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Technology Administration
National Institute of Standards and Technology

NIST HANDBOOK 44

1993

SPECIFICATIONS, TOLERANCES, AND OTHER TECHNICAL REQUIREMENTS FOR WEIGHING AND MEASURING DEVICES

as adopted by the 77th National Conference on Weights and Measures 1992

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[1]At Boulder, CO 80303.
[2]Some elements at Boulder, CO 80303.

NIST Handbook 44
1993 Edition

(Supersedes Handbook 44 - 1992 Edition)

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

Adopted by the 77th
National Conference on Weights and Measures
1992

Henry V. Oppermann, Editor

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Foreword

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

Handbook 44 is published in its entirety each year following the Annual Meeting of the National Conference on Weights and Measures. This 1993 edition was developed by the Committee on Specifications and Tolerances of the National Conference on Weights and Measures, with the assistance of the Office of Weights and Measures of the National Institute of Standards and Technology (NIST). The handbook includes amendments adopted by the 77th National Conference on Weights and Measures during its Annual Meeting in 1992.

The National Institute of Standards and Technology has a statutory responsibility for "cooperation with the States in securing uniformity of weights and measures laws and methods of inspection." In partial fulfillment of this responsibility, the Institute is pleased to publish these recommendations of the National Conference.

John W. Lyons
Director
National Institute of Standards
and Technology

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 customary units where both units appear together and placing separate sections containing requirements for metric units before corresponding sections containing requirements for customary units. 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.

In accord with NIST policy, the meter/liter spellings are used in this document. However, the metre/litre spellings are acceptable, and are preferred by the National Conference on Weights and Measures.

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Editorial Changes

Section	Code	Paragraph	Action	Page
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Introduction

1. Source. - The specifications, tolerances, and other technical requirements published herein comprise, in their latest form, all of the current codes as adopted by the National Conference on Weights and Measures.[1] The National Conference is sponsored by the National Institute of Standards and Technology (NIST), formerly National Bureau of Standards (NBS), which provides the NCWM secretariat and publishes NCWM documents. NIST also develops technical publications for use by weights and measures agencies; these publications may subsequently be endorsed or adopted by the NCWM.

The Conference Committee on Specifications and Tolerances,[2] acting at the request of the Conference or upon its own initiative, with the cooperation of the National Institute of Standards and Technology, annually prepares proposed revisions, amendments, or additions to the material previously adopted by the Conference. Such revisions, amendments, or additions are then presented to the Conference as a whole, where they are discussed by weights and measures officials and representatives of interested manufacturers and industries. Eventually the proposals of the Committee are voted upon by the weights and measures officials.

All of the specifications, tolerances, and other technical requirements given herein are recommended by the National Conference on Weights and Measures for official promulgation in and use by the several 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 by a State agency.

2. Purpose. - The purpose of these technical requirements is to eliminate from use weights and measures and weighing and measuring devices 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.

3. Handbook Amendments. - The Committee on Specifications and Tolerances of the National Conference on Weights and Measures provides the mechanism for consideration of amendments to the code provisions. Recommendations as to amendments and suggestions concerning investigations that might lead either to amendments or to new provisions should be directed to the Executive Secretary, National Conference on Weights and Measures, National Institute of Standards and Technology, Gaithersburg, MD 20899. Recommendations or suggestions with supporting data, including test results, are most helpful.

4. 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.

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[1] When sitting as a voting body, the National Conference on Weights and Measures (NCWM) is made up of State and local weights and measures officials from all parts of the United States. The NCWM normally meets annually.

[2] Communications to this committee may be addressed as follows: Executive Secretary, National Conference on Weights and Measures, National Institute of Standards and Technology, Gaithersburg, MD 20899.

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.1.3. Graduations.
S.1.3.1. Length.
S.1.3.2. Width.

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 are limited to the design of zero indication. Likewise, paragraphs S.1.3.1. and S.1.3.2. are directly related to each other, but are limited to the design of graduations.

5. 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 shall 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 on 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 at hand 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 will show in italic type indicating 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].* It will be a general rule to review each nonretroactive requirement after it has been effective for 10 years to determine the appropriateness of its nonretroactive status.

6. Using the Handbook. - Handbook 44 is designed as a working tool of the weights and measures official and the equipment manufacturer, installer, and repairman. 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 at hand when any of its requirements are being applied. Direct reference is the only sure way to apply a requirement properly and to check to see if other requirements are applicable.

Sec. 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:

(a) To commercial weighing and measuring equipment; that is, to weights and measures and weighing and measuring devices commercially used or employed in establishing the size, quantity, extent, area, or measurement of quantities, things, produce, or articles for distribution or consumption, purchased, offered, or submitted for sale, hire, or award, or in computing any basic charge or payment for services rendered on the basis of weight or measure.

(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.

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

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

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 inch-pound 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 after the effective date for:

(a) devices manufactured within a State after the effective date;

(b) both new and used devices brought into a State after the effective date; and

(c) devices that have been used in noncommercial applications and are then being 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.)*
(Amended 1989)

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 designation that positively identifies the pattern or design of the device;

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

(d) 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]

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)

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

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.
[Made retroactive 1990] (Amended 1978, 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 be applicable also to recorded representations. All recorded values shall be printed digitally.
[Made retroactive 1990] (Amended 1975)

G-S.5.6.1. Recorded Representation of Metric Units on Equipment with Limited Character Sets. - The appropriate defining symbols are shown in Table 1.
(Added 1977)

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. [Nonretroactive as of January 1, 1977.]*
(Amended 1978)

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 affects the metrological integrity of the device can be made to any electronic mechanism.*
[Nonretroactive as of January 1, 1990.]
(Added 1985)(Amended 1989)

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; and 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:

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

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

(c) equipment 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;

Table 1.
Representation of Units

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

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

(e) equipment 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.

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. (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.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 so installed 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. [See also G-UR.3.3.]

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 equipped with a primary indicating element and used in direct sales, except a prescription scale, shall be so positioned that its indications may be accurately read and the weighing or measuring operation may be observed from some reasonable "customer" position. The permissible distance between the equipment and a reasonable customer 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)

G-UR.3.4. Responsibility, Money-Operated Devices. - A device of the money-operated type, except 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 servicing agency for the device.
(Amended 1977)

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 found to be in error predominantly in a direction favorable to the device user shall not be considered "maintained in a proper operating condition."
(Amended 1973, 1991)

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.

Section 2

Sec. 2.20. Scales

A. Application

A.1. General. - This code applies to all types of weighing devices other than automatic bulk-weighing systems and belt-conveyor scales. The code comprises requirements that are generally applicable 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. Also see General Code requirements.

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) On point-of-sale systems, 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 when the scale is in an out-of-balance condition.
(Added 1987)
(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.
[Nonretroactive as of January 1, 1993.]
(Amended 1992)

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;

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

Examples: scale 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; or, scale divisions may be 1/2, 1/4, 1/8, 1/16, etc.
[Nonretroactive as of January 1, 1986.]

S.1.2.1. Weight 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.
[Nonretroactive and enforceable as of January 1, 1989.]
(Added 1987)

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 percent greater than the width of subordinate graduations. Graduations shall not be 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 widest graduation,

(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 Table 1M and 1. When such limiting stops are not provided, the total travel at the weighbeam tip shall be not less than 8 percent of the distance from 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 (cm)	Minimum travel between limiting stops (millimeter)
30 or less	10
30+ to 50, inclusive	13
50+ to 100, inclusive	18
Over 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 or less	0.4
12+ to 20, inclusive	0.5
20+ to 40, inclusive	0.7
Over 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, a 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. - An indicating or recording element shall not display nor record any values when the gross platform load (not counting the initial dead load that has been canceled by an initial zero-setting device) is in excess of:

(a) *scale capacity plus 9 scale divisions for electronic computing scales (excluding postal scales and weight classifiers); or**

(b) 105 percent of the capacity of the system for all other scales.

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) multirevolution dial scales not equipped with unit weights, (3) scales equipped with two or more weighbeams, nor (4) devices that indicate mathematically-derived totalized values. *[*Nonretroactive as of January 1, 1993.]* (Amended 1990 and 1992)

S.1.8. Computing Scales.

S.1.8.1.M. Money-Value Graduations. - 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. (See also S.1.8.2.)

S.1.8.1. Money-Value Graduations. - 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. (See also S.1.8.2.)

S.1.8.2. 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; G-S.5.5.)

S.1.8.3. 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 whole units of weight, and not in common or decimal fractions. (Amended 1985)

S.1.8.4. 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,[1]
(b) the unit price,[1]
(c) the total price, and
(d) the product class or, in a system equipped with price look-up capability, the product name or code number.

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

[1] Weight values shall be identified by kilogram, kg, pound, lb, or the sign "#."

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.

(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 affects the metrological integrity of the device can be made to any electronic mechanism. [Nonretroactive as of January 1, 1990.]
(Amended 1989, 1991)

S.1.12. Manual Gross Weight Entries. *- A device shall accept an entry of a manual gross weight value only when the scale is at gross load zero and the scale indication is at zero in the gross weight display mode. 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.]*
(Added 1992)

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.

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 semi-automatic 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:

(a) plus or minus 3 scale divisions for scales of more than 2 000 kg (5 000 lb) capacity in service prior to January 1, 1981, and for all axle load, railway track, and vehicle scales; or

(b) plus or minus 1 scale division for all other scales.

S.2.1.3. Scales Equipped with an Automatic Zero-Setting Mechanism. *- 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:*

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

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

(c) for all other scales: 1.0 scale division.
[Nonretroactive and enforceable as of January 1, 1981.]

S.2.1.4. Monorail Scales. - On a monorail scale equipped with digital indications, means shall be provided for setting the zero-load balance to within 0.02 percent of scale capacity. On an in-motion system, means shall be provided to automatically maintain these conditions.

S.2.1.5. Initial Zero-Setting Mechanism. -

(a) Scales of accuracy classes I, II, and III may be equipped with an initial zero-setting device.

(b) An initial zero-setting mechanism shall not zero a load in excess of 20 percent 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.

(Added 1990)

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), 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.**
(Amended 1985)

*[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 monorail scale equipped with digital indications, means shall be provided for setting any tare value of less than 5 percent of the scale capacity to within 0.02 percent of scale capacity. On an in-motion system, means shall be provided to automatically maintain this condition.

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 moved from a level position and rebalanced in a position that is out of level in any upright direction by 5 percent (approximately 3 degrees). The level-indicating means shall be readable without removing any scale parts requiring a tool.

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

[Note: Portable wheel-load weighers and portable axle-load scales shall be accurate when placed out of level up to and including 5 percent (approximately three degrees).]
(Amended 1991)

S.2.4.1. Vehicle On-Board Weighing Systems. - A vehicle on-board weighing system shall operate within tolerance when the weighing system is out of

level up to 3 degrees or 5 percent. 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)

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. Electronic Elements. - Electronic 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:

(a) plus or minus 3 scale divisions for scales of more than 2 000 kg (5 000 lb) capacity in service prior to January 1, 1981, and for all vehicle, axle load, livestock, and railway track scales;

(b) plus or minus 1 scale division for all other scales.

The values recorded shall be within applicable tolerances.

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

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 2.

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.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.

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.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 1 000-kg (2 000-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. 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. 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. On a variable division-value (multi-range) scale, the value of "e" shall be equal to the value of "d."[2]
(Added 1986)

S.6. Marking Requirements. [See also G-S.1., G-S.4., G-S.6., G-S.7., G-UR.2.1.1., and UR.3.4.1.]

S.6.1. Nominal Capacity; Vehicle, Axle-Load, and Livestock Scales. *- For all vehicle, axle-load, and livestock 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:*

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

where N = the number of sections in the scale.
(See N.1.3.4. and T.N.3.1.)
[Nonretroactive as of January 1, 1989.]
(Added 1988)

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 G-S.1. of the General Code and S.6. of the Scales Code 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 (COC) have been issued under the National Type Evaluation Program, 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. and explained in the accompanying notes (Table S.6.3.b.).
(Added 1990)

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.
(Amended 1988)

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

Table 3
Parameters for Accuracy Classes

Class	*Value of the verification scale division (d or e[1])*	*Number of scale divisions (n)*	
		Minimum	*Maximum*
	METRIC		
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]	*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*
	INCH-POUND		
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*
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. 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."

[2] A scale marked "For prescription weighing only" may have a scale division not less than 0.01 gram. (Added 1986)

[3] The value of a scale division for crane and hopper (other than grain hopper) scales shall be not less than 0.5 lb (0.2 kg). The minimum number of scale divisions shall be not less than 1 000.

[Nonretroactive as of January 1, 1986.]
(Amended 1986 and 1987)

Table S.6.3.a.

Marking Requirements

Weighing Equipment / To Be Marked With	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 (11)	Other equipment or device (10)
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 (16)
Accuracy Class (17)	x	x (8)	x(19)	x	
Nominal Capacity (3)(18)	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 (12)		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	
Safe Load Limit				x	
Load Cell Verification Interval (v_{min})				x	
Section Capacity (14)		x	x		

For applicable notes, see Table S.6.3.b.

(Added 1990) (Amended 1992)

Table S.6.3.b.

Notes For Table S.6.3.a.

1. Manufacturer's identification and model designation. (See G-S.1.)

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

3. The nominal capacity *and value of the scale division shall be shown together (e.g., 50 000 x 5 kg, 100 000 x 10 lb, 15 x 0.005 kg , or 30 x 0.01 lb adjacent to the weight display when the nominal capacity and value of the scale division are not immediately apparent. Each scale division value or weight unit shall be marked on variable-division value or division-unit scales. [Nonretroactive as of January 1, 1983]*

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

5. *Required only on class III, III L, and IIII scales if the range is other than -10 to 40 °C (14 °F to 104 °F). [Nonretroactive as of January 1, 1986]*

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

7. *Denotes compliance for single or multiple load cell applications. [Nonretroactive as of January 1, 1988]*

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, axle-load, and livestock 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.]*

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 symbol for the serial number 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, axle load, and livestock scales. *Such marking shall be identified as "concentrated load capacity" or by the abbreviation "CLC".* [*Nonretroactive as of January 1, 1989]*

13. *A scale 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, e.g., postal scale, prepack scale, weight classifier, etc. [Nonretroactive as of January 1, 1986]*

14. Required on the indicating element of railway track scales only. When marked on vehicle, axle load, and livestock scales manufactured before January 1, 1989, it may be used as the CLC.

Table S.6.3.b.

Notes For Table S.6.3.a. (Continued)

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

19. *Nonretroactive as of January 1, 1988.*
(Amended 1992)

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. - On scales so marked and with n equal to or greater than 1 000, the decreasing-load test shall be conducted 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 4 000d, 2 000d, and 500d; for scales with n less than 1 000, the test load shall be equal to one-half of the maximum load applied in the increasing-load test. (See Table 6.)

N.1.2.2. All Other Scales. - On all other scales, 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.

N.1.3. Shift Test.

N.1.3.1. Bench or Counter Scales. - A shift test shall be conducted with a half-capacity test load centered successively at four points equidistant between the center and the front, left, back, and right edges of the load-receiving element.

N.1.3.2. Dairy-Product-Test Scales. - A shift test shall be conducted with a test load of 18 grams successively positioned at all points on which a weight might reasonably be placed in the course of normal use of the scale.

N.1.3.3. Equal-Arm Scales. - A shift test shall be conducted with a half-capacity test load positioned

on each pan as prescribed in N.1.3.1. An equal test load shall be centered on the other pan.

N.1.3.4. Vehicle Scales, Axle-Load Scales, and Livestock Scales With More Than Two Sections. - A shift test shall be conducted with at least two different test loads and may be performed anywhere on the load-receiving element using the prescribed test patterns and maximum test loads specified below. (Two-section livestock scales shall be tested consistent with N.1.3.8.)
(Amended 1991)

(a) **Prescribed Test Pattern.** The prescribed test pattern shall be an area at least 1.2 m (4 ft) long and as wide as the scale platform.

(b) **Maximum Loading.** When loading the scale for testing, one side of the test pattern shall be loaded to no more than one quarter of the concentrated load capacity before loading the other side. The maximum test load applied to the prescribed test pattern shall not exceed the concentrated load capacity or, for scales installed prior to January 1, 1989, the rated section capacity.

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

(d) **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)

N.1.3.5. 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.1.3.6. Monorail Scales. - 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.1.3.7. 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.1.3.8. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers. - A shift test shall be conducted with a half-capacity test load centered, as nearly as possible, successively at the center of each quarter of the load-receiving element, or with a quarter-capacity test load centered, as nearly as possible, successively over each main load support.
(Amended 1987)

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. or T.N.6.

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.]
(Added 1985)

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.)
(Renumbered 1988)

N.2. Verification (Testing) Standards. - Field standard weights used in verifying weighing devices shall comply with requirements of NIST Handbook 105-1 (Class F) or the tolerances expressed in Fundamental Considerations, paragraph 3.2. (i.e., one-third of the smallest tolerance applied).
(Amended 1986)

N.3. Recommended Minimum Test Weights and Test Loads*.** - The recommended** minimum test weights and test loads for in-service tests (except railway track scales) are shown in Table 4. [See Table 4 for * and **.]
(Added 1984, Amended 1988)

N.3.1. Minimum Test-Weight Load and Recommended Strain-Load Test for Railway Track Scales.
(Amended 1990)

N.3.1.1. Approval. - 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)

N.3.1.2. Interim Approval. - A test-weight load of not less than 13 500 kg (30 000 lb) and a strain-load test up to at least 25 percent of scale capacity may be used to return a scale into service following repairs.
(Added 1990)
Note: The length of time the scale may be used following an interim test is at the discretion of the official with statutory authority.
(Added 1990)

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)

N.4. Coupled-in-Motion Railroad Weighing Systems[1]

N.4.1. Weighing Systems Used to Weigh Trains of Less Than 10 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 10 or More Cars. - The minimum test train shall be a consecutive-car test train of no less than 10 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 10 or More Cars. -

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[1]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)

Table 4.
Recommended** Minimum Test Weights and Test Loads

Device capacity	Recommended** minimums (in terms of device capacity)		Recommended** (where practicable)
	Test weights (greater of)	Test loads*	
0 to 50 kg (0 to 100 lb)	105%		
51 to 500 kg (101 to 1 000 lb)	50% or 50 kg (100 lb)	105%	
501 to 20 000 kg (1 001 to 40 000 lb)	25% or 250 kg (500 lbs)	50%	Test weights to dial face capacity, 1 000d or test load to used capacity, if greater than minimums specified
20 000 kg+ (40 000 lb+)	12.5% or 5 000 kg (10 000 lb)	25%	

*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 or build-up test methods.

Except for railway track scales, the recommended** minimum test of a class III L scale shall consist of one test from zero to at least 25% of the scale capacity and then one strain load test to at least the used capacity of the device.

Each test is to be conducted using a known test load of at least 25% of scale capacity. This test load may be comprised entirely of test weights or a combination of a test weights equal to at least 12.5% of scale capacity and a substitution load.

**The word "recommended" will be deleted from this section as of January 1, 1994. This will make the amounts of test weights and test loads specified in Table 4 mandatory as of January 1, 1994.
(Amended 1988, 1989)

(a) These weighing systems shall be tested using a consecutive-car test train of no less than 10 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:

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

(2) a 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.

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 to either a distributed-car or 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 shorter consecutive-car test train shall not exceed 0.15 percent. If the difference in test results exceeds 0.15 percent, the length of the shorter consecutive-car test train shall be increased until agreement within 0.15 percent is achieved.
(Added 1990; Amended 1992)

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 10 cars or 10 percent 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 10 cars.

(b) If the consecutive-car test train consists of between 10 and 20 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 20 cars, it shall be run over the scale a minimum of three times in each mode of operation.
(Added 1990; Amended 1992)

N.5. Nominal Capacity of Prescription Scales. - The nominal capacity of a prescription scale shall be assumed to be 1/2 apothecary ounce, unless otherwise marked. (Applicable only to scales not marked with an accuracy class.)

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.
(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. and Table 5.
(Amended 1990)

Table T.1.1. Tolerances for Unmarked Scales

Type of Device	Subcategory	Min. Tol.	Accept. Tol.	Maint. Tol.	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.
Grain test scales	$n \leq 10\,000$ $n > 10\,000$	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	
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	
Monorail Scales, In-Motion		T.N.3.8.			1.0	
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	
Wheel-load weighers and portable axle-load scales	Tested individually or in pairs[2]	0.5d or 50 lb, whichever is greater	1% of test load	2% of test load	1.5	
Prescription scales		0.1 grain (6 mg)	0.1 % of test	0.1% of test load	1.5	
Jewelers' scales	Graduated	0.5d	0.05% of test load	0.05% of test load	1.5	
	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	
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	
	Loads ≥ 2 lb	Table 5	Table 5	Table 5		
Other postal and parcel post scales		Table 5	Table 5	Table 5	1.5	
All other scales	$n > 5\,000$	0.5d 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.
	$n \leq 5\,000$	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.

[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 indications.

(Added 1990; Amended 1992)

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

Scale capacity (lb)	Test loads (lb)	Maintenance tolerance (±) (oz)	(lb)	Acceptance tolerance (±) (oz)	(lb)
0 to 4, inclusive*	0 to 1, inclusive	1/32	0.002	1/32	0.002
	over 1	1/8	0.008	1/16	0.004
over 4*	0 to 7, inclusive	3/16	0.012	3/16	0.012
	7+ to 24, inclusive	3/8	0.024	3/16	0.012
	24+ to 30, inclusive	1/2	0.030	1/4	0.015
	over 30	0.1% of Test Load		0.05% of Test Load	

*See Table T.1.1. 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. through T.2.8.: 2d, 0.2 percent of the scale capacity, or 40 lb, whichever is least.

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

T.2.4. Jewelers' Scales.

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

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

T.2.5. Dairy-Product-Test Scales

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

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

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

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

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

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

T.2.8. Railway Track Scales. 3d 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. 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 onthe 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.4. 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, shall not exceed one scale division (d) or the equipment shall:

(a) blank the indication, or

(b) provide an error message, or

(c) the indicator 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.

(Added 1986)

T.5. 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 and effective January 1, 1981.]
(Added 1986)

T.N. Tolerances Applicable to Devices Marked I, II, III, III L, & 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; the tolerance values apply to certified test loads only.

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.)

T.N.2.4. Multirange (Variable Division-Value) Scales. - For multirange devices, 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.

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. and T.N.3.2.
(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. and T.N.3.2. for Class III L, except that the tolerance for crane and construction materials hopper scales shall not be less than 1d or 0.1 percent of the scale capacity, whichever is less.
(Amended 1986)

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

T.N.3.6. Coupled-In-Motion Railroad Weighing Systems. - Tolerances 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 percent.
(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 percent of the errors may exceed two times the static maintenance tolerance; and

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

(Amended 1990 and 1992)

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 1d for each additional 500d or fraction thereof)	

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. - 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. In-Motion Weighing, Monorail Scales. - On an in-motion test of 20 or more individual test loads, 10% of the individual test loads may be in error, each not to exceed two times the static tolerance applicable. The error on the total of the individual test loads shall not exceed ±0.2 percent.
(Added 1986)

T.N.3.9. Materials Test on Customer-Operated Bulk Weighing Systems for Recycled Materials. - The maintenance and acceptance tolerance shall be ± 5 percent of the applied materials test load except that the average error on 10 or more test materials test loads shall not exceed ±2.5 percent.
(Added 1986)

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. - At constant test conditions, the indication 20 seconds after the application of a load and the indication after 1 hour shall not differ by more than:

(a) one-half of the absolute value of the applicable tolerance for the applied load for class III L devices; and

(b) the absolute value of the applicable tolerance for the applied load for all other devices.

(Amended 1989)

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 1d for scales equipped with balance indicators, and 2d or 0.2 percent 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 1d at zero and 2d 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 1.4d shall cause a change in the indication of at least 1.0d. (See N.1.5.)

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

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, 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.

(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:

Temperature Range by Class	
Class	Temperature Range
I	5 °C (9 °F)
II	15 °C (27 °F)
III, III L, & 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 to 105 kPa (28 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. through T.N.7., inclusive, over the line voltage range of 100 to 130 V or 200 to 250 V rms as appropriate, and over the frequency range of 59.5 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.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 with 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 could not be interpreted, or transmitted into memory or to a recording element, as a correct measurement value.
(Added 1986)

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.

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

(b) For devices not marked with a class designation, Table 7b applies.

UR.1.2. Grain Hopper Scales. - The minimum number of scale divisions for a Class III Hopper Scale used for weighing grain shall be 2 000.

UR.1.3. Value of the Indicated and Recorded Scale Division. - Except for Class I scales, the value of the division as recorded shall be the same as the division value indicated.
[Nonretroactive as of January 1, 1986.]
(Added 1985)

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 1 000 g.
(Added 1992)

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.

Table 7a. Typical Class or Type of Device for Weighing Operations	
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, animal scales, postal scales, and scales used to determine laundry charges
III L	Vehicle, axle-load, livestock, railway track scales, crane, 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, and 1992)	

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 ounce
Animal Scales	1 pound
Grain Hopper Scales Capacity up to and incl. 50 000 lb Capacity over 50 000 lb	 10 pounds (but not greater than 0.05 % of capacity) 20 pounds
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 pounds 50 pounds
Railway Track Scales With weighbeam Automatic indicating	 20 pounds 100 pounds
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.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. *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.]

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 approach end or ends of a vehicle scale installed in any one location for a period of 6 months or more, 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 constructed of concrete or similar durable material to insure 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. Any slope in the remaining portion of the approach shall insure (1) ease of vehicle access, (2) ease for testing purposes, and (3) drainage away from the scale.
[Nonretroactive as of 1976.]
(Amended 1977 and 1983)

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.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.

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.3.3. 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

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 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 10d is recommended for a weight classifier marked in accordance with a statement identifying its use for special applications.
(Amended 1990)

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:

(a) the weight of 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) the weight of 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) shall not be used for other than its intended purpose.[1]

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) 10d when weighing scrap material for recycling;

(b) 50d 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 and 1992)

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 500d. (Amended 1989)

UR.3.9. Use of Manual Gross Weight Entries. - Manual gross weight entries are permitted for use in the following applications only: (1) in point-of-sale systems interfaced with scales when credit is being given for a weighed item; (2) when a device or system is generating labels for standard weight packages; (3) when postal scales or weight classifiers are generating manifests for packages to be picked up at a later time; and (4) on livestock scale systems that generate weight tickets to correct erroneous tickets. (Added 1992)

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 length or the width of the load-receiving element of a scale shall not be increased beyond the manufacturer's design dimension, 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 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.

UR.5. Coupled-In-Motion Railroad Weighing Systems.- 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. and N.4.3.(a), 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. (Added 1990; Amended 1992)

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[1] 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 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.

Sec. 2.21. Belt-Conveyor Scale Systems

A. Application

A.1. This code applies to belt-conveyor scale systems used for the weighing of bulk materials.

A.2. The code does not apply to:

(a) devices used for discrete weighing while moving on conveyors;

(b) devices that measure quantity on a time basis;

(c) check-weighers; or

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

A.3. See also General Code requirements.

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 submultiple of 1, 2, or 5.

S.1.3. Value of the Scale Division.

S.1.3.1. For Scales Installed After January 1, 1986. *- The value of the scale division shall not be greater than 0.1 percent (1/1 000) of the minimum totalized load.*
[Nonretroactive as of January 1, 1986.]

S.1.3.2. For Scales Installed Before January 1, 1986. - The value of the scale division shall not be greater than 1/1 200 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. may be readily and accurately determined in 20 minutes of operation.

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. It shall record the unit of measurement (i.e., kilograms, tonnes, pounds, tons, etc.), the date, and time.*
[Nonretroactive as of January 1, 1986.]

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 35 percent and when the rate of flow is equal to or greater than 98 percent 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)

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.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) shall be held securely in adjustment and shall not be capable of adjustment without breaking a security means.

S.2.3. Overload Protection. - The load-receiving elements shall be equipped with means for overload protection of not less than 150 percent 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. - The range of the zero-setting mechanism shall not be greater than ±2 percent of the rated capacity of the scale without breaking the security means. 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.**
*[*Nonretroactive as of January 1, 1990]*
(Amended 1989)

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. Marking Requirements. - A belt-conveyor scale shall be marked with the following: (Also see G-S.1.)

(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;

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

(e) the operational temperature range if other than -10 to 40 °C (14 to 104 °F).
[Nonretroactive as of January 1, 1986.]

N. Notes

N.1. General. - Belt-conveyor scales are capable of weighing bulk material accurately. (See Tolerances.) However, their performance can be detrimentally affected by the conditions of the installation. (See User Requirements.)

N.1.1. Official Test. - An official test of a belt-conveyor scale system shall be a materials test.

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. It shall be

tested at normal use capacity and may be tested at any other rate of flow that may be used at the installation. Each test shall be conducted for:

(a) not less than 1 000 scale divisions,

(b) at least three revolutions of the belt, and

(c) at least 10 minutes' operation, or for a normal weighment.

(Amended 1986)

N.3. Test Procedures.

N.3.1. Zero Load Tests. - If a belt-conveyor scale system has been idle for a period of 2 hours or more, the system shall be run for not less than 30 minutes when the temperature is above 5 °C (41 °F). When the temperature is below 5 °C (41 °F), additional warmup time, depending upon conditions, is required before beginning the zero-load tests. The variation between the beginning and ending indication of the master weight totalizer shall not be more than ± 1 scale division when the instrument is operated at no load for a period of time equivalent to that required to deliver the minimum totalized load of 1 000 scale divisions.

The zero-load test shall be conducted over a whole number of belt revolutions, but not less than three revolutions or 10 minutes' operation, whichever is greater.

During any portion of the zero-load test, the totalizer shall not change more than three scale divisions from its initial indication.

(Amended 1989)

N.3.2. Material Tests. - Use bulk material, preferably that material for which the device is normally used. Either pass a quantity of preweighed 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. Where practicable, the substitution method of weighing should be used. 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. Stencilled 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 preweighed 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) When a railway track scale is used to weigh the test load, not more than 48 hours should elapse between the test on the belt-conveyor scale and the determination of the weight of the test load. When other scales are used, the elapsed time should be not more than 8 hours.

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

(f) On initial verification, at least three individual tests shall be conducted. On subsequent verifications, at least two individual tests shall be conducted. The performance of the equipment is not to be determined by averaging the results of the individual tests. The results of all of these tests shall be within the tolerance limits.

(Amended 1986, 1989)

N.3.2.1. Accuracy of Material. - The quantity of material comprising the material test shall be weighed statically or on an uncoupled-in-motion railway track scale to an accuracy of at least 0.1 percent. Verifying this accuracy is the responsibility of the official with statutory authority. Typical scales used for this purpose include class II, III, and III L scales, or a scale with the tolerances as described in Table T.1.1. of Handbook 44 Section 2.20.

(Added 1989)(Amended 1991)

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 percent.
(Added 1990)
(Amended 1989 and 1990)

T. Tolerances

T.1. Tolerance Values. - Maintenance and acceptance tolerances on materials tests shall be ± 0.5 percent (1/200) of test load.

T.2. Tolerance Values, Repeatability Tests. - The variation in the values obtained during the conduct of materials tests shall not be greater than 0.25 percent (1/400).

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; and

(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 of from -10 to 40 °C (14 to 104 °F).

T.3.1.1. Effect on Zero-Load Balance. - The zero-load indication shall not change by more than 0.07 percent 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.

T.3.1.2. Temperature Limits. *- If a temperature range other than -10 to 40 °C (14 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 to 130 V or 200 to 250 V as appropriate and over a frequency range of 59.5 to 60.5 Hz.

UR. User Requirements

UR.1. Use Requirements. - A belt-conveyor scale system shall be operated between 35 and 98 percent of its rated capacity.

UR.1.1. Minimum Totalized Load. - Delivered quantities of less than the minimum test load shall not be considered a valid weighment.

UR.1.2. Security Means. - When a security means has been broken, it shall be reported to the official with statutory authority.
(Amended 1991)

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

(a) a belt-conveyor scale shall be so installed that neither its performance nor operation will be

adversely affected by any characteristic of the foundation, supports, or any other equipment;

(b) all live portions of the scale shall be protected by appropriate guard devices to prevent accidental interference with the weighing operation;

(c) suitable protection shall be provided for storage of any simulated load equipment.

UR.2.2.1. For Scales not Installed by the Manufacturer. - Unless the scale is installed in a short conveyor designed and furnished by the scale manufacturer or built to the scale manufacturer's specifications, the conveyor shall comply with the following minimum requirements:

(a) If the belt length is such that a take-up device is required, this device shall be of the counter-weighted type for either vertical or horizontal travel.

(b) The scale shall be so installed that the first weigh idler of the scale is at least 6 m (20 ft) or 5 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 center line of the weigh span of the scale.

(c) There shall be no concave curve in the conveyor between the scale and the loading point. A concave curve beyond the scale shall start no closer than 12 m (40 ft) from the scale.

(d) There shall be no tripper or movable head pulleys in the conveyor.

(e) The conveyor shall be no longer than 300 m (1 000 ft) or shorter than 12 m (40 ft) from head to tail pulley .
[Nonretroactive as of January 1, 1986.]

(f) 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.

(g) The scale area and 4 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.

(h) Conveyor belting shall be no heavier than is required for normal use. Under any load, the belt shall contact the center or horizontal portion of the idlers. Splices shall not cause any undue disturbance in scale operation (see N.3.).

(i) 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.

(j) The belt shall not extend beyond the edge of the idler roller in the weighing area.

***UR.2.3. 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.2.4. Belt Travel (Speed). - 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.

UR.3. Use Requirements.

UR.3.1. Loading. - The feed of material to the scale shall be controlled to assure that, during normal operation, the material flow is in accordance with manufacturer's recommendation for rated capacity.

UR.3.2. Maintenance. - Belt-conveyor scales and idlers shall be maintained and serviced in accordance with manufacturer's instructions and the following:

(a) 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.

(b) Simulated load tests shall be conducted at periodic intervals between official tests, to provide reasonable assurance that the device is performing correctly. The action to be taken as a result of simulated load test is as follows:

- if the error is less than 0.25 percent, no adjustment is to be made;

- if the error is at least 0.25 percent but not more than 0.6 percent, adjustment may be made if the official with statutory authority is notified; (Amended 1991)

- if the error is greater than 0.6 percent but does not exceed 0.75 percent, adjustments shall be made only by a competent service person and the official with statutory authority shall be notified. After such an adjustment, if the results of a subsequent test require adjustment in the same direction, an official test shall be conducted; (Amended 1991)

- if the error is greater than 0.75 percent, an official test is required. (Amended 1987)

(c) Scale Alignment. - "Wire line" (0.5 mm or 0.02 in diameter piano wire or equivalent nylon line) alignment checks shall be conducted when conveyor work is performed in the scale area or in accordance with manufacturer's recommendation. A materials test is required after any realignment. (Amended 1986)

(d) Simulated Load Equipment. - Simulated load equipment shall be clean and properly maintained.

(e) Records. - Records of calibration and maintenance, including conveyor alignment, shall be maintained on site for at least three current years to develop 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. (Amended 1991)

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)

Sec. 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. Also see General Code Requirements.

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 $\pm 1/2$ 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 1/2, 1/4, 1/8, 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 percent 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.

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. - 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.

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. An automatic zero setting mechanism is prohibited.

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:

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[1](Title amended 1986)

(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.

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. (See also G-S.1.)

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.*

*(*See Section 2.20 Scales Code for the parameters for these accuracy classes for scales. The specific requirements for automatic bulk weighing systems applies 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 percent 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 percent 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 percent of test load.

