weight), the indicated piece count value computed by a Class I or Class II prescription scale counting feature shall comply with the tolerances in Table T.N.3.10. Maintenance and Acceptance Tolerances in Excess and in Deficiency for Count.

Table T.N.3.10.
Maintenance and Acceptance Tolerances in Excess and in Deficiency for Count

Indication of Count	Tolerance (piece count)
0 to 100	0
101 to 200	1
201 or more	0.5 %

(Added 2003)

T.N.3.11. Tolerances for Substitution Test. – Tolerances are applied to the scale based on the substitution test load.

(Added 2003)

T.N.3.12. Tolerances for Strain-Load Test. – Tolerances apply only to the test weights or substitution test loads.

(Added 2003)

T.N.4. Agreement of Indications.

T.N.4.1. Multiple Indicating/Recording Elements. – In the case of a scale or weighing system equipped with more than one indicating element or indicating element and recording element combination, where the indicators or indicator/recorder combination are intended to be used independently of one another, tolerances shall be applied independently to each indicator or indicator/recorder combination.

(Amended 1986)

T.N.4.2. Single Indicating/Recording Element. – In the case of a scale or weighing system with a single indicating element or an indicating/recording element combination, and equipped with component parts such as unit weights, weighbeam and weights, or multiple weighbeams that can be used in combination to indicate a weight, the difference in the weight value indications of any load shall not be greater than the absolute value of the applicable tolerance for that load, and shall be within tolerance limits.

(Amended 1986)

T.N.4.3. Single Indicating Element/Multiple Indications. – In the case of an analog indicating element equipped with two or more indicating means within the same element, the difference in the weight indications for any load other than zero shall not be greater than one-half the value of the scale division (d) and be within tolerance limits.

(Amended 1986)

T.N.4.4. Shift or Section Tests. – The range of the results obtained during the conduct of a shift test or a section test shall not exceed the absolute value of the maintenance tolerance applicable and each test result shall be within applicable tolerances.

(Added 1986)

T.N.4.5. Time Dependence. – A time dependence test shall be conducted during type evaluation and may be conducted during field verification, provided test conditions remain constant.

(Amended 1989 and 2005)

T.N.4.5.1. Time Dependence: Class II, III, and IIII Non-Automatic Weighing Instruments. – A non-automatic weighing instrument of Classes II, III, and IIII shall meet the following requirements at constant test conditions. During type evaluation, this test shall be conducted at 20 °C ± 2 °C (68 °F ± 4 °F):

(a) When any load is kept on an instrument, the difference between the indication obtained immediately after placing the load and the indication observed during the following 30 minutes shall not exceed 0.5 e. However, the difference between the indication obtained at 15 minutes and the indication obtained at 30 minutes shall not exceed 0.2 e.

(b) If the conditions in (a) are not met, the difference between the indication obtained immediately after placing the load on the instrument and the indication observed during the following four hours shall not exceed the absolute value of the maximum permissible error at the load applied.

(Added 2005) (Amended 2006 and 2010)

T.N.4.5.2. Time Dependence: Class III L Non-Automatic Weighing Instruments. – A non-automatic weighing instrument of Class III L shall meet the following requirements:

(a) When any load is kept on an instrument, the difference between the indication obtained immediately after placing the load and the indication observed during the following 30 minutes shall not exceed 1.5 e. However, the difference between the indication obtained at 15 minutes and the indication obtained at 30 minutes shall not exceed 0.6 e.

(b) If the conditions in (a) are not met, the difference between the indication obtained immediately after placing the load on the instrument and the indication observed during the following four hours shall not exceed the absolute value of the maximum permissible error at the load applied.

(Added 2005) (Amended 2010)

T.N.4.5.3. Zero Load Return: Non-automatic Weighing Instruments. – A non-automatic weighing instrument shall meet the following requirements at constant test conditions. During type evaluation, this test shall be conducted at 20 °C ± 2 °C (68 °F ± 4 °F). The deviation on returning to zero as soon as the indication has stabilized, after the removal of any load which has remained on the instrument for 30 minutes shall not exceed:

(a) 0.5 e for Class II and IIII devices,

(b) 0.5 e for Class III devices with 4000 or fewer divisions,

(c) 0.83 e for Class III devices with more than 4000 divisions, or

(d) one-half of the absolute value of the applicable tolerance for the applied load for Class III L devices.

For a multi-interval instrument, the deviation shall not exceed 0.83 e_1 (where e_1 is the interval of the first weighing segment of the scale).

On a multiple range instrument, the deviation on returning to zero from Max_i (load in the applicable weighing range) shall not exceed 0.83 e_i (interval of the weighing range). Furthermore, after returning to zero from any load greater than Max_1 (capacity of the first weighing range) and immediately after switching to the lowest weighing range, the indication near zero shall not vary by more than e_1 (interval of the first weighing range) during the following five minutes.

(Added 2010)

T.N.4.6. Time Dependence (Creep) for Load Cells during Type Evaluation. – A load cell (force transducer) marked with an accuracy class shall meet the following requirements at constant test conditions:

(a) Permissible Variations of Readings. – With a constant maximum load for the measuring range (D_{max}) between 90 % and 100 % of maximum capacity (E_{max}), applied to the load cell, the difference between the initial reading and any reading obtained during the next 30 minutes shall not exceed the absolute value of the maximum permissible error (mpe) for the applied load. (Also see Table T.N.4.6. Maximum Permissible Error (mpe) for Load Cells During Type Evaluation.) The difference between the reading obtained at 20 minutes and the reading obtained at 30 minutes shall not exceed 0.15 times the absolute value of the mpe. (Also see Table T.N.4.6. Maximum Permissible Error (mpe) for Load Cells During Type Evaluation)

(b) Apportionment Factors. – The mpe for creep shall be determined from Table T.N.4.6. Maximum Permissible Error (mpe) for Load Cells During Type Evaluation using the following apportionment factors (p_{LC}):

p_{LC} = 0.7 for load cells marked with S (single load cell applications),
p_{LC} = 1.0 for load cells marked with M (multiple load cell applications), and
p_{LC} = 0.5 for Class III L load cells marked with S or M.

(Added 2005, Amended 2006)

Table T.N.4.6.
Maximum Permissible Error (mpe)* for Load Cells During Type Evaluation

mpe in Load Cell Verifications Divisions (v) = p_{LC} × Basic Tolerance in v			
Class	**p_{LC} × 0.5 v**	**p_{LC} × 1.0 v**	**p_{LC} × 1.5 v**
I	0 - 50 000 v	50 001 v - 200 000 v	200 001 v +
II	0 - 5 000 v	5 001 v - 20 000 v	20 001 v +
III	0 - 500 v	501 v - 2 000 v	2 001 v +
IIII	0 - 50 v	51 v - 200 v	201 v +
III L	0 - 500 v	501 v - 1 000 v	(Add 0.5 v to the basic tolerance for each additional 500 v or fraction thereof up to a maximum load of 10 000 v)

v represents the load cell verification interval
p_{LC} represents the apportionment factors applied to the basic tolerance
p_{LC} = 0.7 for load cells marked with S (single load cell applications)
p_{LC} = 1.0 for load cells marked with M (multiple load cell applications)
p_{LC} = 0.5 for Class III L load cells marked with S or M
* mpe = p_{LC} × Basic Tolerance in load cell verifications divisions (v)

(Table Added 2005) (Amended 2006)

T.N.4.7. Creep Recovery for Load Cells During Type Evaluation. – The difference between the initial reading of the minimum load of the measuring range (D_{min}) and the reading after returning to minimum load subsequent to the maximum load (D_{max}) having been applied for 30 minutes shall not exceed:

(a) 0.5 times the value of the load cell verification interval (0.5 v) for Class II and IIII load cells;

(b) 0.5 times the value of the load cell verification interval (0.5 v) for Class III load cells with 4000 or fewer divisions;

(c) 0.83 times the value of the load cell verification interval (0.83 v) for Class III load cells with more than 4000 divisions; or

(d) 2.5 times the value of the load cell verification interval (2.5 v) for Class III L load cells.

(Added 2006) (Amended 2009 and 2011)

T.N.5. Repeatability. – The results obtained from several weighings of the same load under reasonably static test conditions shall agree within the absolute value of the maintenance tolerance for that load, and shall be within applicable tolerances.

T.N.6. Sensitivity. – This section is applicable to all nonautomatic-indicating scales marked I, II, III, III L, or IIII.

T.N.6.1. Test Load.

(a) The test load for sensitivity for nonautomatic-indicating vehicle, axle-load, livestock, and animal scales shall be 1 d for scales equipped with balance indicator, and 2 d or 0.2 % of the scale capacity, whichever is less, for scales not equipped with balance indicators.

(b) For all other nonautomatic-indicating scales, the test load for sensitivity shall be 1 d at zero and 2 d at maximum test load.

T.N.6.2. Minimum Change of Indications. – The addition or removal of the test load for sensitivity shall cause a minimum permanent change as follows:

(a) for a scale with trig loop but without a balance indicator, the position of the weighbeam shall change from the center to the outer limit of the trig loop;

(b) for a scale with balance indicator, the position of the indicator shall change one division on the graduated scale, the width of the central target area, or the applicable value as shown below, whichever is greater:

Scale of Class I or II: 1 mm (0.04 in),

Scale of Class III or IIII with a maximum capacity of 30 kg (70 lb) or less: 2 mm (0.08 in),

Scale of Class III, III L, or IIII with a maximum capacity of more than 30 kg (70 lb): 5 mm (0.20 in);

(c) for a scale without a trig loop or balance indicator, the position of rest of the weighbeam or lever system shall change from the horizontal or midway between limiting stops to either limit of motion.

(Amended 1987)

T.N.7. Discrimination.

T.N.7.1. Analog Automatic Indicating (i.e., Weighing Device with Dial, Drum, Fan, etc.). – A test load equivalent to 1.4 d shall cause a change in the indication of at least 1.0 d. (Also see N.1.5. Discrimination Test.)

T.N.7.2. Digital Automatic Indicating. – A test load equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 2.0 d. This requires the zone of uncertainty to be not greater than three-tenths of the value of the scale division. (Also see N.1.5.1. Digital Device.)

T.N.8. Influence Factors. – The following factors are applicable to tests conducted under controlled conditions only, provided that:

(a) types of devices approved prior to January 1, 1986, and manufactured prior to January 1, 1988, need not meet the requirements of this section;

(b) new types of devices submitted for approval after January 1, 1986, shall comply with the requirements of this section; and

(c) all devices manufactured after January 1, 1988, shall comply with the requirements of this section.

(Amended 1985)

T.N.8.1. Temperature. – Devices shall satisfy the tolerance requirements under the following temperature conditions:

T.N.8.1.1. If not specified in the operating instructions for Class I or II scales, or if not marked on the device for Class III, III L, or IIII scales, the temperature limits shall be: − 10 °C to 40 °C (14 °F to 104 °F).

T.N.8.1.2. If temperature limits are specified for the device, the range shall be at least that specified in Table T.N.8.1.2. Temperature Range by Class.

Table T.N.8.1.2. Temperature Range by Class	
Class	**Temperature Range**
I	5 °C (9 °F)
II	15 °C (27 °F)
III, III L, and IIII	30 °C (54 °F)

T.N.8.1.3. Temperature Effect on Zero-Load Balance. – The zero-load indication shall not vary by more than:

(a) three divisions per 5 °C (9 °F) change in temperature for Class III L devices; or

(b) one division per 5 °C (9 °F) change in temperature for all other devices.

(Amended 1990)

T.N.8.1.4. Operating Temperature. – Except for Class I and II devices, an indicating or recording element shall not display nor record any usable values until the operating temperature necessary for accurate weighing and a stable zero balance condition have been attained.

T.N.8.2. Barometric Pressure. – Except for Class I scales, the zero indication shall not vary by more than one scale division for a change in barometric pressure of 1 kPa over the total barometric pressure range of 95 kPa to 105 kPa (28 in to 31 in of Hg).

T.N.8.3. Electric Power Supply.

T.N.8.3.1. Power Supply, Voltage and Frequency.

(a) Weighing devices that operate using alternating current must perform within the conditions defined in paragraphs T.N.3. Tolerance Values through T.N.7. Discrimination, inclusive, when tested over the range of − 15 % to + 10 % of the marked nominal line voltage(s) at 60 Hz, or the voltage range marked by the manufacturer, at 60 Hz.

(Amended 2003)

(b) Battery operated instruments shall not indicate nor record values outside the applicable tolerance limits when battery power output is excessive or deficient.

T.N.8.3.2. Power Interruption. – A power interruption shall not cause an indicating or recording element to display or record any values outside the applicable tolerance limits.

T.N.9. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility. – The difference between the weight indication due to the disturbance and the weight indication without the disturbance shall not exceed one scale division (d); or the equipment shall:

(a) blank the indication; or

(b) provide an error message; or

(c) the indication shall be so completely unstable that it cannot be interpreted, or transmitted into memory or to a recording element, as a correct measurement value.

The tolerance in T.N.9. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility is to be applied independently of other tolerances. For example, if indications are at allowable basic tolerance error limits when the disturbance occurs, then it is acceptable for the indication to exceed the applicable basic tolerances during the disturbance.

(Amended 1997)

UR. User Requirements

UR.1. Selection Requirements. – 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 capacity, number of scale divisions, value of the scale division or verification scale division, minimum capacity, and computing capability.[3]

UR.1.1. General.

(a) For devices marked with a class designation, the typical class or type of device for particular weighing applications is shown in Table 7a. Typical Class or Type of Device for Weighing Applications.

(b) For devices not marked with a class designation, Table 7b. Applicable to Devices not Marked with a Class Designation applies.

Table 7a.
Typical Class or Type of Device for Weighing Applications

Class	Weighing Application or Scale Type
I	Precision laboratory weighing
II	Laboratory weighing, precious metals and gem weighing, grain test scales
III	All commercial weighing not otherwise specified, grain test scales, retail precious metals and semi-precious gem weighing, grain-hopper scales, animal scales, postal scales, vehicle on-board weighing systems with a capacity less than or equal to 30 000 lb, and scales used to determine laundry charges
III L	Vehicle scales (including weigh-in-motion vehicle scales), vehicle on-board weighing systems with a capacity greater than 30 000 lb, axle-load scales, livestock scales, railway track scales, crane scales, and hopper (other than grain hopper) scales
IIII	Wheel-load weighers and portable axle-load weighers used for highway weight enforcement
Note: A scale with a higher accuracy class than that specified as "typical" may be used.	

(Amended 1985, 1986, 1987, 1988, 1992, 1995, 2012, and 2021)

[3] Purchasers and users of scales such as railway track, hopper, and vehicle scales should be aware of possible additional requirements for the design and installation of such devices.

(Footnote Added 1995)

Table 7b. Applicable to Devices Not Marked with a Class Designation	
Scale Type or Design	**Maximum Value of d**
Retail Food Scales, 50 lb capacity and less	1 oz
Animal Scales	1 lb
Grain Hopper Scales Capacity up to and including 50 000 lb Capacity over 50 000 lb	 10 lb (not greater than 0.05 % of capacity) 20 lb
Crane Scales	not greater than 0.2 % of capacity
Vehicle and Axle-Load Scales Used in Combination Capacity up to and including 200 000 lb Capacity over 200 000 lb	 20 lb 50 lb
Railway Track Scales With weighbeam Automatic indicating	 20 lb 100 lb
Scales with capacities greater than 500 lb except otherwise specified	0.1 % capacity (but not greater than 50 lb)
Wheel-Load Weighers	0.25 % capacity (but not greater than 50 lb)
Note: For scales not specified in this table, G-UR.1.1. and UR.1. apply.	

(Added 1985) (Amended 1989)

UR.1.2. Grain Hopper Scales. – Hopper scales manufactured as of January 1, 1986, that are used to weigh grain shall be Class III and have a minimum of 2000 scale divisions.
(Amended 2012)

UR.1.3. Value of the Indicated and Recorded Scale Division. *– The value of the scale division as recorded shall be the same as the division value indicated.*
[Nonretroactive as of January 1, 1986]
(Added 1985) (Amended 1999)

UR.1.3.1. Exceptions. – The provisions of UR.1.3. Value of the Indicated and Recorded Scale Division shall not apply to:

(a) Class I scales, or

(b) Dynamic monorail weighing systems when the value of d is less than the value of e.

(Added 1999)

UR.1.4. Grain-Test Scales: Value of the Scale Divisions. – The scale division for grain-test scales shall not exceed 0.2 g for loads through 500 g, and shall not exceed 1 g for loads above 500 g through 1000 g.
(Added 1992)

UR.1.5. Recording Element, Class III L Railway Track Scales. *– Class III L Railway Track Scales must be equipped with a recording element.*
[Nonretroactive as of January 1, 1996]
(Added 1995)

UR.2. Installation Requirements.

UR.2.1. Supports. – A scale that is portable and that is being used on a counter, table, or the floor shall be so positioned that it is firmly and securely supported.

UR.2.2. Suspension of Hanging Scale. – A hanging scale shall be freely suspended from a fixed support when in use.

UR.2.3. Protection From Environmental Factors. – The indicating elements, the lever system or load cells, and the load-receiving element of a permanently installed scale, and the indicating elements of a scale not intended to be permanently installed, shall be adequately protected from environmental factors such as wind, weather, and RFI that may adversely affect the operation or performance of the device.

UR.2.4. Foundation, Supports, and Clearance. – The foundation and supports of any scale installed in a fixed location shall be such as to provide strength, rigidity, and permanence of all components, and clearance shall be provided around all live parts to the extent that no contacts may result when the load-receiving element is empty, nor throughout the weighing range of the scale. An in-motion railway track scale is not required to provide clearance using rail gaps to separate the live rail portion of the weighing/load-receiving element from that which is not live if the scale is designed to be installed and operated using continuous rail. *On vehicle and livestock scales, the clearance between the load-receiving elements and the coping at the bottom edge of the platform shall be greater than at the top edge of the platform.**
*[*Nonretroactive as of January 1, 1973]*

(Amended 2014)

UR.2.5. Access to Weighing Elements. – Adequate provision shall be made for ready access to the pit of a vehicle, livestock, animal, axle-load, or railway track scale for the purpose of inspection and maintenance. Any of these scales without a pit shall be installed with adequate means for inspection and maintenance of the weighing elements.

(Amended 1985)

UR.2.6. Approaches.

UR.2.6.1. Vehicle Scales. *– On the entrance and exit end(s) of a vehicle scale there shall be a straight approach as follows:*

(a) the width at least the width of the platform,

(b) the length at least one-half the length of the platform but not required to be more than 12 m (40 ft), and

(c) not less than 3 m (10 ft) of any approach adjacent to the platform shall be in the same plane as the platform. Any slope in the remaining portion of the approach shall ensure (1) ease of vehicle access, (2) ease for testing purposes, and (3) drainage away from the scale.

In addition to (a), (b), and (c), scales installed in any one location for a period of six months or more shall have not less than 3 m (10 ft) of any approach adjacent to the platform constructed of concrete or similar durable material to ensure that this portion remains smooth and level and in the same plane as the platform; however, grating of sufficient strength to withstand all loads equal to the concentrated load capacity of the scale may be installed in this portion.
[Nonretroactive as of January 1, 1976]

(Amended 1977, 1983, 1993, 2006, and 2010)

UR.2.6.2. Axle-Load Scales. – At each end of an axle-load scale there shall be a straight paved approach in the same plane as the platform. The approaches shall be the same width as the platform and of sufficient length to insure the level positioning of vehicles during weight determinations.

UR.2.7. Stock Racks. – A livestock or animal scale shall be equipped with a suitable stock rack, with gates as required, which shall be securely mounted on the scale platform. Adequate clearances shall be maintained around the outside of the rack.

UR.2.8. Hoists. – On vehicle scales equipped with means for raising the load-receiving element from the weighing element for vehicle unloading, means shall be provided so that it is readily apparent to the scale operator when the load-receiving element is in its designed weighing position.

UR.2.9. Provision for Testing Dynamic Monorail Weighing Systems. *– Provisions shall be made at the time of installation of a dynamic monorail weighing systems for testing in accordance with N.1.3.5.1. Dynamic Monorail Weighing Systems (a rail around or other means for returning the test carcasses to the scale being tested).*
[Nonretroactive as of January 1, 1998]
(Added 1997) (Amended 1999)

UR.2.10. Primary Indicating Elements Provided by the User. *– Video display terminals and other user-provided indicating elements on scales interfaced with a cash register in a point-of-sale (POS) system shall comply with the minimum height requirements specified in part (c) of paragraph S.1.1.1. Digital Indicating Elements.*
[Nonretroactive as of January 1, 2021]
(Added 2019)

UR.3. Use Requirements.

UR.3.1. Recommended Minimum Load. – A recommended minimum load is specified in Table 8 since the use of a device to weigh light loads is likely to result in relatively large errors.

Table 8.
Recommended Minimum Load

Class	Value of Scale Division (d or e*)	Recommended Minimum Load (d or e*)
I	equal to or greater than 0.001 g	100
II	0.001 g to 0.05 g, inclusive	20
	equal to or greater than 0.1 g	50
III	All**	20
III L	All	50
IIII	All	10

*For Class I and II devices equipped with auxiliary reading means (i.e., a rider, a vernier, or a least significant decimal differentiated by size, shape or color), the value of the verification scale division "e" is the value of the scale division immediately preceding the auxiliary means. For Class III and IIII devices the value of "e" is specified by the manufacturer as marked on the device; "e" must be less than or equal to "d."

**A minimum load of 10 d is recommended for a weight classifier marked in accordance with a statement identifying its use for special applications.

(Amended 1990)

UR.3.1.1. Minimum Load, Grain Dockage Determination. – When determining the quantity of foreign material (dockage) in grain, the weight of the sample shall be equal to or greater than 500 scale divisions.
(Added 1985)

UR.3.2. Maximum Load. – A scale shall not be used to weigh a load of more than the nominal capacity of the scale.

UR.3.2.1. Maximum Loading for Vehicle Scales. – A vehicle scale shall not be used to weigh loads exceeding the maximum load capacity of its span as specified in Table UR.3.2.1. Span Maximum Load.

(Added 1996)

Table UR.3.2.1.
Span Maximum Load

Distance in Feet Between the Extremes of any Two or More Consecutive Axles	Ratio of CLC to Maximum Load ("r" factor) Carried on Any Group of Two or More Consecutive Axles.							
	2 axles	**3 axles**	**4 axles**	**5 axles**	**6 axles**	**7 axles**	**8 axles**	**9 axles**
4[1]	1.000		INSTRUCTIONS: 1. Determine the scale's CLC. 2. Count the number of axles on the vehicle in a given span and determine the distance in feet between the first and last axle in the span. 3. Multiply the CLC by the corresponding multiplier in the table.* 4. The resulting number is the scale's maximum concentrated load for a single span based on the vehicle configuration. * note and formula found at the end of the table.					
5[1]	1.000							
6[1]	1.000							
7[1]	1.000							
8 and less[1]	1.000	1.000						
More than 8[1]	1.118	1.235						
9	1.147	1.257						
10	1.176	1.279						
11	1.206	1.301						
12	1.235	1.324	1.471	1.632				
13	1.265	1.346	1.490	1.651				
14	1.294	1.368	1.510	1.669				
15	1.324	1.390	1.529	1.688	1.853			
16	1.353	1.412	1.549	1.706	1.871			
17	1.382	1.434	1.569	1.724	1.888			
18	1.412	1.456	1.588	1.743	1.906			
19	1.441	1.478	1.608	1.761	1.924			
20	1.471	1.500	1.627	1.779	1.941			
21	1.500	1.522	1.647	1.798	1.959			
22	1.529	1.544	1.667	1.816	1.976			
23	1.559	1.566	1.686	1.835	1.994			
24	1.588	1.588	1.706	1.853	2.012	2.176		
25	1.618	1.610	1.725	1.871	2.029	2.194		
26		1.632	1.745	1.890	2.047	2.211		
27		1.654	1.765	1.908	2.065	2.228		
28		1.676	1.784	1.926	2.082	2.245	2.412	
29		1.699	1.804	1.945	2.100	2.262	2.429	

Table UR.3.2.1.
Span Maximum Load

Distance in Feet Between the Extremes of any Two or More Consecutive Axles	Ratio of CLC to Maximum Load ("r" factor) Carried on Any Group of Two or More Consecutive Axles.							
	2 axles	3 axles	4 axles	5 axles	6 axles	7 axles	8 axles	9 axles
30		1.721	1.824	1.963	2.118	2.279	2.445	
31		1.743	1.843	1.982	2.135	2.297	2.462	
32		1.765	1.863	2.000	2.153	2.314	2.479	2.647
33			1.882	2.018	2.171	2.331	2.496	2.664
34			1.902	2.037	2.188	2.348	2.513	2.680
35			1.922	2.055	2.206	2.365	2.529	2.697
36			2.000[2]	2.074	2.224	2.382	2.546	2.713
37			2.000[2]	2.092	2.241	2.400	2.563	2.730
38			2.000[2]	2.110	2.259	2.417	2.580	2.746
39			2.000	2.129	2.276	2.434	2.597	2.763
40			2.020	2.147	2.294	2.451	2.613	2.779
41			2.039	2.165	2.312	2.468	2.630	2.796
42			2.059	2.184	2.329	2.485	2.647	2.813
43			2.078	2.202	2.347	2.502	2.664	2.829
44			2.098	2.221	2.365	2.520	2.681	2.846
45			2.118	2.239	2.382	2.537	2.697	2.862
46			2.137	2.257	2.400	2.554	2.714	2.879
47			2.157	2.276	2.418	2.571	2.731	2.895
48			2.176	2.294	2.435	2.588	2.748	2.912
49			2.196	2.313	2.453	2.605	2.765	2.928
50			2.216	2.331	2.471	2.623	2.782	2.945
51			2.235	2.349	2.488	2.640	2.798	2.961
52			2.255	2.368	2.506	2.657	2.815	2.978
53			2.275	2.386	2.524	2.674	2.832	2.994
54			2.294	2.404	2.541	2.691	2.849	3.011
55			2.314	2.423	2.559	2.708	2.866	3.028
56			2.333	2.441	2.576	2.725	2.882	3.044
57			2.353[3]	2.460	2.594	2.742	2.899	3.061
58				2.478	2.612	2.760	2.916	3.077
59				2.496	2.629	2.777	2.933	3.094
60				2.515	2.647	2.794	2.950	3.110

Table UR.3.2.1.
Span Maximum Load

Distance in Feet Between the Extremes of any Two or More Consecutive Axles	**Ratio of CLC to Maximum Load ("r" factor) Carried on Any Group of Two or More Consecutive Axles.**							
	2 axles	**3 axles**	**4 axles**	**5 axles**	**6 axles**	**7 axles**	**8 axles**	**9 axles**

***Note:** This table was developed based upon the following formula. Values may be rounded in some cases for ease of use.

$$W = r \times 500\left[\left(\frac{LN}{N-1}\right) + 12N + 36\right]$$

[1] Tandem Axle Weight.
[2] Exception – These values in the third column correspond to the maximum loads in which the inner bridge dimensions of 36, 37, and 38 ft are considered to be equivalent to 39 ft. This allows a weight of 68 000 lb on axles 2 through 5.
[3] Corresponds to the Interstate Gross Weight Limit.

