NBS HANDBOOK 44
1982

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

as adopted by the 66th National Conference on Weights and Measures 1981

U.S. DEPARTMENT OF COMMERCE/NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

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Programming Science and Technology — Computer Systems Engineering.

[1] Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Washington, DC 20234.
[2] Some divisions within the center are located at Boulder, CO 80303.

NBS HANDBOOK 44
1982

(Superseding Handbook 44 - 1980 Edition. There will be no Edition dated 1981 because of the introduction of a revised dating system.)

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

ADOPTED BY THE 66th
NATIONAL CONFERENCE ON WEIGHTS AND MEASURES
1981

U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

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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. This 1982 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 Bureau of Standards. It includes amendments adopted by the 66th National Conference on Weights and Measures during its annual meeting in 1981. Handbook 44 is published in its entirety each year following the annual meeting of the National Conference on Weights and Measures.

The National Bureau of Standards 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 Bureau is pleased to publish these recommendations of the National Conference.

ERNEST AMBLER
Director
National Bureau of Standards

OUTLINE OF CONTENTS

In accord with NBS 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.

1979 AMENDMENTS

The following table lists those codes, paragraphs, and pages in which amendments were made by the 64th National Conference on Weights and Measures. Each code, section, or paragraph that has been changed will be noted as "Added 1979" or "Amended 1979."

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1980 AMENDMENTS

The following table lists those codes, paragraphs, and pages in which amendments were made by the 65th National Conference on Weights and Measures. Each code, section, or paragraph that has been changed will be noted as "Added 1980" or "Amended 1980."

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1981 AMENDMENTS

The following table lists those codes, paragraphs, and pages in which amendments were made by the 66th National Conference on Weights and Measures. Each code, section, or paragraph that has been changed will be noted as "Added 1981" or "Amended 1981."

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SECTION 1

SEC. 1.10. 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 Conference Committee on Specifications and Tolerances,[2] acting at the request of the Conference or upon its own initiative, prepares from time to time, with the cooperation of the National Bureau of Standards, 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, without prejudice to apparatus that conforms as closely as practicable to the official standards, 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.

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 Bureau of Standards, Washington, D.C. 20234. 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.

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[1]The National Conference on Weights and Measures is a body made up of state and local weights and measures officials from all parts of the United States which normally meets annually under the sponsorship of the National Bureau of Standards.

[2]A standing committee of the National Conference consisting of five members. Communications to this committee may be addressed as follows: Executive Secretary, National Conference on Weights and Measures, National Bureau of Standards, Washington, D.C. 20234.

1.10. Introduction

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.

SR. SENSITIVITY REQUIREMENTS. These paragraphs, occurring in the Scale Code only, set forth requirements for the sensitiveness of nonautomatic-indicating scales.

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

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.

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 Scale 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.1.2. Graduations.
S.1.2.1. Length.
S.1.2.2. Width.

Thus, paragraphs S.1.1. and S.1.2. are directed and limited to paragraph S.1., which pertains to the design of indicating and recording elements and of recorded representations. Likewise, paragraphs S.1.2.1. and S.1.2.2. 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 to be expected, however, 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, at the expiration of which periods such requirements will become retroactive in their application. These periods should be of such length as 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 parentheses and in italic type the year it was adopted 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 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 with considerable frequency. If the Handbook is to serve its purpose, it should be at hand when any of its requirements are being applied. Direct reference to the requirements is the only sure way to apply the requirement properly and to check to see if there are other applicable requirements.

SEC. 1.11. FUNDAMENTAL CONSIDERATIONS
associated with the
ENFORCEMENT OF HANDBOOK 44 CODES

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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 Bureau of Standards 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 Bureau of Standards 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:

1.11. Fundamental Considerations

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 effect 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 repairman or serviceman bring equipment merely within tolerance range when it is possible to adjust closer to zero error.[3]

[3]See General User Requirement Sec. 1.14; G-UR.4.2.

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.[4] A general principle that has long been recognized by the National Bureau of Standards is that 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 25 percent 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 25-percent point previously mentioned.

3.3. ACCURACY OF STANDARDS.- The accuracy of testing apparatus should invariably be verified prior to the official use of the apparatus. 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. Whenever damage to a standard is known or suspected to have occurred, and whenever repairs that might affect the accuracy of a standard have been made, the standard should be recalibrated. Routine recalibration of standards, particularly volumetric standards, even when a change of value is not anticipated, should be made 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. If use is made of secondary standards, such as special fabric testing tapes, these 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 serviceman or official is poorly equipped, it cannot be expected that their results will check consistently. Disagreements between servicemen and officials can be avoided, and the servicing of commercial equipment can be expedited and improved if servicemen and officials will give equal attention to the adequacy and maintenance of their testing apparatus.

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[4] The numerical values of the tolerances recommended by the National Bureau of Standards 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 Bureau of Standards.

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--specifications and performance requirements. Although frequently the term inspection is 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 use 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 equally as important as are tolerance requirements, and both 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 which 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. It is vitally important that the book of specifications, tolerances, and other technical requirements be kept fully up to date by posting therein all changes that are adopted from time to time.

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 offi-

cial must be on the alert to discover any modification that may have been made by an operator which 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 servicemen and plant engineers, from observation of the operations performed by servicemen when reconditioning equipment in the field, and from a study of the devices themselves.

Inspection should include any auxiliary equipment and general conditions external to the device that may affect its performance characteristics.

In order to prolong the life of the equipment and forestall rejection, inspection should also include observation of the general maintenance of the device and of the proper functioning of all required elements. The official should look for worn or weakened mechanical parts, leaks in volumetric equipment, or elements in need of cleaning.

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

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

4.7. ACCURATE AND CORRECT EQUIPMENT.- Finally, the weights and measures official is reminded that commercial equipment may be accurate without being correct. A piece of equipment is accurate when its performance or value (that is, its indications, its deliveries, its recorded representations, or its capacity or actual value, etc., as determined by tests made with suitable standards) conforms to the standard within the applicable tolerances and other performance requirements. Equipment that fails so to conform is inaccurate. A piece of equipment is correct when in addition to being accurate, it meets all applicable specification requirements. Equipment that fails to meet any of the requirements for correct equipment is incorrect. Only equipment that is correct should be sealed and approved for commercial use.[5]

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

[5] See Sec. 1.14; General Code - Definitions of Terms.

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 expressly only one official duty, and that is merely to determine that equipment is or is not suitable for commercial use. If a device conforms to all of the official requirements, the official seals it to indicate approval. If it does not conform to all official requirements, he is required only to reject it and prohibit its use until the device is brought into proper conformance.

Some officials contend that it is justifiable for the official to make minor corrections and adjustments in order to correct faulty equipment 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.

Adjustments should be made, with the permission of the owner or his representative, only when the official is thoroughly competent to make such adjustment and when he is certain that the real cause of the inaccuracy will be corrected thereby and is not due to faulty installation or a defective part. He should never undertake major repairs, or even minor corrections if the services of commercial agencies are readily available.

5.3. GAGING.- 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 gaging 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 Model 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 keep always 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 be begun 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: (1) Test and approve the same as commercial equipment in use. (2) Refrain from testing it and remove it from the premises to preclude its use for commercial purposes. (3) 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: (1) Test and approve the same as commercial equipment. (2) Physically separate the two groups of equipment so that misuse of the noncommercial equipment will be prevented. (3) 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 non-

commercial. 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 graduations 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 "5's" is changed to the one-half principle; that is, add if more than one-half, drop if less than one-half, and apply the odd-and-even rule if exactly one-half.

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

1-1/32 becomes 1. (1/32 is less than half of 4/32 and accordingly is dropped.)
1-2/32 becomes 1. (2/32 is exactly one-half of 4/32; it is dropped because it is rounded [down] to the "even" eighth, which in this instance is 0/8.)
1-3/32 becomes 1-4/32 or 1-1/8. (3/32 is more than half of 4/32, and accordingly is rounded [up] to 4/32 or 1/8.
1-4/32 remains unchanged, being an exact eighth (1-1/8).
1-5/32 becomes 1-4/32 or 1-1/8. (5/32 is 1/32 more than an exact 1/8; 1/32 is less than half of 4/32 and accordingly is dropped.)
1-6/32 becomes 1-2/8 or 1-1/4. (6/32 is 2/32 more than an exact 1/8; 2/32 is exactly one-half of 4/32, and the final fraction is rounded [up] to the "even" eighth, which in this instance is 2/8.)
1-7/32 becomes 1-2/8 or 1-1/4. (7/32 is 3/32 more than an exact 1/8; 3/32 is more than one-half of 4/32 and accordingly the final fraction is rounded [up] to 2/8 or 1/4.)
1-8/32 remains unchanged, being an exact eighth (1-2/8 or 1-1/4.)
1-9/32 becomes 1-2/8 or 1-1/4. (9/32 is 1/32 more than an exact 1/8; 1/32 is less than half of 4/32 and accordingly is dropped.)

SEC. 1.12 UNITS AND SYSTEMS OF WEIGHTS AND MEASURES THEIR ORIGIN, DEVELOPMENT, AND PRESENT STATUS

1. INTRODUCTION

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 Bureau conducts research and development in many fields of physics, mathematics, chemistry, and engineering. At the time of its founding, the Bureau had custody of two primary standards--the meter bar for length and the kilogram cylinder for mass (or weight). With the phenomenal growth of science and technology over the past half century, the Bureau 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 have become necessary to the industrial progress of the Nation. Nevertheless, the country still looks to the Bureau for information on the units of weights and measures, particularly their definitions and equivalents.

The subject of weights and measures 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 interested in laws and regulations on the subject and in methods of 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 weights and measures, 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 weights and measures that experience has shown to be the common subject of inquiry.