T.3.3. For all Other Systems. - The basic maintenance tolerance 0.2 percent of test load.
(Amended 1986)

T.4. Time Dependence. - At constant test conditions, the indication 20 s after the application of a load and the indication after 1 hour shall not differ by more than the absolute value of the applicable tolerance for the applied load.
[Nonretroactive and enforceable 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 1.4d shall cause a change in the indicated or recorded value of at least 2.0d. 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 1 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 to 105 kPa (28 to 31 in of mercury).
[Nonretroactive 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 to 130 V or 200 to 250 V rms as appropriate and over the frequency range of 59.5 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 and enforceable as of January 1, 1984.]
(Amended 1986 and 1992)

U.R.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 percent 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 percent 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)

Sec. 2.23. Weights

A. Application

A.1. This code applies to commercial weights; that is, weights used in connection with commercial weighing devices.

A.2. This code does not apply to test weights or to other "standards" of mass.

A.3. See also General Code requirements.

S. Specifications

S.1. Material. - The material used for weights shall be as follows:

(a) Weights of 6 g or 100 grains 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 grains may be made of aluminum, but shall not be made of iron or of unplated steel, except stainless steel.

S.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 g 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 30 grains or 2 g, 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. (See Appendix A; Fundamental Considerations paragraphs 3.2. and 3.3.)

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. Acceptance tolerances shall be one-half the maintenance tolerances.

T.3. On Metric Weights. - The maintenance tolerances shall be as shown in Table 2. Acceptance tolerances shall be one-half the maintenance tolerances.

T.4. On Carat Weights. - The maintenance tolerances shall be as shown in Table 2. Acceptance tolerances shall be one-half the maintenance tolerances.

T.5. On Apothecaries' and Troy Weights. - The maintenance tolerances shall be as shown in Table 3. 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 1 000		For scales with multiples of 1 000 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				
1/4	1.0	65				
1/2	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	970	12.0	780	6.5	420
6	17	1 190				
7	19	1 200				
8	21	1 400	15.0	970	9.0	580
9	23	1 500				
10	25	1 600	18.0	1160	10.0	650
15	28	1 800				
20	30	1 900				
25	35	2 300				
30	40	2 600				
40	45	2 900				
50	50	3 200				

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	1 000	3.0	3.0
20	1 500	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

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			

Section 3

Sec. 3.30. Liquid-Measuring Devices

A. Application

A.1. - This code applies to:

(a) devices used for the measurement of liquids, including liquid fuels and lubricants, and

(b) wholesale devices used for the measurement and delivery of agri-chemical liquids such as fertilizers, feeds, herbicides, pesticides, insecticides, fungicides, and defoliants.
(Added 1985)

A.2. - This code does not apply to:

(a) meters mounted on vehicle tanks (see Sec. 3.31. Code for Vehicle-Tank Meters),

(b) devices used for dispensing liquefied petroleum gases (see Sec. 3.32. Code for Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices),

(c) devices used for dispensing other liquids that do not remain in a liquid state at atmospheric pressures and temperatures,

(d) water meters, or

(e) devices used solely for dispensing a product in connection with operations in which the amount dispensed does not affect customer charges.

A.3. - In addition to the requirements of this code, liquid-measuring devices shall meet the requirements of Section 1.10. General Code.

S. Specifications

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

S.1.1. General. - A liquid-measuring device:

(a) shall be equipped with a primary indicating element, and

(b) may be equipped with a primary recording element.

S.1.2. Units. - A liquid-measuring device shall indicate, and record if the device is equipped to record, its deliveries in liters, gallons, quarts, pints, kilograms, pounds, or binary-submultiples or decimal subdivisions of the liter or gallon, or decimal subdivisions of the kilogram or pound. The indication of a delivery indicated in units of mass (kilograms, pounds) shall be expressed as "apparent mass versus a density of 8.0 g/cm^3;" that is, as the mass of a reference material having a density of 8.0 g/cm^3 that would produce the same balance (scale) indication as the actual liquid would produce if it were being measured at 20 °C in air with a density of 1.2 mg/cm^3.
(Amended 1987)

S.1.2.1. Retail Motor-Fuel Devices. - Deliveries shall be indicated and recorded, if the device is equipped to record, in liters or gallons and decimal subdivisions or fractional equivalents thereof.
(Added 1979)

S.1.2.2. Agri-Chemical Liquid Devices.

S.1.2.2.1. Liquid Measure. - Deliveries shall be indicated and recorded in liters or gallons and decimal subdivisions or fractional equivalents thereof.

S.1.2.2.2. Mass Measure. - Deliveries shall be indicated and recorded in kilograms or pounds and decimal subdivisions or fractional equivalents thereof.
(Added 1986)

S.1.2.3. Value of Smallest Unit. - The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed the equivalent of:

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

(b) 4 L (1 gal) or 5 kg (10 lb) on wholesale devices.

This requirement does not apply to manually operated devices equipped with stops or stroke-limiting means.
(Amended 1983 and 1986)

S.1.3. Advancement of Indicating and Recording Elements. - It shall not be possible to advance primary indicating and recording elements except by the mechanical operation of the device. Clearing a device by advancing its elements to zero is permitted, but only if:

(a) once started, the advancement movement cannot be stopped until zero is reached, and

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

S.1.4. Graduations.

S.1.4.1. Length. - Graduations shall be varied in length so that they may be conveniently read.

S.1.4.2. Width. - In a series of graduations, the width of:

(a) every graduation shall be at least 0.2 mm (0.008 in) but not greater than the minimum clear interval between graduations, and

(b) main graduations shall be not more than 50 percent greater than the width of subordinate graduations.

S.1.4.3. Clear Interval Between Graduations. - The clear interval between graduations shall be not less than 0.04 in. If the graduations are not parallel, the measurement shall be made:

(a) along the line of movement of the tip of the index of the indicator as it passes over the graduations, or

(b) if the indicator extends over the entire length of the graduations, at the point of widest separation of the graduations.

S.1.5. Indicators.

S.1.5.1. Symmetry. - The portion of the index of an indicator associated with the graduations shall be symmetrical with respect to the graduations.

S.1.5.2. Length.

(a) If the indicator and the graduations are in different planes, the index of the indicator shall extend to each graduation with which it is to be used.

(b) If the indicator is in the same plane as the graduations, the distance between the index 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.1.5.3. Width.

(a) The index of an indicator shall not be wider than the width of the widest graduation.

(b) If the index of an indicator extends over the entire length of a graduation, it shall be of uniform width throughout the portion that coincides with the graduation.

S.1.5.4. Clearance. - If the indicator and the graduations are in different planes, the clearance between the index of an indicator and the plane of the graduations shall be no greater than 1.5 mm (0.06 in).

S.1.5.5. Parallax. - Parallax effects shall be reduced to the practical minimum.

S.1.6. Operating Requirements, Retail Devices (Except Slow Flow Meters).

S.1.6.1. Indication of Delivery. - The device shall automatically show on its face the initial zero condition and the quantity delivered (up to the nominal capacity).

However, the first 0.03 L or (0.009 gal) of a delivery and its associated total sales price need not be indicated.
(Amended 1982)

S.1.6.2. Provisions for Power Loss.

S.1.6.2.1. Transaction Information. *- In the event of a power loss, the information needed to complete any transaction in progress at the time of the power loss (such as the quantity and unit price, or sales price) shall be determinable for at least 15 minutes at the dispenser or at the console if the console is accessible to the customer. [Nonretroactive as of January 1, 1983.]*

S.1.6.2.2. User Information. *- The device memory shall retain information on the quantity of fuel dispensed and the sales price totals during power loss. [Nonretroactive as of January 1, 1983.]*

S.1.6.3. Return to Zero.

(a) The primary indicating elements, and primary recording elements if the device is equipped to record, shall be readily returnable to a definite zero indication. However, a key-lock operated or other self-operated device may be equipped with cumulative indicating or recording elements, provided that it is also equipped with a zero-return indicating element.

(b) It shall not be possible to return primary indicating elements, or primary recording elements beyond the correct zero position.

(Amended 1972)

S.1.6.4. Display of Unit Price and Product Identity.

S.1.6.4.1. Unit Price. -

(a) A computing or money-operated device shall be able to display on each face the unit price at which the device is set to compute or to dispense.

(b) If a grade, brand, blend, or mixture is offered for sale from a device at more than one unit price, then all of the unit prices at which that product is offered for sale shall be displayed or shall be capable of being displayed on the dispenser using controls available to the customer prior to the delivery of the product. It is not necessary that all of the unit prices for all grades, brands, blends, or mixtures be simultaneously displayed prior to the delivery of the product. (Effective and nonretroactive as of January 1, 1991.)

(Amended 1989)

S.1.6.4.2. Product Identity.

(a) A device shall be able to conspicuously display on each side the identity of the product being dispensed.

(b) A device designed to dispense more than one grade, brand, blend, or mixture of product also shall be able to display on each side the identity of the grade, brand, blend, or mixture being dispensed.

S.1.6.5. Money-Value Computations.

(a) A computing device shall compute the total sales price at any single-purchase unit price (i.e., excluding fleet sales and other price contract sales) for which the product being measured is offered for sale at any delivery possible within either the measurement range of the device or the range of the computing elements, whichever is less. (Effective and nonretroactive as of January 1, 1991).

(b) The analog sales price indicated for any delivered quantity shall not differ from a mathematically computed price (quantity x unit price = total sales price) by an amount greater than the value in Table 1.

(Amended 1984 and 1989)

S.1.6.5.1. Money-Value Divisions, Analog. - The values of the graduated intervals representing money values on a computing type device shall be no greater than those in Table 1.
(Amended 1991)

S.1.6.5.2. Money-Value Divisions, Digital. - A computing type device with digital indications shall comply with the requirements of paragraph G.S.5.5. Money Values, Mathematical Agreement, and the total price computation shall be based on quantities not exceeding 0.01-gallon intervals for devices indicating in inch-pound

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

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

units and 0.05 liter for devices indicating in metric units.
(Added 1980)

S.1.6.5.3. Auxiliary Elements. - If a system is equipped with auxiliary indications, all indicated money value divisions of the auxiliary element shall be identical with those of the primary element.
[Nonretroactive and enforceable as of January 1, 1985.]

S.1.6.5.4. Selection of Unit Price.- Except for dispensers used exclusively for truck refueling (e.g., truck stop dispensers used only to refuel trucks), when a product or grade is offered for sale at more than one unit price through a computing device, the selection of the unit price shall be made prior to delivery using controls on the device or other user-activated controls. A system shall not permit a change to the unit price during delivery of product.
[Effective and nonretroactive as of January 1, 1991]
(Added 1989)(Amended 1991 and 1992)

S.1.6.5.5. Display of Quantity and Total Price. - When a delivery is completed, the total price and quantity for that transaction shall be displayed on the face of the dispenser for at least 5 minutes or until the next transaction is initiated by using controls on the device or other user-activated controls.
[Effective and nonretroactive as of January 1, 1994.]
(Added 1992)

S.1.6.6. Agreement Between Indications. - When a quantity value indicated or recorded by an auxiliary element is a derived or computed value based on data received from a retail motor fuel dispenser, the value may differ from the quantity value displayed on the dispenser, provided the following conditions are met:

(a) all total money values for an individual sale that are indicated or recorded by the system agree, and

(b) within each element, the values indicated or recorded meet the formula (quantity x unit price = total sales price) to the closest cent.
[Nonretroactive as of January 1, 1988.]
(Added 1985)(Amended 1987 and 1988)

***S.1.6.7. Recorded Representations, Point of Sale Systems.** - The sales information recorded by cash registers when interfaced with a retail motor-fuel*

dispenser shall contain the following information for products delivered by the dispenser:

(a) the total volume of the delivery,

(b) the unit price,

(c) the total computed price, and

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

[Nonretroactive as of January 1, 1986.]
(Added 1985)

S.1.6.8. Lubricant Devices, Travel of Indicator. -The indicator shall move at least 2.5 cm (1 in) in relation to the graduations, if provided, for a delivery of 0.5 L (1 pt).

S.1.7. Operating Requirements, Wholesale Devices Only.

S.1.7.1. Travel of Indicator. - A wholesale device shall be readily operable to deliver accurately any quantity from 200 L (50 gal) or 225 kg (500 lb) to the capacity of the device. If the most sensitive element of the indicating system utilizes an indicator and graduations, the relative movement of these parts corresponding to a delivery of 4 L (1 gal) or 5 kg (10 lb) shall be not less than 5 mm (0.20 in).
(Amended 1987)

S.1.7.2. Money Values-Mathematical Agreement. - Any digital money-value indication and any recorded money value on a computing-type device shall be in mathematical agreement with its associated quantity indication or representation to within one cent of money value.

S.2. Measuring Elements.

S.2.1. Vapor Elimination.

(a) A liquid-measuring device shall be equipped with a vapor or air eliminator or other automatic means to prevent the passage of vapor and air through the meter.

(b) Vent lines from the air or vapor eliminator shall be made of metal tubing or other rigid material.
(Amended 1975)

S.2.2. Provision for Sealing. - Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that no adjustment may be made of:

(a) any measurement element, or

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

When applicable, the adjusting mechanism shall be readily accessible for purposes of affixing a security seal.
(Amended 1991)

S.2.3. Directional Flow Valves. - Valves intended to prevent reversal of flow shall be automatic in operation.

S.2.4. Stop Mechanism.

S.2.4.1. Indication. - The delivery for which the device is set shall be conspicuously indicated.
(Amended 1983)

S.2.4.2. Stroke Limiting Elements. - Stops or other stroke limiting elements subject to direct pressure or impact shall be:

(a) made secure by positive, nonfrictional engagement of these elements; and

(b) adjustable to provide for deliveries within tolerances.
(Amended 1983)

S.2.4.3. Setting. - If two or more stops or other elements may be selectively brought into operation to permit predetermined quantities of deliveries,

(a) the position for the proper setting of each such element shall be accurately defined; and

(b) any inadvertent displacement from the proper setting shall be obstructed.
(Amended 1983)

S.2.5. Zero-Set-Back Interlock, Retail Motor-Fuel Devices. - A device shall be constructed so that:

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

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

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

(Amended 1981 and 1985)

S.2.6. Temperature Determination, Wholesale Devices Except Mass Flow Devices. - For test purposes, means shall be provided to determine the temperature of the liquid either:

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

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

[Nonretroactive as of January 1, 1985.]

(Added 1984)(Amended 1986)

S.2.7. Wholesale Devices Equipped with Automatic Temperature Compensators.

S.2.7.1. Automatic Temperature Compensation. - A device may be equipped with an automatic means for adjusting the indication and registration of the measured volume of product to the volume at 15 °C (60 °F).

S.2.7.2. Provision for Deactivating. - On a device equipped with an automatic temperature-compensating mechanism that will indicate or record only in terms of gallons compensated to 15 °C (60 °F), provision shall be made for deactivating the automatic temperature-compensating mechanism so that the meter can indicate, and record if it is equipped to record, in terms of the uncompensated volume.

(Amended 1972)

S.2.7.3. Provision for Sealing Automatic Temperature Compensating Systems. - Provision shall be made for applying security seals in such a manner that an automatic temperature-compensating system cannot be disconnected and that no adjustment may be made to the system without breaking the seal.

S.2.7.4. Temperature Determination with Automatic Temperature Compensation. - For test purposes, means shall be provided (e.g., thermometer well) to determine the temperature of the liquid either:

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

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

(Amended 1987)

S.2.8. Exhaustion of Supply, Lubricant Devices other than Meter Types. - When the level of the supply of lubricant becomes so low as to compromise the accuracy of measurement, the device shall:

(a) become inoperable automatically, or

(b) give a conspicuous and distinct warning.

S.2.9. Mass Flow Meters. - An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.

(Added 1987)

S.3. Discharge Lines and Valves.

S.3.1. Diversion Prohibited. - It shall not be possible to divert any measured liquid from the measuring chamber of the meter or its discharge line.

Two or more delivery outlets may be installed only if automatic means are provided to ensure that:

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

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

(Amended 1991)

S.3.2. Exceptions. - The provisions of S.3.1. Diversion Prohibited shall not apply to:

(a) truck refueling devices when diversion of flow to other than the receiving vehicle cannot readily be accomplished and is readily apparent. Allowable deterrents include, but are not limited to, physical barriers to adjacent driveways, visible valves, or lighting systems that indicate which outlets are in operation, and explanatory signs;

(b) other devices, when all discharge outlets designed to operate simultaneously are 3.8 cm (1.5 in) in diameter or larger.

(Amended 1982, 1990, and 1991)

S.3.3. Pump-Discharge Unit. - A pump-discharge unit equipped with a flexible discharge hose shall be of the wet-hose type.

S.3.4. Gravity-Discharge Unit. - On a gravity-discharge unit:

(a) the discharge hose or equivalent pipe shall be of the dry-hose type with no shutoff valve at its outlet end unless the hose or pipe drains to the same level under all conditions of use;

(b) the dry hose shall be sufficiently stiff and only as long as necessary to facilitate drainage;

(c) an automatic vacuum breaker, or equivalent mechanism, shall be incorporated to prevent siphoning and to ensure rapid and complete drainage; and

(d) the inlet end of the hose or outlet pipe shall be high enough to ensure complete drainage.

S.3.5. Discharge Hose. - A discharge hose shall be reinforced so that the performance of the device is not affected by the expansion or contraction of the hose.

S.3.6. Discharge Valve. - A discharge valve may be installed in the discharge line only if the device is of the wet-hose type. Any other shutoff valve on the discharge side of the meter shall be of the automatic or semiautomatic predetermined-stop type or shall be operable only:

(a) by means of a tool (but not a pin) entirely separate from the device, or

(b) by mutilation of a security seal with which the valve is sealed open.

S.3.7. Antidrain Means. - In a wet-hose pressure-type device, means shall be incorporated to prevent the drainage of the discharge hose.

(Amended 1990)

S.4. Marking Requirements.

S.4.1. Limitation on Use. - The limitations on its use shall be clearly and permanently marked on any device intended to measure accurately only:

(a) products having particular properties; or

(b) under specific installation or operating conditions; or

(c) when used in conjunction with specific accessory equipment.

S.4.2. Air Pressure. - If a device is operated by air pressure, the air pressure gauge shall show by special graduations or other means the maximum and minimum working pressures recommended by the manufacturer.

S.4.3. Wholesale Devices.

S.4.3.1. Discharge Rates. - A wholesale device shall be marked to show its designed maximum and minimum discharge rates. However, the minimum discharge rate shall not exceed 20 percent of the maximum discharge rate.

S.4.3.2. Temperature Compensation. - If a device is equipped with an automatic temperature compensator, the primary indicating elements, recording elements, and recorded representation shall be clearly and conspicuously marked to show that the

volume delivered has been adjusted to the volume at 15 °C (60 °F).

S.4.4. Retail Devices. *- On a retail device with a designed maximum discharge rate of 100 L (25 gal) per minute or greater, the maximum and minimum discharge rates shall be marked on an exterior surface of the device and shall be visible after installation. The minimum discharge rate shall not exceed 20 percent of the maximum discharge rate.*
[Nonretroactive as of January 1, 1985.]
(Added 1984)

N. Notes

N.1. Test Liquid.

N.1.1. Type of Liquid. - The liquid used for testing a liquid-measuring device shall be the type the device is used to measure, or another liquid with the same general physical characteristics.

N.1.2. Labeling. - Following the completion of a successful examination of a wholesale device, the weights and measures official should attach a label or tag indicating the type of liquid used during the test.

N.2. Volume Change. - Care shall be taken to minimize changes in volume of the test liquid due to temperature changes and evaporation losses.

N.3. Test Drafts.

N.3.1. Retail Piston-Type and Visible-Type Devices. - Test drafts shall include the full capacity delivery and each intermediate delivery for which the device is designed.

N.3.2. Slow Flow Meters. - Test drafts shall be equal to at least four times the minimum volume that can be measured and indicated through either a visible indication or an audible signal.

N.3.3. Lubricant Devices. - Test drafts shall be 1 L (1 qt). Additional test drafts may include 0.5 L (1 pt), 4 L (4 qt), and 6 L (6 qt).

N.3.4. Other Retail Devices. - On devices with a designed maximum discharge rate of:

(a) less than 80 L (20 gal) per minute, tests shall include drafts of one or more amounts, including a draft of at least 19 liters (5 gal).

(b) 80 L (20 gal) per minute or greater, tests shall include drafts of one or more amounts, including a draft of at least the amount delivered by the device in one minute at the maximum flow rate of the installation.
(Amended 1984)

N.3.5. Wholesale Devices. - Test drafts should be equal to at least the amount delivered by the device in 1 minute at its maximum discharge rate, and shall in no case be less than 200 L (50 gal) or 225 kg (500 lb).
(Amended 1987)

N.4. Testing Procedures.

N.4.1. Normal Tests. - The "normal" test of a device shall be made at the maximum discharge flow rate developed under the conditions of installation. Any additional tests conducted at flow rates down to and including one-half of the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered normal tests.
(Amended 1991)

N.4.1.1. Wholesale Devices Equipped with Automatic Temperature-Compensating Systems. - On wholesale devices equipped with automatic temperature compensating systems, normal tests shall be conducted;

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

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

The first test shall be performed with the automatic temperature-compensating system operating in the "as found" condition.

On devices that indicate or record both the compensated and uncompensated volume for each delivery, the tests in (a) and (b) may be performed as a single test.
(Amended 1987)

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

N.4.2.1. Slow-Flow Meters. - A "special" test shall be made at a flow rate:

(a) not larger than twice the actual minimum flow rate, and

(b) not smaller than the actual minimum flow rate of the installation.

N.4.2.2. Retail Motor-Fuel Devices. -

(a) Devices with a flow-rate capacity less than 100 L (25 gal) per minute shall have a "special" test performed at the slower of the following rates:

(1) 19 L (5 gal) per minute, or

(2) the minimum discharge rate marked on the device, or

(3) the minimum discharge rate at which the device will deliver when equipped with an automatic discharge nozzle set at its slowest setting.

(b) Devices marked with a flow-rate capacity 100 L (25 gal) or more per minute, shall have a "special" test performed at the slowest of the following rates:

(1) the minimum discharge rate marked on the device, or

(2) the minimum discharge rate at which the device will deliver when equipped with an automatic discharge nozzle set at its slowest setting.

(Added 1984)

N.4.2.3. Other Retail Devices. - "Special" tests of other retail devices shall be made at the slower of the following rates:

(a) 50 percent of the maximum discharge rate developed under the conditions of installation, or

(b) the minimum discharge rate marked on the device.

N.4.2.4. Wholesale Devices. - "Special" tests shall be made to develop the operating characteristics of a measuring system and any special associated or attached elements and accessories. "Special" tests shall include a test at the slower of the following rates:

(a) 20 percent of the marked maximum discharge rate; or

(b) the minimum discharge rate marked on the device.

N.4.3. Money-Value Computation Tests.

N.4.3.1. Laboratory Tests. - When testing the device in the laboratory:

(a) compliance with paragraph S.1.6.5., Money-Value Computations, shall be determined by using the cone gear as a reference for the total quantity delivered;

(b) the indicated quantity shall agree with the cone gear representation with the index of the indicator within the width of the graduation; and

(c) the maximum allowable variation of the indicated sales price shall be as shown in Table 1.

(Amended 1984)

N.4.3.2. Field Tests. - In the conduct of field tests to determine compliance with paragraph S.1.6.5., the maximum allowable variation in the indicated sales price shall be as shown in Table 1.

(Added 1982; Amended 1984)

N.5. Temperature Correction on Wholesale Devices. - Corrections shall be made for any changes in volume resulting from the differences in liquid temperatures between time of passage through the meter and time of volumetric determination in the prover. When

adjustments are necessary, appropriate petroleum measurement tables should be used.
(Amended 1974)

T. Tolerances

T.1. Application to Underregistration and to Overregistration. - The tolerances hereinafter prescribed shall be applied to errors of underregistration and errors of overregistration, whether or not a device is equipped with an automatic temperature compensator.

T.2. Tolerance Values.

T.2.1. Retail Devices Except Slow-Flow Meters.

T.2.1.1. Devices Indicating in Inch-Pound Units.-

(a) The maintenance tolerance on normal and special tests shall be 1 in^3 plus 1 in^3 per indicated gallon and never less than 2 in^3.

(b) The acceptance tolerance on normal and special test shall be 1/2 in^3 plus 1/2 in^3 per indicated gallon and never less than 1 in^3.
(Amended 1981 and 1986)

T.2.1.2. Devices Indicating in Metric Units. -

(a) The maintenance tolerance on normal and special tests, shall be 20 mL, plus 4 mL per indicated liter, and never less than 40 mL.

(b) The acceptance tolerance on normal and special tests shall be 10 mL, plus 2 mL per indicated liter and never less than 20 mL.

(c) The tolerance applied to a 19-liter draft shall be that tolerance applicable to a 20-liter draft.
(Amended 1981 and 1986)

T.2.1.3. Repeatability. - When multiple tests are conducted at approximately the same flow rate, the range of the test results for the flow rate shall not exceed 40 percent of the absolute value of the maintenance tolerance.
(Added 1992)

T.2.2. Slow-Flow Meters. - Maintenance tolerances and acceptance tolerances shall be as shown in Table 2.

T.2.3. Wholesale Devices and Mass Flow Meters.

T.2.3.1. Measurement of Agri-Chemical Liquids. - Maintenance tolerances and acceptance tolerances shall be:

	Acceptance	Maintenance
Normal test	0.5%	1.0%
Special test	1.0%	1.0%

T.2.3.2. Measurement of Other Liquids. - Maintenance tolerances and acceptance tolerances shall be:

	Acceptance	Maintenance
Normal test	0.2%	0.3%
Special test	0.5%	0.5%

T.2.3.3. Repeatability. - When multiple tests are conducted at approximately the same flow rate, the range of the test results for the flow rate shall not exceed 40 percent of the applicable tolerance. This tolerance does not apply to the test of the automatic temperature compensating system.
(Added 1992)

T.2.3.4. Automatic Temperature Compensating Systems. *- The difference between the meter error for results determined with and without the automatic temperature compensating system activated shall not exceed:*

(a) 0.2 percent of the test draft for mechanical automatic temperature compensating systems; and
(b) 0.1 percent of the test draft for electronic automatic temperature compensating systems.

The results of each test shall be within the applicable acceptance or maintenance tolerance. [Nonretroactive as of January 1, 1988.]
(Added 1987) (Amended 1992)

Table 2.
Tolerances for Slow-Flow Meters

Indication	Normal tests				Special tests	
	Maintenance tolerance		Acceptance tolerance		Maintenance and acceptance tolerance	
	percent	minims	percent	minims	percent	minims
1 gill	1.0	20	0.75	15	1.25	25
0.05 gallon	1.0	30	0.75	25	1.25	40
1/2 pint	1.0	40	0.75	30	1.25	50
0.10 gallon	1.0	60	0.75	45	1.25	75
1 pint	1.0	75	0.75	60	1.25	95
0.20 gallon	1.0	120	0.75	90	1.25	155
		fl drams		fl drams		fl drams
1 quart	1.0	2-1/2	0.75	2	1.25	3
1/2 gallon	0.75	4	0.60	3	1.0	5
1 gallon and over	0.75	8 per gallon	0.60	6 per gallon	1.0	10 per gallon

UR. User Requirements

UR.1. Selection Requirements.

UR.1.1. Discharge Hose.

UR.1.1.1. Length. - The length of the discharge hose on a retail motor-fuel device:

(a) shall be measured from its housing or outlet of the discharge line to the inlet of the discharge nozzle;

(b) shall be measured with the hose fully extended if it is coiled or otherwise retained or connected inside a housing; and

(c) shall not exceed 5.5 m (18 ft) unless it can be demonstrated that a longer hose is essential to permit deliveries to be made to receiving vehicles or vessels.

An unnecessarily remote location of a device shall not be accepted as justification for an abnormally long hose.
(Amended 1972 and 1987)

UR.1.1.2. Marinas and Airports.

UR.1.1.2.1. Length. - The length of the discharge hose shall be as short as practicable, and shall not exceed 15 m (50 ft) unless it can be demonstrated that a longer hose is essential.

UR.1.1.2.2. Protection. - Discharge hoses exceeding 8 m (26 ft) in length shall be adequately protected from weather and other environmental factors when not in use.
(Made retroactive 1974 and amended 1984)

UR.2. Installation Requirements.

UR.2.1. Manufacturer's Instructions. - A device shall be installed in accordance with the manufacturer's

instructions, and the installation shall be sufficiently secure and rigid to maintain this condition.
(Added 1987)

UR.2.2. Discharge Rate. - A device shall be installed so that the actual maximum discharge rate will not exceed the rated maximum discharge rate. Automatic means for flow regulation shall be incorporated in the installation if necessary.

UR.2.3. Suction Head. - A piston-type device shall be installed so that the total effective suction head will not be great enough to cause vaporization of the liquid being dispensed under the highest temperature and lowest barometric pressure likely to occur.

UR.2.4. Diversion of Liquid Flow. - A motor-fuel device equipped with two delivery outlets used exclusively in the fueling of trucks shall be so installed that any diversion of flow to other than the receiving vehicle cannot be readily accomplished and is readily apparent. Allowable deterrents include, but are not limited to, physical barriers to adjacent driveways, visible valves, or lighting systems that indicate which outlets are in operation, and explanatory signs.
(Amended 1991)

UR.2.5. Product Storage Identification.

(a) The fill connection for any petroleum product storage tank or vessel supplying motor-fuel devices shall be permanently, plainly, and visibly marked as to product contained.

(b) When the fill connection device is marked by means of a color code, the color code key shall be conspicuously displayed at the place of business.

(Added 1975 and amended 1976)

UR.3. Use of Device.

UR.3.1. Return of Indicating and Recording Elements to Zero. - On any dispenser used in making retail deliveries, the primary indicating element, and recording element if so equipped, shall be returned to zero before each delivery.

Exceptions to this requirement are totalizers on key-lock-operated or other self-operated dispensers and the primary recording element if the device is equipped to record.

UR.3.2. Unit Price and Product Identity.

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

(1) all of the unit prices (excluding fleet sales and other price contract sales) at which the product is offered for sale; and

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

Provided that the dispenser complies with S.1.6.4.1., it is not necessary that all the unit prices for all grades, brands, blends, or mixtures be simultaneously displayed or posted.

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

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

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

(Amended 1972, 1983, 1987, 1989, and 1992)

UR.3.3. Computing Device. -

(a) Any computing device placed into service after January 1, 1990, in an application where a product or grade is offered for sale at more than one unit price (excluding fleet sales and other price contract sales), shall be used only for sales for which the device computes and displays the sales price for the selected transaction. Individual single unit-price computing devices installed to replace existing devices or to add to station capacity are exempt from this requirement.
(Added 1989) (Amended 1992)

(b) A computing device shall be used only for sales for which the device computes and displays the sales price for the transaction.
(Effective and retroactive as of January 1, 1999)
(Added 1990)

UR.3.4. Printed Ticket. - The total price, the total volume of the delivery, and the price per gallon or liter shall be shown, either printed or in clear hand script, on any printed ticket issued by a device of the computing type and containing any one of these values.

UR.3.5. Steps After Dispensing. - After delivery to a customer from a retail motor-fuel device:

(a) the starting lever shall be returned to its shutoff position and the zero-set-back interlock engaged; and

(b) the discharge nozzle shall be returned to its designed hanging position unless the primary indicating elements, and recording if the device is equipped and activated to record, have been returned to a definite zero indication.

UR.3.6. Temperature Compensation, Wholesale.

UR.3.6.1. Automatic.

UR.3.6.1.1. When to be Used. - If a device is equipped with a mechanical automatic temperature compensator, it shall be connected, operable, and in use at all times. An electronic or mechanical automatic temperature compensating system may not be removed, nor may a compensated device be replaced with an uncompensated device, without the written approval of the responsible weights and measures jurisdiction.

[Note: This requirement does not specify the method of sale for product measured through a meter.]
(Amended 1989)

UR.3.6.1.2. Invoices.

(a) A written invoice based on a reading of a device that is equipped with an automatic temperature compensator shall show that the volume delivered has been adjusted to the volume at 15 °C (60 °F).

(b) The invoice issued from an electronic wholesale device equipped with an automatic temperature compensating system shall also indicate the API gravity, specific gravity or coefficient of expansion for the product, product temperature, and gross reading.
(Amended 1987)

UR.3.6.2. Nonautomatic.

UR.3.6.2.1. Temperature Determination. - If the volume of the product delivered is adjusted to the volume at 15 °C (60 °F), the product temperature shall be taken during the delivery in:

(a) the liquid chamber of the meter, or

(b) the meter inlet or discharge line adjacent to the meter, or

(c) the compartment of the receiving vehicle at the time it is loaded.

UR.3.6.2.2. Invoices. - The accompanying invoice shall indicate that the volume of the product has been adjusted for temperature variations to a volume at 15 °C (60 °F) and shall also state the product temperature used in making the adjustment.

Sec. 3.31. Vehicle-Tank Meters

A. Application

A.1. - This code applies to meters mounted on vehicle tanks including those used for the measurement and delivery of petroleum products or agri-chemical liquids such as fertilizers, feeds, herbicides, pesticides, insecticides, fungicides, and defoliants.
(Amended 1985)

A.2. - This code does not apply to the following devices:

(a) Devices used for dispensing liquefied petroleum gases (for which see Sec. 3.32; Code for Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices), or other liquids that do not remain in a liquid state at atmospheric pressures and temperatures.

(b) Devices used solely for dispensing a product in connection with operations in which the amount dispensed does not affect customer charges.

(c) Vehicle tanks used as measures (for which see Sec. 4.40; Code for Vehicle Tanks Used as Measures).

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements.

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

S.1.1.2. Units. -

(a) A meter shall indicate, and record if the meter is equipped to record, its deliveries in terms of liters (gallons) or kilograms (pounds). Fractional parts of the liter (gallon) shall be in terms of either decimal or binary subdivisions. Fractional parts of the kilogram (pound) shall be in decimal subdivisions.

(b) When it is an industry practice to purchase and sell milk by weight based upon 1.03 kg/L (8.6 lb/gal), the primary indicating element may indicate in kilograms (pounds) and decimal. The weight value division shall be a decimal multiple or submultiple of 1, 2, or 5. (See S.5.5.)

(c) The mass of all liquid measured through a mass flow meter shall be expressed as apparent mass versus a density of 8.0 g/cm^3.
(Amended 1989)

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

(a) 0.5 L (1 pt) or 5 kg (1 lb) on milk-metering systems and on meters used for retail deliveries of liquid fuel for domestic use, or

(b) 5 L (1 gal) or 5 kg (10 lb) on other meters.
(Amended 1989)

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

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

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

S.1.1.5. Return to Zero. - Primary indicating elements shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of primary indicating elements, and of primary recording elements if these are returnable to zero, beyond their correct zero position.

S.1.2. Graduations.

S.1.2.1. Length. - Graduations shall be so vared in length that they may be conveniently read.

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.008 in wide.

S.1.2.3. Clear Interval Between Graduations. - The clear interval shall be not less than 0.10 in. If the graduations are not parallel, the measurement shall be made:

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

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

(Amended 1986)

S.1.3. Indicators.

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

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

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

(a) the width of the widest graduation, and

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

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

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

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

S.1.3.6. Travel of Indicator. - If the most sensitive element of the primary indicating element utilizes an indicator and graduations, the relative movement of these parts corresponding to the smallest indicated value shall not be less than 5 mm (0.20 in).

S.1.4. Computing-Type Device.