UR.3.3. Single-Draft Vehicle Weighing. – A vehicle or a coupled-vehicle combination shall be commercially weighed on a vehicle scale only as a single draft. That is, the total weight of such a vehicle or combination shall not be determined by adding together the results obtained by separately and not simultaneously weighing each end of such vehicle or individual elements of such coupled combination. However, the weight of:

(a) a coupled combination may be determined by uncoupling the various elements (tractor, semitrailer, trailer), weighing each unit separately as a single draft, and adding together the results; or

(b) a vehicle or coupled-vehicle combination may be determined by adding together the weights obtained while all individual elements are resting simultaneously on more than one scale platform.

Note: This paragraph does not apply to highway-law-enforcement scales and scales used for the collection of statistical data.
(Added 1992)

UR.3.4. Wheel-Load Weighing.

UR.3.4.1. Use in Pairs. – When wheel-load weighers or portable axle-load weighers are to be regularly used in pairs, both weighers of each such pair shall be appropriately marked to identify them as weighers intended to be used in combination.

UR.3.4.2. Level Condition. – A vehicle of which either an axle-load determination or a gross-load determination is being made utilizing wheel-load weighers or portable axle-load weighers, shall be in a reasonably level position at the time of such determination.

UR.3.5. Special Designs. – A scale designed and marked for a special application (such as a prepackaging scale or prescription scale with a counting feature) shall not be used for other than its intended purpose.[4]
(Amended 2003)

UR.3.6. Wet Commodities. – Wet commodities not in watertight containers shall be weighed only on a scale having a pan or platform that will drain properly.
(Amended 1988)

UR.3.7. Minimum Load on a Vehicle Scale. – A vehicle scale shall not be used to weigh net loads smaller than:

(a) 10 d when weighing scrap material for recycling or weighing refuse materials at landfills and transfer stations; and

(b) 50 d for all other weighing.

As used in this paragraph, scrap materials for recycling shall be limited to ferrous metals, paper (including cardboard), textiles, plastic, and glass.
(Amended 1988, 1992, and 2006)

UR.3.8. Minimum Load for Weighing Livestock. – A scale with scale divisions greater than 2 kg (5 lb) shall not be used for weighing net loads smaller than 500 d.
(Amended 1989)

UR.3.9. Use of Manual Weight Entries. – Manual gross or net weight entries are permitted for use in the following applications only when:

(a) a point-of-sale system interfaced with a scale is giving credit for a weighed item;

(b) an item is pre-weighed on a legal for trade scale and marked with the correct net weight;

(c) a device or system is generating labels for standard weight packages;

(d) postal scales or weight classifiers are generating manifests for packages to be picked up at a later time; or

(e) livestock and vehicle scale systems generate weight tickets to correct erroneous tickets.

(Added 1992) (Amended 2000 and 2004)

UR.3.10. Dynamic Monorail Weighing Systems. – When the value of d is different from the value of e, the commercial transaction must be based on e.
(Added 1999)

[4] Prepackaging scales and prescription scales with a counting feature (and other commercial devices) used for putting up packages in advance of sale are acceptable for use in commerce only if all appropriate provisions of NIST Handbook 44 are met. Users of such devices must be alert to the legal requirements relating to the declaration of quantity on a package. Such requirements are to the effect that, on the average, the contents of the individual packages of a particular commodity comprising a lot, shipment, or delivery must contain at least the quantity declared on the label. The fact that a prepackaging scale may overregister, but within established tolerances, and is approved for commercial service is not a legal justification for packages to contain, on the average, less than the labeled quantity.
(Amended 2003)

UR.3.11. Minimum Count. – A prescription scale with an operational counting feature shall not be used to count a quantity of less than 30 pieces weighing a minimum of 90 e.

(Added 2003)

Note: The minimum count as defined in this paragraph refers to the use of the device in the filling of prescriptions and is different from the minimum sample piece count as defined in S.1.2.3. and as required to be marked on the scale by S.6.6.

(Note Added 2004)

UR.3.12. Correct Stored Piece Weight. – For prescription scales with a counting feature, the user is responsible for maintaining the correct stored piece weight. This is especially critical when a medicine has been reformulated or comes from different lots.

(Added 2003)

UR.3.13. Fault Indications for Weigh-in-Motion Vehicle Scales. – The fault conditions defined in S.1.14.1. Identification of a Fault shall be presented to the customer and the operator in a clear and conspicuous manner.

(Added 2021)

UR.4. Maintenance Requirements.

UR.4.1. Balance Condition. – The zero-load adjustment of a scale shall be maintained so that, with no load on the load-receiving element and with all load-counterbalancing elements of the scale (such as poises, drop weights, or counterbalance weights) set to zero, the scale shall indicate or record a zero balance condition. A scale not equipped to indicate or record a zero-load balance shall be maintained in balance under any no-load condition.

UR.4.2. Level Condition. – If a scale is equipped with a level-condition indicator, the scale shall be maintained in level.

UR.4.3. Scale Modification. – The dimensions (e.g., length, width, thickness, etc.) of the load receiving element of a scale shall not be changed beyond the manufacturer's specifications, nor shall the capacity of a scale be increased beyond its design capacity by replacing or modifying the original primary indicating or recording element with one of a higher capacity, except when the modification has been approved by a competent engineering authority, preferably that of the engineering department of the manufacturer of the scale, and by the weights and measures authority having jurisdiction over the scale.

(Amended 1996)

UR.5. Coupled-in-Motion Railroad Weighing Systems.

(a) A coupled-in-motion weighing system placed in service on or after January 1, 1991, should be tested in the manner in which it is operated, with the locomotive either pushing or pulling the cars at the designed speed and in the proper direction. The cars used in the test train should represent the range of gross weights that will be used during the normal operation of the weighing system. Except as provided in N.4.2. Weighing Systems Placed in Service Prior to January 1, 1991, and Used to Weigh Trains of Ten or More Cars and N.4.3.(a) Weighing Systems Placed in Service on or After January 1, 1991, and Used to Weigh Trains of Ten or More Cars, normal operating procedures should be simulated as nearly as practical. Approach conditions for a train length in each direction of the scale site are more critical for a weighing system used for individual car weights than for a unit-train-weights-only facility, and should be considered prior to installation.

(b) For coupled-in-motion point-based weighing systems used only for dynamic weighing, the user shall provide an alternate certified scale to be used as a reference scale. The weights and measures authority having jurisdiction over the weighing system shall determine if the reference scale provided is suitable in terms of size, capacity, minimum division, performance requirements, and the proximity to the weighing system under evaluation. The reference weight cars weighed on the reference scale may then be used for calibration and annual inspection by the jurisdiction with statutory authority for the system.

(Added 1990) (Amended 1992 and 2021)

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Scales Code Index

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A

B

C

D

E

F

G

H

I

J

L

M

N

O

P

R

S

T

U

V

W

Z

Table of Contents

Section 2.21. Belt-Conveyor Scale Systems

A. Application

A.1. General. – This code applies to belt-conveyor scale systems and weigh-belt systems used for the weighing of bulk materials.
(Amended 2015)

A.2. Exceptions. – The code does not apply to the following:

(a) Devices used for discrete weighing while moving on conveyors.

(b) Devices that measure quantity on a time basis.

(c) Checkweighers.

(d) Controllers or other auxiliary devices except as they may affect the weighing performance of the belt-conveyor scale.

A.3. Additional Code Requirements. – In addition to the requirements of this code, Belt-Conveyor Scale Systems shall meet the requirements of Section 1.10. General Code.

S. Specifications

S.1. Design of Indicating and Recording Elements.

S.1.1. General. – A belt-conveyor scale shall be equipped with a primary indicating element in the form of a master weight totalizer *and shall also be equipped with a recording element, and a rate of flow indicator and recorder (which may be analog).** An auxiliary indicator shall not be considered part of the master weight totalizer.
*[*Nonretroactive as of January 1, 1986]*
(Amended 1986)

S.1.2. Units. – A belt-conveyor scale shall indicate and record weight units in terms of pounds, tons, long tons, metric tons, or kilograms. The value of a scale division (d) expressed in a unit of weight shall be equal to:

(a) 1, 2, or 5; or

(b) a decimal multiple or submultiples of 1, 2, or 5.

S.1.3. Value of the Scale Division.

S.1.3.1. For Scales Not Marked with an Accuracy Class and Installed After January 1, 1986. *– The value of the scale division shall not be greater than 0.125 % (1/800) of the minimum totalized load.*
[Nonretroactive as of January 1, 1986]
(Added 1985) (Amended 2009 and 2019)

S.1.3.2. For Scales Installed Before January 1, 1986. – The value of the scale division shall not be greater than 1/1200 of the rated capacity of the device. However, provision shall be made so that compliance with the requirements of the zero-load test as prescribed in N.3.1. Zero Load Tests may be readily and accurately determined in 20 minutes of operation.

S.1.3.3. For Scales Marked with an Accuracy Class. - *The value of the scale division shall not be greater than:*

(a) 0.125 % (1/800) of the minimum totalized load for scales marked Class 0.25; and

(b) 0.05 % (1/2000) of the minimum totalized load for scales marked Class 0.1.
[Nonretroactive as of January 1, 2020]

(Added 2019)

S.1.4. Recording Elements and Recorded Representations. *– The value of the scale division of the recording element shall be the same as that of the indicating element.*

(a) The belt-conveyor scale system shall record the unit of measurement (i.e., kilograms, tonnes, pounds, tons, etc.), the date, and the time.

*(b) The belt-conveyor scale system shall record the initial indication and the final indication of the master weight totalizer and the quantity.**

*All of the information in (a) and (b) must be recorded for each delivery.**
[Nonretroactive as of January 1, 1986]
*[*Nonretroactive as of January 1, 1994]*

(Amended 1993)

S.1.4.1. *The belt-conveyor scale system shall be capable of recording the results of automatic or semi-automatic zero load tests.***
*[**Nonretroactive as of January 1, 2004]*

(Added 2002)

S.1.5. Rate of Flow Indicators and Recorders. *- A belt-conveyor scale shall be equipped with a rate of flow indicator and an analog or digital recorder. Permanent means shall be provided to produce an audio or visual signal when the rate of flow is equal to or less than 20 % and when the rate of flow is equal to or greater than 100 % of the rated capacity of the scale. The type of alarm (audio or visual) shall be determined by the individual installation.*
[Nonretroactive as of January 1, 1986]

(Amended 1989 and 2004)

S.1.6. Advancement of Primary Indicating or Recording Elements. – The master weight totalizer shall advance only when the belt conveyor is in operation and under load.

(Amended 1989)

S.1.7. Master Weight Totalizer. *– The master weight totalizer shall not be resettable without breaking a security means.*
[Nonretroactive as of January 1, 1986]

S.1.8. Power Loss. *– In the event of a power failure of up to 24 hours, the accumulated measured quantity on the master weight totalizer of an electronic digital indicator shall be retained in memory during the power loss.*
[Nonretroactive as of January 1, 1986]

(Amended 1989)

S.1.9. Zero-Ready Indicator. – *A belt-conveyor scale shall be equipped with a zero-ready indicator that produces an audio or visual signal during an unloaded belt condition when the zero balance is within:*

(a) ± 0.12 % of the rated capacity of the scale for scales not marked with an accuracy class;

(b) ± 0.12 % of the rated capacity of the scale for scales marked Class 0.25; and

(c) ± 0.05 % for scales marked Class 0.1.

The type of indication (audio or visual) shall be determined by the individual installation.
[Nonretroactive as of January 1, 2014]

(Added 2012) (Amended 2019)

S.2. Design of Weighing Elements. – A belt-conveyor scale system shall be designed to combine automatically belt travel with belt load to provide a determination of the weight of the material that has passed over the scale.

S.2.1. Speed Measurement. – A belt-conveyor scale shall be equipped with a belt speed or travel sensor that will accurately sense the belt speed or travel whether the belt is empty or loaded.

S.2.2. Adjustable Components. – An adjustable component that can affect the performance of the device (except as prescribed in S.3.1. Design of Zero-Setting Mechanism) shall be held securely in adjustment.

(Amended 1998)

S.2.3. Overload Protection. – The load-receiving elements shall be equipped with means for overload protection of not less than 150 % of rated capacity. The accuracy of the scale in its normal loading range shall not be affected by overloading.

S.3. Zero Setting.

S.3.1. Design of Zero-Setting Mechanism. – Automatic and semiautomatic zero-setting mechanisms shall be so constructed that the resetting operation is carried out only after a whole number of belt revolutions and the completion of the setting or the whole operation is indicated. *An audio or visual signal shall be given when the automatic and semiautomatic zero-setting mechanisms reach the limit of adjustment of the zero-setting mechanism.**

(Amended 1999 and 2002)

Except for systems that record the zero-load reference at the beginning and end of a delivery, the range of the zero-setting mechanism shall not be greater than ± 2 % of the rated capacity of the scale without breaking the security means. *For systems that record the zero-load reference at the beginning and end of a delivery, the range of zero-setting mechanism shall not be greater than ± 5 % without breaking the security means.***
*[*Nonretroactive as of January 1, 1990]*
*[**Nonretroactive as of January 1, 2004]*

(Amended 1989 and 2002)

S.3.1.1. Automatic Zero-Setting Mechanism. *– The automatic zero-setting mechanism shall indicate or record any change in the zero reference.*
[Nonretroactive as of January 1, 2010]

(Added 2009)

S.3.2. Sensitivity at Zero Load (For Type Evaluation). *– When a system is operated for a time period equal to the time required to deliver the minimum test load and with a test load calculated to indicate two scale divisions applied directly to the weighing element, the totalizer shall advance not less than one or more than three scale divisions. An alternative test of equivalent sensitivity, as specified by the manufacturer, shall also be acceptable.*
[Nonretroactive as of January 1, 1986]

S.4. Accuracy Class*. – Weighing devices shall be marked with an appropriate accuracy class as either Class 0.25 or as Class 0.1. This designation is determined by the manufacturer.*
[Nonretroactive as of January 1, 2020]

(Added 2019)

S.5. Marking Requirements. – Belt-conveyor scale systems and weigh-belt systems shall be marked with the following: (Also see also G-S.1. Identification.)

(a) the rated capacity in units of weight per hour (minimum and maximum);

(b) the value of the scale division;

(c) the belt speed in terms of feet (or meters) per minute at which the belt will deliver the rated capacity, or the maximum and minimum belt speeds at which the conveyor system will be operated for variable speed belts;

(d) the load in terms of pounds per foot or kilograms per meter (determined by material tests);

(e) the operational temperature range if other than − 10 °C to 40 °C (14 °F to 104 °F); and*

*(f) the accuracy classification as declared by the manufacturer.***
*[*Nonretroactive as of January 1, 1986][**Nonretroactive as of January 1, 2020]*

(Amended 2015 and 2019)

S.6. 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.

All other devices shall be designed using the format set forth in Table S.6. 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 affects the metrological integrity of the device can be made to any electronic mechanism.
[Nonretroactive as of January 1, 1999]

(Added 1998) (Amended 2019)

Table S.6.
Categories of Device and Methods of Sealing

Categories of Devices	***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 3: *Remote configuration capability.*	*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 through the device or through another on-site device. 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.)*

[Nonretroactive as of January 1, 1999]

(Table Added 1998)

N. Notes

N.1. General. – The performance of belt-conveyor scales can be detrimentally affected by the conditions of the installation. (Also see User Requirements.) The performance of the equipment is not to be determined by averaging the results of the individual tests. The results of all tests shall be within the tolerance limits.

(Amended 2002 and 2019)

N.1.1. Official Test. – An official test of a belt-conveyor scale system shall include tests specified in N.3.1. Zero Load Tests, N.3.2. Material Tests, and, if applicable, N.3.3. Simulated Load Tests.

(Amended 2006)

N.1.2. Simulated Test. – Simulated loading conditions as recommended by the manufacturer and approved by the official with statutory authority may be used to properly monitor the system operational performance between official tests, but shall not be used for official certification.

(Amended 1991)

N.2. Conditions of Tests. – A belt-conveyor scale shall be tested after it is installed on the conveyor system with which it is to be used and under such environmental conditions as may normally be expected. Each test shall be conducted with test loads no less than the minimum test load. Before each test run, the inspector shall check the zero setting and adjust as necessary.

(Amended 1986, 2004, and 2009)

N.2.1. Initial Verification. – A belt-conveyor scale system or a weigh-belt system shall be tested using test runs as indicated in Table N.2.1. Initial Verification.

The minimum testing shall be two test runs performed consecutively and under the same (or practically identical) test conditions; the range of the results of those test runs shall not exceed the absolute value of the tolerance as specified in T.2.1. Tolerance Values, Repeatability Tests. The results of each individual test shall be within the tolerance as specified in T.1. Tolerance Values.

Test runs may also be conducted at any other rate of flow that may be used at the installation to establish linearity of the system.

A minimum of four test runs may be conducted at only one flow rate if evidence is provided that the system is used at a constant speed/constant loading setting and that rate does not vary by an amount more than plus or minus (±) 10 % of the normal flow rate that can be developed at the installation for at least 80 % of the time.

(Added 2004) (Amended 2009, 2015, and 2019)

Table N.2.1. Initial Verification		
Device Configuration	**Minimum of Two Test Runs at Each of the Following Settings**	**Total Tests (Minimum)**
Constant Belt Speed and Variable Loading	- Belt Loading: high (normal) - Belt Loading: medium (intermediate) - Belt Loading: low (35 %)	6
Variable Belt Speed and Constant Loading	- Belt Speed: maximum - Belt Speed: medium - Belt Speed: minimum	6
Variable Belt Speed and Variable Loading	- Belt Speed: maximum; Belt Loading: high (normal) - Belt Speed: maximum; Belt Loading: medium (intermediate) - Belt Speed: maximum; Belt Loading: low (35 %) - Belt Speed: minimum; Belt Loading: high (normal) - Belt Speed: minimum; Belt Loading: medium (intermediate) - Belt Speed: minimum; Belt Loading: low (35 %)	12
Constant Belt Speed and Constant Loading	- When the system is operated only at a single flow rate, minimum of four test runs at the flowrate used in normal operation	*4

1. Use the device configurations in the left-hand column to identify the scale being tested.
2. Perform two test runs (minimum) at each of the settings shown in the center column.
3. The following terminology applies to "Belt Loading":
   - Low: 35 % of the maximum rated capacity of the system.
   - Medium: an intermediate rate between the high and low settings.
   - High: maximum (normal use) operational rate.

*As provided in N.2.1. Initial Verification; for single flow rate systems, a minimum of four test runs at a single flow rate are required.

(Table Added 2015)

N.2.2. Subsequent Verification. – Subsequent testing shall include testing at the normal use flow rate and other flow rates used at the installation using a minimum of two consecutive test runs performed at each flow rate. The official with statutory authority may determine that testing only at the normal use flow rate is necessary for subsequent verifications if evidence is provided that the system is used to operate:

(a) at no less than 70 % of the maximum rated capacity for at least 80 % of the time (excluding time that the belt is unloaded); or

(b) with a normal use flow rate that does not vary by more than plus or minus (±) 10 % of the maximum rated capacity.

Example: If a belt-conveyor scale system has a maximum rated capacity of 200 tons per hour (tph), and the normal use flow rate is 150 tph (75 % of the maximum rated capacity), no testing at additional flow rates is required provided the flow rates remain above 140 tph for more than 80 % of the time. If the same device were operating with a normal use flow rate of 130 tph, it is operating at 65 % of the maximum rated capacity. In this case, testing at flow rates in addition to the normal use flow rate would be required if the normal use flow rate varies by more than 20 tph (10 % of the maximum rated capacity).

(Added 2004) (Amended 2019)

N.2.3. Minimum Test Load.

N.2.3.1. Minimum Test Load, Weigh-Belt Systems. – The minimum test load shall not be less than the largest of the following values:

(a) 800 scale divisions for systems not marked with an accuracy class, 800 scale divisions for systems marked Class 0.25, and 2000 scale divisions for systems marked Class 0.1;

(b) the load obtained at maximum flow rate in one revolution of the belt; or

(c) the load obtained during at least one minute of operation.

(Amended 2015 and 2019)

N.2.3.2. Minimum Test Load, All Other Belt-Conveyor Scale Systems. – Except for applications where a normal weighment is less than ten minutes, the minimum test load shall not be less than the largest of the following values:

(a) 800 scale divisions for systems not marked with an accuracy class, 800 scale divisions for systems marked Class 0.25, and 2000 scale divisions for systems marked Class 0.1; or

(b) the load obtained at maximum flow rate in one revolution of the belt; or

(c) the load obtained during at least ten minutes of operation.

For applications where a normal weighment is less than ten minutes (e.g., belt-conveyor scale systems used exclusively to issue net weights for material conveyed by individual vehicles and railway track cars) the minimum test load shall be the normal weighment that also complies with N.2.3.2.(a) and (b).

The official with statutory authority may determine that a smaller minimum totalized load down to 2 % of the load totalized in one hour at the maximum flow rate may be used for subsequent tests, provided that:

1. the smaller minimum totalized load is greater than the quantities specified in N.2.3.2.(a) and (b); and

2. consecutive official testing with the minimum totalized loads described in N.2.3.2.(a), (b), or (c) and the smaller minimum test load has been conducted that demonstrates the system complies with applicable tolerances for repeatability, acceptance, and maintenance.

(Added 2004) (Amended 2008, 2015, and 2019)

N.3. Test Procedures.

N.3.1. Zero-Load Tests. – A zero-load test shall be conducted to establish that the belt scale system (including the conveyor) is capable of holding a stable, in-service zero.

(Amended 1989 and 2002)

N.3.1.1. Determination of Zero. – A zero-load test is a determination of the error in zero, expressed as an internal reference, a percentage of the full-scale capacity, or a change in a totalized load over a whole number of complete belt revolutions. A zero-load test shall be performed as follows:

(a) For belt-conveyor scales with electronic integrators, the test must be performed over a period of at least three minutes and with a whole number of complete belt revolutions.

(b) For belt-conveyor scales with mechanical integrators, the test shall be performed with no less than three complete revolutions or ten minutes of operation, whichever is greater.

(c) For weigh belt systems, the test must be performed over a period of at least one minute and at least one complete revolution of the belt.

(Added 2002) (Amended 2015)

N.3.1.2. Test of Zero Stability. – The conveyor system shall be operated to warm up the belt and the belt scale shall be zero adjusted as required. A series of zero-load tests shall be carried out immediately before conducting the simulated load or materials test until the three consecutive zero-load tests each indicate an error which does not exceed:

(a) ± 0.06 % of the totalized load at full scale capacity for the duration of the test for scales not marked with an accuracy class;

(b) ± 0.06 % of the totalized load at full scale capacity for the duration of the test for scales marked Class 0.25; or

(c) ± 0.03 % of the totalized load of full scale capacity for the duration of the test for scales that are marked Class 0.1.

No adjustments can be made during the three consecutive zero-load test readings.

(Added 2002) (Amended 2004, 2009, and 2019)

N.3.1.3. Check for Consistency of the Conveyor Belt along Its Entire Length. – During a zero-load test with any operational low-flow lock-out disabled, the absolute value of the difference between the maximum and minimum totalizer readings indicated on the totalizer during any complete revolution of the belt shall not exceed 0.12 % of the minimum test load.

Note: The end value of the zero-load test must meet the values referenced in N.3.1.2. Test for Zero Stability of:

(1) ± 0.06 % for scales not marked with an accuracy class;
(2) ± 0.06 % for scales marked Class 0.25; or
(3) ± 0.03 % for scales marked Class 0.1.

(Added 2002) (Amended 2004, 2011, and 2019)

N.3.2. Material Tests. – Material tests should be conducted using actual belt loading conditions. These belt loading conditions shall include but are not limited to conducting materials tests using different belt loading points, all types and sizes of products weighed on the scale, at least one other belt speed, and in both directions of weighing.

On subsequent verifications, at least two individual tests shall be conducted as specified in N.2.2. Subsequent Verification. The results of all these tests shall be within the tolerance limits.

Either pass a quantity of pre-weighed material over the belt-conveyor scale in a manner as similar as feasible to actual loading conditions or weigh all material that has passed over the belt-conveyor scale. Means for weighing the material test load will depend on the capacity of the belt-conveyor scale and availability of a suitable scale for the test. To assure that the test load is accurately weighed and determined, the following precautions shall be observed:

(a) The containers, whether railroad cars, trucks, or boxes, must not leak, and shall not be overloaded to the point that material will be lost.

(b) The actual empty or tare weight of the containers shall be determined at the time of the test. Stenciled tare weight of railway cars or trucks shall not be used. Gross and tare weights shall be determined on the same scale.

(c) When a pre-weighed test load is passed over the scale, the belt-loading hopper shall be examined before and after the test to assure that the hopper is empty and that only the material of the test load has passed over the scale.

(d) Where practicable, a reference scale should be tested within 24 hours preceding the determination of the weight of the test load used for a belt-conveyor scale material test.

A reference scale which is not "as found" within maintenance tolerance should have its accuracy re-verified after the belt-conveyor test with a suitable known weight load if the "as found" error of the belt-conveyor scale material test exceeds maintenance tolerance values.*

(e) If any suitable known weight load other than a certified test weight load is used for re-verification of the reference scale accuracy, its weight shall be determined on the reference scale after the reference scale certification and before commencing the belt scale material test.*

(f) The test shall not be conducted if the weight of the test load has been affected by environmental conditions.

***Note:** Even if the reference scale is within maintenance tolerance it may require adjusting to be able to meet paragraph N.3.2.1. Accuracy of Material.

(Amended 1986, 1989, 1998, 2000, 2002, 2009, and 2019)

N.3.2.1. Accuracy of Material.

(a) For scales not marked with an accuracy class and those marked Class 0.25, the quantity of material used to conduct a material test shall be weighed on a reference scale to within an accuracy of 0.1 %.

(b) For scales that are marked Class 0.1, the quantity of material used to conduct a material test shall be weighed on a reference scale to within an accuracy of 0.035 %.