2. UNITS AND SYSTEMS OF WEIGHTS AND MEASURES

The expression "weights and measures" is used herein in its basic sense of referring to measurements of length, mass, and capacity, thus excluding such topics as electrical and time measurements and thermometry. This section on units and systems of weights and measures presents some fundamental information to clarify thinking on this subject and to eliminate erroneous and misleading use of terms.

2.1. ORIGIN AND EARLY HISTORY OF UNITS AND STANDARDS.

2.1.1. UNITS AND STANDARDS.- It is essential that there be established and kept in mind the distinction between the terms "units" and "standards" of weights and measures.

A unit is a value, quantity, or magnitude in terms of which other values, quantities, or magnitudes are expressed. In general, a unit is fixed by definition and is independent of such physical conditions as temperature. Examples: The yard, the pound, the gallon, the meter, the liter, the gram.

A standard is a physical embodiment of a unit. In general it is not independent of physical conditions, and it is a true embodiment of the unit only under specified conditions. For example, a yard standard has a length of one yard 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 yard.

2.1.2. GENERAL SURVEY OF EARLY HISTORY OF WEIGHTS AND MEASURES.- 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.

1.12. Units and Systems

Man understandably turned first to parts of his body and his 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 of a 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 systems of weights and measures: 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.

2.1.3. ORIGIN AND DEVELOPMENT OF SOME COMMON CUSTOMARY UNITS.- The origin and development of units of weights and measures 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[6] 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.

[6] 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.

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 type, is recent. It originated with Pierre Simon Fournier in 1737. It was modified and developed by the Didot brothers, Francois Ambroise, and Pierre Francois, in 1755. The point was first used in the United States in 1878 by a Chicago type foundry (Marder, Luse, and Company). Since 1886, a point is 0.013 837 inch, 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. THE METRIC SYSTEM: DEFINITION, ORIGIN, AND DEVELOPMENT.-The metric system is the international system of weights and measures based on the meter and the kilogram. The essential features of the system were embodied in a report made to the French National Assembly by the Paris Academy of Sciences in 1791. The definitive action taken in 1791 was the outgrowth of recommendations along similar lines dating back to 1670. 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 was signed

providing for an International Bureau of Weights and Measures, thus insuring "the international unification and improvement of the metric system." The metric system is now either obligatory or permissive throughout the world.

Although the metric system is a decimal system, the words "metric" and "decimal" are not synonymous, and care should be taken not to confuse the two terms.

2.2.2. UNITS AND STANDARDS OF THE METRIC SYSTEM.- In the metric system the fundamental units of length and mass are the meter and the kilogram. The other units of length and mass, as well as all units of area, volume, and compound units such as density are 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 end-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. Since 1960 the meter has been defined as the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2 p_{10} and 5 d_5 of the krypton 86 atom. 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 which 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. 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 in 1 000 000; except for determinations of high precision, this difference is so small as to be of no consequence.

The modernized metric system includes "base" units such, for example, as units of temperature and time, as well as many "derived" units such, for example, as units of force and work. For details, see NBS Special Publication 330 (latest edition), The International System of Units (SI) [available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402].

2.2.3. THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES.- The International Bureau of Weights and Measures was established at Sevres, 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 of all sorts, and equipment for comparing standards and making precision measurements. The Bureau, maintained by assessed contributions 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 and photometry in addition to its former work in weights and measures with which were included such allied fields as thermometry and the measurement of barometric pressures.

2.2.4. 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.

A specified transition of krypton 86 and U.S. Prototype Kilogram No. 20 are recognized as the primary standards of length and mass for both the metric and the customary systems of measurement in this country because these standards are the most precise and reliable standards available. Obviously it is not possible to accept both a meter and a yard, and both a kilogram and a pound as "primary" standards, unless there is willingness to accept the possibility of continually changing the ratio between the corresponding units. In each case one must be accepted as the primary standard and the other derived therefrom by means of an accepted relation. In the United States, since 1893, the yard has been defined in terms of the meter, and the pound in terms of the kilogram. There is in the United States no primary standard either of length or mass in the customary system.

From 1893 until 1959, the yard was defined as being equal exactly to 3600/3937 meter. In 1959 a small change was made in the definition of the yard to resolve discrepancies both in this country and abroad. Since 1959 the 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 1200/3937 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 where more than five significant figure accuracy is involved.

In 1971 the National Bureau of Standards completed a three-year study of the impact of increasing worldwide metric use on the United States. The study ended with a report to the Congress entitled "A Metric America--A Decision Whose Time Has Come." In the last few years metric use has been increasing rapidly in the U.S., principally in the manufacturing and educational sectors. Public Law 93-380 enacted August 21, 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 with ease and facility as a part of the regular education program. On December 23, 1975, President Ford signed Public Law 94-168, the "Metric Conversion Act of 1975." This act declares a national policy to coordinate the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

2.3. BRITISH AND UNITED STATES SYSTEMS OF WEIGHTS AND MEASURES.- The implication is sometimes made that the customary system of weights and measures in the British Commonwealth countries and that in the United States are identical. It is true that the U.S. and the British inch are defined identically for scientific work, that they are practically identical in commercial usage, that a similar situation exists for the U.S. and the British pound, and that many relationships, such as 12 inches = 1 foot, 3 feet = 1 yard, and 1760 yards = 1 international mile, are the same in both countries; but there are some very important differences.

In the first place, the U.S. bushel and the U.S. gallon, and their subdivisions differ from the corresponding British 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 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 being used in the measurement of liquids, while 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 mentioned thus far are larger in the 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 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 British and the American systems of weights and measures 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 weight.

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. If, however, 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 subdivided 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, gage 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 weights and measures 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 suggestion is made from time to time that we should adopt a duodecimal number system and a duodecimal system of weights and measures. Another suggestion is for an octonary number system (a system with 8 as the basis instead of 10 in our present system or 12 in the duodecimal) and an octonary system of weights and measures. Such suggestions have certain theoretical merits, but are very impractical because it is now too late to modify our number system and unwise to have arbitrary enforcement of any single system of weights and measures. It is far better for each branch of science, industry, and commerce to be free to use whatever system has been found by experience best to suit its needs. The prime requisite of any system of weights and measures is that the units be definite. It is also important that the relations of these units to the units of other systems be definite, convenient, and known, in order that conversion from one system to another may be accurately and conveniently made.

3. STANDARDS OF LENGTH, MASS, AND CAPACITY

3.1. STANDARDS OF LENGTH.- A specified spectral line emitted by krypton 86 is the international standard on which all length measurements are based. To obtain a constant and uniform wavelength, krypton lamps are operated at the temperature of the triple point of nitrogen.

The yard is defined[7] as follows:

1 yard = 0.914 4 meter

The inch is therefore exactly equal to 25.4 millimeters.

3.1.1. TESTS AND CALIBRATIONS OF LENGTH STANDARDS.- The National Bureau of Standards tests standards of length including meter bars, yard bars, miscellaneous precision line standards, steel tapes, invar geodetic tapes, precision gage blocks, micrometers, and limit gages. It also measures the linear dimensions of miscellaneous apparatus such as penetration needles, cement sieves, and haemacytometer chambers. In general the Bureau accepts for test only apparatus of such material, design, and construction as to ensure accuracy and permanence sufficient to justify test by the Bureau. Tests are made in accordance with test-fee schedules, copies of which may be obtained by application to the Bureau.

The Bureau does not test carpenters rules, machinists scales, draftsmans scales, and the like. Such apparatus, if test 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 the National Bureau of Standards. 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.

For many years the British standards were considered to be the primary standards of the United States. Later, for over 50 years, 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 National Bureau of Standards. The avoirdupois pound is defined[8] 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. The weight of a body has in the past been used at times to designate its mass and at other times to designate a force that is related to gravitational attraction. Because these two concepts of weight are incompatible, and have therefore resulted in confusion, the current trend is to discontinue using the term "weight" in the context of force so that when the term "weight" is used, as in weights and measures, it is considered to be synonymous with mass.

Standards of mass (or "weights") are ordinarily calibrated and used on equal-arm balances. If two objects balance each other on an equal-arm balance, they have the same mass. What are balanced are the gravitational forces on the two objects. Even though the value of the acceleration of gravity, g, is different from location to location, because the two objects of equal mass 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.

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[7] See Federal Register for July 1, 1959. See also next to last paragraph of 2.2.4.

[8] See Federal Register for July 1, 1959.

On a spring balance, however, the weight of a body is not balanced against the weight 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 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 corrections furnished by the National Bureau of Standards for the more precise mass standards are given both (a) on the basis of comparison in vacuum, and (b) on the basis of comparison against normal brass standards in air under standard conditions, with no correction applied for the buoyant effect of the air. By definition brass standards have a density of 8 400 kilograms per cubic meter at 0 °C and a coefficient of cubical thermal expansion of 0.000 054 per °C. Standard conditions are defined as air of 1.2 kilograms per cubic meter and temperature of 20 °C. The corrections to be used with precise analytical weights are ordinarily given only in terms of apparent mass against normal brass standards.

A full discussion of this topic is given in NBS Monograph 133, Mass and Mass Values, by Paul E. Pontius (for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.)

3.2.3. TESTS OF STANDARDS OF MASS.- Standards of mass regularly used in ordinary trade should be tested by State or local weights and measures officials. The National Bureau of Standards calibrates mass standards submitted, but it does not manufacture or sell them. Information regarding the weight-calibration service of the Bureau and the regulations governing the submission of weights to NBS for test are contained in NBS Special Publication 250, Calibration and Related Measurement Services of the National Bureau of Standards, 1978 edition.