S.1.4.1. Display of Unit Price. - In a device of the computing type, means shall be provided for displaying on the outside of the device, in a manner clear to the operator and an observer, the unit price at which the device is set to compute.
(Amended 1983)

S.1.4.2. Printed Ticket. - If a computing-type device issues a printed ticket which displays the total computed price, the ticket shall also have printed clearly thereon the total quantity of the delivery, the appropriate fraction of the quantity, and the price per unit of quantity.
(Amended 1989)

S.1.4.3. Money-Value Computations. - Money-value computations shall be of the full-computing type in which the money value at a single unit price, or at each of a series of unit prices, shall be computed for every delivery within either the range of measurement of the device or the range of the computing elements, whichever is less. Value graduations shall be supplied and shall be accurately positioned. The value of each graduated interval shall be 1 cent. On electronic devices with digital indications, the total price may be computed on the basis of the quantity indicated when the value of the smallest division indicated is equal to or less than 0.2 L (0.1 gal) or 0.2 kg (1 lb).
(Amended 1979, 1989)

S.1.4.4. Money Values, Mathematical Agreement. - Any digital money-value indication and any

recorded money value on a computing-type device shall be in mathematical agreement with its associated quantity indication or representation to within 1 cent of money value.

S.2. Design of Measuring Elements.

S.2.1. Vapor Elimination. - A metering system shall be equipped with an effective means to prevent the passage of vapor and air through the meter. Vent lines from the air or vapor eliminator shall be made of metal tubing or some other suitable rigid material.

S.2.2. Provision for Sealing. - Except on devices for metering milk, adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of:

(a) any measurement element, and

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

S.2.2.1. Milk-Metering Systems. - Adequate provision shall be made for applying security seals to the adjustment mechanism and the register. The adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

S.2.3. Directional Flow Valves. - Valves intended to prevent reversal of flow shall be automatic in operation. However, on equipment used exclusively for fueling aircraft, such valves may be manual in operation.

S.2.4. Mass Flow Meters Only. - An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.
(Added 1989)

S.3. Design of Discharge Lines and Discharge Line Valves. -
(Not applicable to milk-metering systems.)

S.3.1. Diversion of Measured Liquid. - Except on equipment used exclusively for fueling aircraft, no means shall be provided by which any measured liquid can be diverted from the measuring chamber of the meter or the discharge line therefrom. However, two or more delivery outlets may be installed if means is provided to insure that:

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

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

S.3.2. Pump-Discharge Unit. - On a pump-discharge unit, the discharge hose shall be of the wet-hose type with a shutoff valve at its outlet end. However, a pump-discharge unit may be equipped also with a dry hose without a shutoff valve at its outlet end, but only if:

(a) the dry hose is as short as practicable, and

(b) there is incorporated in the discharge piping, immediately adjacent to the meter, effective means to insure that liquid can flow through only one of the discharge hoses at any one time and that the meter and the wet hose remain full of liquid at all times.

S.3.3. Gravity-Discharge Unit. - On a gravity-discharge unit, the discharge hose or equivalent pipe shall be of the dry-hose type with no shutoff valve at its outlet end. The dry hose shall be of such stiffness and only of such length as to facilitate its drainage. The inlet end of the hose or of an equivalent outlet pipe shall be of such height as to provide for proper drainage of the hose or pipe. There shall be incorporated an automatic vacuum breaker or equivalent means to prevent siphoning and to insure the rapid and complete drainage.

S.3.4. Discharge Hose. - A discharge hose shall be adequately reinforced.

S.3.5. Discharge Valve. - A discharge valve may be installed in the discharge line only if the device is of the wet-hose type, in which case such valve shall be at the discharge end of the line. Any other shutoff valve on the discharge side of the meter shall be of the automatic or semiautomatic predetermined-stop type or shall be operable only:

(a) by means of a tool (but not a pin) entirely separate from the device, or

(b) by mutilation of a security seal with which the valve is sealed open.

S.3.6. Antidrain Valve. - In a wet-hose, pressure-type device, an effective antidrain valve shall be incorporated in the discharge valve or immediately adjacent thereto. The antidrain valve shall function so as to prevent the drainage of the discharge hose. However, a device used exclusively for fueling and defueling aircraft may be of the pressure type without an antidrain valve.

S.4. Design of Intake Lines (for Milk-Metering Systems).

S.4.1. Diversion of Liquid to be Measured. - No means shall be provided by which any liquid can be diverted from the supply tank to the receiving tank without being measured by the device.

S.4.2. Intake Hose. - The intake hose shall be:

(a) of the dry-hose type;

(b) adequately reinforced;

(c) not more than 6 m (20 ft) in length, unless it can be demonstrated that a longer hose is essential to permit pickups from a supply tank; and

(d) connected to the pump at horizontal or above, to permit complete drainage of the hose.

S.5. Marking Requirements

S.5.1. Limitation of Use. - If a meter is intended to measure accurately only liquids having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately only when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently stated on the meter.

S.5.2. Discharge Rates. - A meter shall be marked to show its designed maximum and minimum discharge rates. However, the minimum discharge rate shall not exceed 20 percent of the maximum discharge rate.

S.5.3. Measuring Components Milk-Metering System. - All components that affect the measurement of milk that are disassembled for cleaning purposes shall be clearly and permanently identified with a common serial number.

S.5.4. Flood Volume, Milk-Metering System. - When applicable, the volume of product necessary to flood the system when dry shall be clearly, conspicuously, and permanently marked on the air eliminator.

S.5.5. Conversion Factor. - When the conversion factor of 1.03 kg/L (8.6 lb/gal) is used to convert the volume of milk to weight, the conversion factor shall be clearly marked on the primary indicating element and recorded on the delivery ticket.
(Added 1989)

N. Notes

N.1. Test Liquid.

(a) A measuring system shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics. Following a satisfactory examination, the weights and measures official should attach a seal or tag indicating the product used during the test.
(Amended 1975)

(b) A milk measuring system shall be tested with the type of milk to be measured when the accuracy of the system is affected by the characteristics of milk (e.g., positive displacement meters).
(Amended 1989)

N.2. Evaporation and Volume Change. - Care shall be exercised to reduce to a minimum, evaporation losses and volume changes resulting from changes in temperature of the test liquid.

N.3. Test Drafts. - Test drafts should be equal to at least the amount delivered by the device in 1 minute at its maximum discharge rate, and shall in no case be less than 180 L (50 gal) or 225 kg (500 lb).
(Amended 1989)

N.4. Testing Procedures

N.4.1. Normal Tests. - The "normal" test of a measuring system shall be made at the maximum discharge rate that may be anticipated under the conditions of the installation. Any additional tests conducted at flow rates down to and including one-half of the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered normal tests.
(Amended 1992)

N.4.1.1. Milk Measuring System. - The "normal" test shall include a determination of the effectiveness of the air elimination system.

N.4.2. Special Tests (Except Milk-Measuring Systems). - "Special" tests shall be made to develop the operating characteristics of a measuring system and any special elements and accessories attached to or associated with the device. Any test except as set forth in N.4.1. shall be considered a special test. Special test of a measuring system shall be made as follows:

(a) at a minimum discharge rate of 20 percent of the marked maximum discharge rate or at the minimum discharge rate marked on the device whichever is less;

(b) to develop operating characteristics of the measuring system during a split-compartment delivery.

(Amended 1978)

N.4.3. Antidrain Valve Test. - The effectiveness of the antidrain valve shall be tested after the pump pressure in the measuring system has been released and a valve between the supply tank and the discharge valve is closed.

N.4.4. System Capacity. - The test of a milk-measuring system shall include the verification of the volume of product necessary to flood the system as marked on the air eliminator.

T. Tolerances

T.1. Application.

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

T.2. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Tables 1, 1a, and 2.

T.3. Tolerance Values on Meters used for the Measurement of Agri-Chemical Liquids. - The maintenance tolerance on normal and special tests shall be 1 percent of the indicated quantity. The acceptance tolerance on a normal test shall be 0.5 percent of the indicated quantity and on special tests, 1 percent of the indicated quantity. (Added 1985, Amended 1989)

T.4. Repeatability. - When multiple tests are conducted at approximately the same flow rate, the range of the test results for the flow rate shall not exceed 40 percent of the applicable tolerance.
(Added 1992)

Table 1.
Tolerances for Vehicle-Tank Meters Except Milk Meters, Agri-Chemical Meters, and Mass Flow Meters

	Normal tests		Special tests
Indication	Maintenance tolerance	Acceptance tolerance	Maintenance and acceptance tolerance
(Gallons)	(Cubic inches)	(Cubic inches)	(Cubic inches)
50	50	25	50
Over 50	Add 1/2 cubic inch per indicated gallon over 50	Add 1/4 cubic inch per indicated gallon over 50	Add 1 cubic inch per indicated gallon over 50

Table 1a. Tolerances for Vehicle-Tank Mass Flow Meters Except for Measuring Milk and Agri-Chemicals			
Indication (pounds)	Normal tests		Special tests
	Maintenance tolerance (pounds)	Acceptance tolerance (pounds)	Maintenance and acceptance tolerance (pounds)
500	2	1	2
Over 500	Add 0.0022 pound per indicated pound over 500	Add 0.0011 pound per indicated pound over 500	Add 0.0043 pound per indicated pound over 500

(Added 1989)

Table 2. Tolerances					
Milk Meters			Mass Flow Meters for Measuring Milk*		
Indication	Maintenance	Acceptance	Indication	Maintenance	Acceptance
gallons	gallons	gallons	pounds	pounds	pounds
100	0.5	0.3	1000	5	3
200	0.7	0.4	2000	7	4
300	0.9	0.5	3000	9	5
400	1.1	0.6	4000	11	6
500	1.3	0.7	5000	13	7
Over 500	Add 0.002 gallon per indicated gallon over 500	Add 0.001 gallon per indicated gallon over 500	Over 5000	Add 0.002 pound per indicated pound over 5000	Add 0.001 pound per indicated pound over 5000

*(Added 1989)

UR. User Requirements

UR.1. Installation Requirements.

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

UR.1.2. Unit Price. - There shall be displayed on the face of a device of the computing type the unit price at which the device is set to compute.

UR.1.3. Intake Hose. - The intake hose in a milk-metering system shall be installed to permit complete drainage and ensure that all available product is measured following each pickup.

UR.2. Use Requirements.

UR.2.1. Return of Indicating and Recording Elements to Zero. - The primary indicating elements (visual), and the primary recording elements, when these are returnable to zero, shall be returned to zero immediately before each delivery is begun and after the pump has been activated and the product to be measured has been supplied to the measuring system. (Amended 1981)

UR.2.2. Ticket in Printing Device. - A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a delivery is begun, and in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

UR.2.3. Credit for Flood Volume. - The volume of product necessary to flood the system as marked on the air eliminator shall be individually recorded on the pickup ticket of each seller affected.

Sec. 3.32. Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices[1]

A. Application.

A.1. - This code applies to devices used for the measurement of liquefied petroleum gas and anhydrous ammonia in the liquid state, whether such devices are installed in a permanent location or mounted on a vehicle.

A.2. - Insofar as they are clearly appropriate, the requirements and provisions of the code may be applied to devices used for the measurement of other liquids that do not remain in a liquid state at atmospheric pressures and temperatures.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements

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

S.1.1.2. Units. - A device shall indicate, and record if the device is equipped to record, its deliveries in terms of gallons, quarts, pints, pounds, or binary-submultiple or decimal subdivisions of the gallon, or decimal subdivisions of the pound. The mass shall be expressed as apparent mass versus a density of 8.0 g/cm^3.
(Amended 1987)

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

(a) 0.5 L (1 pt) or 0.5 kg (1 lb) on retail devices, or

(b) 5 L (1 gal) or 5 kg (10 lb) on wholesale devices.
(Amended 1987)

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

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

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

S.1.1.5. Money Values--Mathematical Agreement. - Any digital money-value indication and any recorded money value on a computing-type device shall be in mathematical agreement with its associated quantity indication or representation to within one cent of money value; except that a stationary retail computing-type device must compute and indicate to the nearest one cent of money value (see Sec. 1.10., G-S.5.5.).
(Amended 1984, 1988)

S.1.1.6. Printed Ticket. - Any printed ticket issued by a device of the computing type on which there is printed the total computed price, shall have printed clearly thereon the total volume of the delivery in terms of liters, gallons, kilograms or pounds and the appropriate decimal fraction of the liter, gallon, kilogram or pound and the corresponding price per liter, gallon, kilogram or pound.
(Added 1979; Amended 1987)

S.1.2. Graduations.

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

[1]Title amended 1986.

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater then the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.008 in width.

S.1.2.3. Clear Interval Between Graduations. - The clear interval shall be not less than 0.04 in. If the graduations are not parallel, the measurement shall be made:

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

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

S.1.3. Indicators.

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

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

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

(a) the width of the widest graduation, and

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

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

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

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

S.1.4. For Retail Devices Only.

S.1.4.1. Indication of Delivery. - A retail device shall be constructed to show automatically its initial zero condition and the amounts delivered up to the nominal capacity of the device.

S.1.4.2. Return to Zero. -

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

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

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

(Amended 1990)

S.1.5. For Stationary Retail Devices Only.

S.1.5.1. Display of Unit Price and Product Identity. - In a device of the computing type, means shall be provided for displaying on each face of the device the unit price at which the device is set to compute or to deliver, as the case may be, and there shall be conspicuously displayed on each side of the device the identity of the product that is being dispensed. If a device is so designed as to dispense more than one grade, brand, blend, or mixture of product, the identity of the grade, brand, blend, or mixture being dispensed shall also be displayed on each face of the device.

S.1.5.2. Money-Value Computations. - A retail device that computes money value shall be capable of computing such values for a single unit price or at each of a series of unit prices for every delivery possible within either the range of measurement of the device or the range of the computing elements, whichever is less. The analog money value indication shall not differ from the mathematically

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

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

computed money value (quantity x unit price = sales price), for any delivered quantity, by an amount greater than the values shown in Table 1. (Amended 1984)

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

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

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

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

(Amended 1984)

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

S.1.5.2.3. Money-Value Divisions, Auxiliary Indications. *In a system equipped with auxiliary indications, all indicated money-value divisions shall be identical.*
[Nonretroactive as of January 1, 1985.]

S.1.6. For Wholesale Devices Only.

S.1.6.1. Travel of Indicator. - A wholesale device shall be readily operable to deliver accurately any quantity from 180 L (50 gal) or 225 kg (500 lb) to the capacity of the device. If the most sensitive element of the indicating system utilizes an indicator and graduations, the relative movement of these parts corresponding to a delivery of 5 L (1 gal) or 5 kg (10 lb) shall be not less than 5 mm (0.20 in). (Amended 1987)

S.2. Design of Measuring Elements.

S.2.1. Vapor Elimination. - A device shall be equipped with an effective vapor eliminator or other effective means to prevent the passage of vapor through the meter.

S.2.2. Provision for Sealing. - Adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of:

(a) any measurement element, and

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

The adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

S.2.3. Directional Flow Valves. - A measuring system shall be equipped with a valve or other effective means, automatic in operation and installed in or adjacent to the measuring element, to prevent reversal of flow of the product being measured.
(Amended 1982).

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

S.2.5. Thermometer Well Except for Direct Mass Flow Devices. - For test purposes, means shall be provided to determine the temperature of the liquid either:

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

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

(Amended 1987)

S.2.6. Automatic Temperature Compensation. - A device may be equipped with an adjustable automatic means for adjusting the indication and registration of the measured volume of product to the volume at 15 °C (60 °F).

S.2.6.1. Provision for Deactivating. - On a device equipped with an automatic temperature compensating mechanism that will indicate or record only in terms of liters compensated to 15 °C or gallons to 60 °F, provision shall be made to facilitate the deactivation of the automatic temperature compensating mechanism so that the meter may indicate, and record if it is equipped to record, in terms of the uncompensated volume.
(Amended 1972)

S.2.6.2. Provision for Sealing. - Provision shall be made for applying security seals in such a manner that an automatic temperature-compensating system cannot be disconnected and that no adjustment may be made to the system.

S.2.7. Mass Flow Meters Only. - An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.
(Added 1987)

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

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

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

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

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

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

S.4. Marking Requirements.

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

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

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

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

S.4.3. Temperature Compensation. - If a device is equipped with an automatic temperature compensator, the primary indicating elements, recording elements, and recorded representation shall be clearly and conspicuously marked to show that the volume delivered has been adjusted to the volume at 15 °C (60 °F).

N. Notes

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

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

N.3. Test Drafts. - Test drafts should be equal to at least the amount delivered by the device in one minute at its normal discharge rate.
(Amended 1982)

N.4. Testing Procedures.

N.4.1. Normal Tests. - The "normal" test of a device shall be made at the maximum discharge rate that may be anticipated under the conditions of installation.

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

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

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

The first test shall be performed with the automatic temperature-compensating system operating in the "as found" condition. On devices that indicate or record both the compensated and uncompensated volume for each delivery, the tests in (a) and (b) may be performed as a single test.
(Amended 1987)

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

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

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

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

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

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

(b) the minimum discharge rate marked on the device, whichever is greater.
(Amended 1973)

N.4.2.3. For Wholesale Devices. - A wholesale device shall be so tested at a minimum discharge rate of:

(a) 40 L (10 gal) or 50 kg (100 lb) per minute for a device with a rated maximum discharge less than 180 L (50 gal) or 225 kg (500 lb) per minute.

(b) 20 percent of the marked maximum discharge rate for a device with a rated maximum discharge of 180 L (50 gal) or 225 kg (500 gal) per minute or more, or

(c) the minimum discharge rate marked on the device, whichever is least.
(Amended 1987)

N.4.3. Money-Value Computation Tests.

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

N.4.3.2. Field Tests. - In the conduct of field tests to determine compliance with paragraph S.1.5.2. the maximum allowable variation in the indicated sales price shall be as shown in Table 1.
(Added 1984)

N.5. Temperature Correction. - Corrections shall be made for any changes in volume resulting from the differences in liquid temperatures between time of passage through the meter and time of volumetric determination in the test measure.

T. Tolerances

T.1. Application.

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

T.2. Tolerance Values. - The maintenance and acceptance tolerances for normal and special tests shall be:

	Acceptance Tolerance	Maintenance Tolerance
Normal Tests	0.6%	1.0%
Special Tests	1.0%	1.0%

(Amended 1988 and 1992)

T.3. Repeatability. - When multiple tests are conducted at approximately the same flow rate, the range of the test results for the flow rate shall not exceed 40 percent of the applicable tolerance. This tolerance does not apply to the test of the automatic temperature compensating system.
(Added 1992)

T.4. Automatic Temperature-Compensating Systems. - The difference between the meter error for results determined with and without the automatic temperature-compensating system activated shall not exceed:

(a) 0.5 percent of the test draft for mechanical automatic temperature-compensating systems; and

(b) 0.25 percent of the test draft for electronic automatic temperature-compensating systems.

The results of each test shall be within the applicable acceptance or maintenance tolerance.
(Added 1991; Amended 1992)

UR. User Requirements

UR.1. Installation Requirements.

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

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

UR.2. Use Requirements.

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

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

UR.2.3. Vapor-Return Line. - During any metered delivery of liquefied petroleum gas from a supplier's tank to a receiving container, there shall be no vapor-return line from the receiving container to the supplier's tank:

(a) in the case of any receiving container to which normal deliveries can be made without the use of such vapor-return line, or

(b) in the case of any new receiving container when the ambient temperature is below 90 °F.

UR.2.4. Temperature Compensation.

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

UR.2.4.2. Temperature Compensated Sale. - All sales of liquefied petroleum gas in a liquid state, when the quantity is determined by an approved measuring system equipped with a temperature compensating mechanism, or by weight and converted to liters or gallons, or by a calibrated container, shall be in terms of liters at 15 °C or the United States gallon of 231 in^3 at 60 °F.
(Added 1984)

UR.2.4.3. Invoices. - Any invoice based on a reading of a device that is equipped with an automatic temperature compensator or based on a weight converted to gallons, or based on the volume of a calibrated container, shall have shown thereon that the volume delivered has been adjusted to the volume at 15 °C (60 °F).
(Amended 1984)

UR.2.4.4. Automated Temperature-Compensating Systems. - Means for determining the temperature of measured liquid in an automatic temperature-compensating system shall be so designed and located that, in any "usual and customary" use of the system, the resulting indications and/or recorded representations are within applicable tolerances.
(Added 1987)

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

UR.2.6. Ticket Printer; Customer Ticket. - *Vehicle-mounted metering systems shall be equipped with a ticket printer. The ticket printer shall be used for all sales; a copy of the ticket issued by the device shall be left with the customer at the time of delivery.*
[Nonretroactive as of January 1, 1993. To become retroactive as of January 1, 1994.]
(Added 1992)

Sec. 3.33. Hydrocarbon Gas Vapor-Measuring Devices[1]

A. Application

A.1. - This code applies to devices used for the measurement of hydrocarbon gas in the vapor state, such as propane, propylene, butanes, butylenes, ethane, methane, natural gas and any other hydrocarbon gas/air mix. (Amended 1984, 1986, 1988, 1991)

A.2. - This code does not apply to:

(a) Liquid-measuring devices used for dispensing liquefied petroleum gases in liquid form (for which see Sec. 3.32; Code for Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices).

(b) Natural, liquefied petroleum, and manufactured-gas-vapor meters when these are operated in a public utility system.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements.

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

S.1.1.2. Units.

(a) A volume-measuring device shall indicate, and record if equipped to record, its deliveries in terms of cubic meters or cubic feet, or multiple or decimal subdivisions of cubic meters or cubic feet.

(b) Deliveries through mass flow meters shall be indicated and recorded in grams, kilograms, metric tons, pounds, or tons and decimal subdivisions thereof.

(Amended 1972, 1991)

S.1.1.3. Value of Smallest Unit.

Volume-Measuring Devices: The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed:

(a) 1 m^3 (1 000 dm^3) (100 ft^3) when the maximum rated gas capacity is less than 100 m^3/h (10 000 ft^3/h);

(b) 10 m^3 (1 000 ft^3) when the maximum rated gas capacity is 280 m^3/h (10 000 ft^3/h) up to but not including 1700 m^3/h (60 000 ft^3/h);

(c) 100 m^3 (10 000 ft^3) when the maximum rated gas capacity is 1700 m^3/h (60 000 ft^3/h) or more.

Mass Flow Meters: The maximum value of the quantity-value division shall not exceed 0.01 kg (0.01 lb) when measuring product as a retail motor fuel.

(Amended 1972, 1988, 1991)

S.1.1.4. Advancement of Indicating and Recording Elements. - Primary indicating and recording elements shall advance digitally or continuously and be susceptible of advancement only by the mechanical operation of the device.

S.1.1.5. Proving Indicator. - Devices rated less than 280 m^3/h (10 000 ft^3/h) gas capacity shall be equipped with a proving indicator measuring 0.025, 0.05, 0.1, 0.2, or 0.25 m^3 per revolution, (1, 2, 5, or 10 ft^3 per revolution) for testing the meter. Devices with larger capacities shall be equipped as follows:

[1]Title changed 1986.

(a) Devices rated 280 m^3 (10 000 ft^3) up to but not including 1700 m^3/h (60 000 ft^3/h) gas capacity shall be equipped with a proving indicator measuring not greater than 1 m^3 (100 ft^3) per revolution.

(b) Devices rated 1700 $m^3\backslash h$ (60 000 $ft^3\backslash h$) gas capacity or more shall be equipped with a proving indicator measuring not more than 10 m^3 (1 000 ft^3) per revolution.

The test circle of the proving indicator shall be divided into 10 equal parts. Additional subdivisions of one or more of such equal parts may be made.
(Amended 1973 and 1988)

S.1.2. Graduations.

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

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and in no case should it exceed 1.0 mm (0.04 in) for indicating elements and 0.5 mm (0.02 in) for proving circles.

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

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

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

S.1.3. Indicators.

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

S.1.3.2. Length. - The index of an indicator shall reach to the finest graduations with which it is used.

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

(a) the width of the widest graduation, and

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

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

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

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

S.2. Design of Measuring Elements.

S.2.1. Pressure Regulation. - Except when measured as a retail motor fuel, the vapor should be measured at a normal gauge pressure of:
(Amended 1991)

(a) 2740 Pa ± 685 Pa (11 in of water (0.40 psi) ± 2.75 in of water (0.10 psi)) for liquefied petroleum gas vapor; or

(b) 1744 Pa ± 436 Pa (7 in of water (0.25 psi) ± 1.75 in of water (0.06 psi)) for natural and manufactured gas.

When vapor is measured at a pressure other than what is specified above for the specific product, a volume multiplier shall be applied within the meter or to the billing invoice based on the following equation:

$$VPM = \frac{AAP + GP}{AAP + NGP}$$

Where
VPM = Volume pressure multiplier
AAP = Assumed atmospheric pressure in psia
GP = Gauge pressure in pascal or psi
NGP = Normal gauge pressure in pascal or psi

The assumed atmospheric pressure is to be taken from Tables 2 and 2M.

When liquefied petroleum gas vapor is measured at a pressure of 6900 Pa (1 lb/in^2) or more, the delivery pressure shall be maintained within ±1725 Pa (±0.25 lb/in^2).

Pressure variations due to regulator lock off shall not increase the operating pressure by more than 25 percent.
(Amended 1980, 1984, 1991)

S.2.2. Provision for Sealing. - Adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of any measurement element.

S.2.3. Maintenance of Vapor State. - A device shall be so designed and installed that the product being measured will remain in a vapor state during passage through the meter.

S.2.4. Automatic Temperature Compensation. - A means for adjusting the indication and registration of the measured volume of vapor product to the volume at 15 °C (60 °F).

S.2.5. Mass Flow Meters; Density Correction. - An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.
(Added 1991)

S.3. Design of Discharge Lines

S.3.1. Diversion of Measured Vapor. - No means shall be provided by which any measured vapor can be diverted from the measuring chamber of the meter or the discharge line therefrom.

S.4. Marking Requirements.

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

S.4.2. Discharge Rates. - A volume-measuring device shall be marked to show its rated gas capacity in cubic meters or cubic feet per hour. A mass flow meter shall be marked with its maximum and minimum flow rates in kilograms or pounds per unit of time.
(Amended 1973, 1991)

S.4.3. Temperature Compensation. - If a device is equipped with an automatic temperature compensator, this shall be indicated on the badge or immediately adjacent to the badge of the device and on the register.

S.4.4. Badge. - A badge affixed in a prominent position on the front of the device shall show the manufacturer's name, serial number and model number of the device, and capacity rate of the device for the particular products that it was designed to meter as recommended by the manufacturer.

N. Notes

N.1. Test Medium. - The device shall be tested with air or the product to be measured.
(Amended 1991)

N.2. Temperature and Volume Change. - Care should be exercised to reduce to a minimum any volume changes. The temperature of the air, bell-prover oil, and the meters under test should be within 1 °C (2 °F) of one another. The devices should remain in the proving room for at least 16 hours before starting any proving operations to allow the device temperature to approximate the temperature of the proving device.

N.3. Test Drafts. - Except for low-flame tests, test drafts shall be at least equal to one complete revolution of the largest capacity proving indicator, and shall in no case be less than 2 ft^3 or 0.05 m^3. All flow rates shall be controlled by suitable outlet orifices.
(Amended 1973 and 1990)

N.4. Test Procedures. - If a device is equipped with an automatic temperature compensator, the proving device reading shall be corrected to 15 °C (60 °F), using an approved table.
(Amended 1972)

N.4.1. Normal Tests. - The normal test of a device shall be made at a rate not to exceed the capacity rate given on the badge of the meter.
(Amended 1988)

N.4.1.1. Automatic Temperature Compensation. - If a device is equipped with an automatic temperature compensator, the quantity of the test draft indication of the standard shall be corrected to 15 °C (60 °F).

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

N.4.2.1. Slow Test. - The device shall be tested at a rate not less than 20 percent of the marked capacity rate, or (at the check rate) not less than the minimum flow rate if marked on the device, whichever is less.
(Amended 1988)

N.4.2.2. Low-Flame Test. - The device shall be tested at an extremely low-flow rate as given in Table 1. The test shall consist of passing air at a pressure of 375 Pa (1.5 in water column) through the meter for not less than 60 minutes. The meter shall continue to advance at the conclusion of the test period.
(Amended 1990, 1991)

N.4.2.3. Pressure Regulation Test. - On devices operating at a pressure of 6900 Pa (1 lb/in^2) or more, a pressure regulation test shall be made at both the minimum and maximum use load to determine the proper operation of the regulator and the proper sizing of the piping and dispensing equipment. These tests may include a test of 24 hours during which the pressure is recorded.
(Added 1984)

N.5. Temperature Correction. - Corrections shall be made for any changes in volume resulting from the difference in air temperatures between time of passage through the device and time of volumetric determination in the proving device.

N.6. Frequency of Test. - A hydrocarbon gas vapor-measuring device shall be tested before installation and allowed to remain in service for 10 years from the time last tested without being retested, unless a test is requested by:

(a) the purchaser of the product being metered,
(b) the seller of the product being metered, or
(c) the weights and measures official.

T. Tolerances

T.1. Tolerance Values on Normal Tests and on Special Tests Other Than Low-Flame Tests. - Maintenance and acceptance tolerances for hydrocarbon gas vapor-measuring devices shall be 3 percent (1.03 proof) of the test draft on underregistration and 1.5 percent (0.985 proof) of the test draft on overregistration.
(Amended 1981)

Table 1.
Capacity of Low-Flow Test Rate Orifices
With Respect to Device Capacity

Metric Units		Inch-Pound Units	
Rated Capacity	Low-Flow Test Rate	Rated Capacity	Low-Flow Test Rate
Up to and including 7 m^3/h	0.007 m^3/h	Up to and including 250 ft^3/h	0.25 ft^3/h
Over 7 m^3/h up to and including 14 m^3/h	0.014 m^3/h	Over 250 ft^3/h up to and including 500 ft^3/h	0.50 ft^3/h
Over 14 m^3/h	0.1 percent of capacity rate	Over 500 ft^3/h	0.1 percent of capacity rate

(Amended 1973)

T.2. Tolerance Values for Mass Flow Meters. - Maintenance and acceptance tolerances for mass flow meters shall be 2.0 percent and 1.5 percent, respectively. (Added 1991)

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Capacity Rate. - A device shall be so installed that the actual maximum flow rate will not exceed the capacity rate except for short durations. If necessary, means for flow regulation shall be incorporated in the installation, in which case this shall be fully effective and automatic in operation.

UR.1.2. Leakage. - The metering system shall be installed and maintained as a pressure-tight and leak-free system.

UR.2. Use Requirements.

UR.2.1. Automatic Temperature Compensation. - A compensated device may not be replaced with an uncompensated device without the written approval of the weights and measures authority having jurisdiction over the device.

UR.2.2. Invoices. - A customer purchasing hydrocarbon gas measured by a vapor meter for other than motor fuel shall receive from the seller an invoice for each billing period. The invoice shall clearly and separately show the following:

(a) The opening and closing meter readings and the dates of those readings.

(b) The altitude correction factor.

(c) The total cubic meters (cubic feet) billed, corrected for elevation.

(d) The charge per cubic meter (cubic foot) after correction for elevation.

(e) All periodic charges independent of the measured gas, such as meter charges, meter readings fees, service charges or a minimum charge for a minimum number of cubic meters (cubic feet).

(f) The total charge for the billing period.

If the vapor meter is equipped with an automatic temperature compensator, or any other means are used to compensate for temperature, the invoice shall show that the volume has been adjusted to the volume at 15 °C (60 °F).
(Amended 1988, 1991)

UR.2.3. Correction for Elevation. - The metered volume of gas shall be corrected for changes in the atmospheric pressure with respect to elevation to the standard pressure of 14.73 lb per square in. The appropriate altitude correction factor from Table 2M or 2 shall be used. (The table is modified from NIST Handbook 117.)
(Amended 1988)

Elevation correction factors (ACF) were obtained by using the following equation:

$$ACF = \frac{GP \text{ of gas} + AAP}{\text{base pressure}}$$

where
GP = gauge pressure
AAP = assumed atmospheric pressure
base pressure = 101.560 kPa = 14.73 psi absolute

2740 Pa = 11 in of water column = 0.397 lb/in^2

1744 Pa = 7 in of water column = 0.253 lb/in^2
(Added 1988)

UR.2.4. Valves and Test Tee. - *All gas meter installations shall be provided with a shut-off valve located adjacent to and on the inlet side of the meter. In the case of a single meter installation utilizing a liquefied petroleum gas tank, the tank service valve may be used in lieu of the shut-off valve. All gas meter installations shall be provided with a test tee located adjacent to and on the outlet side of the meter. (Nonretroactive as of January 1, 1990)*
(Added 1989)

UR.2.5. Use of Auxiliary Heated Vaporizer Systems.- Automatic temperature compensation shall be used on hydrocarbon gas vapor meters equipped with an auxiliary heated vaporizer system unless there is sufficient length of underground piping to provide gas at a uniform temperature to the meter inlet. When required by weights and measures official, a thermometer well (appropriately protected against freezing) shall be installed immediately up-stream of the meter.
(Added 1990)

Table 2M. Corrections for Altitude

Elevation (meters)			Altitude Correction Factor		Assumed Atmospheric Pressure	Assumed Atmospheric Pressure Plus Gauge Pressure	
			2.74 kPa Gauge Pressure	1.74 kPa Gauge Pressure	(kPa)	2.74 kPa Gauge Pressure	1.74 kPa Gauge Pressure
	-50 to	120	1.02	1.01	100.85	103.59	102.58
above	120 to	300	1.00	0.99	98.82	101.56	100.54
above	300 to	470	0.98	0.97	96.79	99.53	98.51
above	470 to	650	0.96	0.95	94.76	97.50	96.48
above	650 to	830	0.94	0.93	92.73	95.47	94.45
above	830 to	1020	0.92	0.91	90.70	93.44	92.42
above	1020 to	1210	0.90	0.89	88.66	91.40	90.39
above	1210 to	1400	0.88	0.87	86.63	89.37	88.36
above	1400 to	1590	0.86	0.85	84.60	87.34	86.33
above	1590 to	1790	0.84	0.83	82.57	85.31	84.29
above	1790 to	2000	0.82	0.81	80.54	83.28	82.26
above	2000 to	2210	0.80	0.79	78.51	81.25	80.23
above	2210 to	2420	0.78	0.77	76.48	79.22	78.20
above	2420 to	2640	0.76	0.75	74.45	77.19	76.17
above	2640 to	2860	0.74	0.73	72.41	75.15	74.15
above	2860 to	3080	0.72	0.71	70.38	73.12	72.12
above	3080 to	3320	0.70	0.69	68.35	71.09	70.08
above	3320 to	3560	0.68	0.67	66.32	69.06	68.05
above	3560 to	3800	0.66	0.65	64.29	67.03	66.01
above	3800 to	4050	0.64	0.63	62.26	65.00	63.98
above	4050 to	4310	0.62	0.61	60.23	62.97	61.95
above	4310 to	4580	0.60	0.59	58.20	60.94	59.92

Table 2. Corrections for Altitude

Elevation (feet)				Altitude Correction Factor		Assumed Atmospheric Pressure	Assumed Atmospheric Pressure Plus Gauge Pressure	
				11 inch WC	7 inch WC	(psia)	11 inch WC (psia)	7 inch WC (psia)
	-150	to	400	1.02	1.01	14.64	15.04	14.89
above	400	to	950	1.00	0.99	14.35	14.74	14.60
above	950	to	1550	0.98	0.97	14.05	14.45	14.30
above	1550	to	2100	0.96	0.95	13.76	14.15	14.01
above	2100	to	2700	0.94	0.93	13.46	13.86	13.71
above	2700	to	3300	0.92	0.91	13.17	13.56	13.42
above	3300	to	3950	0.90	0.89	12.87	13.27	13.12
above	3950	to	4550	0.88	0.87	12.58	12.97	12.83
above	4550	to	5200	0.86	0.85	12.28	12.68	12.53
above	5200	to	5850	0.84	0.83	11.99	12.38	12.24
above	5850	to	6500	0.82	0.81	11.69	12.09	11.94
above	6500	to	7200	0.80	0.79	11.40	11.79	11.65
above	7200	to	7900	0.78	0.77	11.10	11.50	11.35
above	7900	to	8600	0.76	0.75	10.81	11.20	11.06
above	8600	to	9350	0.74	0.73	10.51	10.91	10.76
above	9350	to	10 100	0.72	0.71	10.22	10.61	10.47
above	10 100	to	10 850	0.70	0.69	9.92	10.32	10.17
above	10 850	to	11 650	0.68	0.67	9.63	10.03	9.88
above	11 650	to	12 450	0.66	0.65	9.33	9.73	9.58
above	12 450	to	13 250	0.64	0.63	9.04	9.44	9.29
above	13 250	to	14 100	0.62	0.61	8.75	9.14	9.00
above	14 100	to	14 950	0.60	0.59	8.45	8.85	8.70

Sec. 3.34. Cryogenic Liquid-Measuring Devices

A. Application

A.1. - This code applies to cryogenic liquid-measuring devices used for the measurement of oxygen, nitrogen, and argon, whether such devices are installed in a permanent location, or mounted on a vehicle, or mounted on a portable tank.
(Amended 1986)

A.2. - This code does not apply to the following:

(a) Devices used for dispensing liquefied petroleum gases (for which see Sec. 3.32; Code for Liquefied Petroleum Gas and Anhydrous Ammonia Liquid-Measuring Devices).