Scales typically used for this purpose include Class III and III L scales or a scale without a class designation as described in Handbook 44, Section 2.20., Table T.1.1. Tolerances for Unmarked Scales.

(Added 1989) (Amended 1991, 1993, 1998, 2000, and 2019)

N.3.3. Simulated Load Tests.

(a) As required by the official with statutory authority, simulated load tests as recommended by the manufacturer are to be conducted between material tests to monitor the system's operational performance but shall not be used for official certification.

(Amended 1991)

(b) A simulated load test consisting of at least three consecutive test runs shall be conducted as soon as possible, but not more than 12 hours after the completion of the material test, to establish the factor to relate the results of the simulated load test to the results of the material tests.

(Added 1990)

(c) The results of the simulated load test shall repeat within 0.1 %.

(Added 1990)

(Amended 1989 and 1990)

T. Tolerances

T.1. Tolerance Values.[1] – Maintenance and acceptance tolerances on material tests, relative to the weight of the material, shall be:

(a) ± 0.25 % of the test load for systems not marked with an accuracy class;

(b) ± 0.25 % of the test load for systems marked Class 0.25; and

(c) ± 0.1 % of the test load for systems marked Class 0.1.

(Amended 1993 and 2019)

T.1.1. Tolerance Values – Test of Zero Stability. – Immediately after material has been weighed over the belt-conveyor scale during the conduct of any material test run, the zero-load test shall be repeated. The change in the accumulated or subtracted weight during the zero-load test shall not exceed

(a) 0.12 % of the totalized load at full scale capacity for the duration of that test for scales that are not marked with an accuracy class;

(b) 0.12 % of the totalized load at full scale capacity for the duration of that test for scales marked Class 0.25; and

(c) 0.06 % of the totalized load at full scale capacity for the duration of the test for scales that are marked Class 0.1.

If the range of zero adjustments during a complete (official) verification test exceeds 0.18 % of the totalized load at full scale capacity for the duration of the zero-load test for unmarked scales and those marked Class 0.25 or 0.09 % of the totalized load at full scale capacity for the duration of the zero-load test for scales marked Class 0.1, the official with statutory authority may establish an interval for zero-load testing during normal operation.

(Added 2004) (Amended 2009 and 2019)

T.2. Tolerance Values, Repeatability and Linearity.

T.2.1 Tolerance Values, Repeatability Tests. – In any group of totalization operations performed consecutively and under the same (or practically identical) test conditions during the conduct of material tests, the variation in values shall not be greater than:

(a) 0.25 % (1/400) for systems not marked with an accuracy class;

(b) 0.25 % (1/400) for systems marked Class 0.25; and

(c) 0.1 % (1/1000) for systems marked Class 0.1.

(Amended 2019)

T.2.2. Linearity Tests, for Systems that Operate Using Multiple or Variable Flow Rates. – For totalization operations performed consecutively under different test conditions (e.g., different flow rates, different test loads,

[1] The variables and uncertainties included in the relative tolerance represent only part of the variables that affect the accuracy of the material weighed on belt-conveyor scales. If this tolerance was based on an error analysis beginning with mass standards through all of the test processes and following the principle expressed in Section 3.2. of the Fundamental Considerations in Appendix A, the tolerance would be 0.5 %.

(Added 1993)

different test material) during the conduct of material tests, the results relative to the weight of the reference material shall not exceed:

(a) ± 0.25 % (1/400) for systems not marked with an accuracy class;

(b) ± 0.25 % (1/400) for systems marked Class 0.25; and

(c) ± 0.1 % (1/1000) for systems marked Class 0.1.

(Added 2019)

T.3. Influence Factors. – The following factors are applicable to tests conducted under controlled conditions only, provided that:

(a) types of devices approved prior to January 1, 1986, and manufactured prior to January 1, 1988, need not meet the requirements of this section;

(b) new types of devices submitted for approval after January 1, 1986, shall comply with the requirements of the section; and

(c) all devices manufactured after January 1, 1988, shall comply with the requirements of this section.

T.3.1. Temperature. – Devices shall satisfy the tolerance requirements at temperatures from − 10 °C to 40 °C (14 °F to 104 °F).

T.3.1.1. Effect on Zero-Load Balance. – The zero-load indication shall not change by more than 0.035 % of the rated capacity of the scale (without the belt) for a change in temperature of 10 °C (18 °F) at a rate not to exceed 5 °C (9 °F) per hour.

(Amended 2004)

T.3.1.2. Temperature Limits. *– If a temperature range other than − 10 °C to 40 °C (14 °F to 104 °F) is specified for the device, the range shall be at least 30 °C (54 °F).*
[Nonretroactive as of January 1, 1990]

(Added 1989)

T.3.2. Power Supply, Voltage, and Frequency. – A belt-conveyor scale system shall satisfy the tolerance requirements over a range of 100 V to 130 V or 200 V to 250 V as appropriate and over a frequency range of 59.5 Hz to 60.5 Hz.

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Protection from Environmental Factors. – The indicating elements, the lever system or load cells, and the load-receiving element of a belt-conveyor scale shall be adequately protected from environmental factors such as wind, moisture, dust, weather, and radio frequency interference (RFI) and electromagnetic interference (EMI) that may adversely affect the operation or performance of the device.

UR.1.2. Conveyor Installation. – The design and installation of the conveyor leading to and from the belt-conveyor scale is critical with respect to scale performance. Installation shall be in accordance with the scale manufacturer's instructions and the following:

(a) Installation - General. – A belt-conveyor scale shall be so installed that neither its performance nor operation will be adversely affected by any characteristic of the installation, including but not limited to, the foundation, supports, covers, or any other equipment.

(Amended 2002)

(b) Live Portions of Scale. – All live portions of the scale shall be protected with appropriate guard devices and clearances, as recommended by the scale manufacturer, to prevent accidental interference with the weighing operation. (Also see UR.3.1. Scale and Conveyor Maintenance.)

(Amended 2004)

(c) Storage of Simulated Load Equipment. – Suitable protection shall be provided for storage of any simulated load equipment.

(d) Take-up Device. – Any take-up device shall provide constant and consistent tension for the belt under all operating conditions.

(Amended 2014)

(e) Scale Location and Training Idlers. – The scale shall be so installed that the first weigh idler of the scale is at least 6 m (20 ft) or five idler spaces, whichever is greater, from loading point, skirting, head or tail pulley, or convex curve in the conveyor. Any training idler shall be located at least 18 m (60 ft) from the centerline of the weigh span of the scale. Training idlers shall not be restrained at any time in order to force belt alignment.

(Amended 1998)

(f) Concave Curve. – If there is a concave curve in the conveyor, before or after the scale, the scale shall be installed so that the belt is in contact with all the idler rollers at all times for at least 6 m (20 ft) or five idler spaces, whichever is greater, before and after the scale.[2] A concave curve shall start no closer than 12 m (40 ft) from the scale to the tangent point of the concave curve.

(Amended 1998)

(g) Tripper and Movable Pulleys. – There shall be no tripper or movable head pulleys in the conveyor.

(h) Conveyor Orientation. – The conveyor may be horizontal or inclined, but, if inclined, the angle shall be such that slippage of material along the belt does not occur.

(i) Conveyor Stringers. – Conveyor stringers at the scale and for not less than 6 m (20 ft) before and beyond the scale shall be continuous or securely joined and of sufficient size and so supported as to eliminate relative deflection between the scale and adjacent idlers when under load. The conveyor stringers should be so designed that the deflection between any two adjacent idlers within the weigh area does not exceed 0.6 mm (0.025 in) under load.

(j) Identification of Scale Area. – The scale area and five idlers on both ends of the scale shall be of a contrasting color, or other suitable means shall be used to distinguish the scale from the remainder of the conveyor installation, and the scale shall be readily accessible.

(Amended 1998)

[2] Installing the belt scale five-idler spaces from the tail pulley or the infeed skirting will be in the area of least belt tension on the conveyor and should produce the best accuracy. The performance of a belt-conveyor scale may be adversely affected by a concave curve in the conveyor that is located between the loading point and the scale. Therefore, whenever possible, a belt-conveyor scale should not be installed with a concave curve in the conveyor between the loading point and the scale.

(Amended 1995 and 1998)

(k) **Belt Composition and Maintenance.** – In a loaded or unloaded condition, the belt shall make constant contact with horizontal and wing rollers of the idlers in the scale area. Splices shall not cause any undue disturbance in scale operation. (Also see N.3. Test Procedures.)

(Amended 1998, 2000, 2001, and 2015)

(l) **Uniformity of Belt Loading and Flow.** – The conveyor loading mechanism shall be designed to provide uniform belt loading. The distance from the loading point to the scale shall allow for adequate settling time of the material on the belt before it is weighed. Feeding mechanisms shall have a positive closing or stopping action so that material leakage does not occur. Feeders shall provide an even flow over the scale through the full range of scale operation. Sufficient impact idlers shall be provided in the conveyor under each loading point to prevent deflection of the belt during the time material is being loaded.

(m) **Belt Alignment.** – The belt shall not extend beyond the edge of the outermost roller of any carry side (top) roller in any area of the conveyor nor touch the conveyor structure on the return (bottom) side of the conveyor.

(Amended 1998 and 2008)

(Amended 2002, 2012, 2013, 2014, and 2015)

UR.1.3. Material Test. *– A belt-conveyor scale shall be installed so that a material test can be conveniently conducted.*
[Nonretroactive as of January 1, 1981]

UR.1.4. Belt Travel (Speed or Velocity). – The belt travel sensor shall be so positioned that it accurately represents the travel of the belt over the scale for all flow rates between the maximum and minimum values. The belt travel sensor shall be so designed and installed that there is no slip.

(Amended 2012)

UR.2. Use Requirements.

UR.2.1. Rate of Operation. – A belt-conveyor scale system shall be operated between 20 % and 100 % of its rated capacity.

(Amended 2004)

UR.2.2. Minimum Totalized Load. – Delivered quantities of less than the minimum test load shall not be considered a valid weighment.

UR.2.3. Security Means. – When a security means has been broken, it shall be reported to the official with statutory authority.

(Amended 1991)

UR.2.4. Loading. – The feed of material to the scale shall be controlled to assure that, during normal operation, the material flow is in accordance with the manufacturer's recommendation for rated capacity.

UR.2.5. Diversion or Loss of Measured Product. – There shall be no operation(s) or condition(s) of use that result in loss or diversion that adversely affects the quantity of measured product.

(Added 2005)

UR.2.6. Retention of Maintenance, Test, and Analog or Digital Recorder Information. – Records of calibration and maintenance, including conveyor alignment, analog or digital recorder, zero-load test, and material test data shall be maintained on site for at least the three concurrent years as a history of scale performance. Copies of any report as a result of a test or repair shall be mailed to the official with statutory authority as required.

The current date and correction factor(s) for simulated load equipment shall be recorded and maintained in the scale cabinet.

(Added 2002)

(Amended 2012)

UR.3. Maintenance Requirements – Scale and Conveyor Maintenance. – Weighing systems and idlers shall be maintained and serviced in accordance with manufacturer's instructions and the following:

(a) Zero Balance. – The zero-balance condition of a belt-conveyor scale shall be maintained such that, prior to beginning any commercial transaction, with no load on the belt, the zero-balance condition is within:

(1) ± 0.12 % of the scale's rated capacity for systems marked Class 0.25; and

(2) ± 0.05 % of the scale's rated capacity for systems marked Class 0.1.

(Added 2012) (Amended 2019)

(b) Scale Clearance. – The scale and area surrounding the scale shall be kept clean of debris or other foreign material that can detrimentally affect the performance of the system.

(c) Weighed Material. – There shall be provisions to ensure that weighed material does not adhere to the belt and return to the scale system area.

(Added 2004)

(d) Simulated and Zero-Load Test Intervals. – Zero-load tests and simulated load or material tests shall be conducted at periodic intervals between official tests and after a repair or mechanical adjustment to the conveyor system in order to provide reasonable assurance that the device is performing correctly. The minimum interval for periodic zero-load tests and simulated load tests shall be established by the official with statutory authority or according to manufacturer recommendations.

(1) The actions to be taken as a result of the zero-load test are shown in the following table.

Table UR.3. (d) (i)
Zero-Load Test Intervals and Actions

Change in Zero (Δ 0)	Actions to be Taken
If the change in zero is less than ± 0.25 % (Δ 0 < 0.25 %)	Perform zero adjustment and proceed to simulated load test.
If the change in zero is ± 0.25 % to ± 0.5 % (0.25 % ≤ Δ 0 ≤ 0.5 %)	Inspect the conveyor and weighing area for compliance with UR.1. Installation Requirements and repeat the zero-load test.
If the change in zero is greater than ± 0.5 % (Δ 0 > 0.5 %)	Inspect the conveyor and weighing area for compliance with UR.1. Installation Requirements, repeat the zero-load test, and reduce the interval between zero-load tests.

(2) The action to be taken as a result of the simulated load or material tests is shown in the following table.

Table UR.3. (d) (ii)
Simulated Load or Material Test Intervals and Actions

Change in Factor (Reference) Established in N.3.3.(b) [Δ N.3.3.(b)]	**Action to be Taken**
For scales not marked with an accuracy class and those marked Class 0.25, if the error is less than 0.25 %: (Δ N.3.3.(b) < 0.25 %)	No Action
For scales marked Class 0.1, if the error is less than 0.1%: (Δ N.3.3.(b) < 0.1%)	
For scales not marked with an accuracy class and those marked Class 0.25, if the error is at least 0.25 % but not more than 0.6 %: (0.25 % ≤ Δ N.3.3.(b) ≤ 0.6 %)	Inspect the conveyor and weighing area for compliance with UR.1. Installation Requirements and, after compliance is verified, repeat the test. If the result of that test remains greater than ± 0.25 %, for scales not marked with an accuracy class and those marked Class 0.25, or greater than ± 0.1% for scales marked Class 0.1, a span correction shall be made and the official with statutory authority notified. (Amended 1991 and 2019)
For scales marked Class 0.1, if the error is at least 0.1% but not more than 0.25%: (0.1 % ≤ Δ N.3.3.(b) ≤ 0.25 %)	
For scales not marked with an accuracy class and those marked Class 0.25, if the error is greater than 0.6 % but does not exceed 0.75 %: (0.6 % < Δ N.3.3.(b) ≤ 0.75 %)	Inspect the conveyor and weighing area for compliance with UR.1. Installation Requirements and, after compliance is verified, repeat the test. If the result of that test remains greater than ± 0.6 %, for scales not marked with an accuracy class and those marked Class 0.25, or greater than ± 0.25% for scales marked Class 0.1, a span correction shall be made, the official with statutory authority shall be notified, and an official test shall be conducted. (Amended 1991 and 2019)
For scales marked Class 0.1, if the error is greater than 0.25% but does not exceed 0.3%: (0.25 % < Δ N.3.3.(b) ≤ 0.3 %)	
For scales not marked with an accuracy class and those marked Class 0.25, if the error is greater than 0.75 %: (Δ N.3.3.(b) > 0.75 %)	An official test is required. (Amended 1987)
For scales marked Class 0.1, if the error is greater than 0.3%: (Δ N.3.3.(b) > 0.3 %)	

(Amended 2002, 2009, and 2019)

(e) **Scale Alignment.** – Alignment checks shall be conducted in accordance with the manufacturer's recommendation. A material test is required after any realignment.

(Amended 1986, 2000, and 2015)

(f) **Simulated Load Equipment.** – Simulated load equipment shall be clean and properly maintained.

(g) **Zero Load Reference Information.** – When zero load reference information is recorded for a delivery, the information must be based upon zero load tests performed as a minimum both immediately before and immediately after the totalized load.

(Added 2002)

(Amended 1986, 2000, 2002, 2004, 2009, 2012, and 2015)

UR.4. Compliance. – Prior to initial verification, the scale manufacturer or installer shall certify to the owner that the scale meets code requirements. Prior to initial verification and each subsequent verification, the scale owner or his agent shall notify the official with statutory authority in writing that the belt-conveyor scale system is in compliance with this specification and ready for material testing.

(Amended 1991)

Table of Contents

Section 2.22. Automatic Bulk Weighing Systems[1]

A. Application

A.1. General. – This code applies to automatic bulk weighing systems, that is, weighing systems adapted to the automatic weighing of a commodity in successive drafts of predetermined amounts automatically recording the no-load and loaded weight values and accumulating the net weight of each draft.
(Amended 1987)

A.2. Exceptions. – This code does not apply to batching systems.
(Added 2018)

A.3. Additional Code Requirements. – In addition to the requirements of this code, Automatic Bulk Weighing Systems shall meet the requirements of Section 1.10. General Code.

S. Specifications

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

S.1.1. Zero Indication. – Provisions shall be made to indicate and record a no-load reference value and, if the no-load reference value is a zero-value indication, to indicate and record an out-of-balance condition on both sides of zero.

S.1.1.1. Digital Zero Indication. – A digital zero indication shall represent a balance condition that is within ± ½ the value of the scale division.

S.1.2. Value of Scale Division (d). *– The value of the scale division (d), expressed in a unit of weight, shall be equal to:*

(a) 1, 2, or 5; or

(b) a decimal multiple or submultiple of 1, 2, or 5; or

(c) a binary submultiple of a unit of weight.

Examples: Scale divisions may be 0.01, 0.02, or 0.05; 0.1, 0.2, or 0.5; 1, 2, or 5; 10, 20, or 50; or ½, ¼, ⅛, 1/16, etc.
[Nonretroactive as of January 1, 1986]
(Amended 1987)

S.1.3. Capacity Indication and Recorded Representation. – An indicating or recording element shall not indicate or record any values when the gross load is in excess of 105 % of the capacity of the system.

S.1.4. Weighing Sequence. – For systems used to receive (weigh in), the no-load reference value shall be determined and recorded only at the beginning of each weighing cycle. For systems used to deliver (weigh out), the no-load reference value shall be determined and recorded only after the gross load reference value for each weighing cycle has been indicated and recorded.

[1] (Title amended 1986)

S.1.5. Recording Sequence. – Provision shall be made so that all weight values are indicated until the completion of the recording of the indicated value.

S.1.6. Provision for Sealing Adjustable Components on Electronic Devices. – 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, provision shall be made for applying a security seal in a manner that requires the security seal to be broken before an adjustment can be made to any component affecting the performance of the device.

(Amended 2019)

S.2. Design of Balance and Damping Mechanism.

S.2.1. Zero-Load Adjustment. – The weighing system shall be equipped with manual or semiautomatic means by which the zero-load balance or no-load reference value indication may be adjusted. Automatic zero-tracking and automatic zero-setting mechanisms are prohibited.

(Amended 2010)

S.2.1.1. Manual. – A manual zero-load or no-load reference value setting mechanism shall be operable or accessible only by a tool outside of or entirely separate from this mechanism or enclosed in a cabinet.

S.2.1.2. Semiautomatic. – A semiautomatic zero-load or no-load reference value setting mechanism shall meet the provisions of S.2.1.1. or shall be operable only when:

(a) the indication is stable within ± 3 scale divisions; and

(b) cannot be operated during a weighing operation.

S.2.2. Damping Means. – A system shall be equipped with effective means necessary to bring the indications quickly to a readable, stable equilibrium. Effective means shall also be provided to permit the recording of weight values only when the indication is stable within plus or minus three scale divisions for devices with 10 000 scale divisions, or plus or minus one division for devices with less than 10 000 scale divisions.

S.3. Interlocks and Gate Control.

S.3.1. Gate Position. – Provision shall be made to clearly indicate to the operator the position of the gates leading directly to and from the weigh hopper.

S.3.2. Interlocks. – Each automatic bulk weighing system shall have operating interlocks to provide for the following:

(a) Product cannot be cycled and weighed if the weight recording element is disconnected or subjected to a power loss.

(b) The recording element cannot print a weight if either of the gates leading directly to or from the weigh hopper is open.

(c) A "low paper" sensor, when provided, is activated.

(d) The system will operate only in the proper sequence in all modes of operation.

(e) When an overfill alarm is activated, the system shall indicate and record an overfill condition.

(Amended 1993)

S.3.3. Overfill Sensor.

(a) The weigh hopper shall be equipped with an overfill sensor which will cause the feed gate to close, activate an alarm, and inhibit weighing until the overfill condition has been corrected.
(Added 1993)

(b) If the system is equipped with a lower garner or surge bin, that garner shall also be equipped with an overfill sensor which will cause the gate of the weigh hopper to remain open, activate an alarm, and inhibit weighing until the overfill condition has been corrected.
[Nonretroactive as of January 1, 1998]
(Amended 1997)

S.4. Design of Weighing Elements.

S.4.1. Antifriction Means. – At all points at which a live part of the mechanism may come into contact with another part in the course of normal usage, frictional effects shall be reduced to a minimum by means of suitable antifriction means, opposing surfaces and points being properly shaped, finished, and hardened.

S.4.2. Adjustable Components. – An adjustable component, such as a potentiometer, shall be held securely in adjustment and, except for a component for adjusting level or a no-load reference value, shall not be adjustable from the outside of the device.

S.4.3. Multiple Load-Receiving Elements. – A system with a single indicating or recording element, or a combination indicating recording element, that is coupled to two or more load-receiving elements with independent weighing systems, shall be provided with means to prohibit the activation of any load-receiving element (or elements) not in use, and shall be provided with automatic means to indicate clearly and definitely which load-receiving element (or elements) is in use.

S.4.4. Venting. – All weighing systems shall be vented so that any internal or external pressure will not affect the accuracy or operation of the system.

S.5. Marking Requirements. (Also see Section 1.10. General Code Paragraph G-S.1. Identification.)

S.5.1. Capacity and Value of the Scale Division. – The capacity of the weighing system and the value of the scale division shall be clearly and conspicuously marked on the indicating element near the weight value indications.

S.5.2. Weighing Elements. – On a weighing element not permanently attached to an indicating element, there shall be clearly and permanently marked for the purposes of identification, the name, initials, or trademark of the manufacturer, the manufacturer's designation that positively identifies the pattern or design, and the nominal capacity.

S.5.3. Temperature Limits. *– Unless the temperature range is − 10 °C to + 40 °C (14 °F to 104 °F), the temperature range shall be marked on the device.*
[Nonretroactive as of January 1, 1986]
(Added 1985)

S.5.4. Accuracy Class.

*(a) All systems used to weigh grain shall be marked Class III.**

*(b) All other systems shall be marked either Class III or III L.**

*(*Also see Section 2.20. Scales Code for the parameters for these accuracy classes for scales. The specific requirements for automatic bulk weighing systems apply to these devices when there is a conflict between the Scales Code and the Automatic Bulk Weighing Systems Code.)*
[Nonretroactive as of January 1, 1986]

(Added 1985) (Amended 1992)

N. Notes

N.1. Testing Procedures.

N.1.1. Test Weights. – The increasing load test shall be conducted using test weights equal to at least 10 % of the capacity of the system:

(a) on automatic grain bulk-weighing systems installed after January 1, 1984; and

(b) on other automatic bulk-weighing systems installed after January 1, 1986.

(Amended 1987)

N.1.2. Increasing-Load Test. – An increasing-load test consisting of substitution and strain-load tests shall be conducted up to the used capacity of the weighing system.

(Amended 1987)

N.1.3. Decreasing-Load Test. – A decreasing-load test shall be conducted on devices used to weigh out.

(Added 1986)

N.1.4. Zero-Balance or No-Load Reference Value Change Test. – A test for change of zero-balance or no-load reference value shall be conducted on all scales after the removal of any test load. The change shall not be more than the minimum tolerance applicable.

N.1.5. Discrimination Test. *– A discrimination test shall be conducted on all automatic indicating scales with the weighing device in equilibrium at zero-load and at maximum test load, and under controlled conditions in which environmental factors are reduced to the extent that they will not affect the results obtained.*
[Nonretroactive as of January 1, 1986]

N.1.5.1. Digital Device. – On a digital device, this test is conducted from just below the lower edge of the zone of uncertainty for increasing-load tests, or from just above the upper edge of the zone of uncertainty for decreasing-load tests.

(Added 1987)

N.2. Verification (Testing) Standards. – Standard weights and masses used in verifying weighing devices shall comply with requirements of NIST Handbook 105-1 (Class F) or the tolerances expressed in Appendix A, Fundamental Considerations, paragraph 3.2. (i.e., one-third of the smallest tolerance applied).

T. Tolerances

T.1. Tolerance Application. – Tolerance values shall be applied to all indications and recorded representations of a weighing system.

T.1.1. To Errors of Underregistration and Overregistration. – The tolerances hereinafter prescribed shall be applied equally to errors of underregistration and errors of overregistration.

T.1.2. To Increasing-Load Tests. – Basic tolerances shall be applied.

T.1.3. To Decreasing-Load Tests. – Basic tolerances shall be applied to systems used to weigh out.

(Added 1986)

T.1.4. To Tests Involving Digital Indications or Representations. – To the tolerances that would otherwise be applied, there shall be added an amount equal to one-half the value of the scale division. This does not apply to digital indications or recorded representations that have been corrected for rounding using error weights.

(Added 1986)

T.2. Minimum Tolerance Values. – The minimum tolerance value shall not be less than half the value of the scale division.

T.2.1. For Systems Used to Weigh Construction Materials. – The minimum maintenance and acceptance tolerance shall be 0.1 % of the weighing capacity of the system, or the value of the scale division, whichever is less.

(Added 1986)

T.3. Basic Tolerance Values.

T.3.1. Acceptance Tolerance. – The basic acceptance tolerance shall be one-half the basic maintenance tolerance.

T.3.2. For Systems Used to Weigh Grain. – The basic maintenance tolerance shall be 0.1 % of test load.

T.3.3. For All Other Systems. – The basic maintenance tolerance shall be 0.2 % of test load.

(Amended 1986)

T.4. Time Dependence. *– At constant test conditions, the indication 20 seconds after the application of a load and the indication after one hour shall not differ by more than the absolute value of the applicable tolerance for the applied load.*

[Nonretroactive as of January 1, 1987]

(Added 1986)

T.5. Repeatability. – The results obtained by several weighings of the same load under reasonably static test conditions shall agree within the absolute value of the maintenance tolerance for that load, and shall be within applicable tolerances.

(Added 1986)

T.6. Discrimination, Digital Automatic Indicating Scales. – A test load equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 2.0 d. This requires the zone of uncertainty to be not greater than 0.3 times the value of the scale division.

(Added 1985)

T.7. Influence Factors. *– The following factors are applicable to tests conducted under controlled conditions only, provided that:*

(a) types of devices approved prior to January 1, 1986, and manufactured prior to January 1, 1988, need not meet the requirements of this section; and

(b) new types of devices submitted for approval after January 1, 1986, shall comply with the requirements of this section; and

(c) all devices manufactured after January 1, 1988, shall comply with the requirements of this section.