3.3. STANDARDS OF CAPACITY.- Units of capacity, being derived units, are in this country defined in terms of linear units and are not represented by fundamental standards. Laboratory standards have been constructed and are maintained at the National Bureau of Standards. 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. TESTS OF STANDARDS OF CAPACITY.- Calibrations are made by the Bureau on capacity standards that are in the customary units of trade; that is, the gallon, its multiples, and submultiples, or in metric units. Furthermore, the Bureau calibrates precision grade volumetric glassware which is

normally in metric units. Tests are made in accordance with test-fee schedules, copies of which may be obtained by application to the Bureau.

3.4. MAINTENANCE AND PRESERVATION OF FUNDAMENTAL STANDARD OF MASS.- There is considerable interest in the maintenance and preservation of the national standard of mass at the National Bureau of Standards. It is fully protected by an alarm system. During the regular working hours of the Bureau it can be viewed by those interested. 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 WEIGHTS

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 weight, 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 (weight) 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 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 a 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 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 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 her 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. The cargo tonnage is therefore very distinct from vessel tonnage.

SEC. 1.13. GENERAL TABLES OF WEIGHTS AND MEASURES

These tables have been prepared for the benefit of those requiring tables of weights and measures for occasional ready reference. In Section 4 of 1.13 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 WEIGHTS AND MEASURES

In the metric system of weights and measures, 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.

LINEAR MEASURE

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.

AREA MEASURE

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).

1.13. General Tables

FLUID VOLUME MEASURE

10 milliliters (mL)	= 1 centiliter (cL).
10 centiliters	= 1 deciliter (dL) = 100 milliliters.
10 deciliters	= 1 liter[9] = 1 000 milliliters.
10 liters	= 1 dekaliter (daL).
10 dekaliters	= 1 hectoliter (hL) = 100 liters
10 hectoliters	= 1 kiloliter (kL) = 1 000 liters.

SOLID VOLUME MEASURE

1 000 cubic millimeters (mm^3)	= 1 cubic centimeter (cm^3).
1 000 cubic centimeters	= 1 cubic decimeter (dm^3)
	= 1 000 000 cubic millimeters.
1 000 cubic decimeters	= 1 cubic meter(m^3)
	= 1 000 000 cubic centimeters
	= 1 000 000 000 cubic millimeters.

WEIGHT

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

2. TABLES OF THE UNITED STATES CUSTOMARY WEIGHTS AND MEASURES

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.).

LINEAR MEASURE

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.

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

AREA MEASURE[10]

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.

CUBIC MEASURE[11]

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

GUNTER'S OR SURVEYORS CHAIN MEASURE

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.

LIQUID MEASURE[12]

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 FLUID MEASURE

60 minims (min or ♏)	=	1 fluid dram (fl dr or ƒ℥)
	=	0.225 6 cubic inch.
8 fluid drams	=	1 fluid ounce (fl oz or ƒ℥)
	=	1.804 7 cubic inches.
16 fluid ounces	=	1 pint (pt or 0)
	=	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.

[10] 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.

[11] See footnote 10.

[12] 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.

1.13. General Tables

DRY MEASURE[13]

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.

AVOIRDUPOIS WEIGHT[14]

[The "grain" is the same in avoirdupois, troy, and apothecaries weight.]

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).[15]
20 hundredweights = 1 ton = 2 000 pounds.[15]

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

112 pounds = 1 gross or long hundredweight.[15]
20 gross or long hundredweights = 1 gross or long ton
= 2 240 pounds.[15]

TROY WEIGHT

[The "grain" is the same in avoirdupois, troy, and apothecaries weight.]

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.

[13]When necessary to distinguish the 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.

[14]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.

[15]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.

APOTHECARIES WEIGHT

[The "grain" is the same in avoirdupois, troy, and apothecaries weight.]

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 or ℔)
	= 96 drams apothecaries = 288 scruples
	= 5 760 grains.

3. NOTES ON BRITISH WEIGHTS AND MEASURES TABLES

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 weight, and apothecaries weight are the same as the corresponding United States tables, except for the British spelling "drachm" in the table of apothecaries weight. The table of British avoirdupois weight 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 WEIGHTS AND MEASURES

UNITS OF LENGTH INTERNATIONAL MEASURE*

Units	Inches	Feet	Yards	Miles	Centimeters	Meters
1 inch =	$\frac{1}{}$	0.083 333 33	0.027 777 78	0.000 015 782 83	$\frac{2.54}{}$	$\frac{0.025\ 4}{}$
1 foot =	$\frac{12}{}$	$\frac{1}{}$	0.333 333 3	0.000 189 393 9	$\frac{30.48}{}$	$\frac{0.304\ 8}{}$
1 yard =	$\frac{36}{}$	$\frac{3}{}$	$\frac{1}{}$	0.000 568 181 8	$\frac{91.44}{}$	$\frac{0.914\ 4}{}$
1 mile =	$\frac{63\ 360}{}$	$\frac{5280}{}$	$\frac{1760}{}$	$\frac{1}{}$	$\frac{160\ 934.4}{}$	$\frac{1609.344}{}$
1 centimeter =	0.393 700 8	0.032 808 40	0.010 936 13	0.000 006 213 712	$\frac{1}{}$	$\frac{0.01}{}$
1 meter =	39.370 08	3.280 840	1.093 613	0.000 621 371 2	$\frac{100}{}$	$\frac{1}{}$

UNITS OF LENGTH SURVEY MEASURE*

Units	Links	Feet	Rods	Chains	Miles	Meters
1 link =	$\frac{1}{}$	$\frac{0.66}{}$	$\frac{0.04}{}$	$\frac{0.01}{}$	$\frac{0.000\ 125}{}$	0.201 168 4
1 foot =	1.515 152	$\frac{1}{}$	0.060 606 06	0.015 151 52	$\frac{0.000\ 189}{}$ 393 9	0.304 800 6
1 rod =	$\frac{25}{}$	$\frac{16.5}{}$	$\frac{1}{}$	$\frac{0.25}{}$	$\frac{0.003\ 125}{}$	5.029 210
1 chain =	$\frac{100}{}$	$\frac{66}{}$	$\frac{4}{}$	$\frac{1}{}$	$\frac{0.0125}{}$	20.116 84
1 mile =	$\frac{8000}{}$	$\frac{5280}{}$	$\frac{320}{}$	$\frac{80}{}$	$\frac{1}{}$	1609.347
1 meter =	4.970 960	3.280 833	0.198 838 4	0.049 709 60	0.000 621 369 9	$\frac{1}{}$

*One international foot = 0.999 998 survey foot (exactly)
One international mile = 0.999 998 survey mile (exactly)

Note: 1 survey foot = 1200/3937 meter (exactly)
1 international foot = 12 x 0.0254 meter (exactly)
∴ 1 international foot = 0.0254 x 39.37 survey foot (exactly)

All underlined figures are exact.

UNITS OF AREA INTERNATIONAL MEASURE*

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 =	1296	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	0.000 1
1 square meter =	0.000 000 386 102 2	10 000	1

UNITS OF AREA SURVEY MEASURE*

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	6400	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

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

*One square survey foot = 1.000 004 square international feet
One square survey mile = 1.000 004 square international miles

All underlined figures are exact.

1.13. General Tables

UNITS OF VOLUME

Units	Cubic Inches	Cubic Feet	Cubic Yards
1 cubic inch	$\frac{1}{1728}$	0.000 578 703 7	0.000 021 433 47
1 cubic foot	$\frac{1728}{46\ 656}$	$\frac{1}{27}$	0.037 037 04
1 cubic yard	$\frac{46\ 656}{1}$	$\frac{27}{1}$	$\frac{1}{1}$
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 =	$\frac{1}{1}$	0.001	0.000 001
1 cubic decimeter =	$\frac{1\ 000}{1}$	$\frac{1}{1000}$	0.001
1 cubic meter =	$\frac{1\ 000\ 000}{1}$	$\frac{1000}{1}$	$\frac{1}{1}$

UNITS OF CAPACITY DRY MEASURE

Units	Dry Pints	Dry Quarts	Pecks	Bushels
1 dry pint =	$\frac{1}{1}$	0.5	0.062 5	0.015 625
1 dry quart =	$\frac{2}{1}$	$\frac{1}{1}$	0.125	0.031 25
1 peck =	$\frac{16}{1}$	$\frac{8}{1}$	$\frac{1}{1}$	0.25
1 bushel =	$\frac{64}{1}$	$\frac{32}{1}$	$\frac{4}{1}$	$\frac{1}{1}$
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 =	$\frac{1}{1}$	0.000 578 703 7	0.016 387 06	0.000 016 387 06
1 cubic foot =	$\frac{1728}{1}$	$\frac{1}{1}$	28.316 85	0.028 316 85
1 liter =	61.023 74	0.035 314 67	$\frac{1}{1000}$	0.001
1 cubic meter =	61 023.74	35.314 67	$\frac{1000}{1}$	$\frac{1}{1}$

All underlined figures are exact.