(b) Devices used solely for dispensing a product in connection with operations in which the amount dispensed does not affect customer charges.

(c) Devices used solely for dispensing liquefied natural gas.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements.

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

S.1.1.2. Units. - A device shall indicate and record, if equipped to record, its deliveries in terms of: kilograms or pounds; liters or gallons of liquid at the normal boiling point of the specific cryogenic product; cubic meters (cubic feet) of gas at a normal temperature of 21 °C (70 °F) and an absolute pressure of 101.325 kPa (14.696 psia); or decimal subdivisions or multiples of the measured units cited above.

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

(a) for small delivery devices
  (1) 1 L
  (2) 0.1 gal
  (3) 1 kg
  (4) l lb
  (5) 0.1 m^3 of gas
  (6) 10 ft^3 of gas

(b) for large delivery devices
  (1) 10 L
  (2) 1 gal
  (3) 10 kg
  (4) 10 lb
  (5) 1 m^3 of gas
  (6) 100 ft^3 of gas

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

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

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

S.1.1.5. Return to Zero. - Primary indicating and recording elements shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of primary indicating elements and of primary recording elements beyond their correct zero position.

S.1.2. Graduations.

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

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

S.1.2.3. Clear Interval Between Graduations. - The clear interval shall be no less than 1.0 mm (0.04 in). If the graduations are not parallel, the measurement shall be made:

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

(b) if the indicator is continuous, at the point of widest separation of the graduations.
(See also S.1.3.6.)

S.1.3. Indicators.

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

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

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

(a) the width of the widest graduation, and

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

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

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

S.1.3.5. Parallax. - Parallax effect shall be reduced to the practicable minimum.

S.1.3.6. Travel of Indicator. - If the most sensitive element of the primary indicating element utilizes an indicator and graduations, the relative movement of these parts corresponding to the smallest indicated value shall be not less than 0.5 mm (0.20 in).

S.1.4. Computing-Type Device.

S.1.4.1. Printed Ticket. - Any printed ticket issued by a device of the computing type on which there is printed the total computed price shall have printed clearly thereon also the total quantity of the delivery and the price per unit.

S.1.4.2. Money-Value Computations. - Money-value computations shall be of the full-computing type in which the money value at a single unit price, or at each of a series of unit prices, shall be computed for every delivery within either the range of measurement of the device or the range of the computing elements, whichever is less. Value graduations shall be supplied and shall be accurately positioned. The total price shall be computed on the basis of the quantity indicated when the value of the smallest division indicated is equal to or less than the values specified in S.1.1.3.

S.1.4.3. Money Values--Mathematical Agreement. - Any digital money-value indication and any recorded money value on a computing type device shall be in mathematical agreement with its associated quantity indication or representation to within one cent of money value.

S.2. Design of Measuring Elements.

S.2.1. Vapor Elimination. - A measuring system shall be equipped with an effective vapor eliminator or other effective means to prevent the measurement of vapor that will cause errors in excess of the applicable tolerances. (See Sec. T.)

S.2.2. Directional Flow Valves. - A valve or valves or other effective means, automatic in operation, to

prevent the reversal of flow shall be installed in or adjacent to the measuring device.
(Amended 1978)

S.2.3. Maintenance of Liquid State. - A device shall be so designed that the product being measured will remain in a liquid state during passage through the device.

S.2.4. Automatic Temperature or Density Compensation. - A device shall be equipped with automatic means for adjusting the indication and/or recorded representation of the measured quantity of the product, to indicate and/or record in terms of: kilograms or pounds; liters or gallons of liquid at the normal boiling point of the specific cryogenic product; or the equivalent cubic meters (cubic feet) of gas at a normal temperature of 21 °C (70 °F) and an absolute pressure of 101.325 kPa (14.696 psia). *When a compensator system malfunctions, the indicating and recording elements may indicate and record in uncompensated volume if the mode of operation is clearly indicated, e.g., by a marked annunciator, recorded statement, or other obvious means.* [*Nonretroactive as of January 1, 1992]*
(Amended 1991)

S.2.5. Provision for Sealing. - Adequate provision shall be made for applying security seals in such a manner that no adjustment or interchange may be made of:

(a) any measurement element,

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

(c) any automatic temperature or density compensating system.

Any adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

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

S.3.1. Diversion of Measured Liquid. - No means shall be provided by which any measured liquid can be diverted from the measuring chamber of the device or the discharge line therefrom, except that a manually controlled outlet that may be opened for purging or draining the measuring system shall be permitted. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the device and to indicate clearly and unmistakably when the valve controls are so set as to permit passage of liquid through such outlet.

S.3.2. Discharge Hose. - The discharge hose of a measuring system shall be of the completely draining dry-hose type.

S.4. Level Condition, On-Board Weighing Systems. - Provision shall be made for automatically inhibiting the delivery of a cryogenic liquid when the vehicle is out of level beyond the limit required for the performance to be within applicable tolerance.
(Added 1986)

S.5. Marking Requirements.

S.5.1. Limitation of Use. - If a measuring system is intended to measure accurately only liquids having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately only when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently marked on the device.

S.5.2. Discharge Rates. - A meter shall be marked to show its designed maximum and minimum discharge rates.

S.5.3. Temperature or Density Compensation. - If a device is equipped with an automatic temperature or density compensator, the primary indicating elements, recording elements, and recorded representations shall be clearly and conspicuously marked to show that the quantity delivered has been adjusted to the conditions specified in S.2.4.

N. Notes

N.1. Test Liquid. - A meter shall be tested with the liquid to be commercially measured except that, in a type evaluation examination, nitrogen may be used.

N.2. Vaporization and Volume Change. - Care shall be exercised to reduce to a minimum vaporization and volume changes. When testing by weight, the weigh tank and transfer systems shall be precooled to liquid temperature prior to the start of the test to avoid the venting of vapor from the vessel being weighed.

N.3. Test Drafts.

N.3.1. Gravimetric Test. - Weight test drafts shall be equal to at least the amount delivered by the device in two minutes at its maximum discharge rate, and shall in no case be less than 2 000 lb.

N.3.2. Transfer Standard Test. - When comparing a meter with a calibrated transfer standard, the test draft shall be equal to at least the amount delivered by the device in two minutes at its maximum discharge rate, and shall in no case be less than 180 L (50 gal) or equivalent thereof. When testing uncompensated volumetric meters in a continuous recycle mode, appropriate corrections shall be applied if product conditions are abnormally affected by this test mode.
(Amended 1976)

N.4. Density. - Temperature and pressure of the metered test liquid shall be measured during the test for the determination of density or volume correction factors when applicable. For Liquid Density and Volume Correction Factors (with respect to temperature and pressure) the following publication shall apply: "Thermophysical Properties of Fluids. 1. Argon, Ethylene, Parahydrogen, Nitrogen, Nitrogen Trifluoride, and Oxygen," published in the Journal of Physical and Chemical Reference Data, Volume 11, 1982, Supplement No. 1, and published by the American Chemical Society and the American Institute of Physics for the National Institute of Standards and Technology. (Amended 1986)

N.5. Testing Procedures.

N.5.1. Normal Tests. - The "normal" tests of a device shall be made over a range of discharge rates that may be anticipated under the conditions of installation.

N.5.2. Special Tests. - Any test except as set forth in N.5.1. shall be considered a "special" test. Tests shall be conducted, if possible, to evaluate any special elements or accessories attached to or associated with the device. A device shall be tested at a minimum discharge rate of:

(a) 50 percent of the maximum discharge rate developed under the conditions of installation, or the minimum discharge rate marked on the device, whichever is less, or

(b) the lowest discharge rate practicable under conditions of installation.

Special tests may be conducted to develop any characteristics of the device that are not normally anticipated under the conditions of installation as circumstances require.

N.6. Temperature Correction. - Corrections shall be made for any changes in volume resulting from the differences in liquid temperature between time of passage through the meter and time of volumetric determination of test draft.

N.7. Automatic Temperature or Density Compensation. - When a device is equipped with an automatic temperature or density compensator, the compensator shall be tested by comparing the quantity indicated or recorded by the device (with the compensator connected and operating) with the actual delivered quantity corrected to the normal boiling point of the cryogenic product being measured or to the normal temperature and pressure as applicable.

T. Tolerances

T.1. Application.

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

T.2. Tolerance Values.

T.2.1. On Normal Tests. - The maintenance tolerance on "normal" tests shall be two and one-half percent (2.5%) of the indicated quantity. The acceptance tolerance shall be one and one-half percent (1.5%) of the indicated quantity.

T.2.2. On Special Tests. - The maintenance and acceptance tolerance on "special" tests shall be two and one-half percent (2.5%) of the indicated quantity.

T.3. On Tests Using Transfer Standards. - To the basic tolerance values that would otherwise be applied, there shall be added an amount equal to two times the standard deviation of the applicable transfer standard when compared to a basic reference standard.
(Added 1976)

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Discharge Rate. - A device shall be so installed that the actual maximum discharge rate will not exceed the rated maximum discharge rate. If necessary, means for flow regulation shall be incorporated in the installation.

UR.1.2. Length of Discharge Hose. - The discharge hose shall be of such a length and design as to keep vaporization of the liquid to a minimum.

UR.1.3. Maintenance of Liquid State. - A device shall be so installed and operated that the product being measured shall remain in the liquid state during passage through the meter.

UR.2. Use Requirements.

UR.2.1. Return of Indicating and Recording Elements to Zero. - The primary indicating elements (visual) and the primary recording elements shall be returned to zero immediately before each delivery.

UR.2.2. Condition of Discharge System. - The discharge system, up to the measuring element, shall be precooled to liquid temperatures before a "zero" condition is established prior to the start of a commercial delivery.

UR.2.3. Vapor Return Line. - A vapor return line shall not be used during a metered delivery. (Amended 1976)

UR.2.4. Drainage of Discharge Line. - On a dry-hose system, upon completion of a delivery, the vendor shall leave the discharge line connected to the receiving container with the valve adjacent to the meter in the closed position and the valve at the discharge line outlet in the open position for a period of at least

(a) 1 minute for small delivery devices, and

(b) 3 minutes for large delivery devices,

to allow vaporization of some product in the discharge line to force the remainder of the product in the line to flow into the receiving container. (Amended 1976)

UR.2.5. Conversion Factors. - Established conversion values (see references in N.4.) shall be used whenever metered liquids are to be billed in terms of:

(a) kilograms or pounds based on a meter indication of liters, gallons, cubic meters of gas, or cubic feet of gas; or,

(b) cubic meters or cubic feet of gas based on a meter indication of liters or gallons, kilograms, or pounds; or,

(c) liters or gallons based on a meter indication of kilograms or pounds, cubic meters of gas or cubic feet of gas.

All sales of cryogenic liquids shall be based on either kilograms or pounds, liters or gallons at NBP[1], cubic meters of gas or cubic feet of gas at NTP[1]. (Amended 1986)

UR.2.6. Temperature or Density Compensation.

UR.2.6.1. Use of Automatic Temperature or Density Compensators. - If a device is equipped with an automatic temperature or density compensator, this shall be connected, operable, and in use at all times. Such automatic temperature or density compensator may not be removed, nor may a compensated device be replaced with an uncompensated device, without the written approval of the weights and measures authority having jurisdiction over the device.

UR.2.6.2. Tickets or Invoices. - Any written invoice or printed ticket based on a reading of a device that is equipped with an automatic temperature or density compensator shall have shown thereon that the quantity delivered has been adjusted to the quantity at the NBP of the specific cryogenic product or the equivalent volume of gas at NTP.

UR.2.6.3. Printed Ticket. - Any printed ticket issued by a device of the computing type on which there is printed the total computed price, the total quantity of the delivery, or the price per unit, shall also show the other two values (either printed or in clear hand script).

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[1]See Appendix D, Definitions.

UR.2.6.4. Ticket in Printing Device. - A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a delivery is begun, and in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

UR.2.7. Pressure of Tanks with Volumetric Metering Systems without Temperature Compensation. - When the saturation pressure of the product in the vendor's tank exceeds 240 kPa (35 psia), a correction shall be applied to the written invoice or printed ticket using the appropriate tables as listed in N.4.; or the saturation pressure shall be reduced to 207 kPa (30 psia) (if this can be safely accomplished) prior to making a delivery.
(Added 1976)

Sec. 3.35. Milk Meters

A. Application

A.1. - This code applies to devices used for the measurement of milk; generally applicable to, but not limited to, meters used in dairies, milk processing plants, and cheese factories, to measure incoming bulk milk.

A.2. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements

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

S.1.1.2. Units. -

(a) A meter shall indicate, and record if the meter is equipped to record, its deliveries in terms of liters, gallons, kilograms, or pounds. Fractional parts of the liter shall be in terms of decimal subdivisions. Fractional parts of the gallon shall be in terms of either decimal or binary subdivisions. Fractional parts of the kilogram or pound shall be in decimal subdivisions.

(b) When it is an industry practice to purchase and sell milk by weight based upon 8.6 lb/gal, the primary indicating element may indicate in pounds and decimal pounds. The weight value division shall be a decimal multiple or submultiple of 1, 2, or 5. (See S.4.5.)

(c) The mass of milk measured through a mass flow meter shall be expressed as apparent mass versus a density of 8.0 g/cm^3.

(Amended 1989)

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

(a) 0.5 L or 5 kg (1 pt or 1 lb) when measuring quantities less than or equal to 4 000 L or 4 000 kg (1 000 gal or 8 600 lb), or

(b) 5 L or 5 kg (1 gal or 10 lb) when measuring quantities in excess of 4 000 L or 4 000 kg (1 000 gal or 8 600 lb).

(Amended 1989)

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

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

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

S.1.1.5. Return to Zero. - Primary indicating elements and primary recording elements, if the device is equipped to record, shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of the primary indicating elements and the primary recording elements, if the device is so equipped, beyond their correct zero position.

S.1.1.6. Indication of Measurement. A meter shall be constructed to show automatically its initial zero condition and the volume measured up to the nominal capacity of the device.

S.1.2. Graduations.

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

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater then the width of the minimum clear interval

between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

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

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

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

S.1.3. Indicators.

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

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

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

(a) the width of the widest graduation, and

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

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

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

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

S.1.3.6. Travel of Indicator. - If the most sensitive element of the primary indicating element utilizes an indicator and graduations, the relative movement of these parts corresponding to the smallest indicated value shall be not less than 5 mm (0.20 in).

S.1.4. Computing-Type Devices.

S.1.4.1. Display of Unit Price. - In a device of the computing type, means shall be provided for displaying on the outside of the device, and in close proximity to the display of the total computed price, the price per unit at which the device is set to compute.

S.1.4.2. Printed Ticket. - If a computing-type device issues a printed ticket which displays the total computed price, the ticket also shall have printed clearly thereon the total quantity of the delivery, the appropriate fraction of the quantity, and the price per unit of quantity.
(Amended 1989)

S.1.4.3. Money-Value Computations. - Money-value computations shall be of the full-computing type in which the money value at a single unit price, or at each of a series of unit prices, shall be computed for every delivery within either the range of measurement of the device or the range of the computing elements, whichever is less. Value graduations shall be supplied and shall be accurately positioned. The value of each graduated interval shall be 1 cent.

S.1.4.4. Money Values, Mathematical Agreement. Any digital money-value indication and any recorded money value on a computing-type device shall be in mathematical agreement with its associated quantity indicating or representation to within 1 cent of money value.

S.2. Design of Measuring Elements.

S.2.1. Vapor Elimination. - A metering system shall be equipped with an effective vapor eliminator or other effective means automatic in operation to prevent the passage of vapor and air through the meter. Vent lines from the air (or vapor) eliminator shall be made of metal tubing or some other suitably rigid material.

S.2.2. Maintaining Flooded Condition. - The vent on the vapor eliminator shall be positioned or installed in such a manner that the vapor eliminator cannot easily be emptied between uses.

S.2.3. Provision for Sealing. - Adequate provision shall be made for applying security seals to the adjustment mechanism and the register.

S.2.4. Directional Flow Valves. - Valves intended to prevent reversal of flow shall be automatic in operation.

S.2.5. Mass Flow Meters Only. - An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.
(Added 1989)

S.3. Design of Intake Lines.

S.3.1. Diversion of Liquid to be Measured. - No means shall be provided by which any liquid can be diverted from the supply tank to the receiving tank without being measured by the device.

S.3.2. Intake Hose. - The intake hose shall be:

(a) of the dry-hose type,

(b) adequately reinforced,

(c) not more than 6 m (20 ft) in length unless it can be demonstrated that a longer hose is essential to permit transfer from a supply tank; and

(d) connected to the pump at horizontal or above to permit complete drainage of the hose.

(Amended 1991)

S.4. Marking Requirements.

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

S.4.2. Discharge Rates. - A meter shall be marked to show its designed maximum and minimum discharge rates. However, the minimum discharge rate shall not exceed 20 percent of the maximum discharge rate.

S.4.3. Measuring Components. - All components that affect the measurement of milk that are disassembled for cleaning purposes shall be clearly and permanently identified with a common serial number.

S.4.4. Flood Volume. - When applicable, the volume of product (to the nearest minimum division of the meter) necessary to flood the system when dry shall be clearly, conspicuously, and permanently marked on the air eliminator.

S.4.5. Conversion Factor. - When the conversion factor of 1.03 kg/L (8.6 lb/gal) is used to convert the volume of milk to weight, the conversion factor shall be clearly marked on the primary indicating element and recorded on the delivery ticket.

N. Notes

N.1. Test Liquid.

(a) A meter shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics. Following a satisfactory examination, the weights and measures official should attach a seal or tag indicating the product used during the test.
(Amended 1989)

(b) A milk measuring system shall be tested with the type of milk to be measured when the accuracy of the system is affected by the characteristics of milk (e.g., positive displacement meters).
(Added 1989)

N.2. Evaporation and Volume Change. - Care shall be exercised to reduce to a minimum, evaporation losses and volume changes resulting from changes in temperature of the test liquid.

N.2.1. Temperature Correction. - Corrections shall be made for any changes in volume resulting from the differences in liquid temperatures between time of passage through the meter and time of volumetric determination in the test measure. When adjustments are necessary, appropriate tables should be used.

N.3. Test Drafts. - Test drafts should be equal to at least the amount delivered by the device in one minute at

its maximum discharge rate, and shall in no case be less than 400 L or 400 kg (100 gal or 1 000 lb).
(Amended 1989)

N.4. Testing Procedures.

N.4.1. Normal Tests. - The "normal" test of a meter shall be made at the maximum discharge rate that may be anticipated under the conditions of the installation. The "normal" test shall include a determination of the effectiveness of air elimination system.

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

N.4.3. System Capacity. - The test of a milk-metering system shall include the verification of the volume of product necessary to flood the system as marked on the air eliminator.

T. Tolerances

T.1. Application.

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

T.2. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Table 1.
(Amended 1989)

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Plumb and Level Condition. - A device installed in a fixed location shall be installed plumb and level, and the installation shall be sufficiently strong and rigid to maintain this condition.

UR.1.2. Discharge Rate. - A meter shall be so installed that the actual maximum discharge rate will not exceed the rated maximum discharge rate. If necessary, means for flow regulation shall be incorporated in the installation, in which case this shall be fully effective and automatic in operation.

Table 1. Tolerances

Milk Meters			Mass Flow Meters for Measuring Milk*		
Indication	Maintenance	Acceptance	Indication	Maintenance	Acceptance
gallons	gallons	gallons	pounds	pounds	pounds
100	0.5	0.3	1 000	5	3
200	0.7	0.4	2 000	7	4
300	0.9	0.5	3 000	9	5
400	1.1	0.6	4 000	11	6
500	1.3	0.7	5 000	13	7
Over 500	Add 0.002 gallon per indicated gallon over 500	Add 0.001 gallon per indicated gallon over 500	Over 5 000	Add 0.002 pound per indicated pound over 5 000	Add 0.001 pound per indicated pound over 5 000

*Added 1989

UR.1.3. Unit Price. - There shall be displayed on the face of a device of the computing type the unit price at which the device is set to compute.

UR.1.4. Intake Hose. - The intake hose shall be so installed as to permit complete drainage and that all available product is measured following each transfer.

UR.2. Use Requirements.

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

UR.2.2. Printed Ticket. - Any printed ticket issued by a device of the computing type on which there is printed the total computed price, the total quantity, or the price per unit of quantity, shall also show the other two values (either printed or in clear script).
(Amended 1989)

UR.2.3. Ticket in Printing Device. - A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a transfer is begun. If the meter is mounted on a vehicle, in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

UR.2.4. Credit for Flood Volume. - The volume of product necessary to flood the system as marked on the air eliminator shall be individually recorded on the ticket of each transfer affected.

Sec. 3.36. Water Meters

A. Application

A.1. - This code applies to devices used for the measurement of water; generally applicable to, but not limited to, utilities type meters installed in homes or business establishments and meters installed in batching systems.

A.2. - This code does not apply to water meters mounted on vehicle tanks (for which see Sec. 3.30; Code for Liquid-Measuring Devices).

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements.

S.1.1.1. General. - A water meter shall be equipped with a primary indicating element and may also be equipped with a primary recording element.

S.1.1.2. Units. - A water meter shall indicate and record, if the device is equipped to record, its deliveries in terms of liters, gallons or cubic feet or binary or decimal subdivisions thereof except batch plant meters, which shall indicate deliveries in terms of liters, gallons or decimal subdivisions of the liter or gallon only.

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

(a) 50 L (10 gal) on utility type meters,

(b) 0.2 L (1/10 gal) on batching meters delivering less than 375 L/min (100 gal/min), or

(c) 5 L (1 gal) on batching meters delivering 375 L/min (100 gal/min) or more.

S.1.1.4. Advancement of Indicating and Recording Elements. - Primary indicating and recording elements shall be susceptible to advancement only by the mechanical operation of the device.

S.1.1.5. Return to Zero. - If the meter is so designed that the primary indicating elements are readily returnable to a definite zero indication, means shall be provided to prevent the return of these elements beyond their correct zero position.

S.1.2. Graduations.

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

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

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

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

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

S.1.3. Indicators.

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

S.1.3.2. Length. - The index of an indicator shall reach to the finest graduations with which it is used, unless the indicator and the graduations are in the

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

(a) the width of the widest graduation, and

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

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

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

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

S.2. Design of Measuring Elements.

S.2.1. Provision for Sealing. - Adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of:

(a) any measurement elements, and

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

The adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

S.2.2. Batching Meters Only.

S.2.2.1. Air Elimination. - Batching meters shall be equipped with an effective air eliminator.

S.2.2.2. Directional Flow Valves. - Valves intended to prevent reversal of flow shall be automatic in operation.

N. Notes

N.1. Test Liquid. - A meter shall be tested with water.

N.2. Evaporation and Volume Change. - Care shall be exercised to reduce to a minimum, evaporation losses and volume changes resulting from changes to temperature of the test liquid.

N.3. Test Drafts. - Test drafts should be equal to at least the amount delivered by the device in two minutes and in no case less than the amount delivered by the device in one minute at the actual maximum flow rate developed by the installation. The test drafts shown in Table 1, next page, shall be followed as closely as possible.

N.4. Testing Procedures.

N.4.1. Normal Tests. The normal test of a meter shall be made at the maximum discharge rate developed by the installation. Meters with maximum gallon per minute ratings higher than Table 1 values may be tested up to the meter rating.
(Amended 1990)

N.4.2. Special Tests. - Special tests to develop the operating characteristics of meters may be made according to the rates and quantities shown in Table 2.

N.4.3. Batching Meter Tests. - Tests on batching meters should be conducted at the maximum and intermediate rates only.

T. Tolerances

T.1. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Table 1 and Table 2.

UR. User Requirements

UR.1. Batching Meters Only.

UR.1.1. Strainer. - A filter or strainer shall be provided if it is determined that the water contains excessive amounts of foreign material.

Table 1. Tolerances for Water Meters
Normal Tests

Meter size (inches)	Rate of flow (gal/min)	Maximum Rate		
		Meter indication		Tolerance on over- and under-registration
		gal	ft^3	
5/8	15	50	5	
3/4	25	50	5	
1	40	100	10	
1 1/2	80	300	40	1.5%
2	120	500	40	
3	250	500	50	
4	350	1 000	100	
6	700	1 000	100	

UR.1.2. Siphon Breaker. - An automatic siphon breaker or other effective means shall be installed in the discharge piping at the highest point of outlet, in no case below the top of the meter, to prevent siphoning of the meter and permit rapid drainage of the pipe or hose.

UR.1.3. Provision for Testing. - Acceptable provisions for testing shall be incorporated into all meter systems. Such provisions shall include a two-way valve, or manifold valving, and a pipe or hose installed in the discharge line accessible to the proper positioning of the test measure.

Table 2. Tolerances for Water Meters
Special Tests

Meter size (inches)	Intermediate rate				Minimum rate				
	Rate of flow (gal/min)	Meter indication		Tolerance on over- and underregistration	Rate of flow (gal/min)	Meter indication		Tolerance	
		gal	ft^3			gal	ft^3	Underregistration	Overregistration
5/8	2	10	1		1/4	5	1		
3/4	3	10	1		1/2	5	1		
1	4	10	1		3/4	5	1		
1 1/2	8	50	5	1.5%	1 1/2	10	1	5.0%	1.5%
2	15	50	5		2	10	1		
3	20	50	5		4	10	1		
4	40	100	10		7	50	5		
6	60	100	10		12	50	5		

Sec. 3.37. Tentative Code - Mass Flow Meters

This tentative Code has only 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 for Mass Flow Meters.

A. Application

A.1. Liquids. - This code applies to devices that are designed to dynamically measure the mass of liquids. It also specifies the relevant examination and tests that are to be conducted.

A.2. - Vapor (Gases). - This code applies to devices that are designed to dynamically measure the mass of hydrocarbon gas in the vapor state. Examples of these products are propane, propylene, butanes, butylenes, ethane, methane, natural gas and any other hydrocarbon gas/air mix.

A.3. Exclusions. - This code does not apply to measuring assemblies for cryogenic liquids.

S. Specifications

S.1. Indicating and Recording Elements.

S.1.1. Indicating Elements. - A measuring assembly shall include an indicating element. Indications shall be clear, definite, accurate, and easily read under normal conditions of operation of the instrument.

S.1.2. Units. -

S.1.2.1. Units of Measurement. - Deliveries shall be indicated and recorded in grams, kilograms, metric tons, pounds, or tons and decimal subdivisions thereof.

S.1.2.2. Mass Measurement. - The indication of a delivery shall be on the basis of (true) mass (as opposed to apparent mass versus a density of 8.0 g/cm^3). The quantity indication and any recorded representations shall be identified as follows, "Product quantity is based upon (true) mass" or some similar suitable statement.

S.1.2.3. Numerical Value of Quantity-Value Divisions. - The value of a scale interval shall be equal to:

- 1, 2, or 5, or

- a decimal multiple or submultiple of 1, 2, or 5.

S.1.2.4. Maximum Value of Quantity-Value Divisions.

(a) The maximum value of the quantity-value division for liquids shall be not greater than 0.2 percent of the minimum measured quantity.

(b) The maximum value of the quantity-value division for vapor-measuring devices shall not exceed 0.01 lb (0.01 kg) when measuring product as a retail motor fuel.

S.1.2.5. Values Defined. - Indicated values shall be adequately defined by a sufficient number of figures, words, symbols, or combinations thereof. A display of "zero" shall be a zero digit for all displayed digits to the right of the decimal mark and at least one to the left.

S.2. Operating Requirements.

S.2.1. Return to Zero. - Except for measuring assemblies in a pipeline, one indicator shall be provided with a means for returning the indication to zero either automatically or manually.

S.2.2. Indicator Reset Mechanism. - The reset mechanism for the indicating element shall not be operable during a delivery. Once the zeroing operation has begun, it shall not be possible to indicate a value other than the latest measurement, or "zeros" when the zeroing operation has been completed.

S.2.3. Nonresettable Indicator. - An instrument may also be equipped with a nonresettable indicator if the indicated values cannot be construed to be the indicated values of the resettable indicator for a delivered quantity.

S.3. Measuring Elements and Measuring Systems.

S.3.1. Maximum and Minimum Flow-Rates.

(a) The ratio of the maximum to minimum flow-rates specified by the manufacturer for devices measuring liquified gases shall be 5:1 or greater.

(b) The ratio of the maximum to minimum flow-rates specified by the manufacturer for devices measuring other than liquified gases shall be 10:1 or greater.

S.3.2. Adjustment Means. - An assembly shall be provided with means to change the ratio between the indicated quantity and the quantity of liquid measured by the assembly. A bypass on the measuring assembly shall not be used for these means.

S.3.2.1. Discontinuous Adjusting Means. When the adjusting means changes the ratio between the indicated quantity and the quantity of measured liquid in a discontinuous manner, the consecutive values of the ratio shall not differ by more than 0.1 percent.

S.3.3. Vapor Elimination. - A liquid-measuring instrument or measuring system shall be equipped with an effective gas extractor or other effective means, automatic in operation, to prevent the measurement of vapor and air that results in errors greater than the tolerance for the minimum measured quantity (See N.1.).

S.3.4. Maintenance of Liquid State. - A liquid-measuring device shall be installed so that the measured product remains in a liquid state during passage through the instrument.

S.3.5. Provision for Sealing. - Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that an adjustment on any device that affects the measurement result cannot be made without breaking the security seal. Provision shall be made for the zero adjustment mechanism to meet this requirement.
(Amended 1992)

S.3.6. Mass Flow Meters. - An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.

S.4. Discharge Lines and Valves.

S.4.1. Diversion of Measured Product. - No means shall be provided by which any measured product can be diverted from the measuring instrument. However, two or more delivery outlets may by permanently installed and operated simultaneously, provided that any diversion of flow to other than the intended receiving receptacle cannot be readily accomplished or is readily apparent. Such means include physical barriers, visible valves or indications that make it clear which outlets are in operation, and explanatory signs if deemed necessary.

A manually controlled outlet that may be opened for purging or draining the measuring system shall be permitted. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the measuring system.

S.4.2. Directional Flow Valves. - If a reversal of flow could result in errors that exceed the tolerance for the minimum measured quantity, a valve or valves or other effective means, automatic in operation (and equipped with a pressure limiting device, if necessary) to prevent the reversal of flow shall be properly installed in the system. (See N.1.)

S.4.3. Discharge Valves. - A discharge valve may be installed on a discharge line only if the system is a wet-hose type. Any other shutoff valve on the discharge side of the instrument shall be of the automatic or semiautomatic predetermined-stop type or shall be operable only:

- by means of a tool (but not a pin) entirely separate from the device, or

- by means of a security seal with which the valve is sealed open.

S.4.4. Antidrain Means. - In a wet-hose type device, effective means shall be provided to prevent the drainage of the hose between transactions.

S.4.5. Other Valves. - Check valves and closing mechanisms that are not used to define the measured quantity shall have relief valves (if necessary) to

dissipate any abnormally high pressure that may arise in the measuring assembly.

S.5. Markings. - A measuring system shall be legibly and indelibly marked with the following information:

(a) pattern approval mark (i.e., type approval number);

(b) name and address of the manufacturer or his trademark and, if required by the weights and measures authority, the manufacturer's identification mark in addition to the trademark;

(c) model designation or product name selected by the manufacturer;

(d) nonrepetitive serial number;

(e) maximum and minimum flow rates in pounds per unit of time;

(f) maximum working pressure;

(g) applicable range of temperature if other than -10 °C to +50 °C;

(h) minimum measured quantity; and

(i) product limitations, if applicable.

S.6. Printer. - When an assembly is equipped with means for printing the measured quantity, the following conditions apply:

(a) the scale interval shall be the same as that of the indicator;

(b) the value of the printed quantity shall be the same value as the indicated quantity;

(c) a quantity for a delivery (other than an initial reference value) cannot be recorded until the measurement and delivery has been completed;

(d) the printer is returned to zero when the resettable indicator is returned to zero; and

(e) the printed values shall meet the requirements applicable to the indicated values.

S.6.1. Printed Receipt. - Any delivered, printed quantity shall include an identification number, the time and date, and the name of the seller. This information may be printed by the device or pre-printed on the ticket.

N. Notes

N.1. Minimum Measured Quantity. - The minimum measured quantity shall be specified by the manufacturer.

N.2. Test Medium.

N.2.1. Liquid-Measuring Devices. - The device shall be tested with the liquid that the device is intended to measure or another liquid with the same general physical characteristics.

N.2.2. Vapor-Measuring Devices. - The device shall be tested with air or the product to be measured.

N.3. Test Drafts. - The minimum test shall be one test draft at the maximum flow rate of the installation and one test draft at the minimum flow rate. More tests may be performed at these or other flow rates. (See T.4.)

N.4. Minimum Measured Quantity. - The device shall be tested for a delivery equal to the declared minimum measured quantity when the device is likely to be used to make deliveries on the order of the minimum measured quantity.

N.5. Motor Fuel Dispenser. - When a device is intended for use as a liquid motor-fuel dispenser, the type evaluation test shall include a test for accuracy using 5 starts and stops during a delivery to simulate the operation of the automatic shut-off nozzle. This test may be conducted as part of the normal inspection and test of the meter.

N.6. Air Buoyancy Correction. - Air buoyancy corrections are applied when measuring products into an open vessel; air buoyancy corrections are not applied when measuring product into a closed vessel. When measuring product into an open vessel, weight values from a scale shall be converted to mass values by using Table N.6.

Table N.6. Air Buoyancy Correction Factors

Multiplier for Liquids to Convert Scale Indication to Mass (Air Buoyancy Correction)			
Product Density (g/cm^3)	Multiplier	Product Density (g/cm^3)	Multiplier
0.5011 to 0.5228	1.0022	0.8011 to 0.8582	1.0013
0.5229 to 0.5465	1.0021	0.8583 to 0.9241	1.0012
0.5466 to 0.5725	1.0020	0.9242 to 1.0010	1.0011
0.5726 to 0.6011	1.0019	1.0011 to 1.0919	1.0010
0.6012 to 0.6326	1.0018	1.0920 to 1.2010	1.0009
0.6327 to 0.6677	1.0017	1.2011 to 1.3343	1.0008
0.6678 to 0.7069	1.0016	1.3344 to 1.5009	1.0007
0.7070 to 0.7510	1.0015	1.5010 to 1.7152	1.0006
0.7511 to 0.8010	1.0014	1.7153 to 2.0009	1.0005

T. Tolerances

T.1. Tolerances, General

(a) The tolerances apply equally to errors of underregistration and errors of overregistration.