[Nonretroactive as of January 1, 1986]

T.7.1. Temperature. *– Devices shall satisfy the tolerance requirements under the following temperature conditions:*

T.7.1.1. *If not marked on the device, the temperature limits shall be: − 10 °C to 40 °C (14 °F to 104 °F).*

T.7.1.2. *If temperature limits are specified for the device, the range shall be at least 30 °C (54 °F).*

T.7.1.3. Temperature Effect on Zero-Load Balance. *– The zero-load indicator shall not vary by more than one division per 5 °C (9 °F) change in temperature.*

T.7.1.4. Operating Temperature. *– An indicating or recording element shall not display or record any usable values until the operating temperature necessary for accurate weighing and a stable zero-balance condition has been attained.*
[Nonretroactive as of January 1, 1986]

T.7.2. Barometric Pressure. *– The zero indication shall not vary by more than one scale division for a change in barometric pressure of 1 kPa over the total barometric range of 95 kPa to 105 kPa (28 in to 31 in of mercury).*
[Nonretroactive as of January 1, 1986]

T.7.3. Electric Power Supply.

T.7.3.1. Power Supply, Voltage, and Frequency.

(a) Weighing devices that operate using alternating current must perform within the conditions defined in paragraphs T.2. through T.7., inclusive over the line voltage range of 100 V to 130 V or 200 V to 250 V rms as appropriate and over the frequency range of 59.5 Hz to 60.5 Hz.

(b) Battery-operated instruments shall not indicate nor record values outside the applicable tolerance limits when battery power output is excessive or deficient.

T.7.3.2. Power Interruption. *– A power interruption shall not cause an indicating or recording element to display or record any values outside the applicable tolerance limits.*
[Nonretroactive as of January 1, 1986]

(Added 1985)

UR. User Requirements

UR.1. Selection Requirements.

UR.1.1. For Systems used to Weigh Grain. *– The number of scale divisions of a weighing system shall not be less than 2 000 nor greater than 10 000 divisions.*
[Nonretroactive as of January 1, 1984]

(Amended 1986 and 1992)

UR.1.2. For Systems used to Weigh Commodities other than Grain. *– The number of scale divisions shall not be less than 500 nor greater than 10 000.*
[Nonretroactive as of January 1, 1987]

(Added 1986)

UR.2. Installation Requirements.

UR.2.1. Protection from Environmental Factors. – The indicating elements, the lever system or load cells, the load-receiving element, and any permanently installed test weights shall be adequately protected from environmental factors such as wind, weather, and RFI that may adversely affect the operation or performance of the system.

UR.2.2. Foundation, Supports, and Clearance. – The foundation and supports of any system shall be such as to provide strength, rigidity, and permanence of all components, and clearance shall be provided around all live parts so that no contact can result before or during operation of the system.

UR.3. Loading Requirements.

UR.3.1. For Systems Used to Weigh Grain. – A system shall not be used to weigh drafts less than 40 % of the weighing capacity of the system except for a final partial draft. Loads shall not normally be retained on the weighing element for a period longer than a normal weighing cycle.

(Amended 1986)

UR.3.2. For Systems Used to Weigh Commodities Other than Grain. *– A system shall not be used to weigh drafts less than 20 % of the weighing capacity of the system except for a final partial draft. Loads shall not normally be retained on the weighing element for a period longer than a normal weighing cycle.*
[Nonretroactive as of January 1, 1987]

(Added 1986)

UR.4. System Modification. – The weighing system shall not be modified except when the modification has been approved by a competent engineering authority, preferably that of the engineering department of the manufacturer of the scale, and the official with statutory authority having jurisdiction over the scale.

(Amended 1991)

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Table of Contents

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Section 2.23. Weights

A. Application

A.1. General. – This code applies to commercial weights; that is, weights used in connection with commercial weighing devices.

A.2. Exceptions. – This code does not apply to test weights or to other "standards" of mass.

A.3. Additional Code Requirements. – In addition to the requirements of this code, Weights shall meet the requirements of Section 1.10. General Code.

S. Specifications

S.1. Material. – The material used for weights shall be as follows:

(a) Weights of 6 g or 100 gr and larger shall be made of a metal, or a metal alloy, not softer than brass.

(b) Weights of less than 6 g or 100 gr may be made of aluminum, but shall not be made of iron or of unplated steel, except stainless steel.

T.2. Design.

S.2.1. Surface. – The surface of a weight shall be smooth and shall not be coated with thick, soft, or brittle material. A weight of more than 2 grams or 30 grains or shall not have sharp edges, points, or corners.

S.2.2. Ring. – A ring on a weight shall not be split or removable.

S.3. Adjusting Material. – Adjusting material shall be securely positioned and shall not project beyond the surface of the weight.

S.4. Marking Requirements.

S.4.1. General. – A weight shall be marked to show clearly its nominal value, which shall include identification of the unit; however, the nominal value of a weight of 2 grams or 30 grains, or less, may be designated by dots, lines, figures, distinctive shape, or other appropriate means.

S.4.2. Apothecaries' Weights. – On apothecaries' dram, ounce, and pound weights, the letters "ap" shall be used in combination with the nominal value and the appropriate abbreviation of or symbol for the unit.

S.4.3. Troy Weights. – On troy ounce and pound weights, the letter "t" shall be used in combination with the nominal value and the appropriate symbol of the unit.

S.4.4. Metric Weights. – On metric weights, the symbols "kg," "g," and "mg" shall be used in combination with the nominal value of kilograms, grams, and milligrams, respectively.

S.4.5. Carat Weights. – On carat weights, the letter "c" shall be used in combination with the nominal value.

S.4.6. Counterpoise Weight. – A counterpoise weight shall be marked to show clearly both its nominal value and the value it represents when used on the multiplying-lever scale for which it is intended.

N. Notes

N.1. Testing Procedures. – Commercial weights should be tested on a precision balance using standard weights, the errors of which, when used without correction, do not exceed 1/3 of the smallest tolerance to be applied. (Also see Appendix A, Fundamental Considerations, paragraphs 3.2. Tolerance for Standards and 3.3. Accuracy of Standards.)

T. Tolerances

T.1. In Excess and In Deficiency. – The tolerances hereinafter prescribed shall be applied equally to errors in excess and errors in deficiency.

T.2. On Avoirdupois Weights. – The maintenance tolerances shall be as shown in Table 1. Maintenance Tolerance for Avoirdupois Weights. Acceptance tolerances shall be one-half the maintenance tolerances.

Table 1.
Maintenance Tolerance for Avoirdupois Weights

Maintenance Tolerance						
Nominal Value	Equal-Arm Weights		Counterpoise Weights			
			For scales with multiples of less than 1000		For scales with multiples of 1000 or over	
oz	grains	mg	grains	mg	grains	mg
1/64	0.1	6				
1/32	0.3	19				
1/16	0.4	26				
1/8	0.5	32				
¼	1.0	65				
½	1.5	97	1.0	65		
1	1.7	110	1.0	65		
2	2.0	130	1.0	65		
3	2.0	130	1.5	97		
4	3.0	190	1.5	97	1.0	65
5	3.5	230	1.5	97	1.0	65
6	3.5	230	1.5	97		
8	4.0	260	2.0	130	1.5	97
10	4.0	260	2.5	160	2.0	130
12	5.0	320	2.5	160	2.0	130
lb	grains	mg	grains	mg	grains	mg
1	5.0	320	3.0	190	2.5	160
2	7.0	450	6.0	390	4.0	260
3	9.0	580	9.0	580	5.0	320
4	11.0	710	11.0	710	6.0	390
5	15.0	970	12.0	780	6.5	420
6	17.0	1190				
7	19.0	1200				
8	21.0	1400	15.0	970	9.0	580
9	23.0	1500				
10	25.0	1600	18.0	1160	10.0	650
15	28.0	1800				
20	30.0	1900				
25	35.0	2300				
30	40.0	2600				
40	45.0	2900				
50	50.0	3200				

T.3. On Metric Weights. – The maintenance tolerances shall be as shown in Table 2. Maintenance Tolerances for Metric Weights. Acceptance tolerances shall be one-half the maintenance tolerances.

T.4. On Carat Weights. – The maintenance tolerances shall be as shown in Table 2. Maintenance Tolerances for Metric Weights. Acceptance tolerances shall be one-half the maintenance tolerances.

Table 2.
Maintenance Tolerances for Metric Weights

Nominal Value (mg)	Maintenance Tolerance (mg)	Nominal Value (g)	Maintenance Tolerance (mg)
5 or less	0.1	1	4
10	0.3	2	6
20	0.4	3	8
30	0.6	5	10
50	0.8	10	15
100	1.0	20	20
200	1.5	30	30
300	2.0	50	40
500	3.0	100	70
		200	100
		300	150
		500	175
Nominal Value (kg)	**Maintenance Tolerance (mg)**	**Nominal Value (carats)**	**Maintenance Tolerance (mg)**
1	250	0.25*	0.6
2	400	0.5**	1.0
3	500	1.0	1.5
5	800	2.0	2.0
10	1000	3.0	3.0
20	1500	5.0	4.0
		10.0	6.0
		20.0	10.0
		30.0	12.0
		50.0	15.0
		100.0	25.0
		*25 points or less **50 points	

T.5. On Apothecaries and Troy Weights. – The maintenance tolerances shall be as shown in Table 3. Maintenance Tolerances for Apothecaries' and Troy Weights. Acceptance tolerances shall be one-half the maintenance tolerances.

Table 3.
Maintenance Tolerances for Apothecaries' and Troy Weights

Nominal Value	Maintenance Tolerance		Nominal Value	Maintenance Tolerance	
grains	**grains**	**mg**	**oz**	**grains**	**mg**
1	0.01	0.6	1	0.4	25.0
2	0.02	1.3	2	0.6	40.0
3	0.03	2.0	3	1.0	65.0
5	0.03	2.0	4	1.5	100.0
10	0.04	2.5	5	1.6	105.0
20	0.06	4.0			
scruples	**grains**	**mg**	**oz**	**grains**	**mg**
1	0.06	4.0	6	1.8	115.0
2	0.10	6.5	7	1.9	125.0
			8	2.0	130.0
			9	2.1	135.0
			10	2.2	145.0
dr	**grains**	**mg**	**oz**	**grains**	**mg**
0.5	0.07	4.5	11	2.4	155.0
1.0	0.10	6.5	12	2.5	160.0
2.0	0.20	13.0	20	2.9	190.0
3.0	0.30	20.0	30	3.7	240.0
4.0	0.40	25.0	50	5.4	350.0
5.0	0.50	30.0			
6.0	0.60	40.0			
dwt	**grains**	**mg**	**oz**	**grains**	**mg**
1	0.06	4.0	100	7.7	500.0
2	0.10	6.5	200	12.3	800.0
3	0.15	10.0	300	15.4	1 000.0
4	0.20	13.0	500	23.1	1 500.0
5	0.30	20.0	1 000	38.6	2 500.0
10	0.40	25.0			

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Table of Contents

Section 2.24. Automatic Weighing Systems

A. Application

A.1. General. – This code applies to devices used to automatically weigh pre-assembled discrete loads or single loads or loose materials in applications where automatic weighing systems[1] are used or employed in the determination of quantities, things, produce, or articles for distribution, for purchase, offered or submitted for sale, for distribution, purchase, or in computing any basic charge or payment for services rendered on the basis of weight, and in packaging plants subject to regulation by the USDA. Some weigh-labelers and checkweighers may also include a scale that is incorporated in a conveyor system that weighs packages in a static or non-automatic weighing mode.[2]

This includes:

(a) Automatic weigh-labelers;

(b) Combination automatic and non-automatic weigh-labelers;

(c) Automatic checkweighers;

(d) Combination automatic and non-automatic checkweighers; and

(e) Automatic gravimetric filling machines that weigh discrete loads or single loads of loose materials and determine package and production lot compliance with net content representations.

(Amended 1997 and 2004)

A.2. Exceptions. – This code does not apply to:

(a) Belt-Conveyor Scale Systems;

(b) Railway Track Scales;

(c) Monorail Scales;

(d) Automatic Bulk-Weighing Systems;

(e) Devices that measure quantity on a time basis;

[1] An automatic weighing system does not require the intervention of an operator during the weighing process. The necessity to give instructions to start a process or to release a load or the function of the instrument (static, dynamic, set-up, etc.) is not relevant in deciding the category of automatic or non-automatic instruments.

(Added 2004)

[2] Prepackaging scales (and other commercial devices) used for putting up packages in advance of sale are acceptable for use in commerce if all appropriate provisions of Handbook 44 are met. Users of such devices must be alert to the legal requirements relating to the declaration of quantity on a package. Such requirements are to the effect that, on the average, the contents of the individual packages of a particular commodity comprising a lot, shipment, or delivery must contain at least the quantity declared on the label. The fact that a scale or other commercial device may overregister, but within established tolerances, and is approved for commercial service is not a legal justification for packages to contain, on the average, less than the labeled quantity.

(Added 2004)

(f) Controllers or other auxiliary devices except as they may affect the weighing performance; or

(g) Automatic gravimetric filling machines and other automatic weighing systems employed in determining the weight of a commodity in a plant or business with a separate quantity control program (e.g., a system of statistical process control) using suitable weighing instruments and measurement standards traceable to national standards to determine production lot compliance with net content representations.[3]

(Added 2004)

A.3. Additional Code Requirements. – In addition to the requirements of this code, Automatic Weighing Systems 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. Zero Indication.

(a) A weigh-labeler shall be equipped with an indicating or recording element. Additionally, a weigh-labeler equipped with an indicating or recording element shall either indicate or record a zero-balance condition and an out-of-balance condition on both sides of zero.

(Amended 2004)

(b) An automatic checkweigher may be equipped with an indicating or recording element.

(c) A zero-balance condition may be indicated by other than a continuous digital zero indication, provided that effective automatic means is provided to inhibit a weighing operation or to return to a continuous digital indication when the device is in an out-of-balance condition.

S.1.1.1. Digital Indicating Elements.

(a) A digital zero indication shall represent a balance condition that is within ± ½ scale division.

(b) A digital indicating device shall either automatically maintain a "center of zero" condition to ± ¼ scale division or less or have an auxiliary or supplemental "center-of-zero" indicator that defines a zero-balance condition to ± ¼ scale division or less.

(c) Verification of the accuracy of the center of zero indication to ± ¼ scale division or less during automatic operation is not required on automatic checkweighers.

(Amended 2004)

S.1.2. Value of Division Units. – The value of a division d expressed in a unit of weight shall be equal to:

(a) 1, 2, or 5; or

(b) a decimal multiple or submultiple of 1, 2, or 5.

The requirement that the value of the scale division be expressed only as 1, 2, or 5, or a decimal multiple or submultiple of only 1, 2, or 5 does not apply to net weight indications and recorded representations that are calculated from gross and tare weight indications where the scale division of the gross weight is different from the scale division of the tare weight(s) on multi-interval or multiple range scales. For example, a multiple range

[3] See NIST Handbook 130, "Uniform Laws and Regulations in the Area of Legal Metrology and Fuel Quality," Interpretations and Guidelines, paragraph 2.6.11. Good Quantity Control Practices.

or multi-interval scale may indicate and record tare weights in a lower weighing range (WR) or weighing segment (WS), gross weights in the higher weighing range or weighing segment, and net weights as follows:

55 kg	Gross Weight (WR2 d = 5 kg)		10.05 lb	Gross Weight (WS2 d = 0.05 lb)	
– 4 kg	Tare Weight	(WR1 d = 2 kg)	– 0.06 lb	Tare Weight	(WS1 d = 0.02 lb)
= 51 kg	Net Weight	(Mathematically Correct)	= 9.99 lb	Net Weight	(Mathematically Correct)

(Amended 2008)

S.1.2.1. Weight Units. – Except for postal scales, indicating and recording elements for shipping and postal applications, and scales used to print standard pack labels, a device shall indicate weight values using only a single unit of measure.

(Amended 2004)

S.1.3. Provision for Sealing.

(a) **Automatic Weighing Systems, Except Automatic Checkweighers.** – 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, a device shall be designed with provision(s) as specified in Table S.1.3. Categories of Device and Methods of Sealing 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.

(b) **For Automatic Checkweighers.** – Security seals are not required in applications where it would prohibit an authorized user from having access to the calibration functions of a device.

(Amended 2019)

Table S.1.3.
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.	The hardware enabling access for remote communication must be at the device and sealed using a physical seal or two event counters: one for calibration parameters and one for configuration parameters.
Category 3: Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).	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 through the device or through another on-site device. 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.)

S.1.4. Automatic Calibration. – 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.

S.1.5. Adjustable Components. – Adjustable components shall be held securely in adjustment and, except for a zero-load balance mechanism, shall be located within the housing of the element.

S.2. Design of Zero and Tare Mechanisms.

S.2.1. Zero Load Adjustment.

S.2.1.1. Automatic Zero-Tracking Mechanism. – Except for automatic checkweighers, under normal operating conditions the maximum load that can be "rezeroed," when either placed on or removed from the platform all at once, shall be 1.0 scale division.

Except for an initial zero-setting mechanism, an automatic zero adjustment outside these limits is prohibited.
(Amended 2004 and 2010)

S.2.1.2. Initial Zero-Setting Mechanism. – Except for automatic checkweighers, an initial zero-setting mechanism shall not zero a load in excess of 20 % of the maximum capacity of the automatic weighing system unless tests show that the scale meets all applicable tolerances for any amount of initial load compensated by this device within the specified range.

S.2.2. Tare. – On any automatic weighing system (except for multi-interval scales or multiple range scales when the value of tare is determined in a lower weighing range or weighing segment) the value of the tare division shall be equal to the value of the scale division. The tare mechanism shall operate only in a backward direction (i.e., in a direction of underregistration) with respect to the zero-load balance condition of the automatic weighing system. A device designed to automatically clear any tare value shall also be designed to prevent the automatic clearing of tare until a complete transaction has been indicated.
(Amended 2008)

Note: On a computing automatic weighing system, this requires the input of a unit price, the display of the unit price, and a computed positive total price at a readable equilibrium. Other devices require that a transaction or lot run be completed.
(Note Amended 2004)

S.3. Verification Scale Interval.

S.3.1. Multiple Range and Multi-Interval Automatic Weighing System. – The value of e shall be equal to the value of d.

S.3.2. Load Cell Verification Interval Value. – The relationship of the value for the load cell verification scale interval, v_{min}, to the scale division d for a specific scale installation shall be:

$$v_{\min} \leq \frac{d}{\sqrt{N}}$$ where N is the number of load cells in the scale.

Note: When the value of the scale division d differs from the verification scale division e for the scale, the value of e must be used in the formula above.

This requirement does not apply to complete weighing/load-receiving elements or scales which satisfy all the following criteria:

- *the complete weighing/load-receiving element or scale has been evaluated for compliance with T.7.1. Temperature under the National Type Evaluation Program (NTEP);*
- *the complete weighing/load-receiving element or scale has received an NTEP Certificate of Conformance; and*
- *the complete weighing/load-receiving element or scale is equipped with an automatic zero-tracking mechanism which cannot be made inoperative in the normal weighing mode. (A test mode which permits the disabling of the automatic zero-tracking mechanism is permissible, provided the scale cannot function normally while in this mode.)*

[Nonretroactive as of January 1, 2020]

(Amended 2019)

S.3.3. Value of "e". – For automatic checkweighers, the value of e shall be specified by the manufacturer and may be larger than d, but in no case can e be more than ten times the value of d.

S.4. Weight Indicators, Weight Displays, Reports, and Labels.

S.4.1. Additional Digits in Displays. – Auxiliary digital displays that provide additional digits for use during performance evaluation may be included on automatic checkweighers. However, in cases where these indications are not valid for determining the actual weight of a package (e.g., only appropriate for use in statistical process control programs by users) they shall be clearly and distinctly differentiated from valid weight displays by indicating them to the user.

For example, the additional digits may be differentiated by color, partially covered by placing crosshatch overlays on the display, or made visible only after the operator presses a button or turns a key to set the device in a mode which enables the additional digits.

S.4.2. Damping. – An indicating element equipped with other than automatic recording elements shall be equipped with effective means to permit the recording of weight values only when the indication is stable within plus or minus one scale division. The values recorded shall be within applicable tolerances.

S.4.3. Over Capacity Indication. – An indicating or recording element shall not display nor record any values when the scale capacity is exceeded by nine scale divisions.

S.4.4. Label Printer. – A device that produces a printed ticket to be used as the label for a package shall print all values digitally and of such size, style of type, and color as to be clear and conspicuous on the label.

S.4.4.1. Label Printing. – If an automatic checkweigher prints a label containing weight information that will be used in a commercial transaction, it must conform to all of the requirements specified for weigh-labelers so that the printed ticket meets appropriate requirements.

S.5. Accuracy Class.

S.5.1. Marking. – Weigh-labelers and automatic checkweighers shall be Class III devices and shall be marked accordingly, except that a weigh-labeler marked Class IIIS may be used in package shipping applications.

(Amended 1997)

S.6. Parameters for Accuracy Classes. – The number of divisions for device capacity is designated by the manufacturer and shall comply with parameters shown in Table S.6. Parameters for Accuracy Classes.

Table S.6.
Parameters for Accuracy Classes

		Number of Divisions (n)	
Class	**Value of the Verification Division (e)**	**Minimum**	**Maximum**
SI Units			
III	0.1 g to 2 g, inclusive	100	10 000
	equal to or greater than 5 g	500	10 000
U.S. Customary Units			
III	0.0002 lb to 0.005 lb, inclusive	100	10 000
	0.005 oz to 0.125 oz, inclusive	100	10 000
	equal to or greater than 0.01 lb	500	10 000
	equal to or greater than 0.25 oz	500	10 000
IIIS	greater than 0.01 lb	100	1 000
	greater than 0.25 oz	100	1 000
For Class III devices, the value of e is specified by the manufacturer as marked on the device; d shall not be smaller than 0.1 e. e shall be differentiated from d by size, shape, or color.			

(Amended 2004)

S.7. Marking Requirements. – [Also see G-S.1. Identification, G-S.4. Interchange or Reversal of Parts, G-S.6. Marking Operational Controls, Indications, and Features, G-S.7. Lettering, G-UR.2.1.1. Visibility of Identification, and UR.3.3. Special Designs]

S.7.1. Location of Marking Information. – Automatic weighing systems which are not permanently attached to an indicating element, and for which the load-receiving element is the only part of the weighing/load-receiving element visible after installation, may have the marking information required in Section 1.10. General Code, G-S.1. Identification, and Section 2.24. Automatic Weighing Systems Code, Table S.7.a. Marking Requirements and Table S.7.b. Notes for Table S.7.a. located in an area that is accessible only through the use of a tool; provided that the information is easily accessible (e.g., the information may appear on the junction box under an access plate). The identification information for these automatic weighing systems shall be located on the weighbridge (load-receiving element) near the point where the signal leaves the weighing element, or beneath the nearest access cover.

Table S.7.a.
Marking Requirements

To Be Marked With ⇓	Weighing Equipment				
	Weighing, load-receiving, and indicating element in same housing	**Indicating element not permanently attached to weighing and load-receiving element**	**Weighing and load-receiving element not permanently attached to indicating element**	**Load cell with CC (10)**	**Other equipment or device (9)**
Manufacturer's ID (1)	x	x	x	x	x
Model Designation (1)	x	x	x	x	x
Serial Number and Prefix (2)	x	x	x	x	x (13)
Certificate of Conformance (CC) Number (16)	x	x	x	x	x (16)
Accuracy Class (14)	x	x (8)	x	x	
Nominal Capacity (3)(15)	x	x	x		
Value of Division, d (3)	x	x			
Value of e (4)	x	x			
Temperature Limits (5)	x	x	x	x	
Special Application (11)	x	x	x		
Maximum Number of Scale Divisions, n_{max} (6)		x (8)	x	x	
Minimum Verification Division, (e_{min})			x		
"S" or "M" (7)				x	
Direction of Loading (12)				x	
Minimum Dead Load				x	
Maximum Capacity (Max)	x			x	
Minimum Capacity (Min)	x				
Safe Load Limit				x	
Load Cell Verification Interval (v_{min})				x	
Maximum Belt Speed (m/sec or m/min)	x		x		
Note: Also see Table S.7.b. for applicable parenthetical notes.					

(Amended 1999)

Table S.7.b.
Notes for Table S.7.a.

1. Manufacturer's identification and model designation. (Also see G-S.1. Identification)

2. Serial number and prefix. Also see G-S.1. Identification)

3. The nominal capacity and value of the automatic weighing system division shall be shown together (e.g., 50 000 × 5 kg, or 30 × 0.01 lb) adjacent to the weight display when the nominal capacity and value of the automatic weighing system division are not immediately apparent. Each division value or weight unit shall be marked on variable-division value or division-unit automatic weighing systems.

4. Required only if different from d.

5. Required only on automatic weighing systems if the temperature range on the NTEP CC is narrower than and within – 10 ºC to 40 ºC (14 ºF to 104 ºF).
   (Amended 2007)

6. This value may be stated on load cells in units of 1000; (e.g., n_{max} 10 is 10 000 divisions.)

7. Denotes compliance for single or multiple load cell applications.

8. An indicating element not permanently attached to a weighing element shall be clearly and permanently marked with the accuracy Class III, or IIIS and the maximum number of divisions, n_{max}.

9. Necessary to the weighing system but having no metrological effect (e.g., auxiliary remote display, keyboard, etc.).

10. The markings may be either on the load cell or in an accompanying document; except that, if an accompanying document is provided, the serial number shall appear both on the load cell and in the document. The manufacturer's name or trademark, the model designation, and identifying symbol for the serial number shall also be marked both on the load cell and in any accompanying document.

11. An automatic weighing system designed for a special application rather than general use shall be conspicuously marked with suitable words visible to the operator and customer restricting its use to that application.

12. Required if the direction of loading the load cell is not obvious.

13. Serial number and prefix (Also see G-S.1. Identification) modules without "intelligence" on a modular system (e.g., printer, keyboard module, cash drawer, and secondary display in a point-of-sale system) are not required to have serial numbers.

14. The accuracy class of a device shall be marked on the device with the appropriate designation.

15. The nominal capacity shall be conspicuously marked on any automatic-indicating or recording automatic weighing system so constructed that the capacity of the indicating or recording element, or elements, is not immediately apparent.