UNITS OF CAPACITY LIQUID MEASURE

Units	Minims	Fluid Drams	Fluid Ounces	Gills
1 minim =	$\frac{1}{}$	0.016 666 67	0.002 083 333	0.000 520 833 3
1 fluid dram =	$\frac{60}{}$	$\frac{1}{}$	$\frac{0.125}{}$	$\frac{0.031\ 25}{}$
1 fluid ounce =	$\frac{480}{}$	$\frac{8}{}$	$\frac{1}{}$	$\frac{0.25}{}$
1 gill =	$\frac{1920}{}$	$\frac{32}{}$	$\frac{4}{}$	$\frac{1}{}$
1 liquid pint =	$\frac{7680}{}$	$\frac{128}{}$	$\frac{16}{}$	$\frac{4}{}$
1 liquid quart =	$\frac{15\ 360}{}$	$\frac{256}{}$	$\frac{32}{}$	$\frac{8}{}$
1 gallon =	$\frac{61\ 440}{}$	$\frac{1024}{}$	$\frac{128}{}$	$\frac{32}{}$
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 =	$\frac{0.007\ 812\ 5}{}$	$\frac{0.003\ 906\ 25}{}$	$\frac{0.000\ 976\ 562\ 5}{}$	0.225 585 94
1 fluid ounce =	$\frac{0.062\ 5}{}$	$\frac{0.031\ 25}{}$	$\frac{0.007\ 812\ 5}{}$	$\frac{1.804\ 687\ 5}{}$
1 gill =	$\frac{0.25}{}$	$\frac{0.125}{}$	$\frac{0.031\ 25}{}$	$\frac{7.218\ 75}{}$
1 liquid pint =	$\frac{1}{}$	$\frac{0.5}{}$	$\frac{0.125}{}$	$\frac{28.875}{}$
1 liquid quart =	$\frac{2}{}$	$\frac{1}{}$	$\frac{0.25}{}$	$\frac{57.75}{}$
1 gallon =	$\frac{8}{}$	$\frac{4}{}$	$\frac{1}{}$	$\frac{231}{}$
1 cubic inch =	0.034 632 03	0.017 316 02	0.004 329 004	$\frac{1}{1728}$
1 cubic foot =	59.844 16	29.922 08	7.480 519	
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 =	$\frac{1}{}$	28 316.85	28.316 85
1 milliliter =	0.000 035 314 67	$\frac{1}{1000}$	$\frac{0.001}{}$
1 liter =	0.035 314 67		$\frac{1}{}$

All underlined figures are exact.

1.13. General Tables

UNITS OF MASS NOT LESS THAN AVOIRDUPOIS OUNCES

Units	Avoirdupois Ounces	Avoirdupois Pounds	Short Hundredweights	Short tons
1 avoirdupois ounce =	$\frac{1}{}$	$\frac{0.0625}{}$	$\frac{0.000\ 625}{}$	$\frac{0.000\ 031\ 25}{}$
1 avoirdupois pound =	$\frac{16}{}$	$\frac{1}{}$	$\frac{0.01}{}$	$\frac{0.000\ 5}{}$
1 short hundredweight =	$\frac{1\ 600}{}$	$\frac{100}{}$	$\frac{1}{}$	$\frac{0.05}{}$
1 short ton =	$\frac{32\ 000}{}$	$\frac{2\ 000}{}$	$\frac{20}{}$	$\frac{1}{}$
1 long ton =	$\frac{35\ 840}{}$	$\frac{2\ 240}{}$	$\frac{22.4}{}$	$\frac{1.12}{}$
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	$\frac{0.028\ 349\ 523\ 125}{}$	$\frac{0.000\ 028\ 349\ 523\ 125}{}$
1 avoirdupois pound =	0.000 446 428 6	$\frac{0.453\ 592\ 37}{}$	$\frac{0.000\ 453\ 592\ 37}{}$
1 short hundredweight =	0.044 642 86	$\frac{45.359\ 237}{}$	$\frac{0.045\ 359\ 237}{}$
1 short ton =	0.892 857 1	$\frac{907.184\ 74}{}$	$\frac{0.907\ 184\ 74}{}$
1 long ton =	$\frac{1}{}$	$\frac{1016.046\ 908\ 8}{}$	$\frac{1.016\ 046\ 908\ 8}{}$
1 kilogram =	0.000 984 206 5	$\frac{1}{}$	$\frac{0.001}{}$
1 metric ton =	0.984 206 5	$\frac{1\ 000}{}$	$\frac{1}{}$

All underlined figures are exact.

UNITS OF MASS NOT GREATER THAN POUNDS AND KILOGRAMS

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 ounce =	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	0.056 966 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	1000	1	0.001
1 kilogram =	2.204 623	1 000 000	1 000	1

All underlined figures are exact.

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.

LENGTHS

1 angstrom (Å)[16]	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.
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.

[16] The angstrom is basically defined as 10^{-10} meter.

1 mil	0.001 inch (exactly). 0.025 4 millimeter (exactly).
1 mile (mi) (U.S. statute)[17]	5 280 feet (exactly). 1.609 kilometers.
1 mile (mi) (international)	5 280 feet (exactly).
1 mile (mi) (international nautical)[18]	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).

AREAS OR SURFACES

1 acre[19]	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 (cm^2)	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.
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.

[17]The term statute mile originated with Queen Elizabeth I who changed the definition of the mile from the Roman mile of 5000 feet to the statute mile of 5280 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 5280 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 (1200/3937 meter).

[18]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.

[19]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 $\sqrt{43\ 560}$ = 208.710+ feet.

CAPACITIES OR VOLUMES

1 barrel (bbl), liquid	31 to 42 gallons.[20]
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.[21]
[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 cu inch (in^3)	0.554 fluid ounce. 4.433 fluid drams. 16.387 cubic centimeters.
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)(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.

[20] 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.

[21] Frequently recognized as 1 1/4 bushels, struck measure.

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 $f\bar{3}$)(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.[22]

[22] 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.

1 water ton (English)	270.91 U.S. gallons. 224 British Imperial gallons (exactly).

WEIGHTS OR MASSES

1 assay ton[23] (AT)	29.167 grams.
1 carat (c)	200 milligrams (exactly). 3.086 grains.
1 dram, apothecaries (dr ap or ℨ)	60 grains (exactly). 3.888 grams.
1 dram avoirdupois (dr avdp)	27-11/32 (= 27.344) grains. 1.772 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[24] (gross cwt)	112 pounds (exactly). 50.802 kilograms.
1 hundredweight, net 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 ℨ)	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.

[23] 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 weight in milligrams of precious metal obtained from one assay ton of ore gives directly the number of troy ounces to the net ton.

[24] 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. These units are the same as the British "ton" and "hundredweight."

1 ton, gross or long[25]	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.

[25] 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."

SEC. 1.14. 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.- It is lawful throughout the United States to employ the weights and measures of the metric system, and 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 customary system.

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

G-A.6. NONRETROACTIVE REQUIREMENTS.- "Nonretroactive" requirements are enforceable after the effective date and only with respect to devices that are manufactured in or brought into the state after that 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 herein in italic type.*

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 Bureau of Standards.

G-S SPECIFICATIONS

G-S.1. IDENTIFICATION.- All equipment except weights shall be clearly and permanently marked on *a surface visible in a conventional installation** for purposes of identification with the name, initials, or trademark of the manufacturer or distributor and with the designation that positively identifies the pattern or the design of the device. *All weighing and measuring devices, except those with no moving or electronic component parts (such as weights, liquid measures, and milk bottles), shall be clearly and permanently marked on a surface visible after installation* with a nonrepetitive serial number (nonretroactive as of 1968). (*nonretroactive as of January 1, 1977)* [Amended 1981]. (See also G-UR.2.1.1.)

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 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 or a device that may readily be interchanged or reversed in the course of field assembly or of normal usage shall be so constructed that their interchange or reversal will not materially affect the performance of the device. Parts that may be interchanged or reversed in normal field assembly 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 and recorded representations 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.

[Amended 1973]

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 which 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. DUAL INDICATIONS.- *On equipment designed to indicate or record in both U.S. inch-pound and metric units, comparable values shall be indicated or recorded in each mode of operation (i.e., 10 lb-5 kg; 0.01 lb-5 g; 0.01 gal-50 mL ; 1/8 yd-0.1 m). The values indicated or recorded shall be identified with the appropriate unit, symbol, abbreviation, or word. (Nonretroactive and enforceable as of January 1, 1978.)* [Amended 1978]

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 one 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 which 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 (nonretroactive as of 1976).* [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]

Table 1. REPRESENTATIONS 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

G-S.5.7. Magnified Graduations and Indications. - When in normal usage, a series of graduations and an indicator are necessarily viewed as magnified by an optical system or as magnified and projected on a screen, all particulars of the magnified image shall conform to all appropriate requirements for graduations and indications.

G-S.6. MARKING, OPERATIONAL CONTROLS, INDICATIONS, AND FEATURES.-*All operational controls, indications, and features, including switches, lights, displays, pushbuttons 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-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 RFI, which may adversely affect the performance of a device shall be conducted with equipment and under conditions which are usual and customary with respect to the location and of the device. [Added 1976]

G-T. TOLERANCES

G-T.1. ACCEPTANCE TOLERANCES.- Acceptance tolerances shall apply as follows:

(a) To any equipment about to be put into commercial use for the first time.
(b) To equipment that has been placed in commercial service within the preceding 30 days and is being officially tested for the first time.
(c) To 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.
(d) To equipment that is being officially tested for the first time within 30 days after major reconditioning or overhaul.

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 Definitions of Terms.)

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 radio frequency interference (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 TESTING PURPOSES.- A device shall be so located, or such facilities for normal access thereto shall be provided, that the testing equipment of the weights and measures official, in the amount and size deemed necessary by such official for the proper conduct of the test, may readily be brought to the device by customary means. Otherwise, it shall be the responsibility of the device owner or operator to supply such special facilities, including necessary labor as may be needed to transport the testing equipment to and from the device, as required by the weights and measures official.

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 continuously be 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 predominately in a direction favorable to the device user and near the tolerance limits shall not be considered "maintained in a proper operating condition." [Amended 1973]

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.

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the codes.

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." (See also correct.)

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analog type. Refers to 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.

approval seal. A label, tag, stamped or etched impression, or the like, indicating official approval of a device. (See also security seal.)

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.

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.

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.

computing type. Refers to 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.

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." (See also accurate.)

deficiency. See excess and deficiency.

digital type. Refers to 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.