(b) The tolerances apply to all products at all temperatures between -10 to +50 °C, inclusive, measured at any flow rate within the rated measuring range of the meter.

T.2. Tolerances for Liquid-Measuring Devices. - The maintenance tolerance shall be 0.5 percent of the measured quantity. The acceptance tolerance shall be 0.3 percent of the measured quantity.

T.3. Tolerances for Vapor-Measuring Devices. - Maintenance and acceptance tolerances for mass flow meters shall be 2.0 percent and 1.5 percent, respectively.

T.4. Repeatability. - When multiple tests are conducted at approximately the same flow rate, the range of the test results for the flow rate shall not exceed:

(a) 0.2 percent of the measured quantity for liquid measurement; and

(b) 0.6 percent of the measured quantity for vapor measurement.

(Amended 1992)

UR. User Requirements

UR.1. Minimum Measured Quantity.

(a) The minimum measured quantity shall be specified by the manufacturer.

(b) The minimum measured quantity appropriate for a transaction may be specified by the weights and measures authority. A device may have a minimum measured quantity smaller than that specified by the weights and measures authority; however, the device must perform within the performance requirements for the declared minimum measured quantity.

UR.2. Low-Flow Cut-Off Valve. If a metering system is equipped with a programmable or adjustable "low-flow cut-off" feature:

(a) the low-flow cut-off value shall not be set at flow rates lower than the minimum operating flow rate specified by the manufacturer on the meter; and

(b) the system shall be equipped with flow control valves which prevent the flow of product and stop the indicator from registering product flow whenever the product flow rate is less than the low-flow cut-off value.

(Added 1992)

SECTION 4

Sec. 4.40. Vehicle Tanks Used as Measures

A. Application

A.1. - This code applies to vehicle tanks when these are used as commercial measures.

A.2. - This code does not apply to the following devices:

(a) Devices used solely for dispensing a product in connection with operations in which the amount dispensed does not affect customer charges.

(b) Meters mounted on vehicle tanks (for which see Sec. 3.31; Code for Vehicle-Tank Meters).

A.3. - Also see Sec. 1.10; General Code requirements.

S. Specifications

S.1. Design of Compartments.

S.1.1. Compartment Distortion. - The shell and bulkheads of a vehicle tank shall be so constructed that under any condition of liquid lading they will not become distorted sufficiently to cause a change in the capacity of any compartment (as determined by volumetric test) equal to more than 0.25 L per 750 L (0.5 pt per 200 gal), or fraction thereof, of the nominal compartment capacity, or to more than 0.5 L (1 pt), whichever is greater. (This specification prescribes a limit on permissible distortion only, and is not to be construed as setting up a secondary tolerance on compartment capacities to be added to the values given in tolerance paragraph T.2.)

S.1.2. Venting. - During filling operations, effective venting of a compartment shall be provided to permit air to escape from all spaces designed to be filled with liquid and to permit the influx of air to the compartment during the discharge of liquid therefrom. Venting shall prevent any formation of air pockets.

S.1.3. Completeness of Delivery. - A tank shall be so constructed that, when it is standing on a level surface, complete delivery can be made from any compartment through its delivery faucet or valve whether other compartments are full or empty, and whether or not the delivery is through a manifold.

S.1.4. Fill or Inspection Opening. - The fill or inspection opening of a compartment shall be of such size and location that it can readily be determined by visual inspection that the compartment has been properly filled or completely emptied and shall be so positioned with respect to the ends of the compartment that the indicator may be positioned as required. In no case shall the opening, if circular, have a diameter of less than 20 cm (7-5/8 in), or, if other than circular, have an effective area of less than 290 cm^2 (45 in^2).

S.1.5. Dome Flange and Baffle Plates. - Any dome flange extending into a compartment shall be provided with sufficient perforations or openings flush with the compartment shell to prevent any trapping of air. All baffle plates in a compartment shall be so cut away at top and bottom, and elsewhere as necessary, as to facilitate loading and unloading.

S.1.6. Compartment and Piping Capacities and Emergency Valve. - If a compartment is equipped with an emergency (or safety) valve, this shall be positioned at the lowest point of outlet from the compartment, and the compartment capacity or capacities shall be construed as excluding the capacity of the piping leading therefrom. However, the capacity of the piping leading from such a compartment shall be separately determined and reported, and may be separately marked as specified in S.4.

S.1.6.1. On Vehicle Tanks Equipped for Bottom Loading. - On equipment designed for bottom loading, the compartment capacity shall include the piping of a compartment to the valve located on the upstream side of the manifold and immediately adjacent thereto or, if not manifolded, to the outlet valve, provided that on or immediately adjacent to the marking as specified in S.4. the following words or a statement of similar meaning shall be affixed: "Warning: Emergency valves must be opened before checking measurement."

S.1.7. Expansion Space. - When a compartment is filled to the level of the highest indicator in the compartment, there shall remain an expansion space of at least 0.75 percent of the nominal compartment capacity as defined by that indicator.

S.2. Design of Compartment Indicators.

S.2.1. General. - An indicator shall be so designed that it will distinctly and unmistakably define a capacity point of its compartment when liquid is in contact with the lowest portion of the indicator.

S.2.2. Number of Indicators. - In no case shall a compartment be provided with more than five indicators.
(Amended 1972)

S.2.3. Identification of Multiple Indicators. - If a compartment is provided with multiple indicators, each such indicator shall be conspicuously marked with an identifying letter or number.

S.2.4. Location. - An indicator shall be located:

(a) midway between the sides of its compartment;

(b) as nearly as practicable midway between the ends of its compartment, and in no case offset by more than 10 percent of the compartment space or 15 cm (6 in), whichever is less;

(c) so that it does not extend into, nor more than 15 cm (6 in) from, that section of the compartment defined by a vertical projection of the fill opening;
(Amended 1974)

(d) at a depth, measuring from the top of the dome opening, not lower than 46 cm (18 in) for fill openings of less than 38 cm (15 in) in diameter, or, if other than circular, an effective area of less than 1130 cm^2 (175 in^2), and not lower than 61 cm (24 in) for larger fill openings; and

(e) to provide a clearance of not less than 5 cm (2 in) between indicators.
(Amended 1972)

S.2.5. Permanence. - Any indicator that is not intended to remain adjustable and all brackets or supports shall be securely welded in position.

S.2.6. Adjustable Indicators. - Adequate provision shall be made for conveniently affixing a security seal or seals:

(a) to any indicator intended to remain adjustable, so that no adjustment of the indicator can be made without mutilating or destroying the seal, and

(b) to any removable part to which an indicator may be attached, so that the part cannot be removed without mutilating or destroying the seal.

S.2.7. Sensitiveness. - The position of any indicator in its compartment shall be such that at the level of the indicator a change of 1.0 mm (0.04 in) in the height of the liquid surface will represent a volume change of not more than the value of the tolerance for the nominal compartment capacity as defined by that indicator.

S.3. Design of Compartment Discharge Manifold. - When two or more compartments discharge through a common manifold or other single outlet, effective means shall be provided to ensure:

(a) that liquid can flow through the delivery line leading from only one compartment at one time and that flow of liquid from one compartment to any other is automatically prevented, or

(b) that all compartments will discharge simultaneously.

If the discharge valves from two or more compartments are automatically controlled so that they can only be operated together, thus effectively connecting these compartments to one another, such compartments shall, for purposes of this paragraph, be construed to be one compartment.

S.4. Marking of Compartments.

S.4.1. Compartment Identification. - Each compartment of a multiple-compartment tank shall be conspicuously identified by a letter or number marked on the dome or immediately below the fill opening. Such letters or numbers shall be in regular sequence from front to rear, and the delivery faucets or valves shall be marked to correspond with their respective compartments.

S.4.2. Compartment Capacity, Single Indicator. - A compartment provided with a single indicator shall

be clearly, permanently, and conspicuously marked with a statement of its capacity as defined by its indicator.

S.4.3. Compartment Capacity, Multiple Indicators. - A compartment provided with two or more indicators shall be clearly, permanently, and conspicuously marked with a statement identifying:

(a) each indicator by a letter or number and, immediately adjacent thereto,

(b) the capacity of the compartment as defined by the particular indicator.

N. Notes

N.1. Test Liquid. - Water or light fuel oil shall be used as the test liquid for a vehicle-tank compartment.

N.2. Evaporation and Volume Change. - Care shall be exercised to reduce to a minimum, evaporation losses and volume changes resulting from changes in temperature of the test liquid.

N.3. To Deliver. - A vehicle-tank compartment shall be gauged "to deliver." If the compartment is gauged by measuring the test liquid into the tank, the inside tank walls shall first be thoroughly wetted.

N.4. Gauging of Compartments. - When a compartment is gauged to determine the proper position for an indicator or to determine what a capacity marking should be, whether on a new vehicle tank or following repairs or modifications that might affect compartment capacities, tolerances are not applicable, and the indicator shall be set and the compartment capacity shall be marked as accurately as practicable.

N.5. Adjustment and Remarking. - When a compartment is found upon test to have an error in excess of the applicable tolerance, the capacity of the compartment shall be adjusted to agree with its marked capacity, or its marked capacity shall be changed to agree with its capacity as determined by the test.

T. Tolerances

T.1. Application.

T.1.1. To Excess and to Deficiency. - The tolerances hereinafter prescribed shall be applied to errors in excess and in deficiency.

T.2. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Table 1.

Table 1.
Maintenance and Acceptance Tolerances
on Vehicle Tank Compartments

Nominal capacity of compartment	Maintenance and acceptance tolerance	
gallons	Expressed in quarts	Expressed in gallons
200 or less	2	0.5
201 to 400, inclusive	3	0.75
401 to 600, inclusive	4	1.0
601 to 800, inclusive	5	1.25
801 to 1000, inclusive	6	1.50
over 1000	Add 1 quart per 200 gallons or fraction thereof	Add 0.25 gallon per 200 gallons or fraction thereof

UR. User Requirements

UR.1. Conditions of Use.

UR.1.1. Filling. - A vehicle shall stand upon a level surface during the filling of a compartment.

UR.1.2. Delivering. - During a delivery, a vehicle shall be so positioned as to assure complete emptying of a compartment. Each compartment shall be used for an individual delivery only; that is, an individual delivery shall consist of the entire contents of a compartment or compartments.
(Amended 1976)

Sec. 4.41. Liquid Measures

A. Application

A.1. - This code applies to liquid measures; that is, to rigid measures of capacity designed for general and repeated use in the measurement of liquids.

A.2. - The code does not apply to test measures or other volumetric standards.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. -

a. The capacity of a liquid measure shall be 0.1 L, 0.2 L, 0.5 L, 1 L, 2 L, 5 L, or a multiple of 5 L, and the measure shall not be subdivided.

b. The capacity of a liquid measure shall be 1 gill, 1/2 liquid pint, 1 liquid pint, 1 liquid quart, 1/2 gallon, 1-1/4 gallon, 1-1/2 gallon, or a multiple of 1 gallon, and the measure shall not be subdivided. However, 3-pint and 5-pint brick molds and 2-1/2 gallon (10 quart) cans shall be permitted when used exclusively for ice cream.

S.2. Material. - Measures shall be made of metal, glass, earthenware, enameled ware, composition, or similar and suitable material. If made of metal, the thickness of the metal shall not be less than the appropriate value given in Table 1.

S.3. Capacity Point. - The capacity of a measure shall be determined to a definite edge, or to the lowest portion of a plate, bar, or wire, at or near the top of the measure, and shall not include the capacity of any lip or rim that may be provided.

S.4. Reinforcing Rings. - Reinforcing rings, if used, shall be attached to the outside of the measure and shall show no divisions or lines on the inside surface of the measure.

S.5. Discharge. - A measure equipped with a discharge faucet or valve shall be susceptible of complete discharge through the faucet or valve when the measure is standing on a level surface.

S.6. Marking Requirements. - A measure shall be marked on its side with a statement of its capacity. If the capacity is stated in terms of the pint or quart, the word "Liquid" or the abbreviation "Liq" shall be included.

T. Tolerances

T.1. - Maintenance tolerances in excess and in deficiency shall be as shown in Table 2. Acceptance tolerances shall be one-half the maintenance tolerances.

Table 1.
Minimum Thickness of Metal for Liquid Measures

Nominal capacity	Minimum thickness	
	For iron or steel, plated or unplated (inch)	For copper or aluminum (inch)
1 pint or less	0.010	0.020
1 quart, 1/2 gallon, 1 gallon	0.014	0.028
Over 1 gallon	0.016	0.032

Table 2.
Maintenance Tolerances,
in Excess and in Deficiency, for Liquid Measures

Nominal capacity	Tolerance			
	In excess		In deficiency	
	fluid drams	cubic inches	fluid drams	cubic Inches
1/2 pint or less	2	0.4	1.0	0.2
1 pint	3	0.7	1.5	0.3
1 quart	4	0.9	2.0	0.5
1/2 gallon	6	1.4	3.0	0.7
	fluid ounces			
1 and 1-1/4 gallons	1.0	1.8	4.0	0.9
1-1/2 gallons	1.5	2.7	6.0	1.4
			fluid ounces	
2 gallons	2	3.5	1	1.8
3 and 4 gallons	4	7.0	2	3.6
5 gallons	6	11.0	3	5.4
10 gallons	10	18.0	5	9.0

Sec. 4.42. Farm Milk Tanks

A. Application

A.1. - This code applies to farm milk tanks on the premises of producers when these are used, or are to be used, for the commercial measurement of milk.

A.2. - This code does not apply to tanks mounted on highway vehicles.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Components. - A farm milk tank, whether stationary or portable, shall be considered suitable for commercial use only when it comprises:

(a) a vessel, whether or not it is equipped with means for cooling its contents;

(b) means for reading the level of liquid in the tank, such as a removable gauge rod or surface gauge; and

(c) a chart for converting level-of-liquid readings to volume.

Each compartment of a subdivided tank shall, for the purposes of this code, be construed to be a farm milk tank.

S.2. Design of Tank.

S.2.1. Level. - A farm milk tank shall be designed to be in normal operating position when it is in level. The tank shall be so constructed that it will maintain its condition of level under all normal conditions of lading.

S.2.2. Level-Indicating Means. - A tank shall be permanently equipped with sensitive means by which the level of the tank can be determined.

S.2.2.1. On a Stationary Tank. - A stationary tank shall be provided with such level-indicating means as a two-way or circular level, a plumb bob, two-way leveling lugs, or the like; or the top edge or edges of the tank shall be so constructed throughout as to provide an accurate reference for level determinations; provided, that when leveling lugs or the top edge or edges of the tank are used as the reference for level determinations, there shall be supplied with the tank a sensitive spirit level of appropriate dimensions, and the positions where such level is intended to be used shall be permanently marked on the reference surface of the tank; and provided further, that when leveling lugs are used they shall be so designed, constructed, and installed at the factory that any alteration of the original position or condition, such as by hammering or filing, would be difficult and would become obvious. A stationary tank with a nominal capacity of 2 000 L or 500 gal, or greater shall be provided with at least two similar level-indicating means, and these shall be located in opposite and distant positions from each other to facilitate an accurate level determination in both directions of the tank's horizontal plane.
(Amended 1980)

S.2.2.2. On a Portable Tank. - A portable tank shall be provided with either a two-way or a circular level.

S.2.3. Portable Tank. - A portable tank shall be of the center-reading type; that is, it shall be 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.

S.2.4. Capacity. *- A farm milk tank shall be clearly and permanently marked on a surface visible after installation with its capacity as determined by the manufacturer. The capacity shall not exceed an amount that can be agitated without overflowing and that can be measured accurately with the liquid at rest. [Nonretroactive as of 1979.]*

S.3. Design of Indicating Means.

S.3.1. General. *- A tank shall include indicating means and shall be calibrated over the entire range of the volume of the tank from 5 percent of capacity or*

2 m^3 (500 gal) whichever is less, to its maximum capacity.
[Nonretroactive as of January 1, 1986.]
(Added 1985)

S.3.2. Gauge-Rod Bracket or Supports. - If a tank is designed for use with a gauge rod, a substantial and rigid gauge-rod bracket or other suitable supporting elements for positioning the gauge rod shall be provided. A gauge rod and its brackets or other supporting elements shall be so constructed that, whenever the rod is placed in engagement with the bracket or supports and released, the rod will automatically seat itself at a fixed height and in a vertical position. When a gauge rod is properly seated on its brackets or supports, there shall be a clearance of at least 7.5 cm (3 in) between the graduated face of the rod and any tank wall or other surface that it faces.

S.3.3. Gauge Rod. - When properly seated in position, a rod shall not touch the bottom of the tank unless this is required by the design of the supporting elements. The rod shall be graduated throughout an interval corresponding to the volume range within which readings of liquid level are to be made.

S.3.4. Surface-Gauge Bracket or Supports. - If a tank is designed for use with a surface gauge, a substantial and rigid surface-gauge bracket or other suitable supporting elements for positioning the surface gauge shall be provided. A surface gauge and its brackets or other supporting elements shall be so constructed that, whenever the gauge assembly is placed in engagement with the bracket or supports, the indicator, if not permanently mounted on the tank, will automatically seat itself in correct operating position, and the graduated element will be vertically positioned and will be securely held at any height to which it may be manually set.

S.3.5. Surface Gauge. - When properly engaged with its bracket and set to its lowest position, a surface gauge shall not touch the bottom of the tank. The gauge shall be graduated throughout an interval corresponding to the volume range within which readings of liquid level are to be made.

S.3.6. External Gauge Assemblies (Added 1977)

S.3.6.1. Design and Installation. - The gauge assembly shall be designed to meet sanitary requirements and shall be readily accessible for cleaning purposes. The gauge assembly shall be mounted in a vertical position and equipped with a sliding mechanism to assist in determining the liquid level.

S.3.6.2. Gauge Tube. - The gauge tube shall be borosilicate glass or approved rigid plastic or rigidly supported flexible tubing with a uniform internal diameter not less than 2 cm (3/4 in). It shall be designed and constructed so that all product in the gauge can be discarded in such a manner that no product in the gauge tube will enter the discharge line or tank.
(Amended 1983)

S.3.6.3. Scale Plate. - The scale plate shall be mounted adjacent to and parallel with the gauge tube and be no more than 7 mm (1/4 in) from the tube.

S.3.6.4. Scale Graduations. - The graduation lines shall be clear and easily readable and shall comply with the requirements of paragraphs included under S.3.7. Graduations.

S.3.6.5. Venting. - An external gauge tube shall be adequately vented at the top, open to the atmosphere. Any attachment to the gauge tube shall not adversely affect the operation of this vent.
(Added 1984)

S.3.7. Graduations.

S.3.7.1. Spacing and Width of Graduations. - On a gauge rod or surface gauge, the spacing of the graduations, center to center, shall be not more than 1.6 mm (0.0625 in or 1/16 in) and shall not be less than 0.8 mm (0.03125 in or 1/32 in). The graduations shall not be less than 0.12 mm (0.005 in) in width, and the clear interval between adjacent edges of successive graduations shall be not less than 0.4 mm (0.015625 in or 1/64 in).

S.3.7.2. Values of Graduations. - On a gauge rod or surface gauge, the graduations may be designated in inches or in centimeters and fractions thereof, or may be identified in a numerical series without reference to inches or centimeters or fractions thereof. In either case, a volume chart shall be provided for each such rod or gauge and each tank with which it is associated, showing values in terms of the graduation on the rod or gauge. If a rod or gauge is associated with but one tank, in lieu of linear or numerical series graduations and volume

chart, values in terms of volume of liquid in the tank may be shown directly on the rod or gauge.

S.3.7.3. Value of Graduated Interval. - The value of a graduated interval on a gauge rod or surface gauge (exclusive on the interval from the bottom of the tank to the lowest graduation) shall not exceed:

(a) 2 L for a tank of a nominal capacity of 1 000 L or less; 1/2 gal for a tank of a nominal capacity of 250 gal or less;

(b) 4 L for a tank of a nominal capacity of 1 001 to 2 000 L, inclusive; 1 gal for a tank of a nominal capacity of 251 to 500 gal, inclusive,

(c) 6 L for a tank of a nominal capacity of 2 001 to 6 000 L, inclusive; 1-1/2 gal for a tank of a nominal capacity of 501 to 1 500 gal, inclusive,

(d) 8 L for a tank of a nominal capacity of 6 001 to 10 000 L, inclusive; 2 gal for a tank of a nominal capacity of 1 501 to 2 500 gal, inclusive,

(e) 8 L plus 4 L for each additional 10 000 L or fraction thereof, for tanks of nominal capacity above 10 000 L or 2 gal plus 1 gal for each additional 2 500 gal or fraction thereof, for tanks with nominal capacity above 2 500 gal.

(Amended 1980)

S.3.8. Design of Indicating Means on Tanks with a Capacity Greater than 8 000 Liters or 2 000 gallon. - *Any farm milk tank with a capacity greater than 8 000 L, or 2 000 gal, shall be equipped with an external gauge assembly.*
[Nonretroactive and applicable only to tanks manufactured after January 1, 1981.]
(Added 1980)

S.4. Design of Volume Chart.

S.4.1. General. - A volume chart shall show volume values only, *over the entire range of the volume of the tank from 5 percent of capacity or 2 m^3 (500 gal) whichever is less, to its maximum capacity.** All letters and figures on the chart shall be distinct and easily readable. The chart shall be substantially constructed, and the face of the chart shall be so protected that its lettering and figures will not tend easily to become obliterated or illegible.
*[*Nonretroactive as of January 1, 1986.]*
(Amended 1985)

S.4.2. For a Tank of 1 000 Liters, or 250 Gallons, or Less. - The volume chart for a tank of nominal capacity of 1 000 L, or 250 gal, or less shall show values at least to the nearest 1 L, or 1/4 gal.

S.4.3. For a Tank of 1 001 to 2 000 Liters, or 251 to 500 Gallons. - The volume chart for a tank of nominal capacity of 1 001 to 2 000 L, or 251 to 500 gal, inclusive, shall show values at least to the nearest 2 L, or 1/2 gal.

S.4.4. For a Tank of Greater than 2 000 Liters, or 500 Gallons. - The volume chart for a tank of nominal capacity of greater than 2 000 L, or 500 gal, shall show values at least to the nearest gallon, or 4 L.
(Amended 1980)

S.5. Gauging.

S.5.1. Level. - A farm milk tank shall be level, as shown by the level-indicating means, during the original gauging operation.

S.5.2. To Deliver. - A farm milk tank shall be originally gauged "to deliver." If the tank is gauged by measuring the test liquid into the tank, the inside tank walls shall first be thoroughly wetted and the tank shall then be drained for 30 seconds after the main drainage flow has ceased.

S.5.3. Preparation of Volume Chart. - When a tank is gauged for the purposes of preparing a volume chart, tolerances are not applicable, and the chart shall be prepared as accurately as practicable.

S.6. Identification. - A tank and any gauge rod, surface gauge, spirit level, and volume chart intended to be used therewith shall be mutually identified, as by a common serial number, in a prominent and permanent manner.

N. Notes

N.1. Test Liquid. - Water shall be used as the test liquid for a farm milk tank.

N.2. Evaporation and Volume Change. - Care shall be exercised to reduce to a minimum, evaporation losses and

volume changes resulting from changes in temperature of the test liquid.

N.3. To Deliver. - A farm milk tank shall be tested "to deliver." If the tank is gauged by measuring the test liquid delivered into the tank, the inside tank walls shall first be thoroughly wetted and the tank then shall be drained for 30 seconds after the main drainage flow has ceased.

N.4. Level. - A farm milk tank shall be level, as shown by the level-indicating means, during gauging and testing.

N.5. Test Methods. - Acceptance tests of milk tanks may be of either the prover method or the master meter method provided that the master metering system is capable of operating within 25 percent of the applicable tolerance found in T.3. Subsequent tests may be of either the prover method or the master meter method provided that the master metering system is capable of operating within 25 percent of the applicable tolerance found in T.4.

N.6. Reading the Meniscus. - When a reading or setting is to be obtained from a meniscus formed by milk or other opaque liquid, the index or reading line is the position of the highest point of the center of the meniscus. When calibrating a device with water and the device is to be used with an opaque liquid, the reading should be obtained accordingly; that is, the position of the highest point of the center of the meniscus.
(Added 1984)

T. Tolerances

T.1. Application. - The tolerances hereinafter prescribed shall be applied equally to errors in excess and errors in deficiency.

T.2. Minimum Tolerance Values. - On a particular tank, the maintenance and acceptance tolerance applied shall be not smaller than the volume corresponding to the graduated interval at the point of test draft on the indicating means or one-half gal, or 2 L, whichever is greater.
(Amended 1980)

T.3. Basic Tolerance Values. - The basic maintenance and acceptance tolerance shall be 0.2 percent of the volume of test liquid in the tank at each test draft.
(Amended 1975)

T.4. Basic Tolerance Values, Master Meter Method. - The basic maintenance and acceptance tolerance for tanks tested by the master meter method shall be 0.4 percent of the volume of test liquid in the tank at each test draft.
(Added 1975)

UR. User Requirements

UR.1. Installation. - A stationary tank shall be rigidly installed in level without the use of removable blocks or shims under the legs. If such tank is not mounted permanently in position, the correct position on the floor for each leg shall be clearly and permanently defined.

UR.2. Level Condition.

UR.2.1. Stationary Tank. - A stationary farm milk tank shall be maintained in level.

UR.2.1.1. Leveling Lugs. - If leveling lugs are provided on a stationary tank, such lugs shall not be hammered or filed to establish or change a level condition of the tank.

UR.2.2. Portable Tank. - On a portable tank, measurement readings shall be made only when the tank is approximately level; that is, when it is not out of level by more than 5 percent or approximately 3 degrees in any direction.

UR.3. Weight Chart. - An auxiliary weight chart may be provided, on which shall be prominently displayed the weight per unit volume value used to derive the weight values from the official volume chart.

UR.4. Use. - A farm milk tank shall not be used to measure quantities greater than an amount that can be agitated without overflowing.

Sec. 4.43. Measure-Containers

A. Application

A.1. - This code applies to measure-containers, including lids or closures if such are necessary to provide total enclosure of the measured commodity, as follows:

(a) Retail measure-containers intended to be used only once to determine at the time of retail sale, and from bulk supply, the quantity of commodity on the basis of liquid measure. The retail measure-container serves as the container for the delivery of the commodity.

(b) Prepackaged measure-containers intended to be used only once to determine in advance of sale the quantity of a commodity (such as ice cream, ice milk, or sherbet) on the basis of liquid measure. The prepackaged measure-container serves as the container for the delivery of the commodity, in either a wholesale or a retail marketing unit.

A.2. - This code does not apply to rigid containers used for milk, cream, or other fluid dairy products, which are covered by packaging requirements.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. - The capacity of a measure-container shall be a multiple of or a binary submultiple of a quart or a liter, and the measure shall not be subdivided. However, for prepackaged measure-containers, any capacity less than 1/4 L or 1/2 liquid pint shall be permitted.
(Amended 1979)

S.2. Capacity Point. - The capacity of a measure-container shall be sharply defined by:

(a) the top edge,

(b) a line near the top edge, or

(c) the horizontal cross-sectional plane established by the bottom surface of the removable lid or cap when seated in the container.

S.3. Shape. - A measure-container shall be designed as some suitable geometrical shape, and its capacity shall be determined without distortion from its normal assembled shape.

S.4. Marking.

S.4.1. Capacity Point. - If the capacity point of a measure-container is defined by a line, the container shall be marked conspicuously on its side with a suitable statement clearly identifying this line as the capacity point.

S.4.2. Capacity Statement. - A measure-container shall be clearly and conspicuously marked with a statement of its capacity in terms of one of the units prescribed in S.1.

N. Notes

N.1. Test Liquid. - Water shall be used as the test liquid for a measure-container.

N.2. Preparation of Container for Test.

N.2.1. General. - Before an actual test is begun, a measure-container shall, if necessary, be so restrained that it will maintain its normal assembled shape and that its sides will not bulge when it is filled with water.

N.2.2. Restraining Form for Test.

N.2.2.1. For Rectangular Containers of One Liter, One Quarter Less. - Bulging of the sides of a rectangular measure-container of 1-liter (1-quart) capacity or less may be controlled by holding against each side of the container, with a cord, rubber bands, or tape, a metal plate or a piece of heavy cardboard slightly smaller than the side of the container.
(Amended 1979)

N.2.2.2. For Rectangular Prepackaged Measure-container of Two Quarts or Two Liters or Greater. - A rectangular prepackaged measure-container of 2-liter (2-quart) capacity or greater shall

be supported during a test by a rigid restraining form. This form shall restrain not less than the entire area of the central two-thirds of each side of the container, measured from bottom to top. The inside width dimension of any side panel of the restraining form shall be 1.6 mm (1/16 in) greater than the corresponding outside dimension of the container. (The outside width dimension of any side panel of the container shall be established by adding to the inner side center-of-score to center-of-score dimension two thicknesses of the board used, and the sum thus obtained shall be rounded off to the nearest 0.4 mm (1/64 in).
(Amended 1979)

T. Tolerances

T.1. Tolerances on an Individual Measure. - The acceptance tolerances in excess and in deficiency on an individual measure shall be as shown in Table 1.

T.2. Tolerance on Average Capacity. - The average capacity on a random sample of ten measures selected from a lot of 25 or more shall be equal to or greater than the nominal capacity.
(Amended 1979)

UR. User Requirements

UR.1. Limitation of Use. - The use of a measure-container with a rectangular cross section of a capacity of 2 qt or 2 L or greater shall be limited to the packaging, in advance of sale, of ice cream, sherbet, or other similar frozen desserts.
(Amended 1979)

Table 1.
Acceptance Tolerances,
in Excess and in Deficiency, for Measure-Containers

Nominal Capacity	Tolerance			
	In excess		In deficiency	
	fluid drams	cubic inches	fluid drams	cubic inches
1/2 pint or less	3	0.6	1.5	0.3
1 pint	4	1.0	2.0	0.5
1 quart	6	1.4	3.0	0.7
2 quarts	9	2.0	4.5	1.0
3 quarts	10	2.4	5.0	1.2
4 quarts	12	2.8	6.0	1.2
Over 4 quarts	Add per quart 3 fluid drams	Add per quart 0.7 cubic inch	Add per quart 1.5 fluid drams	Add per quart 0.35 cubic inch
	milliliters		milliliters	
1/4 liter or less	10		5.0	
1/2 liter	15		7.5	
1 liter	20		10.0	
Over 1 liter	Add per liter 10 milliliters		Add per liter 5.0 milliliters	

Sec. 4.44. Graduates

A. Application

A.1. - This code applies to subdivided glass measures of capacity, either cylindrical or conical in shape.

A.2. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. - Nominal capacities, graduation ranges, values of graduated intervals, and numbered graduations applicable to single-scale graduates and to the appropriate portions of double scale graduates shall be as shown in Table 1.

Table 1.
Design Details for Graduates

Nominal capacity	To be graduated between	Value of graduated intervals	Number at each graduation divisible by
milliliters	milliliters	milliliters	milliliters
5	1 and 5	1/2	1
10	2 and 10	1	2
25	5 and 25	5	5
50	10 and 50	5	10
100	20 and 100	10	20
500	100 and 500	25	50
1 000	200 and 1 000	50	100
minims	minims	minims	minims
60	15 and 60	5	10[a]
120	30 and 120	10	20[b]
fluid drams	fluid drams	fluid drams	fluid drams
4	1 and 4	1/2	1
8	2 and 8	1	2
fluid ounces	fluid ounces	fluid ounces	fluid ounces
2	1/2 and 2	1/4	1/2
4	1 and 4	1/2	1
8	2 and 8	1/2	1
16	4 and 16	1	2
32	8 and 32	2	4

[a] And, in addition, at the first (15-minim) graduation.
[b] And, in addition, at the first (30-minim) graduation.

S.2. Initial Interval. - A graduate shall have an initial interval that is not subdivided, equal to not less than one-fifth and not more than one-fourth of the capacity of the graduate.

S.3. Shape. - A graduate of a capacity of more than 15 mL (4 fluid drams) may be of either the cylindrical or circular conical type. A graduate of a capacity of 15 mL (4 fluid drams) or less shall be of the single-scale cylindrical type.

S.4. Material. - A graduate shall be made of good-quality, thoroughly annealed, clear, transparent glass, free from bubbles and streaks that might affect the accuracy of measurement. The glass shall be uniform in thickness and shall not be excessively thick.

S.5. Dimensional Proportions

S.5.1. On a Circular Conical Graduate. - The inside measurement from the bottom of a circular conical graduate to the capacity graduation shall be not less than two times the inside diameter at the capacity graduation. The inside measurement from the bottom of the graduate to the point representing one-fourth of the capacity shall be not less than the inside diameter at that point.

S.5.2. On a Cylindrical Graduate. - The inside measurement from the bottom of a cylindrical graduate to the capacity graduation shall be not less than five times the inside diameter at the capacity graduation.

S.6. Base. - The base of the graduate shall be perpendicular to the vertical axis of the graduate. The diameter of the base shall be of such size that the empty graduate will remain standing on an inclined surface of 25 percent, or approximately 15 degrees, from the horizontal.

S.7. Design of Graduations

S.7.1. General. - Graduations shall be perpendicular to the vertical axis of the graduate and parallel to each other. Graduations shall be continuous, of uniform thickness not greater than 0.4 mm (0.015 in), clearly visible, permanent, and indelible under normal conditions of use.
(Amended 1977)

S.7.2. On a Single-Scale Graduate. - On a single-scale graduate, the main graduations shall completely encircle the graduate and subordinate graduations shall extend at least one-half the distance around the graduate.

S.7.3. On a Double-Scale or a Duplex Graduate. - On a double-scale or duplex graduate, there shall be a clear space between the ends of the main graduations on the two scales, and this space shall be approximately 90 degrees from the lip of the graduate and shall conform to the requirements of Table 2.

Table 2.
Clear Space Between Ends of Main Graduations
on Double Scale Graduates

Inside diameter of graduate at the graduations (inches)	Clear space between ends of main graduations (inch)
Less than 1.5	1/8 to 1/4
1.5 to 3, inclusive	1/4 to 1/2
Over 3	3/8 to 5/8

S.8. Basis of Graduation. - A graduate shall be graduated "to deliver" when the temperature of the graduate is 20 °C (68 °F), and shall be marked accordingly in a permanent and conspicuous manner.

S.9. Marking Requirements. - Each main graduation shall be marked to show its value. Intermediate graduations shall not be marked. Value figures shall be uniformly positioned either directly upon or immediately above the graduations to which they refer. Figures placed upon graduations shall be set in from the ends of the graduations a sufficient distance to allow the ends of the graduations to be used in making a setting.

N. Notes

N.1. Test Liquid. - Water shall be used as the test liquid for graduates.

N.2. Temperature Control. - During the test of a graduate, appropriate precautions shall be exercised to reduce any detrimental temperature effects to the practicable minimum.

T. Tolerances

T.1. - Maintenance and acceptance tolerances in excess and in deficiency shall be as shown in Table 3 for graduates that are graduated "to contain" or "to deliver." (The tolerance to be applied at any graduation is determined by the inside diameter of the graduate at the graduation in question.)