16. Required only if a CC has been issued for the equipment.

S.7.2. Marking Required on Components of Automatic Weighing Systems. – The following components of automatic weighing systems shall be marked as specified in Tables S.7.a. Marking Requirements and S.7.b. Notes for Table S.7.2.a.:

(a) Main elements and components when not contained in a single enclosure for the entire automatic weighing system;

(b) Load cells for which Certificates of Conformance (CC) have been issued under the National Type Evaluation Program; and

(c) Other equipment necessary to a weighing system but having no metrological effect on the weighing system.

N. Notes

N.1. Test Requirements for Automatic Weighing Systems.

N.1.1. Test Pucks and Packages.

(a) Test pucks and packages shall be:

(1) representative of the type, size, and weight ranges to be weighed on a device; and

(2) stable while in motion, hence the length and width of a puck or package should be greater than its height.

(b) For type evaluation the manufacturer shall supply the test pucks or packages for each range of test loads.

(Amended 1997)

N.1.2. Accuracy of Test Pucks or Packages. – The error in any test puck or package shall not exceed one-fourth (¼) of the acceptance tolerance. If packages are used to conduct field tests on automatic weighing systems, the package weights shall be determined on a reference scale or balance with an inaccuracy that does not exceed one-fifth (1/5) of the smallest tolerance that can be applied to the device under test.

N.1.3. Verification (Testing) Standards. – Field standard weights shall comply with requirements of NIST Handbook 105-1, "Specifications and Tolerances for Field Standard Weights (Class F)" or the tolerances expressed in Fundamental Considerations, paragraph 3.2. (i.e., one-third of the smallest tolerance applied).

N.1.4. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility, Field Evaluation. – An RFI test shall be conducted at a given installation when the presence of RFI has been verified and characterized if those conditions are considered "usual and customary."

(Added 2004)

N.1.5. Tests Loads. – A performance test shall consist of four separate test runs conducted at different test loads according to Table N.1.5. Test Loads.

Table N.1.5. Test Loads
At or near minimum capacity
At or near maximum capacity
At two (2) critical points between minimum and maximum capacity
Test may be conducted at other loads if the device is intended for use at other specific capacities

N.1.6. Influence Factor Testing. – Influence factor testing shall be conducted statically.

N.2. Test Procedures - Weigh-Labelers. – If the device is designed for use in a non-automatic weighing mode, it shall be tested in the non-automatic mode according to NIST Handbook 44, Section 2.20. Scales Code.

Note: If the device is designed for only automatic weighing, it shall only be tested in the automatic weighing mode.
(Amended 2004)

N.2.1. Non-Automatic Tests.

N.2.1.1. Increasing-Load Test. – The increasing-load test shall be conducted with the test loads approximately centered on the load-receiving element of the scale.

N.2.1.2. Decreasing-Load Test. – The decreasing-load test shall be conducted with the test loads approximately centered on the load-receiving element of the scale.

N.2.1.3. Shift Test. – To determine the effect of off-center loading, a test load equal to one-half (½) maximum capacity shall be placed in the center of each of the four points equidistant between the center and front, left, back, and right edges of the load receiver.

N.2.1.4. Discrimination Test. – A discrimination test shall be conducted with the weighing device in equilibrium at zero-load and at maximum test load, and under controlled conditions in which environmental factors are reduced to the extent that they will not affect the results obtained. This test is conducted from just below the lower edge of the zone of uncertainty for increasing-load tests, or from just above the upper edge of the zone of uncertainty for decreasing-load tests.

N.2.1.5. Zero-Load Balance Change. – A zero-load balance change test shall be conducted on all automatic weighing systems after the removal of any test load. The zero-load balance should not change by more than the minimum tolerance applicable. (Also see G-UR.4.2. Abnormal Performance)
(Amended 2004)

N.2.2. Automatic Test Procedures.

N.2.2.1. Tests Non-Automatic. – If the automatic weighing system is designed to operate non-automatically, and is used in that manner, during normal use operation, it shall be tested non-automatically using mass standards. The device shall not be tested non-automatically if it is used only in the automatic mode.

N.2.2.2. Automatic Tests. – The device shall be tested at the normal operating speed using packages. Test runs should be conducted using at least two test loads distributed over its normal weighing range (e.g., near the lowest and highest ranges in which the device is typically operated.) Each test load should be run a minimum of ten consecutive times.
(Amended 2004)

N.3. Test Procedures - Automatic Checkweigher.

N.3.1. Tests Non-Automatic. – If the scale is designed to operate non-automatically during normal user operation, it shall be tested non-automatically according to paragraphs N.2.1.1. Increasing Load Test through N.2.1.5. Zero-Balance Change.
(Amended 2004)

N.3.2. Automatic Tests. – The device shall be tested at the highest speed in each weight range using standardized test pucks or packages. Test runs shall be conducted using two test loads. The number of consecutive test weighments shall be as specified in Table N.3.2. Number of Sample Weights per Test for Automatic Checkweighers.

(Amended 2004)

Table N.3.2.
Number of Sample Weights per Test for Automatic Checkweighers

Weighing Range m = mass of test load	Number of Sample Weights per Test	
	Field	Type Evaluation
20 divisions ≤ m ≤ 10 kg 20 divisions ≤ m ≤ 22 lb	30	60
10 kg < m ≤ 25 kg 22 lb < m ≤ 55 lb	16	32
25 kg < m ≤ 100 kg 55 lb < m ≤ 220 lb	10	20
100 kg (220 lb) < m	10	10

T. Tolerances

T.1. Principles.

T.1.1. Design. – The tolerance for a weighing device is a performance requirement independent of the design principle used.

T.1.2. Scale Division. – The tolerance for a weighing device is related to the value of the scale division (d) or the value of the verification scale division (e) and is generally expressed in terms of d or e. The random tolerance for automatic checkweighers is expressed in terms of Maximum Allowable Variance (MAV).

T.2. Tolerance Application.

T.2.1. General. – The tolerance values are positive (+) and negative (−) with the weighing device adjusted to zero at no load. When tare is in use, the tolerance values are applied from the tare zero reference (zero net weight indication); the tolerance values apply to the net weight indication for any possible tare load using certified test loads.

(Amended 2008)

T.2.2. Type Evaluation Examinations. – For type evaluation examinations, the tolerance values apply to increasing and decreasing load tests within the temperature and power supply limits specified in T.7. Influence Factors.

(Amended 2004)

T.2.3. Subsequent Verification Examinations. – For subsequent verification examinations, the tolerance values apply regardless of the influence factors in effect at the time of the conduct of the examination. (Also see G-N.2. Testing with Nonassociated Equipment.)

(Added 2007)

T.2.4. Multiple Range and Multi-Interval Automatic Weighing System. – For multiple range and multi-interval devices, the tolerance values are based on the value of the scale division of the range in use.

T.3. Tolerance Values.

Table T.3. Class III - Tolerance in Divisions (e)		
Test Load in Divisions	**Tolerance in Divisions**	
Class III	**Acceptance**	**Maintenance**
0 - 500	± 0.5	± 1
501 - 2000	± 1.0	± 2
2001 - 4000	± 1.5	± 3
4001 +	± 2.5	± 5

T.3.1. Tolerance Values – Class III Weigh-Labeler. (Also see Section T.3.2. Class IIIS Weigh-Labelers.)

T.3.1.1. Non-automatic Tests. – Tolerance values shall be as specified in Table T.3. Class III - Tolerance in Divisions (e).
(Amended 2004)

T.3.1.2. Automatic Tests. – Acceptance tolerance values shall be the same as maintenance tolerance values specified in Table T.3. Class III - Tolerance in Divisions (e).
(Amended 2004)

T.3.2. Tolerance Values - Class IIIS Weigh-labelers in Package Shipping Applications.
(Added 1997)

T.3.2.1. Non-automatic Tests. – Tolerance values shall be as specified in Table T.3.2.1. Non-automatic Tolerances for Class IIIS Weigh-labelers.
(Amended 2004)

T.3.2.2. Automatic Tests. – Tolerance values specified in Table T.3.2.2. Automatic Tolerances for Class IIIS Weigh-labelers shall be applied.
(Amended 2004)

Table T.3.2.1. Non-Automatic Tolerances for Class IIIS Weigh-Labelers		
Test Load in Divisions	**Tolerance in Divisions**	
Class IIIS	**Acceptance**	**Maintenance**
0 - 50	± 0.5	± 1
51 - 200	± 1.0	± 2
201 - 1000	± 1.5	± 3

(Added 1997) (Amended 2004)

Table T.3.2.2. Automatic Tolerances for Class IIIS Weigh-Labelers		
Test Load in Divisions	**Tolerance in Divisions**	
Class IIIS	**Acceptance**	**Maintenance**
0 - 50	± 1.5	± 2
51 - 200	± 2.0	± 3
201 - 1000	± 2.5	± 4

(Added 1997) (Amended 2004)

T.3.3. Tolerance Values. – Automatic Checkweighers.

T.3.3.1. Laboratory Tests for Automatic Checkweighers.

T.3.3.1.1. Non-Automatic Tests. – The acceptance tolerance values specified in Table T.3. Class III - Tolerance in Divisions (e), shall be applied.
(Amended 2004)

T.3.3.1.2. Automatic Tests.

(a) The systematic error for each test run shall be within the acceptance tolerances specified in Table T.3. Class III - Tolerance in Divisions (e) for the test loads specified in Table N.1.5. Test Loads.
(Amended 2004)

(b) The standard deviation of the results shall not exceed one-ninth ($^1/_9$) of the MAV for specific package weights (which means that three standard deviations cannot exceed one-third ($^1/_3$) of the MAV value) as required in the latest edition of NIST Handbook 133, "Checking the Net Contents of Packaged Goods." This value does not change regardless of whether acceptance or maintenance tolerances are being applied to the device under test.
(Amended 2004)

(1) For U.S. Department of Agriculture (USDA) inspected meat and poultry products packaged at a plant subject to inspection by the USDA Food Safety and Inspection Service, use NIST Handbook 133, Appendix A. Tables, Table 2-9, U.S. Department of Agriculture, Meat and Poultry, Groups and Lower Limits for Individual Packages;

(2) for all other packages with a labeled net quantity in terms of weight, use NIST Handbook 133, Appendix A. Tables, Table 2-5, Maximum Allowable Variations (MAVs) for Packages Labeled by Weight; or

(3) for all packages with a labeled net quantity in terms of liquid or dry volume use NIST Handbook 133, Appendix A. Tables, Table 2-6, Maximum Allowable Variations (MAVs) for Packages Labeled by Liquid or Dry Volume.

(Amended 2004)

T.3.3.2. Field Tests for Automatic Checkweighers.

T.3.3.2.1. Non-Automatic Test. – The tolerance values shall be as specified in Table T.3. Class III – Tolerance in Divisions (e).
(Amended 2004)

T.3.3.2.2. Automatic Test.

(a) The systematic error requirement is not applied in a field test.

(b) The standard deviation of the test results shall not exceed one-ninth ($^1/_9$) of the MAV for specific package weights (which means that three standard deviations cannot exceed one-third ($^1/_3$) of the MAV value) as required in the latest Edition of NIST Handbook 133. This value does not change regardless of whether acceptance or maintenance tolerances are being applied to the device under test.
(Amended 2004)

(1) For USDA inspected meat and poultry products packaged at a plant subject to inspection by the USDA Food Safety and Inspection Service, use NIST Handbook 133, Appendix A, Tables, Table 2-9, U.S. Department of Agriculture, Meat and Poultry, Groups and Lower Limits for Individual Packages;

(2) for all other packages with a labeled net quantity in terms of weight, use NIST Handbook 133, Appendix A. Tables, Table 2-5, Maximum Allowable Variations (MAVs) for Packages Labeled by Weight; or

(3) for all packages with a labeled net quantity in terms of liquid or dry volume use NIST Handbook 133, Appendix A. Tables, Table 2-6. Maximum Allowable Variations (MAVs) for Packages Labeled by Liquid or Dry Volume.

T.4. Agreement of Indications. – In the case of a weighing system equipped with more than one indicating element or indicating element and recording element combination, the difference in the weight value indications of any load shall not be greater than the absolute value of the applicable tolerance for that load and shall be within tolerance limits.

T.5. Repeatability. – The results obtained from several weighings of the same load under reasonably constant test conditions shall agree within the absolute value of the maintenance tolerance for that load and shall be within applicable tolerances.
(Amended 2004)

T.6. Discrimination. – A test load equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 2.0 d. This requires the zone of uncertainty to be not greater than 0.3 d (See N.2.1.4. Discrimination Test).
(Amended 2004)

T.7. Influence Factors. – The following factors are applicable to tests conducted under controlled conditions only.

T.7.1. Temperature. – Devices shall satisfy the tolerance requirements under the following temperature conditions:

T.7.1.1. if not specified in the operating instructions or if not marked on the device, the temperature limits shall be: − 10 °C to 40 °C (14 °F to 104 °F).

T.7.1.2. if temperature limits are specified for the device, the range shall be at least 30 °C (54 °F).

T.7.1.3. Temperature Effect on Zero-Load Balance. – The zero-load indication shall not vary by more than one division per 5 °C (9 °F) change in temperature.

T.7.1.4. Operating Temperature. – The indicating or recording element shall not display nor record any usable values until the operating temperature necessary for accurate weighing and a stable zero balance condition have been attained.

T.7.2. Electric Power Supply.

T.7.2.1. Range of Voltages.

(a) Automatic weighing systems that operate using alternating current must perform within the conditions defined in paragraphs T.3. Tolerance Values through T.6. Discrimination, inclusive, when tested over the range of − 15 % to + 10 % of the marked nominal line voltage(s) at 60 Hz, or the voltage range marked by the manufacturer, at 60 Hz.

(b) Automatic weighing systems that operate using DC current must perform within the conditions defined in paragraphs T.3. Tolerance Values through T.6. Discrimination, inclusive, when tested over the range from minimum operating voltage[4] to + 20 % of the voltage marked on the instrument (nominal voltage).

(c) Battery-operated electronic automatic weighing systems with external or plug-in power supply (AC or DC) shall either continue to function correctly or not indicate any weight values if the voltage is below the manufacturer's specified value, the latter being larger than or equal to the minimum operating voltage.[4]

Note: This requirement applies only to metrologically significant voltage supplies.

(Amended 2001)

(Amended 2004)

T.7.2.2. Power Interruption. – A power interruption shall not cause an indicating or recording element to display or record any values outside the applicable tolerance limits.

T.8. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility. – The difference between the weight indication with the disturbance and the weight indication without the disturbance (also see N.1.4. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility, Field Evaluation) shall not exceed one scale division (d) or the equipment shall:

(a) blank the indication;

(b) provide an error message; or

(c) the indication shall be so completely unstable that it could not be interpreted, or transmitted into memory or to a recording element, as a correct measurement value.

(Amended 2004)

UR. User Requirements

UR.1. Selection Requirements. – 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 capacity, number of scale divisions, value of the scale division or verification scale division, minimum capacity, and computing capability.

UR.1.1. General. – Automatic Weighing Systems shall be designated by the manufacturer for that service.

UR.1.2. Value of the Indicated and Recorded Scale Division. – The value of the division as recorded shall be the same as the division value indicated.

UR.2. Installation Requirements.

UR.2.1. Protection from Environmental Factors. – The indicating elements, the lever system or load cells, and the load-receiving element of a permanently installed scale, and the indicating elements of a scale not intended to be permanently installed, shall be adequately protected from environmental factors such as wind, weather, and RFI that may adversely affect the operation or performance of the device.

UR.2.2. Foundation, Supports, and Clearance. – The foundation and supports of any scale installed in a fixed location shall be such as to provide strength, rigidity, and permanence of all components, and clearance

[4] The minimum operating voltage is defined as the lowest possible operating voltage before the automatic weighing system no longer indicates nor records weight values.

(Added 2004)

shall be provided around all live parts to the extent that no contacts may result when the load-receiving element is empty, nor throughout the weighing range of the scale.

UR.2.3. Entry and Departure from Weighing Area. – The belt or other conveyance that introduces the weighed load to the weighing zone and that carries the weighed load away from the weighing zone shall be maintained per the manufacturer's recommendations.

UR.3. Use Requirements.

UR.3.1. Minimum Load. – The minimum load shall be as specified by the manufacturer, but not less than twenty divisions since the use of a device to weigh light loads is likely to result in relatively large errors.

UR.3.1.1. Minimum Load for Class IIIS Weigh-Labelers. – The minimum load shall be as specified by the manufacturer, but not less than ten divisions since the use of a device to weigh light loads is likely to result in relatively large errors.

(Added 1997)

UR.3.2. Maximum Load. – An automatic weighing system shall not be used to weigh a load of more than its maximum capacity.

(Amended 2004)

UR.3.3. Special Designs. – An automatic weighing system designed and marked for a special application shall not be used for other than its intended purpose.

UR.3.4. Use of Manual Gross Weight Entries. – Manual entries are permitted only when a device or system is generating labels for standard weight packages.

UR.4. Maintenance Requirements.

UR.4.1. Balance Condition. – If an automatic weighing system is equipped with a zero-load display, the zero-load adjustment of an automatic weighing system shall be maintained so that the device indicates or records a zero-balance condition.

UR.4.2. Level Condition. – If an automatic weighing system is equipped with a level-condition indicator, the automatic weighing system shall be maintained in level.

UR.4.3. Automatic Weighing System Modification. – The length or the width of the load-receiving element of an automatic weighing system shall not be increased beyond the manufacturer's design dimension, nor shall the capacity of an automatic weighing system be increased beyond its design capacity by replacing or modifying the original primary indicating or recording element with one of a higher capacity, except when the modification has been approved by competent engineering authority, preferably that of the engineering department of the manufacturer of the automatic weighing system, and by the weights and measures authority having jurisdiction over the automatic weighing system.

Table of Contents

Section 2.25. Weigh-In-Motion Systems Used for Vehicle Enforcement Screening – Tentative Code

This tentative code has a trial or experimental status and is not intended to be enforced. The requirements are designed for study prior to the development and adoption of a final code. Officials wanting to conduct an official examination of a device or system are advised to see paragraph G-A.3. Special and Unclassified Equipment.

(Tentative Code Added 2015)

A. Application

A.1. General. – This code applies to systems used to weigh vehicles, while in motion, for the purpose of screening and sorting the vehicles based on the vehicle weight to determine if a static weighment is necessary.

A.2. Exception. – This code does not apply to weighing systems intended for the collection of statistical traffic data.

A.3. Additional Code Requirements. – In addition to the requirements of this code, weigh-in-motion screening systems 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. Ready Indication. – The system shall provide a means of verifying that the system is operational and ready for use.

S.1.2. Value of System Division Units. – The value of a system division "d" expressed in a unit of weight shall be equal to:

(a) 1, 2, or 5; or

(b) a decimal multiple or submultiple of 1, 2, or 5.

Examples: divisions may be 10, 20, 50, 100; or 0.01, 0.02, 0.05; or 0.1, 0.2, 0.5, etc.

S.1.2.1. Units of Measure. – The system shall indicate weight values using only a single unit of measure.

S.1.3. Maximum Value of Division. – The value of the system division "d" for a Class A, weight-in-motion system shall not be greater than 50 kg (100 lb).

S.1.4. Value of Other Units of Measure.

S.1.4.1. Speed. – Vehicle speeds shall be measured in miles per hour or kilometers per hour.

S.1.4.2. Axle-Spacing (Length). – The center-to-center distance between any two successive axles shall be measured in:

(a) meters and decimal submultiples of a meter;

(b) feet and inches; or

(c) feet and decimal submultiples of a foot.

S.1.4.3. Vehicle Length. – If the system is capable of measuring the overall length of the vehicle, the length of the vehicle shall be measured in feet and/or inches, or meters.

S.1.5. Capacity Indication. – An indicating or recording element shall not display nor record any values greater than 105 % of the specified capacity of the load receiving element.

S.1.6. Identification of a Fault. – Fault conditions shall be presented to the operator in a clear and unambiguous means. The following fault conditions shall be identified:

(a) Vehicle speed is below the minimum or above the maximum speed as specified.

(b) The maximum number of vehicle axles as specified has been exceeded.

(c) A change in vehicle speed greater than that specified has been detected.

S.1.7. Recorded Representations.

S.1.7.1. Values to be Recorded. – At a minimum, the following values shall be printed and/or stored electronically for each vehicle weighment:

(a) transaction identification number;

(b) lane identification (required if more than one lane at the site has the ability to weigh a vehicle in motion);

(c) vehicle speed;

(d) number of axles;

(e) weight of each axle;

(f) identification and weight of axle groups;

(g) axle spacing;

(h) total vehicle weight;

(i) all fault conditions that occurred during the weighing of the vehicle;

(j) violations, as identified in paragraph S.2.1. Violation Parameters, which occurred during the weighing of the vehicle; and

(k) time and date.

S.1.8. Value of the Indicated and Recorded System Division. – The value of the system's division "(d)," as recorded, shall be the same as the division value indicated.

S.2. System Design Requirements.

S.2.1. Violation Parameters. – The instrument shall be capable of accepting user-entered violation parameters for the following items:

(a) single axle weight limit;

(b) axle group weight limit;

(c) gross vehicle weight limit; and

(d) bridge formula maximum.

The instrument shall display and/or record violation conditions when these parameters have been exceeded.

S.3. Design of Weighing Elements.

S.3.1. Multiple Load-Receiving Elements. – An instrument with a single indicating or recording element, or a combination indicating-recording element, that is coupled to two or more load-receiving elements with independent weighing systems, shall be provided with means to prohibit the activation of any load-receiving element (or elements) not in use, and shall be provided with automatic means to indicate clearly and definitely which load receiving element (or elements) is in use.

S.4. Design of Weighing Devices, Accuracy Class.

S.4.1. Designation of Accuracy. – Weigh-in-motion systems meeting the requirements of this code shall be designated as accuracy Class A.

Note: This does not preclude higher accuracy classes from being proposed and added to this Code in the future when it can be demonstrated that weigh-in-motion systems grouped within those accuracy classes can achieve the higher level of accuracy specified for those devices.

S.5. Marking Requirements. – In addition to the marking requirements in G-S.1. Identification (except G.S.1.(e)), the system shall be marked with the following information:

(a) accuracy class;

(b) value of the system division "d";

(c) operational temperature limits;

(d) number of instrumented lanes (not required if only one lane is instrumented);

(e) minimum and maximum vehicle speed;

(f) maximum number of axles per vehicle;

(g) maximum change in vehicle speed during weighment; and

(h) minimum and maximum load.

S.5.1. Location of Marking Information. – The marking information required in Section 1.10. General Code, G-S.1. Identification and Section 2.25. Weigh-in-Motion Systems, S.5. Marking Requirements shall be visible after installation. The information shall be marked on the system or recalled from an information screen.

N. Notes

N.1. Test Procedures.

N.1.1. Selection of Test Vehicles. – All dynamic testing associated with the procedures described in each of the subparagraphs of N.1.5 shall be performed with a minimum of two test vehicles.

(a) The first test vehicle may be a two-axle, six-tire, single-unit truck; that is, a vehicle with two axles with the rear axle having dual wheels. The vehicle shall have a maximum gross vehicle weight of 10 000 lb.

(b) The second test vehicle shall be a five-axle, single-trailer truck with a maximum gross vehicle weight of 80 000 lb.

Note: Consideration should be made for testing the systems using vehicles which are typical to the system's daily operation.

N.1.1.1. Weighing of Test Vehicles. – All test vehicles shall be weighed on a reference scale before being used to conduct the dynamic tests.

N.1.1.2. Determining Reference Weights for Axle, Axle Groups, and Gross Vehicle Weight. – The reference weights shall be the average weight value of a minimum of three static weighments of all single axles, axle groups, and gross vehicle weight.

Note: The axles within an axle group are not considered single axles.

N.1.2. Test Loads.

N.1.2.1. Static Test Loads. – All static test loads shall use certified test weights.

N.1.2.2. Dynamic Test Loads. – Test vehicles used for dynamic testing shall be loaded to 85 % to 95 % of their legal maximum Gross Vehicle Weight. The "load" shall be non-shifting and shall be positioned to present as close as possible, an equal side-to-side load.

N.1.3. Reference Scale. – Each reference vehicle shall be weighed statically on a multiple platform vehicle scale comprised of three individual weighing/load-receiving elements, each an independent scale. The three individual weighing/load receiving elements shall be of such dimension and spacing to facilitate:

the single-draft weighing of all reference test vehicles;

(a) the simultaneous weighing of each single axle and axle group of the reference test vehicles on different individual elements of the scale; and

(b) gross vehicle weight determined by summing the values of the different reference axle and reference axle groups of a test vehicle.

The scale shall be tested immediately prior to using it to establish reference test loads and in no case more than 24 hours prior. To qualify for use as a suitable reference scale, it must meet NIST Handbook 44, Class III L maintenance tolerances.

N.1.3.1. Location of a Reference Scale. – The location of the reference scale must be considered since vehicle weights will change due to fuel consumption.

N.1.4. Test Speeds. – All dynamic tests shall be conducted within 20 % below or at the posted speed limit.

N.1.5. Test Procedures.

N.1.5.1. Dynamic Load Test. – The dynamic test shall be conducted using the test vehicles defined in N.1.1. Selection of Test Vehicles. The test shall consist of a minimum of 20 runs for each test vehicle at the speed as stated in N.1.4. Test Speeds.

At the conclusion of the dynamic test, there will be a minimum of 20 weight readings for each single axle, axle group, and gross vehicle weight of the test vehicle. The tolerance for each weight reading shall be based on the percentage values specified in Table T.2.2. Tolerances for Accuracy Class A.

N.1.5.2. Vehicle Position Test. – During the conduct of the dynamic testing, ensure the vehicle stays within the defined roadway along the width of the sensor. The test shall be conducted with 10 runs with the vehicle centered along the width of the sensor; 5 runs with the vehicle on the right side along the width of the sensor; and 5 runs with the vehicle on the left side along the width of the sensor. Only gross vehicle weight is used for this test and the tolerance for each weighment shall be based on the tolerance value specified in T.2.3. Tolerance Value for Vehicle Position Test.

N.1.5.3. Axle Spacing Test. – The axle spacing test is a review of the displayed and/or recorded axle spacing distance of the test vehicles. The tolerance value for each distance shall be based on the tolerance value specified in T.2.4. Tolerance Value for Axle Spacing.

T. Tolerances

T.1. Principles.

T.1.1. Design. – The tolerance for a weigh-in-motion system is a performance requirement independent of the design principle used.

T.2. Tolerance Values for Accuracy Class A.

T.2.1. Tests Involving Digital Indications or Representations. – To the tolerances that would otherwise be applied in paragraphs T.2.2. Tolerance Value for Dynamic Load Test and T.2.3. Tolerance Value for Vehicle Position Test, there shall be added an amount equal to one-half the value of the scale division to account for the uncertainty of digital rounding.