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. 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."

graduated interval. The distance from the center of one graduation to the center of the next graduation of a series of graduations. (See also value of minimum graduated interval.)

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. (See also main graduation, subordinate graduation.)

increment. The value of the smallest unit that can be indicated or recorded by a digital device in normal operation.

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

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

interval, clear, between graduations. See clear interval between graduations.

interval, graduated. See graduated interval.

main graduation. A graduation defining the primary or principal subdivisions of a graduated series. (See also graduation.)

manufactured device. Any new device and any other device that has been removed from services and substantially altered or rebuilt.

money-operated type. Refers to 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.

multiple. An integral multiple; that is, a result obtained by multiplying by a whole number. (For multiple of a scale, see Sec. 2.20; Scale Code Definitions of Terms.)

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 differ from these by greater or lesser amounts. (For nominal capacity of a scale, see Scale Code Definition of Terms.)

nonretroactive. "Nonretroactive requirements are enforceable only with respect to equipment that is manufactured or placed in commercial service after the effective date. Nonretroactive requirements are printed herein in italic type. (See Sec. 1.14; G-A.6.) (See also retroactive.)

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.

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 the overregistration or underregistration, depending upon whether the indications are, respectively, greater or less than they should be. Examples of devices having errors of "overregistration" are: A fabric-measuring device that indicates more than the true length of material passed through it; and a liquid-measuring device that indicates more than the true amount of the liquid delivered by the device. Examples of devices having errors of "underregistration" are: A meter that indicates less than the true amount of product that it delivers; and a weighing scale that indicates or records less than the true weight of the applied load.

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.

performance requirements. Performance requirements include all tolerance requirements and, in the case of nonautomatic-indicating scales, sensitivity requirements (SR). (See General Code definition for "tolerance" and Sec. 2.20; Scale Code definition for "sensitivity requirement.")

primary indicating or recording elements. The term "primary" is applied to those principal indicating elements (visual) 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, recording element.)

radio frequency interference (RFI). Radio frequency interference is a type of electrical disturbance which, when introduced into electronic and electrical circuits, may cause deviations from the normally expected performance.

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 provide money-value indications.

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.

recorded representation. Refers to the printed, embossed, or other representation that is recorded as a quantity by a weighing or measuring device.

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.

retroactive. "Retroactive" requirements are enforceable with respect to all equipment. Retroactive requirements are printed herein in upright roman type. (See also nonretroactive.)

seal. See approval seal, security seal.

security seal. A lead-and-wire seal, a sufficiently permanent pressure-sensitive seal, or similar device, attached to a weighing or measuring device for protection against or to indicate access to, removal of, or adjustment. (See also approval seal.)

selector-type. Refers to a system of indication or recording in which the mechanism selects, by means of a ratchet-and-paw combination or by other means, one or the other of any two successive values that can be indicated or recorded.

specification. A requirement usually dealing with the design, construction, or marking of a weighing or measuring device. Specifications are primarily directed to the manufacturers of devices.

subordinate graduation. Any graduation other than a main graduation. (See also graduation.)

tolerance. A value fixing the limit of allowable error or departure from true performance or value. (See also basic tolerances.)

underregistration. See overregistration and underregistration.

user requirement. A requirement dealing with the selection, installation, use, or maintenance of a weighing or measuring device. User requirements are primarily directed to the users of devices.

usual and customary. Commonly or ordinarily found in practice or in the normal course of events and in accordance with established practices.

value of minimum graduated interval. The smallest value represented by the interval from the center of one graduation to the center of the succeeding graduation. Also, the smallest increment of recorded value. (See also graduated interval.)

SECTION 2

SEC. 2.20. SCALES

A. APPLICATION

A.1. GENERAL.- This code applies to all types of weighing devices other than 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]

A.2. WHEEL-LOAD WEIGHERS AND AXLE-LOAD SCALES.- The requirements for wheel-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. - See also General Code requirements.

S. SPECIFICATIONS

S.1. DESIGN OF INDICATING AND RECORDING ELEMENTS AND OF RECORDED REPRESENTATIONS.

S.1.1. ZERO INDICATION.- Provision shall be made on a scale equipped with indicating or recording elements to either indicate or record a zero balance condition, and on an automatic-indicating scale or balance indicator to indicate or record an out-of-balance condition on both sides of zero. A digital zero indication shall represent a balance condition that is within plus or minus one-half the value of the minimum increment that can be indicated or recorded. On a digital indicator equipped with an auxiliary or supplemental "center of zero" indicator, this indicator shall define a zero balance condition to ± 1/4 of a scale division or better. [Amended 1980]

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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.02 inch for graduations representing money values and not less than 0.03 inch for other graduations. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and the end of the indicator, or
(b) if the indicator is continuous, at the point of widest separation of the graduations.

2.20. Scales

S.1.3. INDICATORS.

S.1.3.1. SYMMETRY.- The index of an indicator shall be symmetrical with respect to the graduations with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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,
(b) the width of the minimum clear interval between weight graduations, and
(c) three-fourths of the width of the minimum clear interval 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.1.3.4. CLEARANCE.- The clearance between the index of an indicator and the graduations shall in no case be more than 0.06 inch.

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

S.1.4. DIGITAL INDICATIONS.- The zone of uncertainty on digital indicating scales shall be not greater than 0.3 the value of the minimum operating increment. [Added 1974]

S.1.4.1. CAPACITY INDICATION.- *A digital indicating element and recording element shall not display or record any values when the gross platform load is in excess of 105 percent of the nominal capacity of the system. (Nonretroactive and enforceable as of January 1, 1977 and to become retroactive as of January 1, 1981)* [Added 1975]

S.1.4.2. VALUES DISPLAYED, TEMPERATURE CONDITIONS.-*A digital indicating or recording element shall not display or record any usable values until the operating temperature (warm-up time) necessary for accurate weighing and a stable zero balance condition has been attained. (Non-retroactive and effective January 1, 1981)* [Added 1979]

S.1.5. WEIGHT RANGES AND UNIT WEIGHTS.- 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.

S.1.6. FOR COMPUTING SCALES ONLY.

S.1.6.1. MONEY-VALUE GRADUATIONS.- The value of the graduated intervals representing money values on a computing scale with analog indications shall be as follows:

(a) Not more than 1 cent at all unit prices of 25 cents per pound and less.
(b) Not more than 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) Not more than 5 cents at unit prices of $1.26 per pound through $3.40 per pound.
(d) Not more than 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 Sec. 1.14; S.1.6.2. and S.1.6.3. and G-S.5.5.)

S.1.6.2. 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 0.01 pound or less. (See also Sec. 1.14; G-S.5.5.)

S.1.6.3. 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, price per pound, or total price, shall be similarly equipped on the customer's side (nonretroactive as of 1971).* Unit price displays visible to the customer shall be in terms of the price per pound and not in fractions or multiples of a pound. [Amended 1975]

S.1.6.4. 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.

[1]Weight values shall be identified by the word "pound," the symbol "lb" or the sign "#". [Added 1975 and amended 1976]

2.20. Scales

S.1.7. FOR PREPACKAGING SCALES ONLY.

S.1.7.1. VALUE OF GRADUATED INTERVAL.- On a prepackaging scale, the graduated intervals representing weight values shall be uniform throughout the entire reading face, and any recorded representation shall present weight values identical with those on the reading face. [Made retroactive as of 1972]

S.1.7.2. LABEL PRINTER.- A prepackaging scale that, as part of the scale itself or of any auxiliary device attached thereto or used in connection therewith, 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. [Made retroactive as of 1972]

S.1.8. PROVISION FOR SEALING ADJUSTABLE COMPONENTS ON ELECTRONIC DEVICES.- *Provision shall be made for applying a security seal in a manner which requires the security seal to be broken before an adjustment can be made to any component affecting the performance of the device. (Nonretroactive as of January 1, 1979).* [Added 1978]

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, and any loose material used for this purpose shall be so enclosed that it cannot shift in position in such a way that the balance condition of the scale is altered.

S.2.1.2. ON SCALES USED IN DIRECT SALES.- A manual zero setting mechanism shall be operable or accessible only by a tool outside of and entirely separate from this mechanism or enclosed in a cabinet. A balance ball shall either meet this requirement or not itself be rotable.

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

(a) Plus or minus 3 scale divisions for scales of more than 5000 pounds capacity in service prior to January 1, 1981 and for all axle load, railway track, and vehicle scales.

(b) Plus or minus 1 scale division for all other scales. [Amended 1981]

S.2.1.3. ON SCALES EQUIPPED WITH AN AUTOMATIC ZERO SETTING MECHANISM.-Under normal operating conditions, the maximum load that can be "rezeroed" when all at once either placed on or removed from the platform shall be:

(a) For bench, counter, and livestock scales - 0.6 scale division,

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

(c) For all other scales - 1.0 scale division.

(Nonretroactive and enforceable as of January 1, 1981) [Amended 1981]

S.2.1.4. FOR MONORAIL SCALES.- On a monorail scale equipped with digital indications, means shall be provided for setting the zero-load balance and any tare value of less than five percent of the scale capacity to within 0.02% of scale capacity. On an in-motion system, means shall be provided to automatically maintain these conditions. [Added 1974 and Amended 1976]

S.2.1.5. TARE MECHANISM.- The tare mechanism shall operate only in a backward direction (that is, in the direction of under-registration) with respect to the zero-load balance condition of the scale.

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 and shall be separated by not more than 0.04 inch, measured horizontally, when the scale is in balance.