Table 3.
Maintenance and Acceptance Tolerances, in Excess and in Deficiency, for Graduates

Inside diameter of graduate		Tolerance	Inside diameter of graduate		Tolerance
From	to but not including		From	to but not including	
millimeters		milliliters	inches		minims
0	16	0.1	0	9/16	2
16	21	0.2	9/16	13/16	3
21	26	0.4	13/16	1 1/16	6
26	31	0.6	1 1/16	1 5/16	10
31	36	0.8	1 5/16	1 9/16	15
36	41	1.1	1 9/16	1 13/16	20
41	46	1.4	1 13/16	2 1/16	30
46	51	1.8	2 1/16	2 5/16	40
51	56	2.2	2 5/16	2 9/16	50
56	61	2.8	2 9/16	2 13/16	65
61	66	3.4	2 13/16	3 1/16	80
66	71	4.1	3 1/16	3 5/16	95
71	76	4.8	3 5/16	3 9/16	110
76	81	5.6	3 9/16	3 13/16	130
81	86	6.4	3 3/16	4 1/16	150
86	91	7.2			
91	96	8.1			
96	101	9.0			

(Amended 1974)

Sec. 4.45. Dry Measures

A. Application

A.1. - This code applies to rigid measures of capacity designed for general and repeated use in the measurement of solids, including capacities of 1/2 bushel or more.

A.2. - This code does not apply to "standard containers" used for the measurement of fruits and vegetables and as shipping containers thereof.

A.3. - This code does not apply to berry baskets and boxes (for which, see Sec. 4.48; Code for Berry Baskets and Boxes).
(Added 1976)

A.4. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. - The capacity of a measure shall be 1 bushel, a multiple of the bushel, or a binary submultiple of the bushel, and the measure shall not be subdivided or double-ended.

S.2. Material. - A dry measure shall be made of any suitable material that will retain its shape during normal usage.

S.3. Shape. - A measure, other than a basket, of a capacity of 1/2 bushel or less, shall be cylindrical or conical in shape. The top diameter shall in no case be less than the appropriate minimum diameter shown in Table 1 (next page). The bottom of a measure, other than a basket, shall be perpendicular to the vertical axis of the measure and shall be flat, except that a metal bottom may be slightly corrugated. The bottom of a measure shall not be adjustable or movable.

S.3.1. Conical Dry Measure. - If conical, the top diameter shall exceed the bottom diameter by not more than 10 percent of the bottom diameter.

S.4. Capacity Point. - The capacity of a measure shall be determined by the top edge of the measure.

S.5. Top Reinforcement. - The top edge of a measure shall be reinforced. On a wooden measure other than a basket, of a capacity of 1 quart or more, this reinforcement shall be in the form of a firmly attached metal band.

Table 1.
Minimum Top Diameters for Dry Measures other than Baskets

Nominal capacity	Minimum top diameter inches
1 pint	4
1 quart	5 3/8
2 quarts	6 5/8
1/2 peck	8 1/2
1 peck	10 7/8
1/2 bushel	13 3/4

S.6. Marking Requirements. - A measure shall be conspicuously marked on its side with a statement of its capacity. If the capacity is stated in terms of the pint or quart, the word "Dry" shall be included. The capacity statement shall be in letters of the following dimensions:

(a) At least 1/2 inch high and 1/4 inch wide on a measure of any capacity between 1/2 pint and 1 peck.

(b) At least 1 inch high and 1/2 inch wide on a measure of a capacity of 1/2 bushel or more.

(c) On a measure of a capacity of 1/4 pint or less, the statement shall be as prominent as practicable, considering the size and design of such measure.

N. Notes

N.1. Testing Medium.

N.1.1. Watertight Dry Measures. - Water shall be used as the testing medium for watertight dry measures.

N.1.2. Nonwatertight Dry Measures. - A dry measure shall be tested either volumetrically using rape seed as a testing medium or geometrically through inside measurement and calculation.
(Amended 1988)

T. Tolerances

T.1. - Maintenance tolerances in excess and in deficiency shall be as shown in Table 2. Acceptance tolerances shall be one-half the maintenance tolerances.

Table 2.
Maintenance Tolerances, in Excess and in Deficiency,
for Dry Measures

Nominal capacity	Tolerance	
	In excess cubic inches	In deficiency cubic inches
1/32 pint or less	0.1	0.05
1/16 pint	0.15	0.1
1/8 pint	0.25	0.15
1/4 pint	0.5	0.3
1/2 pint	1.0	0.5
1 pint	2.0	1.0
1 quart	3.0	1.5
2 quarts	5.0	2.5
1/2 peck	10.0	5.0
1 peck	16.0	8.0
1/2 bushel	30.0	15.0
1 bushel	50.0	25.0

Sec. 4.46. Berry Baskets and Boxes

A. Application

A.1. - This code applies to baskets and boxes for berries and small fruits in capacities of 1 dry quart and less.

A.2. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. - The capacity of a berry basket or box shall be 1/2 dry pint, 1 dry pint, or 1 dry quart.

S.2. Materials. - A berry basket or box shall be made of any suitable materials that will retain its shape during normal filling, storage, and handling.

S.3. Capacity Point. - The capacity of a berry basket or box shall be determined by its top edges.

N. Notes

N.1. Method of Test. - A berry basket or box may be tested either volumetrically, using rape seed as the testing medium, or geometrically through accurate inside dimension measurement and calculation.

T. Tolerances

T.1. Tolerances on Individual Measures. - Maintenance and acceptance tolerances in excess and deficiency on an individual measure shall be as shown in Table 1.

T.2. Tolerances on Average Capacity. - The average capacity on a random sample of 10 measures selected from a lot of 25 or more shall be equal to or greater than the nominal capacity.
(Amended 1979)

Table 1.
Maintenance and Acceptance Tolerances
in Excess and in Deficiency

Nominal Capacity	Tolerance	
	In excess cu in	In deficiency cu in
1/2 pint	1	0.5
1 pint	2	1.0
1 quart	3	1.5

Section 5

Sec. 5.50. Fabric-Measuring Devices

A. Application

A.1. - This code applies only to mechanisms and machines designed to indicate automatically (with or without value-computing capabilities) the length of fabric passed through the measuring elements.

A.2. - Insofar as they are clearly appropriate, the requirements and provisions of this code apply also to devices designed for the commercial measurement of other material similar to fabrics, in sheet, roll, or bolt form.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. - A fabric-measuring device shall indicate lengths in terms of 10 cm (1/8 yard), 25 cm (1/4 yard), 50 cm (1/2 yard), and meters (yards). In addition, lengths may be indicated in terms of any or all of the following subdivisions: 30 cm (1/3 yard), 6 cm (1/16 yard), meters and centimeters (feet and inches). Digital indicators may indicate values in decimal fractions.
(Amended 1977)

S.2. Design of Indicating Elements.

S.2.1. Graduations.

S.2.1.1. Length. - Graduations shall be so varied in length that they may be conveniently read.

S.2.1.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

S.2.1.3. Clear Interval Between Graduations. - The clear interval between graduations shall be at least 6 mm for cm graduations (1/4 in) for 1/8-yard graduations), and 3 mm for 20-cm graduations (1/8 inch for 1-inch graduations).

S.2.2. Indicator.

S.2.2.1. Symmetry. - The index of an indicator shall be symmetrical with respect to the graduations, at least throughout that portion of its length associated with the graduations.

S.2.2.2. 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.2.2.3. Width. - The index of an indicator shall not be wider than the narrowest graduations with which it is used, and shall in no case exceed 0.4 mm (0.015 in).

S.2.2.4. 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.2.2.5. Parallax. - Parallax effects shall be reduced to the practicable minimum.

S.2.3. Money-Value Computations.

S.2.3.1. Full-Computing Type. - In this type, the money value at each of a series of unit prices shall be computed automatically for every length within the range of measurement of the fabric-measuring device. Value graduations shall be provided and shall be accurately positioned. The value of each graduated interval shall be 1 cent at all prices per yard of 30 cents and less, and shall not exceed 2 cents at higher prices per yard. Five-cent

intervals may be represented in the 2-cent range by special graduations, but these shall not be positioned in the clear intervals between graduations of the regular series.

S.2.3.2. Limited-Computing Type. - In this type, the money value at each of a series of unit prices shall be computed automatically only for lengths corresponding to a definite series of length graduations. There shall be no value graduations. At no position that the chart can assume shall two value figures at the same price per yard be completely and clearly exposed to view at one time. Money values shown shall be mathematically accurate, except that a fraction of less than 1/2 cent shall be dropped and the next higher cent shall be shown in the case of a fraction of 1/2 cent or more. One of the following requirements shall be met:

(a) There shall be a money-value computation for each length graduation within the range of measurement of the device.

(b) No money-value computation shall be exposed to view except at such times as the device shows a length indication for which a corresponding series of value indications is computed.

(c) Each column or row of money-value computations shall be marked to show the length to which the computations correspond, the device shall be marked to show the character and limitations of the computations, and there shall be computations corresponding to at least 10 cm (1/8 yd) throughout the range of measurement of the device.

S.2.4. Return to Zero. - Primary indicating elements shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of the indicating elements beyond their correct zero positions.

S.3. Marking Requirements. - If a device will not accurately measure all fabrics, it shall be marked to indicate clearly its limitations.

S.4. Design Accuracy. - Indications of length and money value shall be accurate whether the values of the indications are being increased or decreased.

N. Notes

N.1. Testing Medium. - A fabric-measuring device shall be tested with a suitable testing tape approximately 3 inches wide and with a graduated length of at least 12 yards, made from such material and having such surface finish as to provide dimensional stability and reduce slippage to the practicable minimum.

T. Tolerances

T.1. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Table 1.

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Installation. - A fabric-measuring device shall be securely supported and firmly fixed in position.

UR.2. Use Requirements.

UR.2.1. Limitation of Use. - A fabric-measuring device shall be used to measure only those fabrics that it was designed to measure, and in no case shall it be used to measure a fabric that a marking on the device indicates should not be measured.

UR.2.2. Return of Indicating Elements to Zero. - The primary indicating elements shall be returned to zero before each measurement.

Table 1.
Maintenance and Acceptance Tolerances
for Fabric-Measuring Devices

Indication of device (yards)	Maintenance tolerance		Acceptance tolerance	
	On under-registration (inches)	On over-registration (inches)	On under-registration (inches)	On over-registration (inches)
2 or less	3/8	1/4	1/4	1/8
3	3/8	5/16	1/4	5/32
4	1/2	5/16	1/4	5/32
5	5/8	3/8	5/16	3/16
6	3/4	3/8	3/8	3/16
7 and 8	1	1/2	1/2	1/4
9	1-1/4	5/8	5/8	5/16
10 and 11	1-1/2	3/4	3/4	3/8
12 and 13	1-3/4	7/8	7/8	7/16
14 and 15	2	1	1	1/2
Over 15	Add 1/8 inch per indicated yard	Add 1/16 inch per indicated yard	Add 1/16 inch per indicated yard	Add 1/32 inch per indicated yard

Sec. 5.51. Wire- and Cordage-Measuring Devices

A. Application

A.1. - This code applies to mechanisms and machines designed to indicate automatically the length of cordage, rope, wire, cable, or similar flexible material passed through the measuring elements.

A.2. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Units. - A wire- or cordage-measuring device shall indicate lengths in terms of feet, yards, or meters, or combinations of units of the same measurement system, and shall have minimum increments with values that do not exceed the equivalent of 0.1 meter or 0.1 yard. (Amended 1989)

S.2. Design of Indicating Elements.

S.2.1. Graduations.

S.2.1.1. Length. - Graduations shall be so varied in length that they may be conveniently read.

S.2.1.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in), nor more than 1.0 mm (0.04 in), in width.

S.2.1.3. Clear Interval Between Graduations. - The clear interval between graduations shall be at least as wide as the widest graduation, and in no case less than 0.8 mm (0.03 in).

S.2.2. Indicator.

S.2.2.1. Symmetry. - The index of an indicator shall be symmetrical with respect to the graduations, at least throughout that portion of its length associated with the graduations.

S.2.2.2. 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.2.2.3. Width. - The index of an indicator shall not be wider than the narrowest graduations with which it is used, and shall in no case exceed 0.4 mm (0.015 in).

S.2.2.4. 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.2.2.5. Parallax. - Parallax effects shall be reduced to the practicable minimum.

S.2.3. Zero Indication. - Primary indicating elements shall be readily returnable to a definite zero indication.

S.3. Design of Measuring Elements.

S.3.1. Sensitiveness. - If the most sensitive element of the indicating system utilizes an indicator and graduations, the relative movement of these parts corresponding to a measurement of 30 cm (1 ft) shall be not less than 6 mm (1/4 in).

S.3.2. Slippage. - The measuring elements of a wire- or cordage-measuring device shall be so designed and constructed as to reduce to the practicable minimum any slippage of material being measured and any lost motion in the measuring mechanism.

S.3.3. Accessibility. - A wire- or cordage-measuring device shall be so constructed that the measuring elements are readily visible and accessible, without disassembly of any supporting frame or section of the main body, for purposes of cleaning or removing any foreign matter carried into the mechanism by the material being measured.

S.4. Marking Requirements.

S.4.1. Limitation of Use. - If a device will measure accurately only certain configurations, diameters, types, or varieties of materials, or with certain accessory equipment, all limitations shall be clearly and permanently stated on the device.

S.4.2. Operating Instructions. - Any necessary operating instructions shall be clearly stated on the device.

S.4.3. Indications. - Indicating elements shall be identified by suitable words or legends so that the values of the indications will be unmistakable.

S.5. Design Accuracy. - Indications of length shall be accurate whether the values of the indications are being increased or decreased.

N. Notes

N.1. Testing Medium. - Wherever feasible, a wire- or cordage-measuring device shall be tested with a steel tape not less than 10 mm (3/8 in) in width and at least 15 m (50 ft) in length. When a device cannot be tested in this manner because of the design of the device, it shall be tested with a dimensionally stable material appropriately marked and compared at frequent periodic intervals with a steel tape in order to assure that any marked interval is not in error by more than 1/3 of the tolerance of the device at that particular interval.
(Amended 1981)

N.2. Minimum Test. - Tests shall be conducted at a minimum initial increment of 5 m (20 ft) and appropriate increments up to at least 15 m (50 ft).

T. Tolerances

T.1. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Table 1.

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Installation. - A wire- or cordage-measuring device shall be securely supported and firmly fixed in position.

UR.2. Use Requirements.

UR.2.1. Limitation of Use. - A wire- or cordage-measuring device shall be used to measure only those materials that it was designed to measure, and in no case shall it be used to measure a material that a marking on the device indicates should not be measured.

UR.2.2. Return to Zero. - The primary indicating elements of a wire- or cordage-measuring device shall be returned to zero before each measurement.

UR.2.3. Operation of Device. - A wire- or cordage-measuring device shall not be operated in such a manner as to cause slippage or inaccurate measurement.

UR.2.4. Cleanliness. - The measuring elements of a wire- or cordage-measuring device shall be kept clean to prevent buildup of dirt and foreign material that would adversely affect the measuring capability of the device.

Table 1.
Maintenance and Acceptance Tolerances for
Wire- and Cordage-Measuring Devices

Indication of device (feet)	Acceptance and maintenance tolerances	
	On underregistration (inches)	On overregistration
20	6	3
Over 20 to 30	8	4
Over 30 to 40	10	5
Over 40 to 50	12	6
Over 50	Add 2 inches per indicated 10 feet	Add 1 inch per indicated 10 feet

Sec. 5.52. Linear Measures

A. Application

A.1. - This code applies to any linear measure or measure of length, whether flexible or inflexible, permanently installed or portable.

A.2. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1.M. Units. - A linear measure may be in total length, and the total length may be subdivided in any or all of the following:

(a) centimeters and tenths of the centimeter;
(b) meters; and
(c) multiples of meters

A 1-meter measure may be graduated, in addition, to show 0.1-meter and multiples of 0.1-meter subdivisions.

S.1. Units. - A linear measure may be in total length, and the total length may be subdivided in any or all of the following:

(a) inches and binary submultiples of the inch;
(b) feet;
(c) yards and multiples of yards.

A 1-yard measure may be graduated, in addition, to show 1/3-yard and 2/3-yard subdivisions. A flexible tape may be graduated in tenths feet, hundredths ft, or both tenths and hundredths. (Any other subdivisions are allowable only on measures of special purposes and when required for such purposes.)

S.2. Material.

S.2.1. Flexible Tape. - A flexible tape shall be made of metal.

S.2.2. End Measure. - If an end measure is made of material softer than brass, the ends of the measure shall be protected by brass (or other metal at least equally hard) securely attached.

S.3. Finish. - Measures shall be smoothly finished.

S.4. Design.

S.4.1. Rigid Measure. - A rigid measure shall be straight.

S.4.2. Folding Measure. - A folding measure shall open to a definite stop, and when so opened shall be straight.

S.5. Graduations.

S.5.1. General. - Graduations shall be perpendicular to the edge of the measure.

S.5.2. Width. - The width of the graduations on any measure shall not exceed one-half the width of the smallest graduated interval on the measure, and in no case shall be wider than 0.75 mm (0.03 in). (Amended 1982)

T. Tolerances

T.1. For Measures Except Metal Tapes. - Maintenance tolerances in excess and in deficiency for measures except metal tapes shall be as shown in Table 1. Acceptance tolerances shall be one-half the maintenance tolerances.

Table 1.
Maintenance Tolerances, in Excess and in Deficiency, for Linear Measures Except Metal Tapes

Nominal interval from zero	Tolerance
feet	inch
1/2 or less	1/64
1	1/32
2	1/16
3	3/32
4	1/8
5	5/32
6	3/16

T.2. For Metal Tapes. - Maintenance and acceptance tolerances in excess and in deficiency for metal tapes shall be as shown in Table 2. Tapes of 10 m (25 ft) or over shall be tested at a tension resulting from a load of 5 kg (10 lb). Tapes less than 10 m (25 ft) shall be tested at a tension resulting from a load of 2.5 kg (5 lb). However, flexible metal tapes of 10 m (25 ft) or less that are not normally used under tension shall be tested with no tension applied. All tapes shall be supported throughout on a horizontal flat surface whenever tested. (Amended 1972)

Table 2.
Maintenance and Acceptance Tolerances,
in Excess and in Deficiency, for Metal Tapes

Nominal interval from zero	Tolerance
feet	inch
6 or less	1/32
7 to 30, inclusive	1/16
31 to 55, inclusive	1/8
56 to 80, inclusive	3/16
81 to 100, inclusive	1/4

Sec. 5.53. Odometers

A. Application

A.1. - This code applies to odometers that are used or are to be used to determine the charges for rent or hire of passenger vehicles and trucks and buses. (When official examinations are undertaken on odometers that form the basis for the payment of fees or taxes to, or the preparation of reports for, governmental agencies, and in similar cases, the requirements of this code shall be applied insofar as they are applicable and appropriate to the conditions of such special uses.)
(Amended 1977)

A.2. - This code does not apply to taximeters (for which see Sec. 5.54; Code for Taximeters).
(Amended 1977)

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Design of Indicating Elements.

S.1.1. General. - The primary indicating element of an odometer may be:

(a) the distance-traveled portion of the "speedometer" assembly of a motor vehicle;

(b) a special cable-driven distance-indicating device; or

(c) a hub odometer attached to the hub of a wheel on a motor vehicle.
(Amended 1977)

S.1.2. Units. - An odometer shall indicate in terms of miles or kilometers.
(Amended 1977)

S.1.3. Minimum Indicated Value. - The value of the interval of indicated distance shall be:

(a) for odometers indicating in miles, 0.1 mile; or

(b) for odometers indicating in kilometers, 0.1 kilometer.
(Amended 1977)

S.1.4. Advancement of Indicating Elements. - The most sensitive indicating elements of an odometer may advance continuously or intermittently; all other elements shall advance intermittently. Except when the indications are being returned to zero, the indications of an installed odometer shall be susceptible to advancement only by the rotation of the vehicle wheel or wheels. (Amended 1977)

S.1.5. Readability. - Distance figures and their background shall be of sharply contrasting colors. Figures indicating tenth units shall be differentiated from other figures with different colors, or with a decimal point, or by other equally effective means. Except during the period of advance of any decade to the next higher indication, only one figure in each decade shall be exposed to view. Any protective covering intended to be transparent shall be in such condition that it can be made transparent by ordinary cleaning of its exposed surface.
(Amended 1977)

S.1.6. Digital Indications and Representation. - Digital indicating odometers (discontinuous registration) shall "round off" indications to the nearest minimum division or truncate indications to the lower minimum division.
(Added 1990)

N. Notes

N.1. Testing Procedures.

N.1.1. Test Methods. - To determine compliance with distance tolerances, a distance test of an odometer shall be conducted utilizing one or more of the following test methods:

(a) Road Test. - A road test consists of driving the vehicle over a precisely measured road course.

(b) Fifth-Wheel Test. - A fifth-wheel test consists of driving the vehicle over any reasonable road

course and determining the distance actually traveled through the use of a mechanism known as a "fifth wheel" that is attached to the vehicle and that independently measures and indicates the distance.

(c) Simulated-Road Test. - A simulated road test consists of determining the distance traveled by use of a roller device, or by computation from rolling circumference and wheel-turn data.
(Amended 1977)

N.1.2. Test Runs. - Not less than two test runs shall be conducted. Acceleration and deceleration shall be carefully controlled to avoid spinning or skidding the wheels.
(Amended 1977)

N.1.2.1. For Devices Indicating in Miles. - The test runs shall be two miles in length, shall start from, and finish at, a dead stop with a minimum of 80 percent of the run between 30 miles per hour and 45 miles per hour.
(Added 1977)

N.1.2.2. For Devices Indicating in Kilometers. - The test runs shall be 3 kilometers in length, shall start from, and finish at, a dead stop with a minimum of 80 percent of the run between 50 kilometers per hour and 75 kilometers per hour.
(Added 1977)

N.1.3. Test Conditions.

N.1.3.1. Tire Stabilization. - Road tests or fifth-wheel tests shall be preceded by a run of at least 8 kilometers or 5 miles, for the purpose of stabilizing tire pressures. Simulated road tests on a roller device shall be made at stable tire pressures.
(Amended 1977)

N.1.3.2. Tire Pressure. - At the completion of the test run or runs, the tires of the vehicle under test shall be checked to determine that the tire pressure is that operating tire pressure posted in the vehicle. If not, the tire pressure should be adjusted to the posted tire pressure and further tests may be conducted to determine the operating characteristics of the odometer.
(Amended 1977)

N.1.3.3. Vehicle Loading.

(a) **Passenger Load.** - During the distance test of an odometer, the vehicle may carry two persons.

(b) **Truck Cargo Load.** - Truck odometers shall be tested by one of the following methods:

1. the truck is loaded with one-half of the maximum cargo load; or

2. unloaded if unloaded test tolerances are applied.

(Amended 1977, 1987)

T. Tolerances

T.1. To Underregistration and to Overregistration. The tolerances hereinafter prescribed shall be applied to errors of underregistration and errors of overregistration.

T.2. Tolerance Values. - Except for unloaded trucks, maintenance and acceptance tolerances on odometers shall be 4 percent of the interval under test.
(Amended 1977, 1987)

T.2.1. Tolerances for Unloaded Trucks. - Maintenance and acceptance tolerances on truck odometers shall be 5 percent for underregistration and 3 percent for overregistration of the interval under test.
(Added 1987)

UR. User Requirements

UR.1. Inflation of Vehicle Tires. - The operational tire pressure of passenger vehicle and truck tires shall be posted in the vehicle and tires shall be maintained at the posted pressure.
(Amended 1977)

Sec. 5.54. Taximeters

A. Application

A.1. This code applies to taximeters; that is, to devices that automatically calculate at a predetermined rate or rates and indicate the charge for hire of a vehicle.

A.2. This code does not apply to odometers on vehicles that are rented on a distance basis (for which see Sec. 5.53 Code for Odometers). (Amended 1977)

A.3. See also Sec. 1.10; General Code requirements.

S. Specifications

S.1. Design of Indicating and Recording Elements.

S.1.1. General. - A taximeter shall be equipped with a primary indicating element and may be equipped with a recording element.
(Amended 1988)

S.1.2. Advancement of Indicating Elements. - Except when a taximeter is being cleared, the primary indicating and recording elements shall be susceptible of advancement only by the movement of the vehicle or by the time mechanism.
(Amended 1988)

S.1.3. Visibility of Indications. - The indications of fare, including extras, and the mode of operation, such as "time" or "hired," shall be constantly displayed whenever the meter is in operation. All indications of passenger interest shall be easily read from a distance of 1.2 m (4 ft) under any condition of normal operation.
(Amended 1986, 1977, and 1988)

S.1.3.1. Minimum Height of Figures, Words, and Symbols. - The minimum height of the figures used to indicate the fare shall be 10 mm and for extras, 8 mm. The minimum height of the figures, words, or symbols used for other indications, including those used to identify or define, shall be 3.5 mm.
(Added 1986)

S.1.3.2. Lighting of Indications. *Integral lighting shall be provided to illuminate the fare, extras, the rate or rate code, and the taximeter status (i.e., vacant, hired, and time off).*
[Nonretroactive as of January 1, 1989]
(Added 1988)(Amended 1990)

S.1.4. Actuation of Fare-Indicating Mechanism. - When a taximeter designed to calculate fares upon the basis of a combination of distance traveled and time elapsed is operative with respect to fare indication, the fare-indicating mechanism shall be actuated by the distance mechanism whenever the vehicle is in motion at such a speed that the rate of distance revenue equals or exceeds the time rate, and may be actuated by the time mechanism whenever the vehicle speed is less than this and when the vehicle is not in motion. Means shall be provided for the vehicle operator to render the time mechanism either operative or inoperative with respect to the fare-indicating mechanism.
(Amended 1977)

S.1.5. Operating Condition.

S.1.5.1. General. - When a taximeter is cleared, the indication "Not Registering," "Vacant," or an equivalent expression shall be shown. Whenever a taximeter is set to register charges, it shall indicate "Registering," "Hired," or an equivalent expression and the rate at which it is set shall be automatically indicated (Rate 1 or Rate A, for example).
(Amended 1988)

S.1.5.2. Time not Recording. - When a taximeter is set for fare registration with the time mechanism inoperative, it shall indicate "Time Not Recording" or an equivalent expression.
(Amended 1988)

S.1.6. Fare Identification. - Fare indications shall be identified by the word "Fare" or by an equivalent expression. Values shall be defined by suitable words or monetary signs.

S.1.7. Extras. - Extras shall be indicated as a separate item and shall not be included in the fare indication. They shall be identified by the word "Extras" or by an equivalent expression. Values shall be defined by suitable words or monetary signs.

Means may be provided to totalize the fare and extras if the totalized amount returns to separate indications of fare and extras within five seconds or less.
(Amended 1988)

S.1.7.1. Nonuse of Extras. - If and when taximeter extras are prohibited by legal authority or are discontinued by a vehicle operator, the extras mechanisms shall be rendered inoperable or the extras indications shall be effectively obscured by permanent means.

S.1.8. Protection of Indications. - Indications of fare and extras shall be displayed through and entirely protected by glass or other suitable transparent material securely attached to the housing of the taximeter.

S.1.9. Design of Recording Elements. *- A recording element shall be equipped to record date, time, and fare. On a taximeter equipped with extras indications, the recording element shall also record extras. [Nonretroactive as of January 1, 1989]*
(Added 1988)

S.2. Basis of Fare Calculations. - A taximeter shall calculate fares only upon the basis of:

(a) distance traveled,

(b) time elapsed, or

(c) a combination of distance traveled and time elapsed.
(Amended 1977)

S.2.1. Initial Time and Distance Intervals. - The time and distance intervals of a taximeter shall be directly proportional as expressed in the following formula:

$$\frac{\text{Seconds of Initial Time Interval}}{\text{Seconds per Non-Initial Time Interval}} = \frac{\text{Distance of Initial Mileage Interval}}{\text{Distance per Non-Initial Mileage Interval}}$$

(Added 1990)

S.3. Design of Operating Control.

S.3.1. Positions of Control. The several positions of the operating controls shall be clearly defined and shall be so constructed that accidental or inadvertent changing of the operating condition of the taximeter is improbable. Movement of the operating controls to an operating position immediately following movement to the cleared position shall be delayed enough to permit the taximeter to come to a complete rest in the cleared position.
(Amended 1988)

S.3.2. Flag. - If the control for the operating condition is a lever-arm and flag, the flag shall be at its highest position when the taximeter is cleared, and in this position the whole of the flag shall be above the level of the taximeter housing.

S.3.3. Control for Extras Mechanism. - The knob, handle, or other means provided to actuate the extras mechanism shall be inoperable whenever the taximeter is cleared.

S.4. Interference. - The design of a taximeter shall be such that there will be no interference between the time and the distance portions of the mechanism device at any speed of operation.
(Amended 1977 and 1988)

S.5. Provision for Security Seals. - Adequate provision shall be made for affixing security seals to a taximeter and to other parts required for service operation of a complete installation on a vehicle, so that no adjustments, alterations, or replacements affecting accuracy or indications of the device or the assembly can be made without mutilating the seal or seals. The sealing means shall be such that it is not necessary to disassemble or remove any part of the device or of the vehicle to apply or inspect the seals.
(Amended 1988)

S.6. Power Interruption, Electronic Taximeters.

(a) After a power interruption of 3 sec or less, the fare and extras indications shall return to the previously displayed indications and may be susceptible to advancement without the taximeter being cleared.

(b) After a power interruption exceeding 3 sec, the fare and extras indications shall return to the previously displayed indications and shall not be susceptible to advancement until the taximeter is cleared.

[Effective and nonretroactive as of January 1, 1994. Retroactive after January 1, 1999.]
(Added 1988)(Amended 1989 and 1990)

N. Notes

N.1. Distance Tests.

N.1.1. Test Methods. - To determine compliance with distance tolerances, a distance test of a taximeter shall be conducted utilizing one or more of the following test methods:

(a) **Road Test.** - A road test consists of driving the vehicle over a precisely measured road course.

(b) **Fifth-Wheel Test.** - A fifth-wheel test consists of driving the vehicle over any reasonable road course and determining the distance actually traveled through the use of a mechanism known as a "fifth wheel" that is attached to the vehicle and that independently measures and indicates the distance.

(c) **Simulated-Road Test.** - A simulated road test consists of determining the distance traveled by use of a roller device, or by computation from rolling circumference and wheel-turn data.

(Amended 1977)

N.1.2. Test Procedures. - The distance test of a taximeter, whether a road test, a simulated-road test, or a fifth-wheel test, shall include at least duplicate runs of sufficient length to cover at least the third money drop or one mile, whichever is greater, and shall be at a speed approximating the average speed traveled by the vehicle in normal service. In the case of metric-calibrated taximeters, the test should cover at least the third money drop or 2 km, whichever is greater.
(Amended 1977)

N.1.3. Test Conditions.

N.1.3.1. Vehicle Lading. - During the distance test of a taximeter, the vehicle shall carry two persons, or in the case of a simulated-road test, 70 kg or 150 lb of test weights may be substituted in lieu of the second person.

N.1.3.2. Tire Pressure. - At the completion of test run or runs, the tires of the vehicle under test shall be checked to determine that the tire pressure is that operating tire pressure posted in the vehicle. If not, the tire pressure should be adjusted to the posted tire pressure and further tests may be conducted to determine the operating characteristics of the odometer.
(Amended 1977)

N.2. Time Test. - If a taximeter is equipped with a timing device through which charges are made for time intervals, the timer shall be tested at the initial interval, four separate subsequent intervals, and an average time test of at least four consecutive subsequent time intervals.
(Amended 1988)

N.3. Interference Test. - If a taximeter is equipped with a timing device through which charges are made for time intervals, a test shall be conducted to determine whether there is interference between the time and distance elements. During the interference test, the vehicle's operating speed shall be 3 or 4 km/h, or 2 or 3 mi/h faster than the speed at which the basic distance rate equals the basic time rate. The basic rate per hour divided by the basic rate per mile is the speed (km/h or mi/h) at which the basic time rate and basic distance rate are equal.
(Amended 1988)

T. Tolerances

T.1. Tolerance Values.

T.1.1. On Distance Tests. - Maintenance and acceptance tolerances for taximeters shall be as follows:

(a) On Overregistration: 1 percent of the interval under test.

(b) On Underregistration: 4 percent of the interval under test, with an added tolerance of 30 m or 100 ft whenever the initial interval is included in the interval under test.

T.1.2. On Time Tests.

T.1.2.1. On Individual Time Intervals. - Maintenance and acceptance tolerances on individual time intervals shall be as follows:

(a) On Overregistration: 3 second per minute (5 percent).

(b) On Underregistration: 9 second per minute (15 percent) on the initial interval, and 6 second per minute (10 percent) on subsequent intervals.

T.1.2.2. On Average Time Interval Computed After the Initial Interval. - Except for the initial interval, maintenance and acceptance tolerances on the average time interval shall be as follows:

(a) On Overregistration: 0.2 second per minute (0.33 percent).

(b) On Underregistration: 3 second per minute (5 percent).

(Amended 1991)

T.1.3. On Interference Tests.

T.1.3.1. The registration of a taximeter in the "time on" position shall agree within one percent of its performance in the "time off" position.
(Added 1988)

UR. User Requirements

UR.1. Inflation of Vehicle Tires. - The operational tire pressure of passenger vehicles and truck tires shall be posted in the vehicle and shall be maintained at the posted pressure.
(Amended 1977)

UR.2. Position and Illumination of Taximeter. - A taximeter shall be so positioned and illuminated that its indications, operational markings, and controls of passenger interest can be conveniently read by a passenger seated in the back seat of the vehicle.
(Amended 1985 and 1986)

UR.3. Statement of Rates. - The distance and time rates for which a taximeter is set, including the initial distance interval and the initial time interval, and the schedule of extras when an extras indication is provided, shall be conspicuously displayed inside the front and rear passenger compartments. The words "Rate," "Rates," or "Rates of Fare" shall precede the rate statement. The rate statement shall be fully informative, self-explanatory, and readily understandable by the ordinary passenger, and shall either be of a permanent character or be protected by glass or other suitable transparent material.
(Amended 1977, 1988, and 1990)

Sec. 5.55. Timing Devices

A. Application

A.1. - This code applies to devices used to measure time during which services are being dispensed (such as vehicle parking, laundry drying, and car washing).

A.2. - See also Sec. 1.10; General code requirements.

S. Specifications

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

S.1.1. Primary Elements.

S.1.1.1. General. - A timing device shall be equipped with a primary indicating element, and may also be equipped with a primary recording element. A readily observable in-service light or other equally effective means that automatically indicates when laundry driers, vacuum cleaners, and car washes are in operation shall be deemed an appropriate primary indicating element.
(Amended 1979)

S.1.1.2. Units. - A timing device shall indicate and record, if the device is equipped to record, the time in terms of minutes for time intervals of 60 minutes or less and in hours and minutes for time intervals greater than 60 minutes.

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

(a) one-half hour on parking meters indicating time in excess of 2 hours;

(b) Six minutes on parking meters indicating time in excess of 1 but not greater than 2 hours; or

(c) Five minutes on all other devices, except those equipped with an in-service light.
(Amended 1975)

S.1.1.4. Advancement of Indicating and Recording Elements. - Primary indicating and recording elements shall be susceptible to advancement only during the mechanical operation of the device, except that clocks may be equipped to manually reset the time.

S.1.1.5. Operation of In-Service Indicator Light. - The in-service light indicator shall be operative only during the time the device is in operation.

S.1.1.6. Discontinuous Indicating Parking Meters. - An indication of the time purchased shall be provided at the time the meter is activated in units of no more than 1 minute for times less than 1 hour and not more than 2 minutes for times of 1 hour or more. Convenient means shall be provided to indicate to the purchaser the unexpired time.
(Added 1975 and amended 1976)

S.1.2. Graduations.