T.2.2. Tolerance Values for Dynamic Load Test. – The tolerance values applicable during dynamic load testing are as specified in Table T.2.2.

Table T.2.2.
Tolerances for Accuracy Class A

Load Description*	Tolerance as a Percentage of Applied Test Load
Axle Load	± 20 %
Axle Group Load	± 15 %
Gross Vehicle Weight	± 10 %

* No more than 5 % of the weighments in each of the load description subgroups shown in this table shall exceed the applicable tolerance.

T.2.3. Tolerance Value for Vehicle Position Test. – The tolerance value applied to each gross vehicle weighment is ± 10 % of the applied test load.

T.2.4. Tolerance Value for Axle Spacing. – The tolerance value applied to each axle spacing measurement shall be ± 0.15 m (0.5 ft).

T.3. Influence Factors. – The following factor is applicable to tests conducted under controlled conditions only.

T.3.1. Temperature. – Systems shall satisfy the tolerance requirements under all operating temperature unless a limited operating temperature range is specified by the manufacturer.

T.4. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility. – The difference between the weight indication due to the disturbance and the weight indication without the disturbance shall not exceed the tolerance value as stated in Table T.2.2. Tolerances for Accuracy Class A.

UR. User Requirements

UR.1. Selection Requirements. – 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 capacity, number of scale divisions, value of the scale division, or verification scale division and minimum capacity.

UR.1.1. General. – The typical class or type of device for particular weighing applications is shown in Table 1. Typical Class or Type of Device for Weighing Applications.

Table 1.
Typical Class or Type of Device for Weighing Applications

Class	Weighing Application
A	Screening and sorting of vehicles based on axle, axle group, and gross vehicle weight.
Note: A WIM system with a higher accuracy class than that specified as "typical" may be used.	

UR.2. User Location Conditions and Maintenance. – The system shall be installed and maintained as defined in the manufacturer's recommendation.

UR.2.1. System Modification. – The dimensions (e.g., length, width, thickness, etc.) of the load receiving element of a system shall not be changed beyond the manufacturer's specifications, nor shall the capacity of a scale be increased beyond its design capacity by replacing or modifying the original primary indicating or recording element with one of a higher capacity, except when the modification has been approved by a competent engineering authority, preferably that of the engineering department of the manufacturer of the system, and by the weights and measures authority having jurisdiction over the system.

UR.2.2. Foundation, Supports, and Clearance. – The foundation and supports shall be such as to provide strength, rigidity, and permanence of all components.

On load-receiving elements, which use moving parts for determining the load value, clearance shall be provided around all live parts to the extent that no contacts may result when the load-receiving element is empty, nor throughout the weighing range of the system.

UR.2.3. Access to Weighing Elements. – If necessary, adequate provision shall be made for inspection and maintenance of the weighing elements.

UR.3. Maximum Load. – A system shall not be used to weigh a load of more than the marked maximum load of the system.

Appendix D. Definitions

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

A

axle. – The axis oriented transversely to the nominal direction of vehicle motion, and extending the full width of the vehicle, about which the wheel(s) at both ends rotate. [2.25]

axle-group load. – The sum of all tire loads of the wheels on a group of adjacent axles; a portion of the gross-vehicle weight. [2.25]

axle load. – The sum of all tire loads of the wheels on an axle; a portion of the gross-vehicle weight. [2.25]

axle spacing. – The distance between the centers of any two axles. When specifying axle spacing, the axels used also need to be identified. [2.25]

S

single-axle load. – The load transmitted to the road surface by the tires lying on the same longitudinal axis (that axis transverse to the movement of the vehicle and about which the wheels rotate). [2.25]

T

tandem-axle load. – The load transmitted to the road surface by the tires of two single-axles lying on the same longitudinal axis (that axis transverse to the movement of the vehicle and about which the wheels rotate). [2.25]

triple-axle load. – The load transmitted to the road surface by the tires of three single-axles lying on the same longitudinal axis (that axis transverse to the movement of the vehicle and about which the wheels rotate). [2.25]

W

weigh-in-motion (WIM). – A process of estimating a moving vehicle's gross weight and the portion of that weight that is carried by each wheel, axle, or axle group, or combination thereof, by measurement and analysis of dynamic vehicle tire forces. [2.25]

weigh-in-motion screening scale. – A weigh-in-motion system used to identify potentially overweight vehicles. [2.25]

wheel weight. – The weight value of any single or set of wheels on one side of a vehicle on a single axle. [2.25]

WIM System. – A set of sensors and supporting instruments that measure the presence of a moving vehicle and the related dynamic tire forces at specified locations with respect to time; estimate tire loads; calculate speed, axle spacing, vehicle class according to axle arrangement, and other parameters concerning the vehicle; and process, display, store, and transmit this information. This standard applies only to highway vehicles. [2.25]

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Section 5

Table of Contents

Table of Contents

Section 5.58. Multiple Dimension Measuring Devices

A. Application

A.1. General. – This code applies to dimension and volume measuring devices used for determining the dimensions and/or volume of objects for the purpose of calculating freight, storage, or postal charges based on the dimensions and/or volume occupied by the object. A multiple dimension measuring device:

(a) is generally used to measure hexahedron-shaped objects; and
(Added 2008)

(b) may be used to measure irregularly-shaped objects.
(Added 2008)

(Amended 2008)

A.2. Other Devices Designed to Make Multiple Measurement Automatically to Determine a Volume. – Insofar as they are clearly applicable, the provisions of this code apply also to devices designed to make multiple measurements automatically to determine a volume for other applications as defined by Section 1.10. General Code Paragraph G-A.1. Commercial and Law-Enforcement Equipment.

A.3. Additional Code Requirements. – In addition to the requirements of this code, Multiple Dimension Measuring Devices shall meet the requirements of Section 1.10. General Code.

A.4. Exceptions. – This code does not apply to:

(a) devices designed to indicate automatically (with or without value-computing capabilities) the length of fabric passed through the measuring elements (also see Section 5.50. for Fabric-Measuring Devices);

(b) devices designed to indicate automatically the length of cordage, rope, wire, cable, or similar flexible material passed through the measuring elements (also see Section 5.51. for Wire- and Cordage-Measuring Devices); or

(c) any linear measure, measure of length, or devices used to measure individual dimensions for the purpose of assessing a charge per unit of measurement of the individual dimension (also see Section 5.52. for Linear Measures).

A.5. Type Evaluation. – The National Type Evaluation Program (NTEP) will accept for type evaluation only those devices that comply with all requirements of this code.

S. Specifications

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

S.1.1. Zero or Ready Indication.

(a) Provision shall be made to indicate or record either a zero or ready condition.

(b) A zero or ready condition may be indicated by other than a continuous digital zero indication, provided that an effective automatic means is provided to inhibit a measuring operation when the device is in an out-of-zero or non-ready condition.

S.1.2. Digital Indications. – Indicated and recorded values shall be presented digitally.

S.1.3. Negative Values. – Negative values shall not be indicated or recorded.
(Amended 2021)

S.1.4. Dimensions Indication. – If in normal operation the device indicates or records only volume, a testing mode shall be provided to indicate dimensions for all objects measured.

S.1.5. Value of Dimension/Volume Division Units. – The value of a device division "d" expressed in a unit of dimension shall be presented in a decimal format. The value of "d" for each measurement axis shall be in the same unit of measure and expressed as:

(a) 1, 2, or 5;

(b) a decimal multiple or submultiple of 1, 2, or 5; or

(c) a binary submultiple of a specific U.S. customary unit of measure.

Examples: device divisions may be 0.01, 0.02, 0.05; 0.1, 0.2, or 0.5; 1, 2, or 5; 10, 20, 50, or 100; 0.5, 0.25, 0.125, 0.0625, etc.
(Amended 2016)

S.1.5.1. For Indirect Sales. – In addition to the values specified in S.1.5. Value of Dimension/Volume Division Units, the value of the division may be 0.3 inch and 0.4 inch.

S.1.5.2. Devices Capable of Measuring Irregularly-Shaped Objects. – For devices capable of measuring irregularly shaped objects, the value of the division size (d) shall be the same for the length axis (x) and the width axis (y) and may be different for the height axis (z), provided that electronic rotation of the object to determine the smallest hexahedron is calculated in only a two-dimension horizontal plane, retaining the stable side plane as the bottom of the hexahedron.
(Added 2008)

S.1.6. Customer Indications and Recorded Representations. – Multiple dimension measuring devices or systems must provide information as specified in Table S.1.6. Required Information to be Provided by Multiple Dimension Measuring Systems. As a minimum, all devices or systems must be able to meet either column I or column II in Table S.1.6. Required Information to be Provided by Multiple Dimension Measuring Systems.
(Amended 2004)

Table S.1.6.
Required Information to be Provided by Multiple Dimension Measuring Systems

Information	Column I[1]	Column II[1]		Column III
	Provided by device	Provided by invoice or other means		Provided by invoice or other means as specified in contractual agreement
		Customer present	Customer not present	
1. Device identification[2]	D or P	P	P	P or A
2. Error message (when applicable)	D or P	P	N/A	N/A
3. Hexahedron dimensions[3]	D or P	P	P	P or A
4. Hexahedron volume (if used)[3]	D or P	P	P	P or A
5. Actual weight (if used)[3]	D or P	P	P	P or A
6. Dimensional Offset (if used)[3]	D or P	N/A	N/A	N/A
7. Hexahedron measurement statement[4]	D or P or M	P	P	P or G

A = AVAILABLE UPON REQUEST BY CUSTOMER[5]
D = DISPLAYED
G = PUBLISHED GUIDELINES OR CONTRACTS
M = MARKED
N/A = NOT APPLICABLE
P = PRINTED or RECORDED IN A MEMORY DEVICE and AVAILABLE UPON REQUEST BY CUSTOMER[5]

Notes:
[1] As a minimum all devices or systems must be able to meet either column I or column II.

[2] This is only required in systems where more than one device or measuring element is being used.

[3] Some devices or systems may not utilize all of these values; however, as a minimum either hexahedron dimensions or hexahedron volume must be displayed or printed.

[4] This is an explanation that the dimensions and/or volume shown are those of the smallest hexahedron in which the object that was measured may be enclosed rather than those of the object itself.

[5] The information "available upon request by customer" shall be retained by the party having issued the invoice for at least 30 calendar days after the date of invoicing.

(Amended 2004 and 2021)

S.1.7. Minimum Measurement. – Except for entries of dimensional offset, the minimum measurement by a device is 12 d. The manufacturer may specify a longer minimum measurement. For multi-interval devices, this applies only to the first measuring range (or segment) of each measurement axis (length, width, and height).

(Amended 2017 and 2021)

S.1.8. Indications Below Minimum and Above Maximum. – When objects are smaller than the minimum dimensions identified in paragraph S.1.7. Minimum Measurement or larger than any of the maximum dimensions plus 9 d, and/or maximum volume marked on the device plus 9 d, or when a combination of dimensions, including dimensional offset, for the object being measured exceeds the measurement capability of the device, the indicating or recording element shall either:

(a) not indicate or record any usable values; or

(b) identify the indicated or recorded representation with an error indication.

(Amended 2004, 2017, and 2021)

S.1.9. Operating Temperature. – An indicating or recording element shall not indicate nor record any usable values until the operating temperature necessary for accurate measuring and a stable zero reference or ready condition has been attained.

S.1.10. Adjustable Components. – Adjustable components shall be held securely in adjustment and, except for a zeroing mechanism (when applicable), shall be located within the housing of the element.

S.1.11. 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.

(a) The device or system 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 can be made to any measuring element.

(b) Audit trails shall use the format set forth in Table S.1.11. Categories of Devices and Methods of Sealing for Multiple Dimension Measuring Systems.

(Amended 2019)

Table S.1.11.
Categories of Devices and Methods of Sealing for Multiple Dimension Measuring Systems

Categories of Devices	Methods of Sealing
Category 1: No remote configuration.	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. Device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode.	The hardware enabling access for remote communication must be at the device and sealed using a physical seal or two event counters: one for calibration parameters and one for configuration parameters.
Category 3: Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).	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 through the device or through another on-site device. 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.)

S.2. Design of Zero and Dimensional Offset.

S.2.1. Zero or Ready Adjustment. – A device shall be equipped with means by which the zero reference or ready condition can be adjusted, or the zero reference or ready condition shall be automatically maintained. The zero reference or ready control circuits shall be interlocked so that their use is prohibited during measurement operations.

S.2.2. Dimensional Offset. – The dimensional offset shall eliminate the effect of the conveyance method resulting in the measurement of only the object intended to be measured.

(Amended 2021)

S.2.2.1. Maximum Value of Dimensional Offset for Multi-Interval (Variable Division-Value Devices). – A multi- interval device shall not accept any dimensional offset value greater than the maximum capacity of the lowest range of the height axis.

(Added 2016) (Amended 2021)

(Added 2016)

S.3. Systems with Two or More Measuring Elements. – A multiple dimension measuring system with a single indicating or recording element, or a combination indicating-recording element, that is coupled to two or more measuring elements with independent measuring systems, shall be provided with means to prohibit the activation of any measuring element (or elements) not in use, and shall be provided with automatic means to indicate clearly and definitely which measuring element is in use.

Note: This requirement does not apply to individual devices that use multiple emitters/sensors within a device in combination to measure objects in the same measurement field.

(Amended 2004)

S.4. Marking Requirements. – (Also see G-S.1. Identification, G-S.4. Interchange or Reversal of Parts, G-S.5.2.5. Permanence, G-S.6. Marking Operational Controls, Indications, and Features, G-S.7. Lettering, G-UR.2.1.1. Visibility of Identification, and G-UR.3.1. Method of Operation.)

S.4.1. Multiple Dimension Measuring Devices, Main Elements, and Components of Measuring Devices. – Multiple dimension measuring devices, main elements of multiple dimension measuring devices when not contained in a single enclosure for the entire dimension/volume measuring device, and other components shall be marked as specified in Table S.4.1.a. Marking Requirements for Multiple Dimension Measuring Systems and explained in the accompanying notes, Table S.4.1.b. Multiple Dimension Measuring Systems Notes for Table S.4.1.a.

Table S.4.1.a.
Marking Requirements for Multiple Dimension Measuring Systems

To Be Marked With ⇓	Multiple Dimension Measuring Equipment			
	Multiple Dimension Measuring Device and Indicating Element in Same Housing	**Indicating Element not Permanently Attached to Multiple Dimension Measuring Element**	**Multiple Dimension Measuring Element Not Permanently Attached to the Indicating Element**	**Other Equipment (1)**
Manufacturer's ID	x	x	x	x
Model Designation	x	x	x	x
Serial Number and Prefix	x	x	x	x (2)
Certificate of Conformance Number (8)	x	x	x	x (8)
Minimum and Maximum Dimensions for Each Axis for Each Range in Each Axis (3)(9)	x	x	x	
Value of Measuring Division, d (for each axis and range) (9)	x	x	x	
Temperature Limits (4)(9)	x	x	x	
Minimum and Maximum speed (5)(9)	x	x	x	
Special Application (6)(9)	x	x	x	
Limitation of Use (7)(9)	x	x	x	

(Amended 2016)

Table S.4.1.b.
Multiple Dimension Measuring Systems Notes for Table S.4.1.a.

1. Necessary to the dimension and/or volume measuring system, but having no effect on the measuring value, e.g., auxiliary remote display, keyboard, etc.

2. Modules without "intelligence" on a modular system (e.g., printer, keyboard module, etc.) are not required to have serial numbers.

3. The minimum and maximum dimensions (using upper or lower case type) shall be marked. For example:
   Length: min _______ max _______
   Width: min _______ max _______
   Height: min _______ max _______

4. Required if the range is other than − 10 °C to 40 °C (14 °F to 104 °F).

5. Multiple dimension measuring devices, which require that the object or device be moved relative to one another, shall be marked with the minimum and maximum speeds at which the device is capable of making measurements that are within the applicable tolerances.

6. A device designed for a special application rather than general use shall be conspicuously marked with suitable words visible to the operator and the customer restricting its use to that application.

7. Materials, shapes, structures, combination of object dimensions, speed, spacing, minimum protrusion size, or object orientations that are inappropriate for the device or those that are appropriate.

8. Required only if a Certificate of Conformance has been issued for the equipment.

9. This marking information may be readily accessible via the display. Instructions for displaying the information shall be described in the NTEP CC.

(Amended 2004, 2008, and 2016)

S.4.2. Location of Marking Information. – The required marking 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.

N. Notes

N.1. Test Procedures.

N.1.1. General. – The device shall be tested using test standards and objects of known and stable dimensions.

N.1.2. Position Test. – Measurements are made using different positions of the test object and consistent with the manufacturer's specified use for the device.

N.1.2.1. Irregularly-Shaped Test Object Placement. – Irregularly-shaped test objects must be measured while placed on a stable side. The rotation of the object to determine the smallest hexahedron should be calculated in a two-dimensional plane, retaining the stable side plane as the bottom of the hexahedron.

(Added 2008)

N.1.3. Disturbance Tests, Field Evaluation. – A disturbance test shall be conducted at a given installation when the presence of disturbances specified in T.6. Disturbances, Field Evaluation has been verified and characterized if those conditions are considered "usual and customary."

N.1.4. Test Object Size. – Test objects may vary in size from the smallest dimension to the largest dimension marked on the device, and for field verification examinations, shall be an integer multiple of "d."

N.1.4.1. Test Objects. – Verification of devices may be conducted using appropriate test objects of various sizes and of stable dimensions. Test object dimensions must be known to an expanded uncertainty (coverage factor k = 2) of not more than one-third of the applicable device tolerance. The dimensions shall also be checked to the same uncertainty when used at the extreme values of the influence factors.

The dimension of all test objects shall be verified using a reference standard that is traceable to NIST (or equivalent national laboratory) and meet the tolerances expressed in NIST Handbook 44 Fundamental Considerations, paragraph 3.2. (i.e., one-third of the smallest tolerance applied to the device).

(Added 2004)

N.1.4.2. Irregularly-Shaped Test Objects. – For irregularly-shaped test objects, at least one angle shall be obtuse and the smallest dimension for an axis shall be equal to or greater than the minimum dimension for that axis.

(Added 2008)

(Amended 2008 and 2012)

N.1.5. Digital Zero Stability. – A zero indication change test shall be conducted on all devices which show a digital zero. After the removal of any test object, the zero indication shall not change. (Also see G-UR.4.2. Abnormal Performance.)

T. Tolerances

T.1. Design. – The tolerance for a multiple dimension measuring device is a performance requirement independent of the design principle used.

T.2. Tolerance Application.

T.2.1. Type Evaluation. – For type evaluations, the tolerance values apply to tests within the influence factor limits of temperature and power supply voltage specified in T.5.1. Temperature and T.5.2. Power Supply Voltage.

T.2.2. Subsequent Verification. – For subsequent verifications, the tolerance values apply regardless of the influence factors in effect at the time of the verification. (Also see G-N.2. Testing with Nonassociated Equipment.)

T.2.3. Multi-interval (Variable Division-Value) Devices. – When there exist two or more partial measuring ranges (or segments) specified for any of the "dimensioning" axes (length (x), width (y), or height (z)) and the division values corresponding to those partial measuring ranges (or segments) within the same "dimensioning" axis differ, the tolerance values shall be based on the value of the division of the range in use.

(Amended 2016)

T.2.4. Mixed-Interval Devices. – For devices that measure to a different division value in at least one dimensioning axes and all axes are single range, the tolerance values shall be based on the value of the division of the axis in use.

(Added 2016)

T.3. Tolerance Values. – The maintenance and acceptance tolerance values shall be ± 1 division.

(Amended 2004)

T.4. Position Tests. – For a test standard measured several times in different positions by the device all indications shall be within applicable tolerances.

T.5. Influence Factors. – The following factors are applicable to tests conducted under controlled conditions only.

T.5.1. Temperature. – Devices shall satisfy the tolerance requirements under the following temperature conditions.

T.5.1.1. Temperature Limits. – If not marked on the device, the temperature limits shall be − 10 °C to 40 °C (14 °F to 104 °F).

T.5.1.2. Minimum Temperature Range. – If temperature limits are specified for the device, the range shall be at least 30 °C or 54 °F.

T.5.1.3. Temperature Effect on Zero Indication. – The zero indication shall not vary by more than one division per 5 °C (9 °F) change in temperature.

T.5.2. Power Supply Voltage.

T.5.2.1. Alternating Current Power Supply. – Devices that operate using alternating current must perform within the conditions defined in paragraphs T.3. through T.6., inclusive, from − 15 % to + 10 % of the marked nominal line voltage(s) at 60 Hz, or the voltage range marked by the manufacturer, at 60 Hz.

(Added 2004)

T.5.2.2. Direct Current Power Supply. – Devices that operate using direct current shall operate and perform within the applicable tolerance at any voltage level at which the device is capable of displaying metrological registrations.

(Added 2004)

(Amended 2004)

T.6. Disturbances, Field Evaluation. – The following requirements apply to devices when subjected to disturbances which may normally exist in the surrounding environment. These disturbances include radio frequency interference (RFI), electromagnetic interference (EMI), acoustic changes, ambient light emissions, etc. The difference between the measurement indication with the disturbance and the measurement indication without the disturbance shall not exceed one division "d" or the equipment shall:

(a) blank the indication;

(b) provide an error message; or

(c) the indication shall be so completely unstable that it could not be interpreted, or transmitted into memory or to a recording element, as a correct measurement value.

UR. User Requirements

UR.1. Selection Requirements. – 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 maximum capacity, value of the division, minimum capacity, and computing capability.

UR.1.1. Value of the Indicated and Recorded Division. – The value of the division recorded shall be the same as the division value indicated.

UR.2. Installation Requirements.

UR.2.1. Supports. – A device that is portable and is being used on a counter, table, or the floor shall be so positioned that it is firmly and securely supported.

UR.2.2. Foundation, Supports, and Clearance. – The foundations and support of a device installed in a fixed location shall be such as to provide strength, rigidity, and permanence of all components, and clearance shall be provided around all live parts to the extent that no contacts may result when the measuring element is empty, nor throughout the performance range of the device such that the operation or performance of the device is adversely affected.

UR.2.3. Protection from Environmental Factors. – The indicating and measuring elements of a device shall be adequately protected from environmental factors such as wind, weather, and RFI that may adversely affect the operation or performance of the device.

UR.3. Use Requirements.

UR.3.1. Minimum and Maximum Measuring Ranges. – A device shall not be used to measure objects smaller than the minimum or larger than the maximum dimensions marked on the device.

UR.3.2. Special Designs. – A multiple dimension measuring device designed and marked for a special application shall not be used for other than its intended purpose.

UR.3.3. Object Placement. – If the object being measured must be transported (e.g., shipped) on a stable side, that irregularly-shaped object must be measured while placed on that stable side. The electronic rotation of the object to determine the smallest hexahedron shall be calculated in a two-dimensional horizontal plane, retaining the stable side plane as the bottom of the hexahedron.

(Added 2008)

(Amended 2008)

UR.4. Maintenance Requirements.

UR.4.1. Zero or Ready Condition. – The zero-setting adjustment of a multiple dimension measuring device shall be maintained so that, with no object in or on the measuring element, the device shall indicate or record a zero or ready condition.

UR.4.2. Level Condition. – If a multiple dimension measuring device is equipped with a level-condition indicator, the device shall be maintained in a level condition.

UR.4.3. Device Modification. – The measuring capabilities of a device shall not be changed from the manufacturer's design unless the modification has been approved by the manufacturer and the weights and measures authority having jurisdiction over the device.

UR.5. Customer Information Provided. – The user of a multiple dimension measuring device or system shall provide transaction information to the customer as specified in Table UR.5. Customer Information Provided.

(Added 2004)

Table UR.5.
Customer Information Provided

Information	No Contractual Agreement		Contractual Agreement
	Customer Present	Customer not Present	
1. Object identification	N/A	P	P or A
2. Billing method (scale or dimensional weight if used)	D or P	P	P or A
3. Billing rate or rate chart	D or P or A	P or G or A	P or A
4. Dimensional weight (if used)	P	P	P or A
5. Conversion factor (if dimensional weight is used)	D or P or A	P	P or G
6. Dimensional weight statement[1] (if dimensional weight is used)	D or P	P	P or G
7. Total price	P	P	P or A

A = Available upon Request by Customer[2]
D = Displayed
G = Published Guidelines or Contracts
M = Marked
N/A = Not Applicable
P = Printed

Notes:

[1] This is an explanation that the dimensional weight is not a true weight but is a calculated value obtained by applying a conversion factor to the hexahedron dimensions or volume of the object.

[2] The information "available upon request by customer" shall be retained by the party having issued the invoice for at least 30 calendar days after the date of invoicing.

(Added 2004)

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Table of Contents

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

1. Uniformity of Requirements

1.1. National Conference Codes. – Weights and measures jurisdictions are urged to promulgate and adhere to the National Conference 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 Conference 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 Conference 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 Conference 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 Conference 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 Conference requirements by language somewhat as follows:

> The specifications, tolerances, and other technical requirements for weighing and measuring devices as recommended by the National Conference 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).

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

3.2. 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.

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

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

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

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

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

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 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.

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.[3]

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.

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

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

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 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.

(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.

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 $1^{1}/_{32}$, $1^{2}/_{32}$, $1^{3}/_{32}$, $1^{4}/_{32}$, $1^{5}/_{32}$, $1^{6}/_{32}$, $1^{7}/_{32}$, $1^{8}/_{32}$, $1^{9}/_{32}$. Assume that these values are to be rounded off to the nearest eighth ($^{4}/_{32}$). Then,

$1^{1}/_{32}$ becomes 1. ($^{1}/_{32}$ is less than half of $^{4}/_{32}$ and accordingly is dropped.)

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

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

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

$1^{5}/_{32}$ 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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Table of Contents

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Appendix B. Units and Systems of Measurement: Their Origin, Development, and Present Status

1. Introduction

The National Institute of Standards and Technology (NIST) (formerly the National Bureau of Standards) was established by Act of Congress in 1901 to serve as a national scientific laboratory in the physical sciences, and to provide fundamental measurement standards for science and industry. In carrying out these related functions the Institute conducts research and development in many fields of physics, mathematics, chemistry, and engineering. At the time of its founding, the Institute had custody of two primary standards – the meter bar for length and the kilogram cylinder for mass. With the phenomenal growth of science and technology over the past century, the Institute has become a major research institution concerned not only with everyday weights and measures, but also with hundreds of other scientific and engineering standards that are necessary to the industrial progress of the nation. Nevertheless, the country still looks to NIST for information on the units of measurement, particularly their definitions and equivalents.