S.2.3. LEVELING-INDICATING MEANS.- If the weighing performance of a portable scale (except a prescription, jewelers, or dairy-product-test scale) 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 or approximately 3 degrees, the scale shall be equipped with level-indicating means. The indications of this level-indicating means shall be readily observable without the necessity of disassembly of any scale parts requiring the use of mechanical means separate from the scale. [Amended 1979] [Made fully retroactive as of 1979]

S.2.4. DAMPING MEANS.- An automatic-indicating scale, and balance indicator, shall be equipped with effective means for damping the oscillations whenever such means are necessary to bring the indicating elements quickly to rest. [Amended 1972]

S.2.4.1. 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 5000 pounds capacity in service prior to January 1, 1981 and for all axle load, railway track, livestock, and vehicle scales.

(b) plus or minus 1 scale division for all other scales. [Amended 1981]

The values recorded shall be within applicable tolerances.

S.2.5. FOR DAIRY-PRODUCT-TEST, GRAIN-TEST, JEWELERS, AND PRESCRIPTION SCALES ONLY. [AMENDED 1979]

S.2.5.1. BALANCE INDICATOR.- A dairy-product-test, grain-test, jewelers, or prescription scale shall be equipped with a balance indicator. If this consists of an indicator and a graduated scale that are not in the same plane, the clearance between the indicator and the graduations shall be not more than 0.04 inch.

S.2.6. FOR JEWELERS AND PRESCRIPTION SCALES ONLY.

S.2.6.1. ARRESTING MEANS.- A jewelers or prescription 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 1.

TABLE 1.- MINIMUM TRAVEL OF PANS OF NONAUTOMATIC INDICATING EQUAL-ARM SCALE WITHOUT BALANCE INDICATOR.

Nominal capacity	Minimum travel of pans
Pounds	Inch
4 or less	0.35
5 to 12, incl	.5
13 to 26, incl	.75
Over 26	1.0

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

S.3.3. SCOOP COUNTERBALANCE.- A scoop on a scale used for direct sales to retail customers shall not be counter-balanced by a removable weight. A permanently attached scoop-counterbalance shall indicate clearly on both the dealer'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 ELEMENTS.- 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 elements, opposing surfaces and points being

properly shaped, finished, and hardened. A platform scale having a frame around the platform shall be equipped with means to prevent interference between platform and frame.

S.4.2. ADJUSTABLE COMPONENTS.- An adjustable component such as a nose-iron, pendulum, spring, or potentiometer (but not a component for adjusting level or zero-load balance) shall be held securely in adjustment and shall not be adjustable from the outside of the scale. The position of a nose-iron on a scale of more than 2000 lbs capacity, as determined by the factory adjustment, shall be accurately, clearly, and permanently defined. [Amended 1975]

S.4.3. MULTIPLE LOAD-RECEIVING ELEMENTS.- *Except for 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. (Nonretroactive as of 1969.)*

S.5. DESIGN OF WEIGHBEAMS AND POISES.

S.5.1. WEIGHBEAMS

S.5.1.1. NORMAL BALANCE POSITION.- The normal balance position of the weighbeam of a beam scale shall be horizontal.

S.5.1.2. 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 weigh-beam tip shall be not less than the minimum travel shown in table 2. 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 the weighbeam fulcrum to the weighbeam tip.

TABLE 2.- MINIMUM TRAVEL OF WEIGHBEAM OF BEAM SCALE BETWEEN LIMITING STOPS.

Distance from weighbeam fulcrum to limiting stops	Minimum travel between limiting stops
Inches	Inch
12 or less	0.4
13 to 20, incl	.5
21 to 40, incl	.7
Over 40	.9

S.5.1.3. SUBDIVISION.- A subdivided weighbeam bar shall be subdivided by means of 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 so positioned in relation to the notches as to indicate notch values clearly and accurately.

S.5.1.4. 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.5.1.5. CAPACITY.- On an automatic-indicating scale having a nominal capacity of 30 pounds 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.5.1.6. 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.5.2. POISES.

S.5.2.1. 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.5.2.2. ADJUSTING MATERIAL.- The adjusting material in a poise shall be securely enclosed and firmly fixed in position, and if softer than brass it shall not be in contact with the weighbeam.

S.5.2.3. 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. That 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.5.2.4. 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.6. MARKING REQUIREMENTS. (See also G-S.1.)

S.6.1. NOMINAL CAPACITY.- 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 and recording element or elements are not immediately apparent. [Amended 1978]
(d) On any scale with a nominal capacity less than the sum of the reading elements.

S.6.2. FOR PREPACKAGING SCALES ONLY.- A prepackaging scale shall be conspicuously marked on the operator's side and on the opposite side with the words "For Prepackaging Use Only" or with a similar and suitable statement.

(See the footnote following the section on user requirements in the Scale Code.)

S.6.3. FOR LIVESTOCK, VEHICLE, AND RAILWAY TRACK SCALES ONLY.-A livestock, vehicle, or 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. [Made retroactive as of 1979.]

S.6.4. MARKING REQUIREMENTS--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. [Added and nonretroactive as of 1972]*

N. NOTES

N.1. TESTING 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, in which case the available 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.- The decreasing-load test shall be conducted on automatic indicating scales only and with a test load equal to one-half of the maximum applied test load, approximately centered on the load receiving element of the scale.

N.1.2.1. ZERO BALANCE SHIFT.- A balance shift test shall be conducted on all scales after the removal of any test load. The balance should not change more than the minimum tolerance applicable. (See also G-UR.4.2.) [Added 1977]

N.1.3. SHIFT TEST.

N.1.3.1. ON BENCH OR COUNTER SCALES.- The 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. ON DAIRY-PRODUCT-TEST SCALES.- The shift test shall be conducted with a test load of 18 grams, this load being successively positioned at all points at which a weight might reasonably be placed in the course of normal use of the scale.

N.1.3.3. ON EQUAL-ARM SCALES.- The shift test shall be conducted with a half-capacity test load shifted, as prescribed in N.1.3.1., on each pan, with an equal test load centered on the other pan.

N.1.3.4. ON VEHICLE SCALES.- The shift test shall be conducted with at least two different test loads successively distributed between the two load bearings (or other weighing elements) that support each section of the scale. [Amended 1972]

N.1.3.5. ON RAILWAY TRACK SCALES WEIGHING INDIVIDUAL CARS IN SINGLE DRAFTS.- The shift test shall be conducted with at least two different test loads, if available, distributed over, or to the right and left of, each pair of main levers or other weighing elements supporting each section of the scale. [Added 1972]

N.1.3.6. ON ALL OTHER SCALES EXCEPT CRANE SCALES AND HANGING SCALES.- The shift test shall be conducted on all other scales, except crane scales and hanging scales, 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.

N.1.4. TEST FOR SENSITIVENESS FOR NON-AUTOMATIC-INDICATING SCALES.- The test for sensitiveness shall be conducted on all nonautomatic-indicating scales. SR tests shall be made at zero load and at the maximum test load applied to the scale by either increasing or decreasing by a specified amount (see SR. Sensitivity Requirements) the test-weight load on the load-receiving element of the scale. The minimum response of the scale shall be as follows:

(a) On 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) On a Scale With a Single Balance Indicator and Having a Nominal Capacity of Less Than 500 Pounds. - The position of rest of a single indicator on a scale having a nominal capacity of less than 500 pounds shall change at least 0.04 inch or at least one division on the graduated scale, whichever is greater.
(c) On a Scale With a Single Balance Indicator and Having a Nominal Capacity of 500 Pounds or Greater. - The position of rest of a single indicator on a scale having a nominal capacity of 500 pounds or greater shall change at least 0.25 (1/4) inch or at least one division on the graduated scale (or the width of the central target area), whichever is greater. However, the indicator on a batching scale shall change at least 0.12 (1/8) inch or at least one division on the graduated scale, whichever is greater.
(d) On a Scale with Two Opposite-Moving Balance Indicators. -The position of rest of the two indicators moving in opposite directions shall change, with respect to each other, by at least 0.04 inch.

(e) On a 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.

N.1.5. ZONE OF UNCERTAINTY TEST.- The zone of uncertainty test on digital instruments shall be conducted under controlled conditions in which environmental factors are reduced to the extent that they will not affect the results obtained. [Added 1974]

N.1.6. RATIO TEST.- A ratio test shall be conducted on all scales employing counterpoise weights and on nonautomatic-indicating equal-arm scales.

N.2. MINIMUM TEST-WEIGHT LOAD FOR RAILWAY TRACK SCALES.- In the test of a railway track scale, the test-weight load shall be not less than 30 000 pounds.

N.2.1. FOR COUPLED-IN-MOTION TESTS.- A test train shall be a train of no less than 10 cars yielding 100 car weights. [Added 1974]

N.3. NOMINAL CAPACITY OF PRESCRIPTION SCALES.- In the absence of information to the contrary the nominal capacity of a prescription scale shall be assumed to be 1/2 apothecaries ounce. [Amended 1972]

SR. SENSITIVITY REQUIREMENTS

SR.1. APPLICATION.- The sensitivity requirement (SR) applicable to a scale is the same regardless of whether acceptance or maintenance tolerances apply.

SR.2. GENERAL.- Except for equipment specified in paragraphs SR.3 through SR.8, the SR on a nonautomatic-indicating scale shall be twice the value of the minimum graduated interval on the weighbeam, 0.2 percent of the nominal capacity of the scale, or 40 pounds, whichever is least. [Amended 1979]

SR.3. FOR PRESCRIPTION SCALES.- The SR shall be 0.1 grain (6 milligrams). [Amended 1972 and 1975]

SR.4. FOR JEWELERS SCALES. [Amended 1975]

SR.4.1. WITH A CAPACITY OF ONE-HALF OUNCE OR LESS.- The SR shall be 0.1 grain (6 milligrams). [Added 1975]

SR.4.2. WITH A CAPACITY OF MORE THAN ONE-HALF OUNCE.- The SR shall be the value of the minimum graduated interval of the device or 0.05 percent of the capacity of the scale, whichever is less. [Amended 1977]

SR.5. FOR DAIRY-PRODUCT-TEST SCALES.- [AMENDED 1979]

SR.5.1. USED IN DETERMINING BUTTERFAT CONTENT.-The SR shall be 0.5 grain (32 milligrams).