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

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations and the width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

S.1.2.3. Clear Interval Between Graduations. - The clear interval shall be not less than 0.75 mm (0.03 in). If the graduations are not parallel, the measurement shall be made:

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

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

S.1.3. Indicators.

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

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

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

(a) the width of the widest graduation, and

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

S.1.3.4. Parallax. - Parallax effect shall be reduced to a practicable minimum.

S.1.4. Printed Tickets. - A printed ticket issue or stamped by a timing device shall have printed clearly thereon:

(a) the time and day when the service ends and the time and day when the service begins, except that a self-service money-operated device that clearly displays the time of day need not record the time and day when the service begins; or

(b) the time interval purchased, and the time and day that the service either begins or ends.

(Amended 1983)

S.2. Marking Requirements, Operating Instructions. - Operating instructions shall be clearly stated on the device.

N. Notes

N.1. Test Method. - A timing device shall be tested with a timepiece with an error of not greater than plus or minus 15 seconds per 24-hour period. In the test of timing devices with a nominal capacity of 1 hour or less, stopwatches with a minimum division of not greater than one-fifth second shall be used. In the test of timing devices with a nominal capacity of more than 1 hour, the value of the minimum division on the timepiece shall be not greater than 1 second. Time pieces and stopwatches shall be calibrated with standard time signals as described in National Institute of Standards and Technology Special Publication 432, NIST Time and Frequency Dissemination Services, or any superseding publication. (Amended 1978)

N.2. Broadcast Times and Frequencies. - Time and frequency standards are broadcast by the stations listed in Table N.2.

T. Tolerances

T.1. Tolerance Values. - Maintenance and acceptance tolerances for timing devices shall be as follows:

Table N.2.* Broadcast Times and Frequencies

Station	Location, Latitude, Longitude	Frequency (MHz)	Times of Transmission (UTC)
WWV	Fort Collins, Colorado 40°41' N 105°02' W	2.5 5.0 10.0 15.0	Continuous
WWVH	Kauai, Hawaii 21°59' N 159°46'	2.5 5.0 15.0	Continuous
CHU	Ottawa, Canada 45°18'N 75°45'W	3.330 7.335 14.670	Continuous

*From NIST Special Publication 559, "Time and Frequency Users' Manual," 1979.
(Added 1988)

T.1.1. For Timing Devices other than those Specified in T.1.2. and T.1.3. - The maintenance and acceptance tolerances shall be:

(a) On Overregistration: 5 seconds for any time interval of 1 minute or more; and

(b) On Underregistration: 6 seconds per indicated minute.

(Amended 1975 and 1986)

T.1.2. For Time Clocks and Time Recorders. - The maintenance and acceptance tolerances on overregistration and under registration shall be 3 seconds per hour, but not to exceed 1 minute per day.

(Amended 1975)

T.1.3. On Parking Meters. - The maintenance and acceptance tolerances are shown in Table 1.

T.2. 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 minimum value that can be indicated or recorded.

UR. User Requirements

UR.1. Statement of Rates. - The price in terms of money per unit or units of time for the service dispensed and the number of coins the device will accept and be activated by at one time, shall be clearly, prominently, and conspicuously displayed.

(Amended 1976)

UR.2. Time Representations. - Any time representation shall be within plus or minus 2 minutes of the correct time in effect in the area, except on an individual clock used only for "time out"; in addition, the time indication of the "time-out" clock shall be the same as or less than that of the "time-in" clock.

(Amended 1975)

Table 1.
Maintenance and Acceptance Tolerance
for Parking Meters

Maintenance and Acceptance Tolerance		
Nominal time capacity	On overregistration	On underregistration
30 minutes or less	No tolerance	10 seconds per minute, but not less than two minutes
Over 30 minutes to and including 1 hour	No tolerance	5 minutes plus 4 seconds per minute over 30 minutes
Over 1 hour	No tolerance	7 minutes plus 2 minutes per hour over 1 hour

Sec. 5.56. Grain Moisture Meters

A. Application

A.1. - This code applies to grain moisture meters; that is, devices used to indicate directly or through conversion and/or correction tables the moisture content of cereal grain and oil seeds. The code consists of general requirements applicable to all moisture meters and specific requirements applicable only to certain types of moisture meters.

A.2. - This code does not apply to devices used for in-motion measurement of grain moisture content or seed moisture content.

A.3. - See also Sec. 1.10; General Code requirements.

S. Specifications

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

S.1.1. Primary Elements, General. - A meter shall be equipped with a primary indicating element and may also be equipped with a primary recording element. If the meter indicates directly and/or is equipped to record, the meter shall indicate and/or record its measurements in terms of percent moisture content, wet basis. Subdivisions of this unit shall be in terms of decimal subdivisions (not fractions). If the meter indicates in the conventional scale and requires conversion or correction tables, the resulting values after use of such tables shall be in terms of percent moisture content, wet basis. Subdivisions of this unit shall be in terms of decimal subdivisions (not fractions).

S.1.2. Graduations.

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

S.1.2.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of the main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

S.1.2.3. Clear Interval Between Graduations. - The clear interval shall be not less than 0.75 mm (0.03 in) between 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.1.3. Indicators.

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

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

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

(a) the width of the widest graduation, nor

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

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

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

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

S.1.4. Digital Indications.

S.1.4.1. Measurement Completion. - A digital indicating element shall not display any values (either moisture content or conventional scale) before the end of the measurement cycle.

S.1.5. Recording Elements.

S.1.5.1. General. - If a meter is equipped with a recording element, it shall record in terms of percent moisture content, wet basis only, and not in terms of conventional scale.

S.1.5.2. Measurement Completion. - A recording element shall not record any values before the end of the measurement cycle.

S.1.5.3. Range of Moisture Content. - A recording element shall not record any values when the moisture content of the grain sample is beyond the operating range of the device.

S.1.6. Design of Direct Reading Grain Moisture Meters.

S.1.6.1. Grain or Seed Kind and Class Selection and Recording. - Provision shall be made for selecting and recording, if equipped to record, the kind and class (as appropriate) of grain or seed to be measured. The means to select the kind and class of grain or seed shall be readily visible and the kind and class of grain or seed selected shall be clearly and definitely identified in letters (such as Wheat or WHT, HRWW, etc.).

S.1.6.2. Operating Range. - *A meter shall automatically and clearly indicate when the operating range of the meter has been exceeded or the manufacturer shall:*

(a) clearly and conspicuously mark the operating ranges on the meter; or

(b) furnish the operating ranges of the meter and the means to clearly and conspicuously display this information on or immediately adjacent to the device.

The operating range shall specify the following:

(a) the temperature range over which the meter may be used and still comply with the applicable requirements;

(b) the moisture range for each grain or seed for which the meter is to be used;

(c) the temperature range for each grain or seed for which the meter is to be used; and

(d) the maximum allowable difference in temperature between the meter and the sample for which an accurate moisture determination can be made.

Examples of clearly indicating these conditions include an error indication, flashing the displayed moisture value, or blanking the display.
[Nonretroactive as of January 1, 1989]
(Amended 1986 and 1988)

S.1.6.3. Value of Minimum Indication. - The value of the minimum indicated or recorded moisture indication shall not be greater than 0.1 percent.
(Added 1988)

S.1.7. Electric Power Supply.

S.1.7.1. Power Supply, Voltage and Frequency.

(a) A meter that operates using alternating current must perform within the tolerances defined in Section T.2. - Tolerance Values over the line voltage range 100-130 volts, or 200-250 volts rms as designed, and over the frequency range of 59.5 to 60.5 Hz.

(b) Battery-operated instruments shall not indicate or record values outside the applicable tolerance limits when battery power output is excessive or deficient.
[Nonretroactive as of January 1, 1989]

S.1.7.2. 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, 1989]
(Added 1988)

S.1.8. Level Indicating Means. - *A meter shall be equipped with level-indicating means if its performance*

is changed by an amount greater than the absolute value of the acceptance tolerance when the meter is moved from a level position and zeroed in a position that is out of level in any upright direction by up to 5 percent (approximately 3 degrees).

The level-indicating means shall be readable without removing any meter parts requiring a tool.
[Nonretroactive as of January 1, 1989]
(Added 1988)

S.1.9. Operating Temperature:

(a) A meter shall not display or record any usable values until the operating temperature necessary for accurate determination has been attained, or the meter shall bear a conspicuous statement adjacent to the indication stating that the meter shall be turned on for a time period specified by the manufacturer prior to use.

(b) A meter shall meet the requirements of T.2. - Tolerance Values when operated in the temperature range of 2 °C to 40 °C (35 °F to 104 °F) or within the range specified by the meter manufacturer.

(c) If the manufacturer specifies a temperature range, the range shall be at least 10 °C (20 °F) and shall be marked on the device.
[Nonretroactive as of January 1, 1989]
(Added 1988)

S.2. Design of Measuring Elements.

S.2.1. Design of Zero-Setting and Test Point Mechanisms. - If a grain moisture meter is equipped with a zero setting and/or test point mechanism(s), this (these) mechanism(s) shall be adjustable only with a tool outside and entirely separate from this mechanism or enclosed in a cabinet. This requirement shall not apply to manual operations that the operator must make (following operating instructions) in order to obtain a meter reading on a grain sample.

S.2.2. Provision for Sealing. - 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 of the grain moisture meter that is set by the manufacturer or authorized service representative and not intended to be adjusted by the user.

S.3. Accessory Equipment. - When the operating instructions for a moisture meter require accessory equipment separate from and external to the moisture meter, such equipment shall be appropriate and complete for the measurement.

S.3.1. Grain-Test Scale. - If the moisture meter requires the weighing of the grain sample, the weighing device shall meet the requirements of the General Code and those applicable portions of the Scales Code.

S.3.2. Thermometers or Other Temperature Sensing Equipment. -

(a) The temperature sensing equipment or thermometer shall be designed to be in direct contact with a grain sample in a closed container. It is acceptable to insert thermometer through a small hole in the lid of the container used to hold the grain sample.

(b) A separate thermometer or other temperature sensing equipment shall have temperature divisions not greater than the temperature increments used by the manufacturer in the correction table.
(Amended 1988)

S.3.3. Conversion and Correction Tables. - Conversion and correction tables, charts, graphs, slide rules, or other apparatus to convert the conventional scale values read from a moisture meter to moisture content values, if such apparatus is required, shall be appropriate and correct for the moisture meter being used and shall be marked with the following information:

(a) name and address or trademark of the manufacturer;

(b) the type or design of the device with which it is intended to be used;

(c) date of issue;

(d) the kind or classes of grain or seed for which the device is designed to measure moisture content;

(e) the limitations of use, including but not confined to the moisture measurement range, grain or seed temperature, kind or class of grain or seed, moisture meter temperature, voltage and

frequency ranges, electromagnetic interferences, and necessary accessory equipment; but

(f) values exceeding any measurement range shall not be included.

(Added 1984)

S.3.4. Operating Instructions and Use Limitations. - Operating instructions shall be furnished by the manufacturer with each device with all of the information required by paragraph S.3.3. Complete information concerning the accuracy, sensitivity, and use of accessory equipment (e.g., test weight per bushel equipment, thermometer, etc.) necessary in obtaining a moisture content shall be included.

N. Notes

N.1. Testing Procedures.

N.1.1. Transfer Standards.[1] - Official grain samples shall be used as the official transfer standards with moisture content values assigned by the reference methods. The reference methods shall be the oven drying methods as specified by the USDA FGIS. Tolerances shall be applied to the average of at least three measurements on each official grain sample. Official grain samples shall be clean and naturally moist, but not tempered (i.e., water not added).
(Amended 1992)

N.1.2. Minimum Test.[1] - A minimum test of a grain moisture meter shall consist of tests:

(a) with samples (need not exceed three) of each grain or seed for which the device is used, and

(b) with samples having at least two different moisture content values within the operating range of the device.

(Amended 1986, 1989)

N.1.3. Temperature Measuring Equipment. - The accuracy of accessory temperature measuring equipment shall be determined by comparison with a calibrated temperature sensor, such as a total immersion thermometer with 0.1 °C (0.2 °F) subdivisions, indicating over a range of from 0 °C to 40 °C (32 °F to 104 °F) with a maximum error of ±0.1 °C (0.2 °F). Tests shall be conducted at two temperatures using liquid baths (e.g., ice water and room temperature water). The two temperatures selected shall not exceed the range of temperatures identified in the moisture meter operating instructions.
(Amended 1988)

T. Tolerances[2]

T.1. To Underregistration and to Overregistration. - The tolerances hereinafter prescribed shall be applied to errors of under registration and errors of overregistration.

T.2. Tolerance Values. - Maintenance and acceptance tolerances shall be as shown in Table 1. Tolerances are expressed as a fraction of the percent moisture content of the official grain sample, together with a minimum tolerance.

T.3. For Test Weight Per Bushel Indications or Recorded Representations. - The maintenance and acceptance tolerances on test weight per bushel indications or recorded representations shall be 0.193 kg/hL or 0.15 lb/bu. The test methods used shall be those specified by the USDA FGIS.
(Amended 1992)

T.4. Thermometers or Other Temperature Sensing Equipment. - The tolerance for a separate thermometer or temperature sensing equipment used to determine the temperature of grain samples for the purpose of making temperature corrections in moisture determinations shall be ±0.5 °C (1 °F).
(Added 1988)

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[1] The U.S. Department of Agriculture, Federal Grain Inspection Service (FGIS) uses a single brand and model of moisture meter for official inspection of moisture content in grains and other commodities. The calibrations for the model are based on the official air-oven method and are developed and monitored on an established schedule using a broad range (with respect to geographical source, kind, class, moisture content, maturity, etc.) of grain samples at its central laboratory. The FGIS uses a hierarchical series of meter-to-meter intercomparisons to determine whether its field meters are operating within acceptable tolerances (±0.2% with respect to standard meters). It has been shown that field meters checked by FGIS procedures perform within H-44 maintenance tolerances (T.2.) when tested (N.1.) using official grain samples. Agencies lacking a sample capability representing the entire nation and traceable to the official laboratory reference method shall not use meter-to-meter field testing.

[2] These tolerances do not apply to tests in which grain moisture meters are the transfer standards.

Table 1. Tolerances for Grain Moisture Meters		
Acceptance Tolerances		
Type of grain or seed	Tolerance	Minimum Tolerance
Corn, rice, sorghum, sunflower content	0.04 of the percent moisture	0.6 percent in moisture content
All other cereal grains and oil seeds	0.03 of the percent moisture content	0.5 percent in moisture content
Maintenance Tolerances		
Type of grain or seed	Tolerance	Minimum Tolerance
Corn, rice, sorghum sunflower content	0.05 of the percent moisture	0.8 percent in moisture content
All other cereal grains and oil seeds content	0.04 of the percent moisture	0.7 percent in moisture content

UR. User Requirements

UR.1. Selection Requirements.

UR.1.1. Value of the Smallest Unit on Primary Indicating and Recording Elements. - The value of the smallest unit on a moisture meter, whether the moisture meter reads directly in terms of moisture content, or when the conventional scale unit is converted or corrected to moisture content, shall be equal to or less than one-half the value of the minimum acceptance tolerance.

UR.1.2. See G-UR.1.2.

UR.2. Installation Requirements.

The grain moisture meter shall be installed in an environment within the range of temperature and/or other environmental factors specified (a) in the operating manual, and (b) on the conversion or correction tables if such tables are necessary for the operation of the device.

UR.3. Use Requirements.

UR.3.1. Operating Instructions. - The operating instructions for the use of the grain moisture meter shall be readily available to the user, service technician, and weights and measures official at the place of installation. It shall include a list of accessory equipment, conversion and correction charts if any are required to obtain moisture content values, and the kinds of grain or seed to be measured with the moisture meter.
(Amended 1988)

UR.3.2. Other Devices not used for Commercial Measurement. - If there are other moisture meters on the premises not used for trade or determining other charges for services, these devices shall be clearly and conspicuously marked "Not for Use in Trade or Commerce."

UR.3.3. Maintaining Integrity of Grain Samples. - Whenever there is a time lapse (temperature change) between taking the sample and testing the sample, means to prevent condensation of moisture or loss of moisture from grain samples shall be used. For example, a cold grain sample may be kept in a closed container in order to permit the cold grain to come to the operating temperature range of the meter before the grain moisture measurements are made.

UR.3.4. Printed Tickets. - Printed tickets, if the meter is so equipped, shall be free from any previous indication of moisture content or type of grain or seed selected.

UR.3.5. Accessory Devices. - Accessory devices, if necessary in the determination of a moisture content value, shall be in close proximity to the moisture meter and allow immediate use.

UR.3.6. Sampling. - A grain sample shall be obtained by following appropriate sampling methods and equipment. These include, but are not limited to grain probes of appropriate length used at random locations in the bulk, the use of a pelican sampler, or other techniques and equipment giving equivalent results. The grain sample shall be taken such that it is representative of the lot.

UR.3.7. Location. - See G-UR.3.3.

UR.3.8. Level Condition. - If equipped with a level indicator, a meter shall be maintained in a level condition.
(Added 1988)

UR.3.9. Operating Limitation. - Unless otherwise specified by the meter manufacturer, moisture determinations shall not be made when the difference in temperatures between the grain sample and the meter exceeds 10 °C (20 °F).
(Added 1988)

UR.3.10. Current Calibration Chart or Data. - Grain moisture determinations shall be made using only the most recently published calibration charts or calibration data.
(Added 1988)

UR.3.11. Posting of Meter Operating Range. - The operating range of the grain moisture meter shall be clearly and conspicuously posted in the place of business such that the information is readily visible from a reasonable customer position. The posted information shall include the following:

(a) The temperature range over which the meter may be used and still comply with the applicable requirements. If the temperature range varies for different grains or seed, the range shall be specified for each.

(b) The moisture range for each grain or seed for which the meter is to be used.

(c) The temperature range for each grain or seed for which the meter is to be used.

(d) The maximum allowable difference in temperature that may exist between the meter and the sample for which an accurate moisture determination can be made.
(Added 1988)

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

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

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

3. Testing Apparatus

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

3.2. Tolerances for Standards.[2] - The error in a standard used by a weights and measures official should be known and corrected for when the standard is used; or if the standard is to be used without correction, its error should be not greater than one-third of the smallest tolerance to be applied when the standard is used. The reason for this is to keep at a minimum the proportion of the tolerance on the item tested that will be used up by the error of the standard. Expressed differently, the reason is to give the item being tested as nearly as practicable the full benefit of its own tolerance.

Field testing operations are complicated to some degree when corrections to standards are applied. Except for work of relatively high precision, it is recommended that the accuracy of standards used in testing commercial weighing and measuring equipment be so established and maintained that the use of corrections is not necessary. Also, whenever it can readily be done, it will be desirable to reduce the error on a standard below the one-third point previously mentioned.

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

[2] The numerical values of the tolerances recommended by the NationalInstitute of Standards and Technology, for the standards of length, mass, and capacity used by weights and measures officials, may be obtained upon request from the Office of Weights and Measures of the National Institute of Standards and Technology.

3.3. Accuracy of Standards. - Prior to the official use of testing apparatus, its accuracy should invariably be verified. Standards should be reverified as often as circumstances require. By their nature, metal volumetric standards are more susceptible to damage in handling than are standards of some other types. A standard should be recalibrated whenever damage is known or suspected to have occurred or significant repairs have been made. In addition, standards, particularly volumetric standards, should be recalibrated 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 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 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 official to familiarize himself 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 deter mined 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 of 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 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. - The weights and measures official has one official duty, to determine that equipment is or is not suitable for commercial use. If a device conforms to all legal requirements, the official seals it to indicate approval. If it does not conform to all official requirements, he is required to reject it and prohibit its use until the device is brought into proper conformance.

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[3]See Sec. 1.10.; General Code and Appendix D. Definitions.

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" during the repair of the device.

Before adjustments are made at the request of the owner or his 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. He should never undertake major repairs, or even minor corrections, if services of commercial agencies are readily available.

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 State Law on Weights and Measures contains a provision stating that the director shall reject and mark rejected such weights and measures as he finds to be incorrect. Weights and measures 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 condemn 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. He 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 numerous items of measuring equipment. This is true in the case of most linear measures, of many liquid and dry measures, and 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 so long as 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 where 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.

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, and this should always be done unless the repairs are to begin immediately. However, the tagging of equipment as condemned 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.

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. The official will be well advised to keep careful records of equipment that is rejected, so that he may follow up to insure 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 4,738, this can be rounded off to the nearest thousand, hundred, or ten, as desired. Such rounded-off values would be, respectively, 5,000, 4,700, 4,740. 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, 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 4,738 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 4,700. 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 4,738 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 5,000. 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 4,501 to the nearest thousand, 1 is added to the thousands figure and the result becomes 5,000.

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, 4,500 would become 4,000 and 1,500 would become 2,000.

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 gradua-

tions are numbered by two's, 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 round (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.)

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 half 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 and 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 1 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 in order to have a length of 1 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 man. Primitive societies needed rudimentary measures for many tasks: constructing dwellings of an appropriate size and shape, fashioning clothing, or bartering food or raw materials.

Man 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. Some rather early standards have been recovered by archaeologists and preserved 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 decide on 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 indicate 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 foot was inherited from the Egyptians by the Greeks and Romans. The Roman foot was divided into both 12 unciae (inches) and 16 digits. The Romans also introduced the mile of 1 000[1] paces or double steps, the pace being equal to 5 Roman feet. The Roman mile of 5 000 feet was introduced into England during the occupation. Queen Elizabeth, who reigned from 1558 to 1603, changed, by statute, the mile to 5 280 feet or 8 furlongs, a furlong being 40 rods of 5-1/2 yards each.

The introduction of the use of the yard as a unit of length came later, but its origin is not definitely known. Some believe the origin is the double cubit, others believe that it originated from cubic measure. Regardless of its origin, the early yard was divided by the binary system 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

[1] It should be noted that a space has been inserted instead of commas in all of the numerical values given in this document, following a growing practice originating in tabular work to use the space to separate large numbers into groups of three digits. This practice avoids conflict with the practice of those countries that use the comma for a decimal marker.

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 0.3514598 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 1/144 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 percent 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 are larger units of mass still used in Great Britain. The present stone is 14 pounds, but an earlier unit appears to have been 16 pounds. The other units are multiples of 2, 8, and 160 times the stone, or 28 112, and 2 240 pounds. The hundredweight is approximately equal to 2 talents. In the U.S. the ton of 2 240 pounds is known as the long ton. The short ton is equal to 2 000 pounds.

Units of time and angle: The division of the circle into 360 degrees and the day into hours, minutes, and seconds can be traced 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 centimeter, gram, and second (cgs) and 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 (SI) of units; it is also based on the meter, kilogram and second as well as additional base units for temperature, electricity, radiation, and the quantity of substance that enters into chemical reactions. the International System of units is often called the modernized metric system.

The adoption of the 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 17 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 customary inch-pound system of the English-speaking countries. It was recognized that additional steps were needed to promote a worldwide measurement system. As a result, in 1948, the 9th General Conference on Weights and Measures asked the International Committee of Weights and Measures to conduct an international study of the measurement needs of the scientific, technical, and educational communities. On the basis of the findings of this study, the 10th General Conference in 1954 decided that an international system should be derived from six base units in order 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 (which later was renamed the kelvin), and the candela.

In 1960, the 11th General Conference of Weights and Measures named the system based on the six base quantities the International System of Units. The generally adopted abbreviation, SI, is taken from the French name: Le Système International D'Unités. The SI metric system is now either obligatory or permissible throughout the world.

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, as well as 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 1 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 it was found by precise measurements 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 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 vacuum during a time interval of 1/299 792 458 of a second.

The kilogram, previously defined as the mass of one cubic decimeter of water at the temperature of maximum density, was known as the Kilogram of the Archives. It was replaced after the International Metric Convention in 1875 by the International Prototype

Kilogram which became the unit of mass without reference to the mass of a cubic decimeter of water or to the Kilogram of the Archives. Each of the countries that subscribed to the International Metric Convention was assigned one or more copies of the international standards; these are known as National Prototype Meters and Kilograms.

The liter is a unit of capacity or volume. In 1964, the 12th General Conference on Weights and Measures redefined the liter as being one cubic decimeter. By its previous definition as being the volume occupied, under standard conditions, by a quantity of pure water having a mass of 1 kilogram, the liter was larger than the cubic decimeter by 28 parts per 1 000 000; except for determinations of high precision, this difference is so small as to be of no consequence.

The modernized metric system (SI) includes three classes of units:

> base units for length, mass, time, temperature, electricity, radiation and amount of substance;
>
> supplementary units for plane angle and solid angle; and
>
> derived units for all other quantities (e.g., work, force, power) expressed in terms of the nine base units and supplementary units.

For details, see NIST Special Publication 330 (1991), The International System of Units (SI) and NIST Special Publication 811, Guide for the Use of the International System of Units (available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402).

2.2.4. The International Bureau of Weights and Measures. - The International Bureau of Weights and Measures was established at Sèvres, a suburb of Paris, France, in accordance with the International Metric Convention of May 20, 1875. At the Bureau there are kept the International Prototype Kilogram, 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 International Bureau has been considerably broadened. It now carries on researches in the fields of electricity, photometry and radiometry, ionizing radiations, and time and frequency in addition to its work in mass, length, and thermometry.

2.2.5. Present 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, but was not made obligatory then or since.

Following the signing of the Convention of the Meter in 1875, the United States aquired national prototype standards for the meter and the kilogram. U.S. Prototype Kilogram No. 20 continues to be the primary standard for mass in the United States; it is recalibrated from time to time at BIPM. The prototype meter has been replaced by modern stabilized lasers in accordance with the most recent definition of the meter.

From 1893 until 1959, the yard was defined as being equal exactly to 3 600/3 937 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 yard is defined as being equal exactly to 0.9144 meter; the new yard is shorter than the old yard by exactly two parts in a million. At the same time, it was decided that any data expressed in feet derived from geodetic surveys within the U.S. would continue to bear the relationship as defined in 1893 (one foot equals 1 200/3 937 meter). This foot is called the U.S. survey foot, while the foot defined in 1959 is called the international foot. Measurements expressed in U.S. statute miles, survey feet, rods, chains, links, or the squares thereof, and also acres should therefore be converted to the corresponding metric values by using pre-1959 conversion factors if more than five significant figure accuracy is involved.

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 Notice dated December 20, 1990.

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. Under both this act and the Metric Conversion Act of 1975, 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 (sec. 4(4), Pub. L. 94-168; sec. 403(a)(3), Pub. L. 93-380). The Secretary has delegated authority under these subsections to the Director of the National Institute of Standards and Technology.

Section 5164 of Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988, amends Public Law 94-168, The Metric Conversion Act of 1975. In particular, section 3 of the latter 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 United States 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 most recent revision of the Code of Federal Regulations makes the use of metric units mandatory for agencies of the Federal Government. (Federal Register, Vol. 56, No. 23, page 160, January 2, 1991.)

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 metric system is now the official system of units in the United Kingdom, while the customary units are still predominantly used in the United States. 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 inch were defined identically for scientific work and were identical in commercial usage. A similar situation existed for the U.S. and the British pound, and many relationships, such as 12 inches = 1 foot, 3 feet = 1 yard, and 1 760 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 2,240 pounds, whereas the ton generally used in the United States is the short ton of 2,000 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, these two gallons were abandoned by the British when they adopted the British Imperial gallon, which is 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, the bushel was redefined 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; the bushel, with its subdivisions, is used in the measurement of certain dry commodities. The U.S. gallon is divided into 4 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 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 the foregoing it is seen that in the customary British system an avoirdupois ounce of water at 62 °F has a volume of 1 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 8-1/3 pounds, or 133-1/3 avoirdupois ounces, and the U.S. gallon is equivalent to 4 x 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 , it should be noted that the use of the troy pound was abolished in England January 6, 1879, only the troy ounce and its subdivisions being retained, whereas the troy pound is still legal in the United States, although it is not now greatly used. The common use in England of the stone of 14 pounds should be mentioned, this being a unit now unused 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 stones). In the apothecaries system of liquid measure the British insert 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 their mass.

2.4. Subdivision of Units. - In general, units are subdivided by one of three systems: (a) decimal, that is into tenths; (b) duodecimal, into twelfths; or (c) binary, into halves. Usually the subdivision is continued by the use of the same system. 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 4-3/8 inches. However, if these measured lengths are to be subsequently used in calculations of area or volume, that method of subdivision at once becomes extremely inconvenient. For that reason, 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 on the basis of convenience to the user. The fact that units have commonly been sub divided into certain subunits for centuries does not preclude their also having another mode of subdivision in some frequently used cases where convenience indicates the value of such other method. Thus, the gallon is usually subdivided into quarts and pints, but the majority of gasoline--measuring pumps of the price-computing type are graduated to show tenths of a gallon.

Although the mile has for centuries been divided into rods, yards, feet, and inches, the odometer part of an automobile speedometer indicates tenths of a mile. Although our dollar is divided 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 3/32, 3/16, 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1-1/2, and 3 inches, respectively, represent 1 foot full scale, as well as having a scale graduated in the usual manner to 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. Elevations of land above sea level are given in feet even though 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 vacuum, is the unit on which all length measurements are based.

The yard is defined[2] as follows:

1 yard = 0.914 4 meter

and the inch is exactly equal to 25.4 millimeters.

3.1.1. Calibration of Length Standards. - NIST calibrates standards of length including meter bars, yard bars, miscellaneous precision line standards, steel tapes, invar geodetic tapes, precision gauge blocks, micrometers, and limit gauges. It also measures the linear dimensions of miscellaneous apparatus such as penetration needles, cement sieves, and hemacytometer chambers. 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. Calibrations are made in accordance with fee schedules, copies of which may be obtained by application to NIST.

NIST does not calibrate carpenters rules, machinists scales, draftsman scales, and the like. Such apparatus, if calibration is required, should be submitted to State or local weights and measures officials.

3.2. Standards of Mass. - The primary standard of mass for this country is United States Prototype Kilogram 20, which is a platinum-iridium cylinder kept at NIST. The value of this mass standard is known in terms of the International Prototype Kilogram, a platinum-iridium standard which is kept at the International Bureau of Weights and Measures.

In colonial times the British standards were considered to be 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. 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[3] in terms of the kilogram by the relation:

1 avoirdupois pound = 0.453 592 37 kilogram.

These changes in definition have not made any appreciable change in the value of the pound.

The grain is 1/7 000 of the avoirdupois pound and is identical in the avoirdupois, troy, and apothecaries systems. The troy ounce and the apothecaries ounce differ from the avoirdupois ounce but are equal to each other, and equal to 480 grains. The avoirdupois ounce is equal to 437 1/2 grains.

3.2.1. Mass and Weight. - The mass of a body is a measure of its inertial property or the amount of 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 as 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.

[2] See Federal Register for July 1, 1959. See also next to last paragraph of 2.2.5.

[3] See Federal Register for July 1, 1959.

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 the comparison weighing is made, 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.

A full discussion of this topic is given in NIST Monograph 133, Mass and Mass Values, by Paul E. Pontius [for sale by the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (COM 7450309).]

3.2.3. Calibrations of Standards of Mass. - Standards of mass regularly used in ordinary trade should be tested by State or local weights and measures officials. NIST calibrates mass standards submitted, but it does not manufacture or sell them. Information regarding the mass calibration service of NIST and the regulations governing the submission of standards of mass to NIST for calibration are contained in NIST Special Publication 250, Calibration and Related Measurement Services of NIST, latest edition.

3.3. Standards of Capacity. - Units of capacity or volume, being derived units, are in this country defined in terms of linear units. 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. Similarly, standards of capacity have been made and distributed to the several States. Other standards of capacity have been verified by calibration for a wide variety of uses in science, technology, and commerce.

3.3.1. Calibrations of Standards of Capacity. - Calibrations are made by NIST 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. Furthermore, NIST calibrates precision grade volumetric glassware which is normally in metric units. Calibrations are made in

accordance with fee schedules, copies of which may be obtained by application to 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 at NIST and also to realize all the other base units. It 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 2 000 pounds.

b. The long, gross, or shipper's ton of 2 240 pounds.

c. The metric ton of 1 000 kilograms, or 2 204.6 pounds.

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 use has 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 on account of 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 that are deducted are those totally unavailable for carrying cargo, such as the engine room, coal bunkers, crews quarters, chart and instrument room, etc. The net tonnage is used in computing the amount of 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 2 240 pounds, or the metric ton of 2 204.6 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 2 240 pounds or metric tons of 2 204.6 pounds. The short ton is only occasionally used. Therefore, the cargo tonnage is very distinct from vessel tonnage.

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, thus 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 1 000, 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 1 000 and for subdivisions smaller than one-thousandth. Accordingly, the following prefixes have been introduced and these are now generally recognized:

exa,	(E),	meaning 10^{18}	deci,	(d),	meaning 10^{-1}
peta,	(P),	meaning 10^{15}	centi,	(c),	meaning 10^{-2}
tera,	(T),	meaning 10^{12}	milli,	(m),	meaning 10^{-3}
giga,	(G),	meaning 10^{9}	micro,	(μ),	meaning 10^{-6}
mega,	(M),	meaning 10^{6}	nano,	(n),	meaning 10^{-9}
kilo,	(k),	meaning 10^{3}	pico,	(p),	meaning 10^{-12}
hecto,	(h),	meaning 10^{2}	femto,	(f),	meaning 10^{-15}
deka,	(da),	meaning 10^{1}	atto,	(a),	meaning 10^{-18}

Thus a kilometer is 1 000 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) = 1 000 millimeters
10 meters	= 1 dekameter (dam)
10 dekameters	= 1 hectometer (hm) = 100 meters
10 hectometers	= 1 kilometer (km) = 1 000 meters

Units of Area

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

Units of Liquid Volume

10 milliliters (mL)	= 1 centiliter (cL)
10 centiliters	= 1 deciliter (dL) = 100 milliliters
10 deciliters	= 1 liter[1] = 1 000 milliliters
10 liters	= 1 dekaliter (daL)
10 dekaliters	= 1 hectoliter (hL) = 100 liters
10 hectoliters	= 1 kiloliter (kL) = 1 000 liters

Units of Volume

1 000 cubic millimeters (mm3)	= 1 cubic centimeter (cm^3)
1 000 cubic centimeters	= 1 cubic decimeter (dm^3)
	= 1 000 000 cubic millimeters
1 000 cubic decimeters	= 1 cubic meter (m^3)
	= 1 000 000 cubic centimeters
	= 1 000 000 000 cubic millimeters

Units of Mass

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

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

2. TABLES OF U.S. UNITS OF MEASUREMENT[2]

In these tables where foot or mile is underlined, it is survey foot or U.S. statute mile rather than international foot or mile that is meant (see Section 2.2.4.).

Units of Length

12 inches (in)	= 1 foot (ft)
3 feet	= 1 yard (yd)
16-1/2 feet	= 1 rod (rd), pole, or perch
40 rods	= 1 furlong (fur) = 660 feet
8 furlongs	= 1 U.S. statute mile (mi) = 5 280 feet
1 852 meters	= 6 076.115 49 feet (approximately)
	= 1 international nautical mile

Units of Area[3]

144 square inches (in^2)	= 1 square foot (ft^2)
9 square feet	= 1 square yard (yd^2)
	= 1 296 square inches
272-1/4 square feet	= 1 square rod (sq rd)
160 square rods	= 1 acre = 43 560 square feet
640 acres	= 1 square mile (mi^2)
1 mile square	= 1 section of land
6 miles square	= 1 township
	= 36 sections = 36 square miles

Units of Volume[3]

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

Gunter's or Surveyors Chain Units of Measurement

0.66 foot (ft)	= 1 link (li)
100 links	= 1 chain (ch)
	= 4 rods = 66 feet
80 chains	= 1 U.S. statute mile (mi)
	= 320 rods = 5 280 feet

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[2] This section lists units of measurement that have traditionally been used in the United States. In keeping with the Omnibus Trade and Competitiveness Act of 1988, the ultimate objective is to make the International System of Units the primary measurement system used in the United States.