The subject of measurement systems and units can be treated from several different standpoints. Scientists and engineers are interested in the methods by which precision measurements are made. State weights and measures officials are concerned with laws and regulations that assure equity in the marketplace, protect public health and safety, and with methods for verifying commercial weighing and measuring devices. But a vastly larger group of people is interested in some general knowledge of the origin and development of measurement systems, of the present status of units and standards, and of miscellaneous facts that will be useful in everyday life. This material has been prepared to supply that information on measurement systems and units that experience has shown to be the common subject of inquiry.

2. Units and Systems of Measurement

The expression "weights and measures" is often used to refer to measurements of length, mass, and capacity or volume, thus excluding such quantities as electrical and time measurements and thermometry. This section on units and measurement systems presents some fundamental information to clarify the concepts of this subject and to eliminate erroneous and misleading use of terms.

It is essential that the distinction between the terms "units" and "standards" be established and kept in mind.

A unit is a special quantity in terms of which other quantities are expressed. In general, a unit is fixed by definition and is independent of such physical conditions as temperature. Examples: the meter, the liter, the gram, the yard, the pound, the gallon.

A standard is a physical realization or representation of a unit. In general, it is not entirely independent of physical conditions, and it is a representation of the unit only under specified conditions. For example, a meter standard has a length of one meter when at some definite temperature and supported in a certain manner. If supported in a different manner, it might have to be at a different temperature to have a length of one meter.

2.1. Origin and Early History of Units and Standards.

2.1.1. General Survey of Early History of Measurement Systems. – Weights and measures were among the earliest tools invented by humans. Primitive societies needed rudimentary measures for many tasks: constructing dwellings of an appropriate size and shape, fashioning clothing, or bartering food or raw materials.

Humans understandably turned first to parts of the body and the natural surroundings for measuring instruments. Early Babylonian and Egyptian records and the Bible indicate that length was first measured with the forearm, hand, or finger and that time was measured by the periods of the sun, moon, and other heavenly bodies. When it was necessary to compare the capacities of containers such as gourds or clay or metal vessels, they were filled with plant seeds which were then counted to measure the volumes. When means for weighing were invented, seeds and stones served as standards. For instance, the "carat," still used as a unit for gems, was derived from the carob seed.

Our present knowledge of early weights and measures comes from many sources. Archaeologists have recovered some rather early standards and preserved them in museums. The comparison of the dimensions of buildings with the descriptions of contemporary writers is another source of information. An interesting example of this is the comparison of the dimensions of the Greek Parthenon with the description given by Plutarch from which a fairly accurate idea of the size of the Attic foot is obtained. In some cases, we have only plausible theories and we must sometimes select the interpretation to be given to the evidence.

For example, does the fact that the length of the double-cubit of early Babylonia was equal (within two parts per thousand) to the length of the seconds pendulum at Babylon suggest a scientific knowledge of the pendulum at a very early date, or do we merely have a curious coincidence? By studying the evidence given by all available sources, and by correlating the relevant facts, we obtain some idea of the origin and development of the units. We find that they have changed more or less gradually with the passing of time in a complex manner because of a great variety of modifying influences. We find the units modified and grouped into measurement systems: the Babylonian system, the Egyptian system, the Phileterian system of the Ptolemaic age, the Olympic system of Greece, the Roman system, and the British system, to mention only a few.

2.1.2. Origin and Development of Some Common Customary Units. – The origin and development of units of measurement has been investigated in considerable detail and a number of books have been written on the subject. It is only possible to give here, somewhat sketchily, the story about a few units.

Units of length: The cubit was the first recorded unit used by ancient peoples to measure length. There were several cubits of different magnitudes that were used. The common cubit was the length of the forearm from the elbow to the tip of the middle finger. It was divided into the span of the hand (one-half cubit), the palm or width of the hand (one sixth), and the digit or width of a finger (one twenty-fourth). The Royal or Sacred Cubit, which was 7 palms or 28 digits long, was used in constructing buildings and monuments and in surveying. The inch, foot, and yard evolved from these units through a complicated transformation not yet fully understood. Some believe they evolved from cubic measures; others believe they were simple proportions or multiples of the cubit. In any case, the Greeks and Romans inherited the foot from the Egyptians. The Roman foot was divided into both 12 unciae (inches) and 16 digits. The Romans also introduced the mile of 1000 paces or double steps, the pace being equal to five Roman feet. The Roman mile of 5000 feet was introduced into England during the occupation. Queen Elizabeth, who reigned from 1558 to 1603, changed, by statute, the mile to 5280 feet or 8 furlongs, a furlong being 40 rods of 5½ yards each.

The introduction of the yard as a unit of length came later, but its origin is not definitely known. Some believe the origin was the double cubit, others believe that it originated from cubic measure. Whatever its origin, the early yard was divided by the binary method into 2, 4, 8, and 16 parts called the half-yard, span, finger, and nail. The association of the yard with the "gird" or circumference of a person's waist or with the distance from the tip of the nose to the end of the thumb of Henry I are probably standardizing actions, since several yards were in use in Great Britain.

The point, which is a unit for measuring print type, is recent. It originated with Pierre Simon Fournier in 1737. It was modified and developed by the Didot brothers, Francois Ambroise and Pierre Francois, in 1755. The point was first used in the United States in 1878 by a Chicago type foundry (Marder, Luse, and Company). Since 1886, a point has been exactly 0.351 459 8 millimeters, or about $^1/_{72}$ inch.

Units of mass: The grain was the earliest unit of mass and is the smallest unit in the apothecary, avoirdupois, Tower, and Troy systems. The early unit was a grain of wheat or barleycorn used to weigh the precious metals silver and gold. Larger units preserved in stone standards were developed that were used as both units of mass and of monetary currency. The pound was derived from the mina used by ancient civilizations. A smaller unit was the shekel, and a larger unit was the talent. The magnitude of these units varied from place to place. The Babylonians and Sumerians had a system in which there were 60 shekels in a mina and 60 minas in a talent. The Roman talent consisted of 100 libra (pound) which were smaller in magnitude than the mina. The Troy pound used in England and the United States for monetary purposes, like the Roman pound, was divided into 12 ounces, but the Roman uncia (ounce) was smaller. The carat is a unit for measuring gemstones that had its origin in the carob seed, which later was standardized at $^{1}/_{444}$ ounce and then 0.2 gram.

Goods of commerce were originally traded by number or volume. When weighing of goods began, units of mass based on a volume of grain or water were developed. For example, the talent in some places was approximately equal to the mass of one cubic foot of water. Was this a coincidence or by design? The diverse magnitudes of units having the same name, which still appear today in our dry and liquid measures, could have arisen from the various commodities traded. The larger avoirdupois pound for goods of commerce might have been based on volume of water, which has a higher bulk density than grain. For example, the Egyptian hon was a volume unit about 11 % larger than a cubic palm and corresponded to one mina of water. It was almost identical in volume to the present U.S. pint.

The stone, quarter, hundredweight, and ton were larger units of mass used in Great Britain. Today only the stone continues in customary use for measuring personal body weight. The present stone is 14 pounds, but an earlier unit appears to have been 16 pounds. The other units were multiples of 2, 8, and 160 times the stone, or 28, 112, and 2240 pounds, respectively. The hundredweight was approximately equal to two talents. In the United States the ton of 2240 pounds is called the "long ton." The "short ton" is equal to 2000 pounds.

Units of time and angle: We can trace the division of the circle into 360 degrees and the day into hours, minutes, and seconds to the Babylonians who had a sexagesimal system of numbers. The 360 degrees may have been related to a year of 360 days.

2.2. The Metric System.

2.2.1. Definition, Origin, and Development. – Metric systems of units have evolved since the adoption of the first well-defined system in France in 1791. During this evolution the use of these systems spread throughout the world, first to the non-English-speaking countries, and more recently to the English-speaking countries. The first metric system was based on the units centimeter, gram, and second (cgs) for the quantities of length, mass, and time. These units were particularly convenient in science and technology. Later metric systems were based on the meter, kilogram, and second (mks) to improve the value of the units for practical applications. The present metric system is the International System of Units (SI). It uses the historical base units of the meter, kilogram and second as well as additional base units for the quantities thermodynamic temperature, electric current, luminous intensity, and amount of substance. The International System of Units is referred to as the modern metric system.

The adoption of the metric system in France was slow, but its desirability as an international system was recognized by geodesists and others. On May 20, 1875, an international treaty known as the International Metric Convention or the Treaty of the Meter was signed by seventeen countries including the United States. This treaty established the following organizations to conduct international activities relating to a uniform system for measurements:

(1) The General Conference on Weights and Measures (French initials: CGPM), an intergovernmental conference of official delegates of member nations and the supreme authority for all actions;

(2) The International Committee of Weights and Measures (French initials: CIPM), consisting of selected scientists and metrologists, which prepares and executes the decisions of the CGPM and is responsible for the supervision of the International Bureau of Weights and Measures;

(3) The International Bureau of Weights and Measures (French initials: BIPM), a permanent laboratory and world center of scientific metrology, the activities of which include the establishment of the basic standards and scales of the principal physical quantities and maintenance of the international prototype standards.

The National Institute of Standards and Technology provides official United States representation in these organizations. The CGPM, the CIPM, and the BIPM have been major factors in the continuing refinement of the metric system on a scientific basis and in the evolution of the International System of Units.

Multiples and submultiples of metric units are related by powers of ten. This relationship is compatible with the decimal system of numbers and it contributes greatly to the convenience of metric units.

2.2.2. International System of Units. – At the end of World War II, a number of different systems of measurement still existed throughout the world. Some of these systems were variations of the metric system, and others were based on the U.S. customary system of the English-speaking countries. It was recognized that additional steps were needed to promote a worldwide measurement system. As a result, the 9th CGPM, in 1948, asked the CIPM to conduct an international study of the measurement needs of the scientific, technical, and educational communities. Based on the findings of this study, the 10th CGPM in 1954 decided that an international system should be derived from six base units to provide for the measurement of temperature and optical radiation in addition to mechanical and electromagnetic quantities. The six base units recommended were the meter, kilogram, second, ampere, Kelvin degree (later renamed the kelvin), and the candela.

In 1960, the 11th CGPM named the system based on the six base quantities the International System of Units, abbreviated SI from the French name: Le Système International d'Unités. In 1971, the 14th CGPM adopted the mole for the quantity of substance as the seventh base unit. The SI, commonly known as the metric system, is now either obligatory or permissible throughout the world.

In 2018, the 26th CGPM approved the most significant change to the SI since its establishment in 1960, which is documented in NIST Special Publication 330.[1] SP 330 itself is based on the definitive international reference known as the BIPM SI Brochure (available at **https://www.bipm.org/en/publications/si-brochure/**). The SI is now established in terms of seven defining constants, some of which are fundamental constants of nature such as the Planck constant and the speed of light in a vacuum. The seven SI base units can be derived from the defining constants.

The definitions for the SI no longer make reference to any artifact standard, material property, or measurement description. These changes enable the realization of all units with an accuracy that is ultimately limited only by the quantum structure of nature and our technical abilities, but not by the definitions themselves.

2.2.3. Units and Standards of the Metric System. – In the early metric system there were two fundamental or base units, the meter and the kilogram, for length and mass. The other units of length and mass, and all units of area, volume, and compound units such as density were derived from these two fundamental units.

The meter was originally intended to be one ten-millionth part of a meridional quadrant of the earth. The Meter of the Archives, the platinum length standard which was the standard for most of the 19th century, at first was supposed to be exactly this fractional part of the quadrant. More refined measurements over the earth's surface showed that this supposition was not correct. In 1889, a new international metric standard of length, the International Prototype Meter, a graduated line standard of platinum-iridium, was selected from a group of bars because precise measurements found it to have the same length as the Meter of the Archives. The meter was then defined as the distance, under specified conditions, between the lines on the International Prototype Meter without reference to any measurements of the earth or to the Meter of the Archives, which it superseded. Advances in science and technology have made it possible to improve the definition of the meter and reduce the uncertainties associated with artifacts. From 1960 to 1983, the meter was defined as the length equal to 1 650 763.73 wavelengths in a vacuum of the radiation corresponding to the transition between the specified energy levels of the krypton 86 atom. Since 1983 the meter has been defined as the length of the path traveled by light in a vacuum during an interval of $1/299\,792\,458$ of a second. With the decision of the 26th CGPM in 2018,

[1] Newell, David B. and Tiesinga, Eite (2019) The International System of Units (SI). (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 330. **https://doi.org/10.6028/NIST.SP.330-2019**.

the wording of the meter definition was revised to include the fixed numerical value of the speed of light and the definition of the second in terms of the hyperfine transition frequency of the cesium 133 atom.

The kilogram, originally defined as the mass of one cubic decimeter of water at the temperature of maximum density, was known as the Kilogram of the Archives. After the International Metric Convention in 1875, in 1889 the definition of the kilogram was simply the mass of the International Prototype Kilogram (IPK), an artifact made of platinum-iridium (it took from 1875 until 1889 to fabricate the IPK). Each country that subscribed to the International Metric Convention was assigned one or more copies of the international standard, known as National Prototype Kilogram. That IPK artifact was the definition of the kilogram from 1889 until the decision of the 26th CGPM in 2018 noted earlier that redefines the SI. The fundamental revision to the SI now defines the kilogram from the fixed value of the Planck constant, along with definitions of the meter and second. The numerical value of the Planck constant is such that at the time of its adoption, the kilogram was equal to the mass of the IPK of 1 kg. Going forward, primary realizations of base units will be determined according to the relevant Consultative Committees published on the BIPM website.[2]

The liter is a unit of capacity or volume. In 1964, the 12th GCPM redefined the liter as being one cubic decimeter. By its previous definition – the volume occupied, under standard conditions, by a quantity of pure water having a mass of one kilogram – the liter was larger than the cubic decimeter by 28 parts per 1 000 000.

The International System of Units (SI) includes two classes of units:

(a) base units for length, mass, time, temperature, electric current, luminous intensity, and amount of substance; and

(b) derived units for all other quantities (e.g., area, volume, force, pressure, power, Celsius temperature) expressed in terms of the seven base units.

For details, see the current edition of NIST Special Publication 330 and NIST Special Publication 811.[3]

2.2.4. International Bureau of Weights and Measures. – The International Bureau of Weights and Measures (BIPM) was established at Sèvres, a suburb of Paris, France, by the International Metric Convention of May 20, 1875. The BIPM maintains the former International Prototype Kilogram (IPK), many secondary standards, and equipment for comparing standards and making precision measurements. The Bureau, funded by assessment of the signatory governments, is truly international. In recent years the scope of the work at the Bureau has been considerably broadened. It now carries on researches in the fields of electricity, photometry and radiometry, ionizing radiations, and time and frequency besides its work in mass, length, and thermometry.

2.2.5. Status of the Metric System in the United States. – The use of the metric system in this country was legalized by Act of Congress in 1866 and use is voluntary.[4] Following the signing of the Convention of the Meter in 1875, the United States acquired national prototype standards for the meter and the kilogram. Up to 2019, mass measurements in the U.S. were traceable to U.S. national prototype kilograms which were in turn traceable to the IKP. From 2019 onward, mass measurements in the U.S. are traceable to Planck's constant

[2] International Bureau of Weights and Measures (BIPM) (2022) Practical realization of the definition of some important units. Available at **https://www.bipm.org/en/publications/mises-en-pratique**.

[3] Thompson, Ambler and Taylor, Barry N. (2008) The NIST Guide for the use of the International System of Units (SI). (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 811. **https://www.nist.gov/pml/special-publication-811**.

[4] Metric Act of 1866 (14 Stat 339) PDF legalized the use of the metric system in the United States. The law was amended by the America Competes Act of 2007 (U.S. Public Law 110-69), replacing the old metric system definition with the International System of Units (SI).

through the U.S. national prototype kilograms. The prototype meter was subsequently replaced by a *Mise en Pratique*, an internationally approved method to realize the unit, using stabilized lasers.[5]

From 1893 until 1959, the yard was defined as equal exactly to 3600/3937 meter. In 1959, a small change was made in the definition of the yard to resolve discrepancies both in this country and abroad. Since 1959, the U.S. has defined the yard as equal exactly to 0.9144 meter; the new yard is shorter than the old yard by exactly two parts in a million.[6] At the same time, it was decided that any data expressed in feet derived from geodetic surveys within the United States would continue to bear the relationship as defined in 1893 (one foot equals 1200/3937 meter) until the basic geodetic survey networks of the United States were readjusted. Based on this decision, the 1893 definition of the foot is called the U.S. survey foot, while the foot definition adopted in 1959 is called the international foot.

The intent of the 1959 action was that continued use of the U.S. survey foot would be temporary and that its use would be discontinued once the United States geodetic networks were readjusted. This was completed in 1986; however, use of the U.S. survey foot continued after 1986, creating a situation where it was used simultaneously with the international foot. This concurrent use of two nearly identical definitions of the foot caused confusion and errors. To remedy this situation, the National Oceanic and Atmospheric Administration (NOAA) and NIST took collaborative action to provide national uniformity in the measurement of length. In 2020, a Federal Register notice was published announcing the final decision to retire the U.S. survey foot with a deprecation date of December 31, 2022.[7] 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 units 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.

Since 1970, actions have been taken to encourage the use of metric units of measurement in the United States. A brief summary of actions by Congress is provided below as reported in the Federal Register.[8]

Section 403 of Public Law 93-380, the Education Amendment of 1974, states that it is the policy of the United States to encourage educational agencies and institutions to prepare students to use the metric system of measurement as part of the regular education program.[9] Under both this act and the Metric Conversion Act of 1975[10], the "metric system of measurement" is defined as the International System of Units as established in 1960 by the General Conference on Weights and Measures and interpreted or modified for the United States by the Secretary of Commerce (Section 4(4)- Public Law 94-168; Section 403(a)(3)- Public Law 93-380). The Secretary has delegated authority under these subsections to the Director of the National Institute of Standards and Technology.

[5] The *mise en pratique* for each SI base unit is prepared by the relevant Consultative Committee and published on the BIPM website, where they may be revised more frequently than the BIPM SI Brochure. Available at **https://www.bipm.org/en/publications/mises-en-pratique**.
[6] *Federal Register*, July 1, 1959, Vol. 24, No. 128, p. 5348.
[7] *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**.
[8] *Federal Register*, July 28, 1998, Vol. 63, No. 144, p. 40334.
[9] Section 403 of Public Law 93 380, the Education Amendment of 1974. Available at **https://www.govinfo.gov/content/pkg/STATUTE-88/pdf/STATUTE-88-Pg484.pdf**.
[10] Metric Conversion Act of 1975 (15 U.S.C. 205a et seq.) amended by the Omnibus Trade and Competitiveness Act of 1988. Available at: **https://www.govinfo.gov/content/pkg/USCODE-2020-title15/pdf/USCODE-2020-title15-chap6-subchapII-sec205a.pdf**.

Section 5164 of Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988, amended Public Law 94-168, The Metric Conversion Act of 1975. In particular, Section 3, The Metric Conversion Act is amended to read as follows:

"Sec. 3. It is therefore the declared policy of the United States–

(1) to designate the metric system of measurement as the preferred system of weights and measures for United States trade and commerce;

(2) to require that each federal agency, by a date certain and to the extent economically feasible by the end of the fiscal year 1992, use the metric system of measurement in its procurements, grants, and other business-related activities, except to the extent that such use is impractical or is likely to cause significant inefficiencies or loss of markets to U.S. firms, such as when foreign competitors are producing competing products in non-metric units;

(3) to seek ways to increase understanding of the metric system of measurement through educational information and guidance and in government publications; and

(4) to permit the continued use of traditional systems of weights and measures in nonbusiness activities."

The Code of Federal Regulations makes the use of metric units mandatory for agencies of the federal government.[11]

2.3. British and United States Systems of Measurement. – In the past, the customary system of weights and measures in the British Commonwealth countries and that in the United States were very similar; however, the SI is now the official system of units in the United Kingdom, while both the SI and the U.S. customary units are used in the United States. It is incorrect to use the terms "Imperial" or "British" to describe the U.S. customary system because there are significant differences between many of these traditional measurement systems and the customary units in the U.S. NIST recommends use of the term "U.S. customary system of measurement" to describe the collection of non-SI measurement units currently used in the U.S.[12]

Because references to the units of the old British customary system are still found, the following discussion describes the differences between the U.S. and British customary systems of units.

After 1959, the U.S. and the British inches were defined identically for scientific work and were identical in commercial usage.[13] A similar situation existed for the U.S. and the British pounds, and many relationships, such as 12 inches = 1 foot, 3 feet = 1 yard, and 1760 yards = 1 international mile, were the same in both countries; but there were some very important differences.

In the first place, the U.S. customary bushel and the U.S. gallon, and their subdivisions differed from the corresponding British Imperial units. Also the British ton is 2240 pounds, whereas the ton generally used in the United States is the short ton of 2000 pounds. The American colonists adopted the English wine gallon of 231 cubic inches. The English of that period used this wine gallon and they also had another gallon, the ale gallon of 282 cubic inches. In 1824, the British abandoned these two gallons when they adopted the British Imperial gallon, which they defined as the volume of 10 pounds of water, at a temperature of 62 °F, which, by calculation, is equivalent to 277.42 cubic inches. At the same time, they redefined the bushel as 8 gallons.

In the customary British system, the units of dry measure are the same as those of liquid measure. In the United States these two are not the same; the gallon and its subdivisions are used in the measurement of liquids and the bushel, with its subdivisions, is used in the measurement of certain dry commodities. The U.S. gallon is divided into four liquid quarts and the U.S. bushel into 32 dry quarts. All the units of capacity or volume mentioned thus far are larger in the

[11] *Federal Register*, January 2, 1991, Vol. 56, No. 1, p. 160.
[12] *Federal Register*, October 5, 2020, 85 FR 62698, p. 62698.
[13] *Federal Register*, July 1, 1959, Vol. 24, No. 128, p. 5348.

customary British system than in the U.S. system. But the British fluid ounce is smaller than the U.S. fluid ounce, because the British quart is divided into 40 fluid ounces whereas the U.S. quart is divided into 32 fluid ounces.

From this we see that in the customary British system an avoirdupois ounce of water at 62 °F has a volume of one fluid ounce, because 10 pounds is equivalent to 160 avoirdupois ounces, and 1 gallon is equivalent to 4 quarts, or 160 fluid ounces. This convenient relation does not exist in the U.S. system because a U.S. gallon of water at 62 °F weighs about 8⅓ pounds, or 133⅓ avoirdupois ounces, and the U.S. gallon is equivalent to 4 × 32, or 128 fluid ounces.

1 U.S. fluid ounce	= 1.041 British fluid ounces
1 British fluid ounce	= 0.961 U.S. fluid ounce
1 U.S. gallon	= 0.833 British Imperial gallon
1 British Imperial gallon	= 1.201 U.S. gallons

Among other differences between the customary British and the United States measurement systems, we should note that the British government abolished the use of the troy pound on January 6, 1879, retaining only the troy ounce and its subdivisions. The troy pound is still legal in the United States, although it is infrequently used. Although the stone of 14 pounds is in common use for body weight in Britain, it is not used in the United States, although its influence was shown in the practice until World War II of selling flour by the barrel of 196 pounds (14 stone). In the apothecary system of liquid measure the British add a unit, the fluid scruple, equal to one third of a fluid drachm (spelled dram in the United States) between their minim and their fluid drachm. In the United States, the general practice now is to sell dry commodities, such as fruits and vegetables, by mass.

2.4. Subdivision of Units. – In general, units are subdivided by one of three methods: (a) decimal, into tenths; (b) duodecimal, into twelfths; or (c) binary, into halves (twos). Usually the subdivision is continued by using the same method. Each method has its advantages for certain purposes, and it cannot properly be said that any one method is "best" unless the use to which the unit and its subdivisions are to be put is known.

For example, if we are concerned only with measurements of length to moderate precision, it is convenient to measure and to express these lengths in feet, inches, and binary fractions of an inch, thus 9 feet, $4\frac{3}{8}$ inches. However, if these lengths are to be subsequently used to calculate area or volume, that method of subdivision at once becomes extremely inconvenient. For that reason, surveyors and civil engineers, who are concerned with areas of land, volumes of cuts, fills, excavations, etc., instead of dividing the foot into inches and binary subdivisions of the inch, divide it decimally; that is, into tenths, hundredths, and thousandths of a foot.

The method of subdivision of a unit is thus largely made based on convenience to the user. The fact that units have commonly been subdivided into certain subunits for centuries does not preclude also having another mode of subdivision in some frequently used cases where convenience indicates the value of such other method. Thus, while we usually subdivide the gallon into quarts and pints, most gasoline-measuring pumps, of the price-computing type, are graduated to show tenths, hundredths, or thousandths of a gallon.

Although the mile has for centuries been divided into rods, yards, feet, and inches, the odometer part of an automobile speedometer shows tenths of a mile. Although we divide our dollar into 100 parts, we habitually use and speak of halves and quarters. An illustration of rather complex subdividing is found on the scales used by draftsmen. These scales are of two types: (a) architects, which are commonly graduated with scales in which $\frac{3}{32}$, $\frac{3}{16}$, $\frac{1}{8}$, ¼, $\frac{3}{8}$, ½, ¾, 1, 1½, and 3 inches, respectively, represent 1 foot full scale, and also having a scale graduated in the usual manner to $\frac{1}{16}$ inch; and (b) engineers, which are commonly subdivided to 10, 20, 30, 40, 50, and 60 parts to the inch.

The dictum of convenience applies not only to subdivisions of a unit but also to multiples of a unit. Land elevations above sea level are given in feet although the height may be several miles; the height of aircraft above sea level as given by an altimeter is likewise given in feet, no matter how high it may be.

On the other hand, machinists, toolmakers, gauge makers, scientists, and others who are engaged in precision measurements of relatively small distances, even though concerned with measurements of length only, find it convenient to use the inch, instead of the tenth of a foot, but to divide the inch decimally to tenths, hundredths, thousandths, etc., even down to millionths of an inch. Verniers, micrometers, and other precision measuring instruments are usually graduated in this manner. Machinist scales are commonly graduated decimally along one edge and are also graduated along another edge to binary fractions as small as 1/64 inch. The scales with binary fractions are used only for relatively rough measurements.

It is seldom convenient or advisable to use binary subdivisions of the inch that are smaller than 1/64. In fact, 1/32-, 1/16-, or 1/8-inch subdivisions are usually preferable for use on a scale to be read with the unaided eye.