SR.5.2. USED IN DETERMINING MOISTURE CONTENT.-The SR shall be 0.3 grain (19 milligrams).

SR.6. FOR GRAIN TEST SCALES.-The SR shall be the value of the minimum graduated interval or 0.05 percent of the capacity of the scale, whichever is less. [Added 1979]

2.20. Scales

SR.7. FOR ANIMAL, LIVESTOCK, AXLE-LOAD, AND VEHICLE SCALES.

SR.7.1. NOT EQUIPPED WITH BALANCE INDICATORS.- The SR shall be twice the value of the minimum graduated interval on the weighbeam, or 0.2 percent of the nominal capacity of the scale, whichever is less.

SR.7.2. EQUIPPED WITH BALANCE INDICATORS.- The SR shall be the value of the minimum graduated interval on the weighbeam.

SR.8. FOR RAILWAY TRACK SCALES.- The SR shall be three times the value of the minimum graduated interval on the weighbeam, or 100 pounds, whichever is less.

T. TOLERANCES

T.1. TOLERANCE APPLICATION.- Tolerance values shall be applied to all indications and recorded representations of a scale.

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 SCALES WITH MULTIPLE ELEMENTS.- Tolerances shall be applied independently to each separate indicating and recording element of a scale. However, the following requirements pertaining to analog and digital elements within the same element shall also apply [Amended 1979]:

(a) All analog indications within the same element shall not differ from one another and all digital elements shall not differ from one another.
(b) All analog indications and recorded representations shall not differ from digital indications and recorded representations by an amount greater than the value of the minimum graduated interval on the device, except the elements shall not differ under a no-load zero balance condition. The values indicated and recorded shall be within applicable tolerances. [Amended 1978]
(c) All components of the same element used in combination (such as a dial and unit weights) shall not differ by an amount greater than the applicable tolerance at any given test load.

T.1.3. 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 minimum value that can be indicated or recorded. This does not apply to digital indications or recorded representations that have been corrected for the rounding error. [Amended 1981]

T.1.4. TO SHIFT TESTS.- Basic tolerances shall be applied.

T.1.5. TO INCREASING-LOAD TESTS.- Basic tolerances shall be applied.

T.1.6. TO DECREASING-LOAD TESTS ON AUTOMATIC-INDICATING SCALES.-One and one-half (1.5) times basic tolerances shall be applied.

T.1.7. TO RATIO TESTS.- Three-fourths (0.75) of basic tolerances shall be applied.

T.1.8. TO SECTIONAL TESTS ON VEHICLE, LIVESTOCK, AND RAILROAD TRACK SCALES.- The maximum deviation between indicated values on test loads applied to individual sections shall not be greater than the absolute value of the maintenance tolerance applicable to that test load. [Added 1977]

T.2. MINIMUM TOLERANCE VALUES.

T.2.1. GENERAL.- Except for equipment specified in paragraphs T.2.2. through T.2.11., the maintenance tolerance and the acceptance tolerance applied to a scale shall be not smaller than the appropriate value shown in Table 3 or one-half the value of the minimum graduated interval, whichever is less. [Amended 1979]

T.2.2. FOR PRESCRIPTION SCALES.- The minimum tolerance shall be 0.1 grain (6 milligrams). [Amended 1972]

T.2.3. FOR JEWELERS SCALES. [Amended 1975]

T.2.3.1. WITH A CAPACITY OF ONE-HALF OUNCE OR LESS.- The minimum tolerance shall be 0.1 grain (6 milligrams). [Added 1975]

T.2.3.2. WITH A CAPACITY OF MORE THAN ONE-HALF OUNCE.-The minimum tolerance shall be one-half the value of the scale division or 0.05% of the nominal capacity of the scale, whichever is less. [Amended 1977]

T.2.4. FOR DAIRY-PRODUCT-TEST SCALES.- The minimum tolerance shall be 0.2 grain (13 milligrams). [Amended 1979]

T.2.5. FOR POSTAL AND PARCEL POST SCALES.- The minimum tolerance shall be the appropriate value shown in Table 3 or 1/2 the value of the scale division, whichever is less.

T.2.5.1. FOR POSTAL AND PARCEL POST SCALES DESIGNED AND/OR USED TO WEIGH LOADS LESS THAN 2 POUNDS.- The minimum tolerance shall be 15 grains, 1 gram, 1/32 ounce, or 0.002 pound, as appropriate. [Added 1979]

T.2.6. FOR ANIMAL SCALES.- The minimum maintenance tolerance and acceptance tolerance shall be 1 pound.

T.2.7. FOR LIVESTOCK SCALES.- The minimum maintenance tolerance and acceptance tolerance shall be 2 pounds, or one-half the value of the minimum graduated interval, whichever is greater.

T.2.8. FOR CRANE AND CONSTRUCTION MATERIAL HOPPER SCALES.- The minimum tolerance shall be 0.1 percent of the weighing capacity of the scale or the value of the smallest unit, whichever is less. [Amended 1974]

T.2.9. FOR WHEEL-LOAD WEIGHERS. The minimum tolerance shall be 0.125% of the nominal capacity of the device or one-half the value of the scale division, whichever is less. [Added 1977]

T.2.10. FOR RAILWAY TRACK SCALES.- The minimum tolerance shall be 30 pounds.

T.2.11. FOR SCALES INDICATING IN METRIC UNITS.- The minimum tolerance shall be one-half the value of the minimum division or 0.05% of the nominal capacity for nonautomatic-indicating scales[2] or reading face capacity for automatic-indicating scales[3] whichever is less.

[Added 1976]

TABLE 3. MINIMUM TOLERANCE VALUES FOR SCALES EXCEPT FOR EQUIPMENT SPECIFIED IN PARAGRAPHS T.2.2. THROUGH T.2.11.

(This table applies where the appropriate value in the table is smaller than one-half the value of the minimum graduated interval on the device under test.)

Nominal capacity for non-automatic-indicating scales* or Reading-face capacity for automatic-indicating scales**	Minimum tolerance value		
Pounds	Expressed in grains	Expressed in ounces	Expressed in pounds
0 to 4, incl	15	1/32	0.002
5 to 10, incl	30	1/16	.004
11 to 20, incl	.....	1/8	.008
21 to 30, incl	.....	3/16	.012
31 to 50, incl	.....	1/2	.031
51 to 100, incl	.....	3/4	.047
101 to 150, incl	.....	1 1/4	.078
151 to 250, incl	.....	2	.125
251 to 500, incl	.....	4	.250
501 to 1,000, incl	.....	8	.500
1,001 to 2,500, incl	.....	.....	1
2,501 to 5,000, incl	.....	.....	2 1/2
5,001 to 10,000 incl	.....	.....	5
10,001 to 20,000, incl	.....	.....	10
20,001 to 50,000, incl	.....	.....	20
Above 50,000	.....	.....	25

*Including, in addition, scales equipped with over-and-under indicators.
**Excluding scales equipped with over-and-under indicators. (The reading-face capacity of a multi-revolution scale shall be the total capacity of the scale.)

[Amended 1974]

[2]Including scales equipped with over-and-under indicators.
[3]Excluding scales equipped with over-and-under indicators. (The reading-face capacity of a multi-revolution scale shall be the total capacity of the scale.)

T.3. BASIC TOLERANCE VALUES.

T.3.1. GENERAL.- Except for equipment specified in paragraphs T.3.2. through T.3.10., the basic maintenance and acceptance tolerances shall be as shown in table 4 (for scales indicating or recording in avoirdupois units) and table 5 (for scales indicating or recording in apothecaries or metric units). (Basic tolerance values include the minimum tolerance values as set forth in section T.2.). [Amended 1978]

T.3.2. FOR PRESCRIPTION SCALES.- The basic maintenance and acceptance tolerance shall be 0.1 percent of the test load. [Amended 1972]

T.3.3. FOR JEWELERS SCALES.- The basic maintenance and acceptance tolerance shall be 0.05 percent of the test load. [Amended 1975]

T.3.4. FOR DAIRY-PRODUCT-TEST SCALES.- The basic maintenance tolerance (applied on an 18-gram load shall be 0.5 grain (32 milligrams). The basic acceptance tolerance shall be 0.3 grain (19 milligrams).

T.3.5. FOR GRAIN-TEST SCALES.- The basic maintenance and acceptance tolerances shall be as shown in the following table:

BASIC TOLERANCE VALUES FOR GRAIN-TEST SCALES.
(APPLICABLE TO INCREASING AND DECREASING LOAD TESTS.)