[3] Squares and cubes of customary but not of metric units are sometimes expressed by the use of abbreviations rather than symbols. For example, sq ft means square foot, and cu ft means cubic foot.

Units of Liquid Volume[4]

4 gills (gi)	= 1 pint (pt) = 28.875 cubic inches
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 (min or ♏)	= 1 fluid dram (fl dr or ƒ 3)
	= 0.225 6 cubic inch
8 fluid drams	= 1 fluid ounce (fl oz or ƒ 3̄)
	= 1.804 7 cubic inches
16 fluid ounces	= 1 pint (pt or O)
	= 28.875 cubic inches
	= 128 fluid drams
2 pints	= 1 quart (qt) = 57.75 cubic inches
	= 32 fluid ounces = 256 fluid drams
4 quarts	= 1 gallon (gal) = 231 cubic inches
	= 128 fluid ounces = 1 024 fluid drams

Units of Dry Volume[5]

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

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

[5] 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[6]

[The "grain" is the same in avoirdupois, troy, and apothecaries units of mass.

27-11/32 grains	= 1 dram (dr)
16 drams	= 1 ounce (oz)
	= 437-1/2 grains
16 ounces	= 1 pound (lb) = 256 drams
	= 7 000 grains
100 pounds	= 1 hundredweight (cwt)[7]
20 hundredweights	= 1 ton
	= 2 000 pounds[6]

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

112 pounds	= 1 gross or long hundredweight [6]
20 gross or long hundredweights	= 1 gross or long ton
	= 2 240 pounds[6]

Troy Units of Mass

[The "grain" is the same in avoirdupois, troy, and apothecaries units of mass.

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

Apothecaries Units of Mass

[The "grain" is the same in avoirdupois, troy, and apothecaries units of mass.

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

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[6] 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, the word "avoirdupois" or the abbreviation "avdp" should be used in combination with the name or abbreviation of the avoirdupois unit.

[7] When the terms "hundredweight" and "ton" are used unmodified, they are commonly understood to mean the 100-pound hundredweight and the 2 000-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.

3. NOTES ON BRITISH UNITS OF MEASUREMENT

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

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

The present British gallon and bushel--known as the "Imperial gallon" and "Imperial bushel"--are, respectively, about 20 percent and 3 percent 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

(all underlined figures are exact)

Units of Length - International Measure[8]

Units		Inches	Feet	Yards	Miles	Centimeters	Meters
1 inch	=	1	0.083 333 33	0.027 777 78	0.000 015 782 83	2.54	0.025 4
1 foot	=	12	1	0.333 333 3	0.000 189 393 9	30.48	0.304 8
1 yard	=	36	3	1	0.000 568 181 8	91.44	0.914 4
1 mile	=	63 360	5 280	1 760	1	160 934.4	1609.344
1 centimeter	=	0.393 700 8	0.032 808 40	0.010 936 13	0.000 006 213 712	1	0.01
1 meter	=	39.370 08	3.280 840	1.093 613	0.000 621 371 2	100	1

Units of Length - Survey Measure[8]

Units		Links	Feet	Rods	Chains	Miles	Meters
1 link	=	1	0.66	0.04	0.01	0.000 125	0.201 168 4
1 foot	=	1.515 152	1	0.060 606 06	0.015 151 52	0.000 189 393 9	0.304 800 6
1 rod	=	25	16.5	1	0.25	0.003 125	5.029 210
1 chain	=	100	66	4	1	0.0125	20.116 84
1 mile	=	8 000	5 280	320	80	1	1609.347
1 meter	=	4.970 960	3.280 833	0.198 838 4	0.049 709 60	0.000 621 369 9	1

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[8] One international foot = 0.999 998 survey foot (exactly)
One international mile = 0.999 998 survey mile (exactly)

Note: 1 survey foot = 1 200/3 937 meter (exactly)
1 international foot = 12 x 0.0254 meter (exactly)
1 international foot = 0.0254 x 39.37 survey foot (exactly)

Units of Area - International Measure[9]
(all underlined figures are exact)

Units		Square Inches	Square Feet	Square Yards
1 square inch	=	1	0.006 944 444	0.000 771 604 9
1 square foot	=	144	1	0.111 111 1
1 square yard	=	1 296	9	1
1 square mile	=	4 014 489 600	27 878 400	3 097 600
1 square centimeter	=	0.155 000 3	0.001 076 391	0.000 119 599 0
1 square meter	=	1550.003	10.763 91	1.195 990

Units		Square Miles	Square Centimeters	Square Meters
1 square inch	=	0.000 000 000 249 097 7	6.451 6	0.000 645 16
1 square foot	=	0.000 000 035 870 06	929.030 4	0.092 903 04
1 square yard	=	0.000 000 322 830 6	8361.273 6	0.836 127 36
1 square mile	=	1	25 899 881 103.36	2 589 988.110 336
1 square centimeter	=	0.000 000 000 038 610 22	1	0.0001
1 square meter	=	0.000 000 386 102 2	10 000	1

Units of Area - Survey Measure[9]

Units		Square Feet	Square Rods	Square Chains	Acres
1 square foot	=	1	0.003 673 095	0.000 229 568 4	0.000 022 956 84
1 square rod	=	272.25	1	0.062 5	0.006 25
1 square chain	=	4 356	16	1	0.1
1 acre	=	43 560	160	10	1
1 square mile	=	27 878 400	102 400	6 400	640
1 square meter	=	10.763 87	0.039 536 70	0.002 471 044	0.000 247 104 4
1 hectare	=	107 638.7	395.367 0	24.710 44	2.471 044

[9] One square survey foot = 1.000 004 square international feet
One square survey mile = 1.000 004 square international miles

Units		Square Miles	Square Meters	Hectares
1 square foot	=	0.000 000 035 870 06	0.092 903 41	0.000 009 290 341
1 square rod	=	0.000 009 765 625	25.292 95	0.002 529 295
1 square chain	=	0.000 156 25	404.687 3	0.040 468 73
1 acre	=	0.001 562 5	4 046.873	0.404 687 3
1 square mile	=	1	2 589 998	258.999 8
1 square meter	=	0.000 000 386 100 6	1	0.000 1
1 hectare	=	0.003 861 006	10 000	1

Units of Volume
(all underlined figures are exact)

Units		Cubic Inches	Cubic Feet	Cubic Yards
1 cubic inch	=	1	0.000 578 703 7	0.000 021 433 47
1 cubic foot	=	1 728	1	0.037 037 04
1 cubic yard	=	46 656	27	1
1 cubic centimeter	=	0.061 023 74	0.000 035 314 67	0.000 001 307 951
1 cubic decimeter	=	61.023 74	0.035 314 67	0.001 307 951
1 cubic meter	=	61 023.74	35.314 67	1.307 951

Units		Milliliters (Cubic Centimeters)	Liters (Cubic Decimeters)	Cubic Meters
1 cubic inch	=	16.387 064	0.016 387 064	0.000 016 387 064
1 cubic foot	=	28 316.846 592	28.316 846 592	0.028 316 846 592
1 cubic yard	=	764 554.857 984	764.554 857 984	0.764 554 857 984
1 cubic centimeter	=	1	0.001	0.000 001
1 cubic decimeter	=	1 000	1	0.001
1 cubic meter	=	1 000 000	1 000	1

Units of Capacity or Volume - Dry Volume Measure

Units		Dry Pints	Dry Quarts	Pecks	Bushels
1 dry pint	=	1	0.5	0.062 5	0.015 625
1 dry quart	=	2	1	0.125	0.031 25
1 peck	=	16	8	1	0.25
1 bushel	=	64	32	4	1
1 cubic inch	=	0.029 761 6	0.014 880 8	0.001 860 10	0.000 465 025
1 cubic foot	=	51.428 09	25.714 05	3.214 256	0.803 563 95
1 liter	=	1.816 166	0.908 083 0	0.113 510 4	0.028 377 59
1 cubic meter	=	1 816.166	908.083 0	113.510 4	28.377 59

Units		Cubic Inches	Cubic Feet	Liters	Cubic Meters
1 dry pint	=	33.600 312 5	0.019 444 63	0.550 610 5	0.000 550 610 5
1 dry quart	=	67.200 625	0.038 889 25	1.101 221	0.001 101 221
1 peck	=	537.605	0.311 114	8.809 768	0.008 809 768
1 bushel	=	2 150.42	1.244 456	35.239 07	0.035 239 07
1 cubic inch	=	1	0.000 578 703 7	0.016 387 06	0.000 016 387 06
1 cubic foot	=	1 728	1	28.316 85	0.028 316 85
1 liter	=	61.023 74	0.035 314 67	1	0.001
1 cubic meter	=	61 023.74	35.314 67	1 000	1

Units of Capacity or Volume - Liquid Volume Measure
(All underlined figures are exact)

Units		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	=	60	1	0.125	0.031 25
1 fluid ounce	=	480	8	1	0.25
1 gill	=	1 920	32	4	1
1 liquid pint	=	7 680	128	16	4
1 liquid quart	=	15 360	256	32	8
1 gallon	=	61 440	1 024	128	32
1 cubic inch	=	265.974 0	4.432 900	0.554 112 6	0.138 528 1
1 cubic foot	=	459 603.1	7660.052	957.506 5	239.376 6
1 milliliter	=	16.230 73	0.270 512 2	0.033 814 02	0.008 453 506
1 liter	=	16 230.73	270.512 2	33.814 02	8.453 506

Units		Liquid Pints	Liquid Quarts	Gallons	Cubic Inches
1 minim	=	0.000 130 208 3	0.000 065 104 17	0.000 016 276 04	0.003 759 766
1 fluid dram	=	0.007 812 5	0.003 906 25	0.000 976 562 5	0.225 585 94
1 fluid ounce	=	0.062 5	0.031 25	0.007 812 5	1.804 687 5
1 gill	=	0.25	0.125	0.031 25	7.218 75
1 liquid pint	=	1	0.5	0.125	28.875
1 liquid quart	=	2	1	0.25	57.75
1 gallon	=	8	4	1	231
1 cubic inch	=	0.034 632 03	0.017 316 02	0.004 329 004	1
1 cubic foot	=	59.844 16	29.922 08	7.480 519	1 728
1 milliliter	=	0.002 113 376	0.001 056 688	0.000 264 172 1	0.061 023 74
1 liter	=	2.113 376	1.056 688	0.264 172 1	61.023 74

Units		Cubic Feet	Milliliters	Liters
1 minim	=	0.000 002 175 790	0.061 611 52	0.000 061 611 52
1 fluid dram	=	0.000 130 547 4	3.696 691	0.003 696 691
1 fluid ounce	=	0.001 044 379	29.573 53	0.029 573 53
1 gill	=	0.004 177 517	118.294 1	0.118 294 1
1 liquid pint	=	0.016 710 07	473.176 5	0.473 176 5
1 liquid quart	=	0.033 420 14	946.352 9	0.946 352 9
1 gallon	=	0.133 680 6	3785.412	3.785 412
1 cubic inch	=	0.000 578 703 7	16.387 06	0.016 387 06
1 cubic foot	=	1	28 316.85	28.316 85
1 milliliter	=	0.000 035 314 67	1	0.001
1 liter	=	0.035 314 67	1 000	1

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

Units	Avoirdupois Ounces	Avoirdupois Pounds	Short Hundred-weights	Short tons
1 avoirdupois ounce=	1	0.0625	0.000 625	0.000 031 25
1 avoirdupois pound=	16	1	0.01	0.000 5
1 short hundredweight =	1 600	100	1	0.05
1 short ton =	32 000	2 000	20	1
1 long ton =	35 840	2 240	22.4	1.12
1 kilogram =	35.273 96	2.204 623	0.022 046 23	0.001 102 311
1 metric ton =	35 273.96	2204.623	22.046 23	1.102 311

Units		Long Tons	Kilograms	Metric Tons
1 avoirdupois ounce	=	0.000 027 901 79	0.028 349 523 125	0.000 028 349 523 125
1 avoirdupois pound	=	0.000 446 428 6	0.453 592 37	0.000 453 592 37
1 short hundredweight	=	0.044 642 86	45.359 237	0.045 359 237
1 short ton	=	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	=	0.000 984 206 5	1	0.001
1 metric ton	=	0.984 206 5	1 000	1

Units of Mass Not Greater Than Pounds and Kilograms
(all underlined figures are exact)

Units	Grains	Apothecaries Scruples	Pennyweights	Avoirdupois Drams
1 grain =	1	0.05	0.041 666 67	0.036 571 43
1 apoth. scruple =	20	1	0.833 333 3	0.731 428 6
1 pennyweight =	24	1.2	1	0.877 714 3
1 avdp. dram =	27.343 75	1.367 187 5	1.139 323	1
1 apoth. dram =	60	3	2.5	2.194 286
1 avdp. ounce =	437.5	21.875	18.229 17	16
1 apoth. or troy oz. =	480	24	20	17.554 29
1 apoth. or troy pound =	5 760	288	240	210.651 4
1 avdp. pound =	7 000	350	291.666 7	256
1 milligram =	0.015 432 36	0.000 771 617 9	0.000 643 014 9	0.000 564 383 4
1 gram =	15.432 36	0.771 617 9	0.643 014 9	0.564 383 4
1 kilogram =	15432.36	771.617 9	643.014 9	564.383 4

Units	Apothecaries Drams	Avoirdupois Ounces	Apothecaries or Troy Ounces	Apothecaries or Troy Pounds
1 grain =	0.016 666 67	0.002 285 714	0.002 083 333	0.000 173 611 1
1 apoth. scruple =	0.333 333 3	0.045 714 29	0.041 666 67	0.003 472 222
1 pennyweight =	0.4	0.054 857 14	0.05	0.004 166 667
1 avdp. dram =	0.455 729 2	0.062 5	0.56 966 15	0.004 747 179
1 apoth. dram =	1	0.137 142 9	0.125	0.010 416 67
1 avdp. ounce =	7.291 667	1	0.911 458 3	0.075 954 86
1 apoth. or troy ounce =	8	1.097 143	1	0.083 333 333
1 apoth. or troy pound =	96	13.165 71	12	1
1 avdp. pound =	116.666 7	16	14.583 33	1.215 278
1 milligram =	0.000 257 206 0	0.000 035 273 96	0.000 032 150 75	0.000 002 679 229
1 gram =	0.257 206 0	0.035 273 96	0.032 150 75	0.002 679 229
1 kilogram =	257.206 0	35.273 96	32.150 75	2.679 229

Units	Avoirdupois Pounds	Milligrams	Grams	Kilograms
1 grain =	0.000 142 857 1	64.798 91	0.064 798 91	0.000 064 798 91
1 apoth. scruple=	0.002 857 143	1295.978 2	1.295 978 2	0.001 295 978 2
1 pennyweight =	0.003 428 571	1555.173 84	1.555 173 84	0.001 555 173 84
1 avdp. dram =	0.003 906 25	1771.845 195 312 5	1.771 845 195 312 5	0.001 771 845 195 312 5
1 apoth. dram =	0.008 571 429	3887.934 6	3.887 934 6	0.003 887 934 6
1 avdp. ounce =	0.062 5	28 349.523 125	28.349 523 125	0.028 349 523 125
1 apoth. or troy ounce =	0.068 571 43	31 103.476 8	31,103 476 8	0.031 103 476 8
1 apoth. or troy pound =	0.822 857 1	373 241.721 6	373.241 721 6	0.373 241 721 6
1 avdp. pound =	1	453 592.37	453.592 37	0.453 592 37
1 milligram =	0.000 002 204 623	1	0.001	0.000 001
1 gram =	0.002 204 623	1 000	1	0.001
1 kilogram =	2.204 623	1 000 000	1 000	1

5. TABLES OF EQUIVALENTS

In these tables it is necessary to differentiate between the "international foot" and the "survey foot" (see Section 2.2.4.); the survey foot is underlined.

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

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

UNITS OF LENGTH

angstrom (Å)[10]----------	0.1 nanometer (exactly) 0.000 1 micrometer (exactly). 0.000 000 1 millimeter (exactly). 0.000 000 004 inch.
1 cable's length----------	120 fathoms (exactly). 720 feet (exactly). 219 meters.
1 centimeter (cm)----------	0.393 7 inch

[10] The angstrom is basically defined as 10^{-10} meter.

1 chain (ch)---------- (Gunter's or surveyors)	66 feet (exactly). 20.116 8 meters.
1 decimeter (dm)----------	3.937 inches.
1 dekameter (dam)----------	32.808 feet.
1 fathom----------	6 feet (exactly). 1.828 8 meters.
1 foot (ft)----------	0.304 8 meter (exactly).
1 furlong (fur)----------	10 chains (surveyors) (exactly). 660 feet (exactly). 1/8 U.S. statute mile (exactly). 201.168 meters.
[1 hand]----------	4 inches.
1 inch (in)----------	2.54 centimeters (exactly).
1 kilometer (km)----------	0.621 mile.
1 league (land)----------	3 U.S. statute miles (exactly). 4.828 kilometers.
1 link (li) (Gunter's or surveyors)----	0.66 foot (exactly). 0.201 168 meter.
1 meter (m)----------	39.37 inches. 1.094 yards.
1 micrometer----------	0.001 millimeter (exactly). 0.000 039 37 inch.
1 mil----------	0.001 inch (exactly). 0.025 4 millimeter (exactly).
1 mile (mi) (U.S. statute)[11] ----------	5 280 feet (exactly). 1.609 kilometers.
1 mile (mi) (international)----------	5 280 feet (exactly).

[11] The term "statute mile" originated with Queen Elizabeth I who changed the definition of the mile from the Roman mile of 5 000 feet to the statute mile of 5 280 feet (see 2.1.3.). The international mile and the U.S. statute mile differ by about 3 millimeters although both are defined as being equal to 5 280 feet. The international mile is based on the international foot (0.3048 meter) whereas the U.S. statute mile is based on the survey foot (1 200/3 937 meter).

1 mile (mi) (international nautical)[12]	1.852 kilometers (exactly). 1.151 survey miles.
1 millimeter (mm)----------	0.039 37 inch.
1 nanometer (nm)----------	0.001 micrometer (exactly). 0.000 000 039 37 inch.
1 Point (typography)----------	0.013 837 inch (exactly). 1/72 inch (approximately). 0.351 millimeter.
1 rod (rd), pole, or perch----------	16 1/2 feet (exactly). 5.029 2 meters.
1 yard (yd)----------	0.914 4 meter (exactly).

UNITS OF AREA

1 acre[13]----------	43 560 square feet (exactly). 0.405 hectare.
1 are----------	119.599 square yards. 0.025 acre.
1 hectare----------	2.471 acres.
[1 square (building)]----------	100 square feet.
1 square centimeter (cm2)----------	0.155 square inch.
1 square decimeter (dm^2)----------	15.500 square inches.
1 square foot (ft^2)----------	929.030 square centimeters.
1 square inch (in^2)----------	6.451 6 square centimeters (exactly).
1 square kilometer (km^2)----------	247.104 acres 0.386 square mile
1 square meter (m^2)----------	1 196 square yards. 10.764 square feet.

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[12] The international nautical mile of 1 852 meters (6 076.115 49...feet) was adopted effective July 1, 1954, for use in the United States. The value formerly used in the United States was 6 080.20 feet = 1 nautical (geographical or sea) mile.

[13] The question is often asked as to the length of a side of an acre of ground. An acre is a unit of area containing 43 560 square feet. It is not necessarily square, or even rectangular. But, if it is square, then the length of a side is equal to $\sqrt{43560}$ = 208.710+ feet.

1 square mile (mi^2)----------	258.999 hectares.
1 square millimeter (mm^2)----------	0.002 square inch.
1 square rod (rd^2), sq pole, or sq perch----------	25.293 square meters.
1 square yard (yd^2)----------	0.836 square meter.

UNITS OF CAPACITY OR VOLUME

1 barrel (bbl), liquid----------	31 to 42 gallons[14]
1 barrel (bbl), standard for fruits, vegetables, and other dry---------- commodities, except cranberries	7 056 cubic inches 105 dry quarts 3.281 bushels, struck measure
1 barrel (bbl), standard, cranberry----	5 826 cubic inches 86 45/64 dry quarts 2.709 bushels, struck measure.
1 bushel (bu) (U.S.) struck measure----	2 150.42 cubic inches (exactly) 35.239 liters.
[1 bushel, heaped (U.S.)]----------	2 747.715 cubic inches. 1.278 bushels, struck measure.[15]
[1 bushel (bu) (British Imperial) (struck measure)]----------	1.032 U.S. bushels, struck measure 2 219.36 cubic inches.
1 cord (cd) (firewood)----------	128 cubic feet (exactly).
1 cubic centimeter (cm^3)----------	0.061 cubic inch.
1 cubic decimeter (dm^3)----------	61.024 cubic inches.
1 cubic foot (ft^3)----------	7.481 gallons. 28.316 cubic decimeters.
1 cubic inch (in^3)----------	0.554 fluid ounce. 4.433 fluid drams. 16.387 cubic centimeters.

[14] There are a variety of "barrels" established by law or usage. For example, Federal taxes on fermented liquors are based on a barrel of 31 gallons; many State laws fix the "barrel for liquids" as 31-1/2 gallons; one State fixes a 36-gallon barrel for cistern measurement; Federal law recognizes a 40-gallon barrel for "proof spirits"; by custom, 42 gallons comprise a barrel of crude oil or petroleum products for statistical purposes, and this equivalent is recognized "for liquids" by four States.

[15] Frequently recognized as 1-1/4 bushels, struck measure.

1 cubic meter (m^3)----------	1.308 cubic yards.
1 cubic yard (yd^3)----------	0.765 cubic meter.
1 cup, measuring----------	8 fluid ounces (exactly). 237 milliliters. 1/2 liquid pint (exactly).
1 dekaliter (daL)----------	2.642 gallons. 1.135 pecks.
1 dram, fluid (or liquid) (fl dr or ƒ 3) (U.S.)----------	1/8 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)----------	26.418 gallons. 2.838 bushels.
1 liter (1 cubic decimeter exactly)----	1.057 liquid quarts. 0.908 dry quart. 61.025 cubic inches
1 milliliter (mL)----------	0.271 fluid dram. 16.231 minims. 0.061 cubic inch.
1 ounce, fluid (or liquid) (fl oz or ƒ 3)(U.S.)----------	1.805 cubic inches. 29.573 milliliters. 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. 1/2 fluid ounce (exactly).
1 teaspoon, measuring----------	1/3 tablespoon (exactly). 5 milliliters 1-1/3 fluid drams.[16]
1 water ton (English)----------	270.91 U.S. gallons. 224 British Imperial gallons (exactly).

UNITS OF MASS

1 assay ton[17] (AT)----------	29.167 grams.
1 carat (c)----------	200 milligrams (exactly). 3.086 grains.
1 dram apothecaries (dr ap or ℨ)-----	60 grams (exactly) 3.888 grams.

[16] The equivalent "1 teaspoon = 1-1/3 fluid drams" has been found by the Bureau 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.

[17] Used in assaying. The assay ton bears the same relation to the milligram that a ton of 2 000 pounds avoirdupois bears to the ounce troy; 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.

1 dram avoirdupois (dr avdp)----------	27-11/32 (= 27.344) grains. 1.777 grams.
1 gamma (γ)----------	1 microgram (exactly).
1 grain----------	64.798 91 milligrams (exactly).
1 gram (g)----------	15.432 grains. 0.035 ounce, avoirdupois.
1 hundredweight, gross or long[18] (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)----------	2.205 pounds.
1 microgram (μg) [the Greek letter mu in combination with the letter g]---	0.000 001 gram (exactly).
1 milligram (mg)----------	0.015 grain.
1 ounce, avoirdupois (oz avdp)---------	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 pennyweight (dwt)----------	1.555 grams.
1 point----------	0.01 carat. 2 milligrams.
1 pound, avoirdupois (lb avdp)---------	7 000 grains (exactly). 1.215 troy or apothecaries pounds. 453.592 37 grams (exactly).
1 pound, troy or apothecaries (lb t or lb ap)----------	5 760 grains (exactly). 0.823 avoirdupois pound. 373.242 grams.
1 scruple (s ap or ℈)----------	20 grains (exactly). 1.296 grams.

[18] 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 "hundredweight."

1 ton, gross or long[19]----------	2 240 pounds (exactly). 1.12 net tons (exactly). 1.016 metric tons.
1 ton, metric (t)----------	2 204.623 pounds 0.984 gross ton. 1.102 net tons.
1 ton, net or short----------	2 000 pounds (exactly). 0.893 gross ton. 0.907 metric ton.

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

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.[4.43]

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.")[1.10]

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 g/cm^3 at 20 °C.[3.30, 3.32]

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

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]

automatic zero-setting mechanism. Automatic means provided to maintain zero balance indication without the intervention of an operator.[2.20]

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.[2.20]

automatic hopper scale. One adapted to the automatic weighing of bulk commodity in successive drafts of predetermined amounts. (This is not an "automatic-indicating scale" defined below.)[2.20]

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 a normal temperature of 70 °F and absolute pressure of 14.696 psia.[3.34]

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]

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 non-automatic 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 time rate. The charge for time for all intervals except the initial interval.[5.54]

basic tolerances. Basic tolerances are those 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.[1.10]

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

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

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]

beam. See "weighbeam."[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]

bench scale. See "counter scale."[2.20]

binary submultiples. Fractional parts obtained by successively dividing by the number 2. Thus, one-half, one-fourth, one-eighth, one-sixteenth, and so on, are binary submultiples.[1.10]

C

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]

chart recorder. An element used with a belt-conveyor scale that continuously records the rate-of-flow of bulk material over the scale.[2.21]

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

checkweighing scale. One used to verify predetermined weight within prescribed limits.[2.20]

class of grain. Hard Red Winter Wheat as distinguished from Hard Red Spring Wheat as

distinguished from Soft Red Winter Wheat, etc.[5.56]

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]

coal-mine scale. One used at a coal mining operation for determining the basic wages of miners on a production basis.[2.20]

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

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]

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]

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). A capacity rating of a vehicle, axle-load, or livestock scale, specified by the manufacturer, defining the maximum load concentration for which the weighbridge is designed. In the case of vehicle and axle-load scales, it is the maximum axle-load concentration for which the weighbridge is designed as specified by the manufacturer. This capacity rating is for both test and use.[2.20]
(Added 1988)(Amended 1991)

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

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]

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]

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]

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.")[1.10]

counter scale. One that, by reason of its size, arrangement of parts, and moderate nominal capacity, is adapted for use on a counter or bench. Sometimes called "bench scale."[2.20]

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

counterpoise weight. A slotted or "hanger" weight intended for application near the tip of the weighbeam of a scale having a multiple greater than 1.[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]
(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]

cryogenic liquid-measuring device. A system including a mechanism or machine of (a) the meter or mass flow type, or (b) a weighing type of device mounted on a vehicle, designed to measure and deliver cryogenic liquids in the liquid state. Means may be provided to indicate automatically, for one of a series of unit prices, the total money value of the liquid measured.[3.34]
(Amended 1986)

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

cubic foot, standard. That quantity of gas that occupies a volume of one cubic foot when under a pressure of 14.73 psia and at a temperature of 60 °F.[3.33]

cubic foot, metered. That quantity of gas that occupies one cubic foot when under pressure and temperature conditions existing in the meter.[3.33]

cubic-foot bottle. A metal bottle open at the lower end and so supported that it may be easily raised or lowered in a tank that contains a sealing medium. With the level of the sealing medium properly adjusted, the bottle, when lowered, will displace exactly one cubic foot of air upon coming to rest on the bottom of the tank. The marks on the bottle defining the cubic foot are the bottom of the lower neck and the gauge mark that partially surrounds the gauge glass in the upper neck.[3.33]

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 pounds per square inch absolute (psia) that occupies one cubic foot. (See NTP.)[3.34]

D

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]

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]
(Amended 1987)

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

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]

direct sale. A sale in which both parties in the transaction are present when the quantity is being determined.[2.20]

discharge line. A rigid pipe connected to the outlet of a measuring device. [3.30]
(Added 1987)

discharge hose. A flexible hose connected to the discharge outlet of a measuring device or its discharge line. [3.30]
(Added 1987)

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]

dispenser. See motor-fuel device.[3.30]

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 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. [See "dry hose."] [3.30, 3.34]

dry hose. A discharge hose intended to be completely drained at the end of each delivery of liquid. [See "dry-hose type."][3.30]

E

equal-arm scale. A scale having only a single lever with equal arms (that is, with a multiple of 1), 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]

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. (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]
(Added 1987)

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 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]

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]

flag. A plate at the end of the lever arm or similar part by which the operating condition of a taximeter is controlled and indicated.[5.54]

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]

ft^3/h. Cubic feet per hour.[3.33]

G

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.][4.43]

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.][4.43]

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 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]

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

grain-test scale. A scale adapted to weighing grain samples used in determining moisture content, dockage, weight per unit volume, etc.[2.20, 5.56]

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

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]

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-material hopper scale."[2.20]

I

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

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]

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

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]

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 weigh-beam-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 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)

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

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

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

J

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

K

kind of grain. Corn as distinguished from soybeans as distinguished from wheat, etc.[5.56]

L

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

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

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 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.[3.32]

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.[3.32, 3.33]

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)

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]

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

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-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]

load **cell.** A device, whether electric, hydraulic, or pneumatic, that produces a signal proportional to the load applied.[2.20]

loading point. The location at which material to be conveyed is applied to the conveyor.[2.21]

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-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]

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]

manual zero-setting mechanism. Nonautomatic means provided to attain a zero balance indication by the direct operation of a control.[2.20]

manufactured device. Any new device or any other device that has been removed from service and substantially altered or rebuilt.[1.10]

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.[3.30, 3.32]

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.][4.43]

master weight totalizer. An indicating element used with a belt conveyor scale to indicate the weight of material that was passed over the scale. The master weight totalizer is a primary indicating element of the belt-conveyor scale.[2.21]

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 percent.[2.21]
(Amended 1989)

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]

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 1/2, 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]

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

minimum tolerances. 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. (See also definition for basic tolerances.)[2.20]

minimum clear interval. The shortest distance between adjacent graduations when the graduations are not parallel. (Also see "clear interval.")[3.30]

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]

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]

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]

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]

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 (see definition of "retail device").[3.30]

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

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 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 1 pound applied to the tip pivot of the weighbeam.)[2.20]

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

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

N

NBP. Normal boiling point of a cryogenic liquid at 14.696 psia.[3.34]

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 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 2-1/2 percent 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]

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. (See nominal capacity of a scale)[1.10]

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 that have been used in noncommercial applications and are then being 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.[1.10]

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]

NTP. Normal temperature of 21 °C (70 °F) and pressure of 101.325kPa (14.696 psia) respectively.[3.34]

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]

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)

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 over registration 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]

performance requirements. Performance requirements include all tolerance requirements and, in the case of nonautomatic-indicating scales, sensitivity requirements (SR). (See definitions for "tolerance" and "sensitivity requirement.")[1.10]

point-of-sale system. An assembly of elements including a weighing element, an indicating element, and a recording element, (and may be equipped with a "scanner") used to complete a direct sales transaction.[2.20]
(Added 1986)

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]

portable cubic-foot standard. A gasometer of the annular type, the bell being sealed with a light oil, the amount of its rise (and consequently of the volume of air or gas being measured) being under absolute control so that an exact cubic foot can be delivered.[3.33]

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)

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]

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. (See "indicating element" and "recording element.")[1.10]

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]

prover test 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.][4.43]

R

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]

ranges, weight. See "weight ranges."[2.20]

rated scale capacity. That value representing the weight that can be delivered by the device in one hour.[2.21]

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 1/2-inch water column.[3.33]

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 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]

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]

recorded representation. The printed, embossed, or other representation that is recorded as a quantity by a weighing or measuring device.[1.10]

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 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 railroad car weighed on a scale for temporary use as a mass standard over a short period of time (typically, the time required to test one scale) as part of a test train.

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)

retail device. A device used for:

single deliveries of less than 100 gallons,

retail deliveries of motor fuels to individual highway vehicles, or

single deliveries of liquefied petroleum gas for domestic use and liquified petroleum gas or liquid anhydrous ammonia for nonresale use.
(Amended 1987)[3.32]

retroactive. "Retroactive" requirements are enforceable with respect to all equipment. Retroactive requirements are printed herein in upright roman type. (Also see "non-retroactive.")[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]

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 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]

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]

scale. See specific type of scale.[2.20]

seal. See "approval seal," "security seal."[1.10]

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 lead-and-wire seal, a pressure-sensitive seal sufficiently permanent to indicate its removal, or similar device attached to a weighing or measuring device for protection against or indication of access to adjustment. (Also see "approval seal.")[1.10]

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. Automatic means provided to attain a direct zero balance indication requiring a single initiation by an operator.[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]

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]

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-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 10 gallons per hour), of liquid fuels at individual domestic installations.[3.30]

small-delivery device. Any device other than a large-delivery device.[3.34]

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]

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]

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]

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.][4.43]

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-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]

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]

taximeter. A device that automatically calculates, at a predetermined rate or rates, and indicates the charge for hire of a vehicle.[5.54]

testing. An operation consisting of a series of volumetric determinations made to verify the accuracy of the volume chart that was developed by gauging.[4.43]

test liquid. The liquid used during the test of a device.[3.30]

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 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)

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. (See also "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.[3.34]

tripper. A device for unloading a belt conveyor at a point between the loading point and the head pulley.[2.21]

U

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.[3.30]
(Added 1992)

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]

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]

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.[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]

V

value of minimum graduated interval. The value represented by the interval from the center of one graduation to the center of the succeeding graduation. Also, the increment between successive recorded values. (Also see "graduated interval.")[1.10]

variable division-unit scale. A scale so designed that the unit of weight of the scale division is selectable by the operator (e.g., gram, troy ounce, pennyweight).[2.20]

variable division-value scale. A scale so designed that the value of the verification scale division (e), in the same unit of weight, increases at certain load values within the weighing range of the scale. (Amended 1986)[2.20]

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 or trailer.[2.20]

vehicle scale. A scale adapted to weighing highway, farm, or other large industrial vehicles (except railroad freight cars), loaded or unloaded.[2.20]

verification scale division, value of (e). A value, expressed in units of weight 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]

W

weighbeam. An element comprising one or more bars, equipped with movable poises or means for applying counterpoise weights or both.[2.20]

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]
(Added 1988)

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]

wet hose. A discharge hose intended to be full of liquid at all times. [See "wet-hose type."][3.30]

wet-hose type. A type of device designed to be operated with the discharge hose full of liquid at all times. [See "wet hose."][3.30]

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. [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. (See also "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-setting mechanism. Means provided to attain a zero balance indication with no load on the load-receiving element. Three types of these mechanisms are:[2.20]

> **manual zero-setting mechanism.** Nonautomatic means provided to attain a zero balance indication by the direct operation of a control.[2.20]
>
> **semi-automatic zero-setting mechanism.** Automatic means provided to attain a direct zero balance indication requiring a single initiation by an operator.[2.20]
>
> **automatic zero-setting mechanism.** Automatic means provided to maintain zero balance indication without the intervention of an operator.[2.20]

zone of uncertainty. The zone between adjacent increments on a digital device in which the value of either of the adjacent increments may be displayed.[2.20]

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