2.5. Arithmetical Systems of Numbers. – The subdivision of units of measurement is closely associated with arithmetical systems of numbers. The systems of units used in this country for commercial and scientific work, having many origins as has already been shown, naturally show traces of the various number systems associated with their origins and developments. Thus, (a) the binary subdivision has come down to us from the Hindus, (b) the duodecimal system of fractions from the Romans, (c) the decimal system from the Chinese and Egyptians, some developments having been made by the Hindus, and (d) the sexagesimal system (division by 60) now illustrated in the subdivision of units of angle and of time, from the ancient Babylonians. The use of decimal numbers in measurements is becoming the standard practice.

3. Standards of Length, Mass, and Capacity or Volume

3.1. Standards of Length. – The meter, which is defined in terms of the speed of light in a vacuum, is the unit on which all length measurements are based.

The yard is defined[14] as follows:

1 yard = 0.914 4 meter exactly, and

1 inch = 25.4 millimeters exactly.

3.1.1. Calibration of Length Standards. – NIST calibrates standards of length including gage blocks, line standards, metal tapes, step gages, and a variety of other special length standards. In general, NIST accepts for calibration only apparatus of such material, design, and construction as to ensure accuracy and permanence sufficient to justify calibration by the Institute. NIST performs dimensional calibrations that are described in the online catalog and Special Publication 250 Measurement Services series[15]

When carpenter rules, machinist scales, draftsman scales, and the like require calibration, they should be submitted to state or local weights and measures calibration laboratory officials.[16]

3.2. Standards of Mass. Mass measurements in the U.S. are traceable to the SI using Planck's constant through the U.S. national prototype kilograms.

In Colonial times, the British standards were considered the primary standards of the United States. Later, the U.S. avoirdupois pound was defined in terms of the Troy Pound of the Mint, which is a brass standard kept at the United States Mint in Philadelphia, Pennsylvania. In 1911, the Troy Pound of the Mint was superseded, for coinage purposes, by the Troy Pound of the Institute.

The avoirdupois pound is defined in terms of the kilogram by the relation:

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[14] *Federal Register*, July 1, 1959, Vol. 24, No. 128, p. 5348.

[15] NIST Special Publication (SP) 250 Series on Measurement Services. Available at **https://shop.nist.gov/** and **https://www.nist.gov/calibrations/sp-250-publications**.

[16] The current recognition status (NIST Handbook 143) and accreditation status (National Voluntary Laboratory Accreditation Program, NVLAP) of state and local calibration laboratories are available at **https://www.nist.gov/pml/owm/resources/state-laboratories** and measurement service scopes summarized at **https://www.nist.gov/pml/owm/state-calibration-scope**.

1 avoirdupois pound = 0.453 592 37 kilogram.[17]

These changes in definition have not made any appreciable change in the value of the pound.

The grain is 1/7000 of the avoirdupois pound and is identical in the avoirdupois, troy, and apothecary systems. The troy ounce and the apothecary ounce differ from the avoirdupois ounce but are equal to each other, and equal to 480 grains. The avoirdupois ounce is equal to 437.5 grains.

3.2.1. Mass and Weight. – The mass of a body is a measure of its inertial property or how much matter it contains. The weight of a body is a measure of the force exerted on it by gravity or the force needed to support it. Gravity on earth gives a body a downward acceleration of about 9.8 m/s^2. (In common parlance, weight is often used as a synonym for mass in weights and measures.) The incorrect use of weight in place of mass should be phased out, and the term mass used when mass is meant.

Standards of mass are ordinarily calibrated by comparison to a reference standard of mass. If two objects are compared on a balance and give the same balance indication, they have the same "mass" (excluding the effect of air buoyancy). The forces of gravity on the two objects are balanced. Even though the value of the acceleration of gravity, g, is different from location to location, because the two objects of equal mass in the same location (where both masses are acted upon by the same g) will be affected in the same manner and by the same amount by any change in the value of g, the two objects will balance each other under any value of g.

However, on a spring balance the mass of a body is not balanced against the mass of another body. Instead, the gravitational force on the body is balanced by the restoring force of a spring. Therefore, if a very sensitive spring balance is used, the indicated mass of the body would be found to change if the spring balance and the body were moved from one locality to another locality with a different acceleration of gravity. But a spring balance is usually used in one locality and is adjusted or calibrated to indicate mass at that locality.

3.2.2. Effect of Air Buoyancy. – Another point that must be taken into account in the calibration and use of standards of mass is the buoyancy or lifting effect of the air. A body immersed in any fluid is buoyed up by a force equal to the force of gravity on the displaced fluid. Two bodies of equal mass, if placed one on each pan of an equal-arm balance, will balance each other in a vacuum. A comparison in a vacuum against a known mass standard gives "true mass." If compared in air, however, they will not balance each other unless they are of equal volume. If of unequal volume, the larger body will displace the greater volume of air and will be buoyed up by a greater force than will the smaller body, and the larger body will appear to be of less mass than the smaller body.

The greater the difference in volume, and the greater the density of the air in which we make the comparison weighing, the greater will be the apparent difference in mass. For that reason, in assigning a precise numerical value of mass to a standard, it is necessary to base this value on definite values for the air density and the density of the mass standard of reference.

The apparent mass of an object is equal to the mass of just enough reference material of a specified density (at 20 °C) that will produce a balance reading equal to that produced by the object if the measurements are done in air with a density of 1.2 mg/cm^3 at 20 °C. The original basis for reporting apparent mass is apparent mass versus brass. The apparent mass versus a density of 8.0 g/cm^3 is the more recent definition, and is used extensively throughout the world. The use of apparent mass versus 8.0 g/cm^3 is encouraged over apparent mass versus brass. The difference in these apparent mass systems is insignificant in most commercial weighing applications.

[17] *Federal Register*, July 1, 1959, Vol. 24, No. 128, p. 5348.

A full discussion of this topic is given in NIST Monograph 133.[18]

3.2.3. Calibrations of Mass Standards. – Many mass laboratory and field standards typically used in ordinary trade should be calibrated by state or local weights and measures officials.[19] NIST typically calibrates primary mass standards, but it does not manufacture or sell them. NIST mass calibration services are described in the online catalog and NIST Special Publication 250 series.[20]

3.3. Standards of Capacity. – Units of capacity or volume, being derived units, are defined in terms of linear units in the United States. Laboratory standards have been constructed and are maintained at NIST. These have validity only by calibration with reference either directly or indirectly to the linear standards. In the past, Congress authorized NIST to distribute capacity standards to the state laboratories. Other capacity standards have been purchased by organizations and verified by calibration for a variety of uses in science, technology, engineering, and commerce.

3.3.1. Calibrations of Capacity Standards. – NIST makes calibrations on capacity or volume standards that are in the customary units of trade; that is, the gallon, its multiples, and submultiples, or in metric units. Further, NIST calibrates precision-grade volumetric glassware which is normally in metric units. NIST makes calibrations in accordance with fee schedules, copies of which may be obtained from NIST.

3.4. Maintenance and Preservation of Fundamental Standard of Mass. – It is a statutory responsibility of NIST to maintain and preserve the national standard of mass and to realize all the other base units. The U.S. Prototype Kilogram maintained at NIST is fully protected by an alarm system. All measurements made with this standard are conducted in special air-conditioned laboratories to which the standard is taken a sufficiently long time before the observations to ensure that the standard will be in a state of equilibrium under standard conditions when the measurements or comparisons are made. Hence, it is not necessary to maintain the standard at standard conditions, but care is taken to prevent large changes of temperature. More important is the care to prevent any damage to the standard because of careless handling.

4. Specialized Use of the Terms "Ton" and "Tonnage"

As weighing and measuring are important factors in our everyday lives, it is quite natural that questions arise about the use of various units and terms and about the magnitude of quantities involved. For example, the words "ton" and "tonnage" are used in widely different senses, and a great deal of confusion has arisen regarding the application of these terms.

The ton is used as a unit of measure in two distinct senses: (1) as a unit of mass, and (2) as a unit of capacity or volume.

In the first sense, the term has the following meanings:

(a) The short, or net ton of 2000 pounds.

(b) The long, gross, or shipper's ton of 2240 pounds.

(c) The metric ton of 1000 kilograms, or 2204.6 pounds.

[18] Pontius, Paul E. (1974) Mass and Mass Values (National Institute of Standards and Technology, Gaithersburg, MD), NIST Monograph 133. Available at **https://nvlpubs.nist.gov/nistpubs/Legacy/MONO/nbsmonograph133.pdf**.
[19] The current recognition status (NIST Handbook 143) and accreditation status (National Voluntary Laboratory Accreditation Program, NVLAP) of state and local calibration laboratories are available at **https://www.nist.gov/pml/owm/resources/state-laboratories** and measurement service scopes summarized at **https://www.nist.gov/pml/owm/state-calibration-scope**.
[20] NIST Special Publication (SP) 250 Series on Measurement Services. Available at **https://shop.nist.gov/** and **https://www.nist.gov/calibrations/sp-250-publications**.

In the second sense (capacity), it is usually restricted to uses relating to ships and has the following meaning:

(a) The register ton of 100 cubic feet.

(b) The measurement ton of 40 cubic feet.

(c) The English water ton of 224 British Imperial gallons.

In the United States and Canada the ton (mass) most commonly used is the short ton. In Great Britain, it is the long ton, and in countries using the metric system, it is the metric ton. The register ton and the measurement ton are capacity or volume units used in expressing the tonnage of ships. The English water ton is used, chiefly in Great Britain, in statistics dealing with petroleum products.

There have been many other uses of the term ton such as the timber ton of 40 cubic feet and the wheat ton of 20 bushels, but their uses have been local and the meanings have not been consistent from one place to another.

Properly, the word "tonnage" is used as a noun only in respect to the capacity or volume and dimensions of ships, and to the amount of the ship's cargo. There are two distinct kinds of tonnage; namely, vessel tonnage and cargo tonnage and each of these is used in various meanings. The several kinds of vessel tonnage are as follows:

Gross tonnage, or gross register tonnage, is the total cubical capacity or volume of a ship expressed in register tons of 100 cubic feet, or 2.83 cubic meters, less such space as hatchways, bakeries, galleys, etc., as are exempted from measurement by different governments. There is some lack of uniformity in the gross tonnages as given by different nations due to lack of agreement on the spaces that are to be exempted. Official merchant marine statistics of most countries are published in terms of the gross register tonnage. Press references to ship tonnage are usually to the gross tonnage.

The net tonnage, or net register tonnage, is the gross tonnage less the different spaces specified by maritime nations in their measurement rules and laws. The spaces deducted are those totally unavailable for carrying cargo, such as the engine room, coal bunkers, crew quarters, chart and instrument room, etc. The net tonnage is used in computing how much cargo that can be loaded on a ship. It is used as the basis for wharfage and other similar charges.

The register under-deck tonnage is the cubical capacity of a ship under her tonnage deck expressed in register tons. In a vessel having more than one deck, the tonnage deck is the second from the keel.

There are several variations of displacement tonnage.

The dead weight tonnage is the difference between the "loaded" and "light" displacement tonnages of a vessel. It is expressed in terms of the long ton of 2240 pounds, or the metric ton of 2204.6 pounds, and is the weight of fuel, passengers, and cargo that a vessel can carry when loaded to its maximum draft.

The second variety of tonnage, cargo tonnage, refers to the weight of the particular items making up the cargo. In overseas traffic it is usually expressed in long tons of 2240 pounds or metric tons of 2204.6 pounds. The short ton is only occasionally used. Therefore, the cargo tonnage is very distinct from vessel tonnage.

Table of Contents

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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 metric system of measurement, designations of multiples and subdivisions of any unit may be arrived at by combining with the name of the unit the prefixes deka, hecto, and kilo meaning, respectively, 10, 100, and 1000, and deci, centi, and milli, meaning, respectively, one-tenth, one-hundredth, and one-thousandth. In some of the following metric tables, some such multiples and subdivisions have not been included for the reason that these have little, if any currency in actual usage.

In certain cases, particularly in scientific usage, it becomes convenient to provide for multiples larger than 1000 and for subdivisions smaller than one-thousandth. Accordingly, the following prefixes have been introduced and these are now generally recognized:

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

Thus, a kilometer is 1000 meters and a millimeter is 0.001 meter.

Units of Length

10 millimeters (mm)	= 1 centimeter (cm)
10 centimeters	= 1 decimeter (dm) = 100 millimeters
10 decimeters	= 1 meter (m) = 1000 millimeters
10 meters	= 1 dekameter (dam)
10 dekameters	= 1 hectometer (hm) = 100 meters
10 hectometers	= 1 kilometer (km) = 1000 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[1] = 1000 milliliters
10 liters	= 1 dekaliter (daL)
10 dekaliters	= 1 hectoliter (hL) = 100 liters
10 hectoliters	= 1 kiloliter (kL) = 1000 liters
1000 cubic millimeters (mm^3)	= 1 cubic centimeter (cm^3)
1000 cubic centimeters	= 1 cubic decimeter (dm^3)
	= 1 000 000 cubic millimeters
1000 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) = 1000 milligrams
10 grams	= 1 dekagram (dag)
10 dekagrams	= 1 hectogram (hg) = 100 grams
10 hectograms	= 1 kilogram (kg) = 1000 grams
1000 kilograms	= 1 megagram (Mg) or 1 metric ton (t)

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

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

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)[4] = 5280 feet
1852 meters (m)	= 6076.115 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)	= 5280 feet = 8 furlongs = 80 chains = 320 rods
1 league	= 15 840 feet = 3 miles

[2] 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.

[3] *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**.

[4] Originally referred to as the "statute mile," when Queen Elizabeth I changed the definition of the mile from the Roman mile of 5000 feet to the statute mile of 5280 feet. Although the U.S. statute mile was originally based on the U.S. survey foot (1200/3937 meter), its definition is now based the international foot (0.3048 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 5280 feet.

Units of Area[5]

1 square foot (ft^2)	=144 square inches (in^2)
1 square yard (yd^2)	= 9 square feet = 1296 square inches
1 square rod (rd^2), square pole, or square perch	= 272.25 square feet = 0.0625 square chain (ch^2)
1 square chain	= 4356 square feet = 16 square rods = 0.1 acre
1 acre	= 43 560 square feet = 160 square rods
	= 10 square chains
1 square mile (mi^2)	= 27 878 400 square feet = 640 acres

Units of Volume

1728 cubic inches (in^3)	= 1 cubic foot (ft^3)
27 cubic feet	= 1 cubic yard (yd^3)

Units of Liquid Volume[6]

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 ƒ ʒ)
	= 0.225 6 cubic inch (in^3)
8 fluid drams	= 1 fluid ounce (fl oz or ƒ ℥)
	= 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 = 1024 fluid drams

Units of Dry Volume[7]

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) = 2150.42 cubic inches
	= 32 quarts

[5] 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.
[6] When necessary to distinguish the "liquid pint" or "liquid quart" from the "dry pint" or "dry quart," the word "liquid" or the abbreviation "liq" should be used in combination with the name or abbreviation of the liquid unit.
[7] 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.

Avoirdupois Units of Mass[8]

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

1 µlb	= 0.000 001 pound (lb)
$27\frac{11}{32}$ grains (gr)	= 1 dram (dr)
16 drams	= 1 ounce (oz)
	= 437½ grains
16 ounces	= 1 pound (lb)
	= 256 drams
	= 7000 grains
100 pounds	= 1 hundredweight (cwt)[9]
20 hundredweights	= 1 ton (tn)[10]
	= 2000 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
	= 2240 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 = 5760 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).”

[9] 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.

[10] 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 = 5760 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 = 2240 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)

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 "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[11]
(All underlined figures are exact.)

Starting Unit ↓	Ending Unit →	Inches	Feet	Yards	Miles	Centimeters	Meters
		Multiply by the Conversion Factor Below the Ending Unit:					
1 inch (in) =		1	0.083 333 33	0.027 777 78	0.000 015 782 8 3	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	1609.344
1 centimeter (cm) =		0.393 700 8	0.032 808 40	0.010 936 13	0.000 006 213 7 12	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 = $^{1200}/_{3937}$ meter (exactly)
1 international foot = 12 × 0.0254 meter = 0.304 8 (exactly)
1 international foot = 0.999 998 survey foot (exactly)
1 international foot = 0.0254 × 39.37 U.S. survey foot (exactly)
1 international mile = 0.999 998 survey mile (exactly)

[11] *See Footnote 3.*

Units of Length – International Foot and Survey Equivalent Measurements[12]
(All underlined figures are exact.)

Starting Unit ↓		**International foot metric equivalent**	**U.S. survey foot metric equivalent**
	Ending Unit →	**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 =		1609.344	1609.347 218 694
1 rod (rd), perch, or pole =		5.029 2	5.029 210 058

[12] *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.

Units of Length – Survey Measure
(All underlined figures are exact; conversions to meters based on international foot.[13])

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:						
	Ending Unit →	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	1609.344
1 meter (m) =		4.970 970	3.280 840	0.198 838 8	0.049 709 70	0.000 621 371 2	1

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

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:			
	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.				

[13] See Footnote 3.

Units of Area[14]

(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:			
	Ending Unit →	**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) =		1550.003	10.763 91	1.195 990

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:			
	Ending Unit →	**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	8361.273 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	0.0001
1 square meter (m^2) =		0.000 000 386 102 2	10 000	1

[14] 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.

Units of Area – International Foot and Survey Equivalent Measurements[15]
(All underlined figures are exact.)

Starting Unit ↓	Ending Unit →	International foot metric equivalent Square Meters	U.S. survey foot metric equivalent 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) =		4046.856 422 4	4046.872 609 874
1 square mile (mi^2) =		2 589 988.110 336	2 589 998.470 319 521

Units of Area – Survey Measure [15]
(All underlined figures are exact; SI equivalents based on the international foot.)

Starting Unit ↓	Ending Unit →	Square Feet	Square Rods	Square Chains	Acres
		Multiply by the Conversion Factor Below the Ending Unit:			
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

[15] *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.

Starting Unit ↓	Ending Unit →	Square Miles	Square Meters	Hectares
		Multiply by the Conversion Factor Below the Ending Unit:		
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 (a) =		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

Units of Volume[16]

(All underlined figures are exact.)

Starting Unit ↓	Ending Unit →	Cubic Inches	Cubic Feet	Cubic Yards
		Multiply by the Conversion Factor Below the Ending Unit:		
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

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

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:			
	Ending Unit →	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	1000	1

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

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:				
	Ending Unit →	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 Conversion Factor Below the Ending Unit:				
		Ending Unit →	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)	=		1728	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	1000	1

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

Starting Unit ↓		Multiply by the Conversion Factor Below the Ending Unit:				
		Ending Unit →	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	1024	128	32
1 cubic inch (in^3)	=		265.974 0	4.432 900	0.554 112 6	0.138 528 1
1 cubic foot (ft^3)	=		459 603.1	7660.052	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 ↓	Ending Unit →	Liquid Pints	Liquid Quarts	Gallons	Cubic Inches
		Multiply by the Conversion Factor Below the Ending Unit:			
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

Starting Unit ↓	Ending Unit →	Cubic Feet	Milliliters	Liters
		Multiply by the Conversion Factor Below the Ending Unit:		
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	3785.411 784	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[17]
(All underlined figures are exact.)

Starting Unit ↓		International foot metric equivalent	U.S. survey foot metric equivalent
	Ending Unit →	Cubic Meters	Cubic Meters
acre-foot		1233.481 837 547 52	1233.489 238 468 149
Note: The following is an exact mathematical relationship for U.S. Customary Units. 1 acre-foot = 43 560 cubic feet			

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

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:				
	Ending Unit →	Avoirdupois Ounces	Avoirdupois Pounds	Short Hundredweights	Short Tons
1 avoirdupois ounce (oz) =		1	0.0625	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	2204.623	22.046 23	1.102 311

[17] *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.

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:			
	Ending Unit →	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	1016.046 908 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

Units of Mass Not Greater Than Pounds and Kilograms
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:				
	Ending Unit →	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) =		15432.36	771.617 9	643.014 9	564.383 4

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:				
	Ending Unit →	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	0.56 966 15	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)					
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 Conversion Factor Below the Ending Unit:				
	Ending Unit →	**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

Units of Pressure
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:						
	Ending Unit →	**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 5006 15	0.004 014 742 13
1 kPa =		1000.0	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.

5. Tables of Equivalents[18]

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.

[18] *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.

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.

Units of Length (all SI equivalents that use the foot are based on the international foot definition, 1 foot = 0.3048 m exactly)	
1 cable's length	120 fathoms (exactly) 720 feet (exactly) 219.456 meters (exactly)
1 centimeter (cm)	0.01 meter (exactly) 0.393 7 inch
1 chain (ch) (Gunter's or surveyor's)	66 feet (exactly) 20.116 8 meters (exactly)
1 decimeter (dm)	0.1 meter (exactly) 3.937 inches
1 dekameter (dam)	10 m (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)	1000 meters (exactly) 0.621 mile
1 league (land)	3 miles (exactly) 4.828 032 kilometers (exactly)
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 micrometer (µm)[19]	0.001 millimeter (exactly) 0.000 001 m (exactly) 0.000 039 37 inch
1 mil	0.001 inch (exactly) 0.025 4 millimeter (exactly) 25.4 micrometer (exactly)
1 mile (mi)	5280 feet (exactly) 1.609 344 kilometers (exactly)

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

Units of Length (all SI equivalents that use the foot are based on the international foot definition, 1 foot = 0.3048 m exactly)	
1 mile (mi) (international nautical)[20]	1852 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)

Units of Area	
1 acre	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)

[20] **NIST SP 447**, *Weights and Measures Standards of the United States, A Brief History* (1975). The international nautical mile of 1852 meters (6076.115 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 6080.20 feet = 1 nautical (geographical or sea) mile.

Units of Area	
	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) 1296 square inches (exactly)
[1 township]	[6 miles square] (approximate) [36 sections (of land)] 36 square miles (approximate)

Units of Capacity or Volume	
1 barrel (bbl), liquid	31 to 42 gallons[21]
1 barrel (bbl), standard for fruits, vegetables, and other dry commodities, except cranberries	7056 cubic inches 105 dry quarts 3.281 bushels, struck measure
1 barrel (bbl), standard, cranberry	5826 cubic inches 86 45/64 dry quarts 2.709 bushels, struck measure
1 bushel (bu) (U.S.) struck measure	2150.42 cubic inches (exactly) 35.238 liters
[1 bushel, heaped (U.S.)]	2747.715 cubic inches 1.278 bushels, struck measure[22]
[1 bushel (bu) (British Imperial) (struck measure)]	1.032 U.S. bushels, struck measure 2219.36 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)	1000 cubic centimeters (exactly) 1000 milliliters (exactly) 1 liter (exactly) 61.024 cubic inches
1 cubic foot (ft^3)	7.481 gallons

[21] 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.

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

Units of Capacity or Volume	
	28.316 cubic decimeters (liters)
1 cubic inch (in^3)	0.554 fluid ounce (fl oz) (or *f* ℥) 4.433 fluid drams (fl dr) (or *f* ʒ) 16.387 cubic centimeters
1 cubic meter (m^3)	1000 cubic decimeters 1000 liters 1.308 cubic yards
1 cubic yard (yd^3)	0.765 cubic meter 27 cubic feet (exactly)
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 *f* 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) 1000 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 *f* ℥) (U.S.)	1.805 cubic inches 29.573 milliliters

Units of Capacity or Volume	
	1.041 British fluid ounces
[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[23]
1 water ton (English)	270.91 U.S. gallons 224 British Imperial gallons (exactly)

Units of Mass	
1 assay ton (AT)[24]	29.167 grams
1 carat (c)[25]	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)

[23] 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.
[24] 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.
[25] 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**.

Units of Mass	
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[26] (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)	1000 grams exactly 2.205 pounds
1 microgram (μg)[27]	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
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)	7000 grains (exactly) 1.215 troy or apothecaries pounds 453.592 37 grams (exactly)
1 micropound (μlb)[28]	0.000 001 pound (exactly)
1 pound, troy (lb t)	5760 grains (exactly) 0.823 avoirdupois pound 373.242 grams
1 pound, apothecaries (lb ap)	5760 grains (exactly) 0.823 avoirdupois pound 373.242 grams

[26] 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."
[27] The SI symbol for the prefix micro is the Greek letter mu (μ).
[28] 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).

Units of Mass	
1 scruple (s ap or ℈)	20 grains (exactly) 1.296 grams
1 ton, gross or long[29]	2240 pounds (exactly) 1.12 net tons (exactly) 1.016 metric tons
1 ton, metric (t)	2204.623 pounds 0.984 gross ton 1.102 net tons
1 ton, net or short (tn)[29]	2000 pounds (exactly) 0.893 gross ton 0.907 metric ton

[29] 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)

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]

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)

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

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]

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)]

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]

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]

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 5000 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]

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)

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 division. – See "verification scale division, 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. [2.20, 2.21, 2.24]

(Added 1997)

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)

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 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]

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)

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]

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]

K

kilowatt (kW). – A unit of power equal to 1000 watts (W). [3.40]
(Added 2022)

kilowatt-hour (kWh). – A unit of energy equal to 1000 watthours (W h). [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, 2000 pounds, 20 000 cubic feet, 2000 liters, or 2000 kilograms. [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. [3.33]

(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]

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]

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]

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]

megajoule (MJ). – An SI unit of energy equal to 1 000 000 joules (J). [3.40]

(Added 2022)

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

(Added 2022)

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]

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)

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. [2.20, 2.21, 2.24]

(Added 1997)

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]

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. devices manufactured within a state after the effective date;

2. both new and used devices brought into a state after the effective date; and

3. 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.

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)

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 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:

$$s=\sqrt{\frac{1}{n-1}\sum\left(x_i-\bar{x}\right)^2} \text{ or } s=\sqrt{\frac{1}{n-1}\left(\sum x_i^2-\frac{\left(\sum x_i\right)^2}{n}\right)}$$

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]

recorded representation. – The printed, embossed, or other representation that is recorded as a quantity by a weighing or measuring device. [1.10]

recorded representation. – 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)

recording element. – An element incorporated in a weighing or measuring device by means of which its 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. [1.10, 2.21]

recording element. – 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)

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)

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). – Quotient of the capacity divided by the value of the verification scale division. [2.20]

$$n = \frac{Capacity}{e}$$

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)

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]

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]

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:

$$\bar{x} = \frac{\Sigma x}{n}$$

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)

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]

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

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]

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 division, 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 division is applied to all scales, in particular to ungraduated devices since they have no graduations. The verification scale division (e) may be different from the displayed scale division (d) for certain other devices used for weight classifying or weighing in pre-determined amounts, and certain other Class I and II scales. [2.20]

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. – 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)

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 scale division. These scales usually have a verification scale division (e) that is smaller than the displayed scale division. [2.20]

(Added 1987)

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]

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]