Test Load		Maintenance Tolerances	Acceptance Tolerances
from	to and including	in scale div (d)	in scale div (d)
min	500d	1	0.5
500d	2000d	2	1.0
2000d	10000d	3	1.5

[Added 1979]

T.3.6. FOR POSTAL AND PARCEL POST SCALES.- The basic maintenance and acceptance tolerance shall be as specified in Table 4 except that for Postal and Parcel Post Scales designed and/or used to weigh loads less than 2 pounds, the basic acceptance and maintenance tolerance shall be 15 grains, 1 gram, 1/32 ounce, 0.03 ounce, or 0.002 pound, as appropriate. [Added 1979]

T.3.7. FOR ANIMAL, LIVESTOCK, CRANE, AXLE-LOAD, HOPPER (OTHER THAN GRAIN HOPPER), AND VEHICLE SCALES.- The basic maintenance tolerance shall be 2 pounds per 1 000 pounds of test load (0.2 percent). The acceptance tolerance shall be one-half the basic maintenance tolerance. [Amended 1973]

T.3.7.1. FOR GRAIN HOPPER SCALES.- The basic maintenance tolerance shall be 1 pound per 1 000 pounds of test load (0.1 percent). The acceptance tolerance shall be one-half of the basic maintenance tolerance. [Added 1978]

T.3.8. FOR RAILWAY TRACK SCALES. [Added 1973]

T.3.8.1. WEIGHING STATICALLY.- The basic maintenance tolerance shall be 2 pounds per 1 000 pounds of test load (0.2 percent). The acceptance tolerance shall be one-half the basic maintenance tolerance. [Added 1973]

T.3.8.2. WEIGHING UNCOUPLED-IN-MOTION CARS.- The basic maintenance and acceptance tolerance shall be 2 pounds per 1 000 pounds of test load (0.2 percent). [Added 1973]

T.3.8.3. WEIGHING COUPLED IN MOTION.- The basic maintenance and acceptance tolerances shall be as follows:

(a) The difference between the motion gross weight value and the static gross weight value of the test train shall not exceed two pounds per 1 000 pounds (0.2 percent).
(b) The difference between the motion gross weight values and the static gross weight values on 100 car weights shall meet the following conditions:

(1) At least 70 percent of the individual car weight differences shall be within plus or minus 0.2 percent.
(2) Not more than 5 percent of the individual car weight differences shall exceed plus or minus 0.5 percent.
(3) No individual car weight difference shall exceed plus or minus 1.0 percent.

This means that at least 70 of the car weights must be within plus or minus 0.2 percent, that 25 car weight differences can be more than plus or minus 0.2 percent up to and including plus or minus 0.5 percent, and that 5 car weight differences can be more than plus or minus 0.5 percent up to and including plus or minus 1.0 percent.
[Amended 1979]

T.3.9. FOR WHEEL-LOAD WEIGHERS.- The basic maintenance tolerance for individual wheel-load weighers shall be 2 percent of the known test load. The basic acceptance tolerance shall be 1 percent of the known test load. When two wheel-load weighers are marked and tested as a pair, the tolerance shall be applied to the sum of the indications of the two weighers, and the pair shall be approved or rejected upon the basis of the combined indications. [Amended 1977]

T.3.10. FOR MONORAIL SCALES. [Added 1976]

T.3.10.1. WEIGHING STATICALLY.- The basic maintenance tolerance shall be 1 lb per 1 000 lbs of test load (0.1%). The basic acceptance tolerance shall be 1/2 the basic maintenance tolerance. [Added 1976]

T.3.10.2. WEIGHING IN MOTION.- The basic maintenance and acceptance tolerances shall be 1 lb per 1 000 lb of test load (0.1%). On a dynamic test of 20 or more drafts, 10 percent of the individual test drafts may be in error not to exceed two times the basic tolerance provided the error on the total test load of all drafts does not exceed 0.2 percent. [Added 1976]

TABLE 4. - BASIC TOLERANCES FOR SCALES INDICATING OR RECORDING IN AVOIRDUPOIS UNITS, EXCEPT FOR EQUIPMENT SPECIFIED IN PARAGRAPHS T.3.2 THROUGH T.3.10.
[Amended 1978]
(See T.1., T.2., and T.3.)

Test Load		Maintenance tolerances		Acceptance tolerances	
From	to but not including	Expressed in grains	Expressed in pounds	Expressed in grains	Expressed in pounds
Ounces avdp.					
0	2	2	---	1	---
2	4	4	---	2	---
4	8	8	---	4	---
8	16	16	---	8	---
Pounds avdp.		in ounces		in ounces	
1	2	1/16	0.004	1/32	0.002
2	4	1/8	.008	1/16	.004
4	7	3/16	.012	3/32	.006
7	10	1/4	.016	1/8	.008
10	15	5/16	.020	5/32	.010
15	20	3/8	.023	3/16	.012
20	30	1/2	.031	1/4	.016
30	40	5/8	.039	5/16	.020
40	50	3/4	.047	3/8	.023
50	75	1	.062	1/2	.031
75	100	1-1/2	.094	3/4	.047
100	150	2	.125	1	.062
150	200	3	.188	1-1/2	.094
200	300	4	.250	2	.125
300	400	6	.375	3	.188
400	600	8	.500	4	.250
600	800	12	.750	6	.375
800	1,000	14	.875	7	.438
1,000 and over		0.1 % of test load		0.05 % of test load	

2.20. Scales

TABLE 5. BASIC TOLERANCES FOR SCALES INDICATING OR RECORDING IN EITHER APOTHECARIES OR METRIC UNITS EXCEPT FOR EQUIPMENT SPECIFIED IN PARAGRAPHS T.3.2. THROUGH T.3.10. [Amended 1979] (See T.1., T.2., and T.3.)

Test Load		Maintenance tolerances	Acceptance tolerances
From	to but not including	Expressed in Grains	Expressed in Grains
Ounces apoth.			
0	1	1	0.5
1	2	2	1.0
2	4	4	2.0
4	6	7	3.5
6	8	10	5.0
8	12	12	6.0
Grams		Milligrams	Milligrams
0	10	15	8
10	20	50	25
20	40	100	50
40	60	150	75
60	100	250	125
100	150	350	175
150	200	500	250
200	300	650	325
300	400	800	400
		Grams	Grams
400	500	1.0	0.5
500	750	1.5	0.75
750	1,000	2.0	1.0
Kilograms			
1	2	4.0	2.0
2	3	5.5	2.8
3	5	7.5	3.8
5	10	11.0	6.0
10	15	15.0	7.5
15	20	19.0	8.5
20	30	25.0	12.5
30	40	35.0	17.5
40	50	45.0	22.5
50 kilograms and over		0.1 percent of test load	0.05 percent of test load

UR. USER REQUIREMENTS

UR.1. SELECTION REQUIREMENTS. [Amended 1974]

UR.1.1. VALUE OF THE SMALLEST UNIT ON PRIMARY INDICATING AND RECORDING ELEMENTS.

UR.1.1.1. FOR RETAIL FOOD SCALES ONLY.- The value of the smallest unit on a scale used for the retail sale of foodstuffs, with a nominal capacity of 50 pounds or less, shall be not greater than 1 ounce.

UR.1.1.2. FOR ANIMAL SCALES ONLY.- The value of the smallest unit shall be not greater than 1 pound.

UR.1.1.3. FOR LIVESTOCK SCALES ONLY.- The value of the smallest unit shall be not greater than 5 pounds.

UR.1.1.4. FOR GRAIN HOPPER SCALES ONLY.- The value of the smallest unit shall be not greater than 10 pounds for scales with a nominal capacity of 50 000 pounds or less, and not greater than 20 pounds for scales with a nominal capacity of more than 50,000 pounds.

UR.1.1.5. FOR CRANE SCALES ONLY.- The value of the smallest unit shall be not greater than 0.2 percent of the nominal capacity of the scale. [Made retroactive as of 1972]

UR.1.1.6. FOR VEHICLE SCALES AND AXLE-LOAD SCALES USED IN COMBINATION.- The value of the smallest division on a scale or scales used to determine the weight of a vehicle shall be as follows:

(a) For Scales with a capacity up to and including 200 000 lb, not greater than 20 lb.
(b) For Scales with a capacity greater than 200 000 lb, not greater than 50 lb.
[Amended 1979]

UR.1.1.7. FOR RAILWAY TRACK SCALES ONLY.- *The value of the smallest unit shall be:*

(a) Not greater than 20 pounds on nonautomatic indicating scales.
(b) Not greater than 100 pounds on automatic indicating scales.

(Nonretroactive as of 1971.)

UR.1.1.8. FOR SCALES WITH NOMINAL CAPACITIES OF 500 POUNDS OR MORE, OTHER THAN ANIMAL, LIVESTOCK, GRAIN HOPPER, CRANE,VEHICLE, AND RAILWAY TRACK SCALES.-The value of the smallest unit shall be not greater than 0.1 percent of the nominal capacity of the scale and in any case not greater than 50 pounds. (Note: For scales with nominal capacities of less than 500 pounds, refer to paragraph G-UR.1.1. Suitability of Equipment of Sec. 1.14; General Code.) [Amended 1973]

UR.1.1.9. FOR WHEEL-LOAD WEIGHERS.- The value of the scale division shall be not greater than 0.25% of nominal capacity of the scale and in any case not greater than 50 pounds. [Added 1977]

UR.1.2. FOR GRAIN-TEST SCALES ONLY.- The design of a scale selected for use as a grain test scale shall be:

Scale Division (d)	Number of Divisions (n = Max/d)		Minimum Capacity (Min)
	Minimum	Maximum	
0.1 g $\leq$ d $\leq$ 0.5 g	500	10 000	20d

[Added 1979]

UR.2. INSTALLATION REQUIREMENTS.

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

UR.2.2. SUSPENSION OF HANGING SCALE.- A hanging scale shall be freely suspended from a fixed support when in use.

UR.2.3. PROTECTION FROM ENVIRONMENTAL FACTORS.- The indicating elements, the lever system or load cells, and the load receiving element of a permanently installed scale, and the indicating elements of a scale not intended to be permanently installed, shall be adequately protected from environmental factors such as wind, weather, and RFI which may adversely affect the operation or performance of the device. [Amended 1976]

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 and throughout the weighing range of the scale. *On motor truck 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 1973)* [Amended 1973].

UR.2.5. ACCESS TO PIT.- Adequate provision shall be made for ready access to the pit of a permanently installed vehicle, livestock, or animal scale for purposes of inspection and maintenance.

UR.2.6. APPROACHES.

UR.2.6.1. TO VEHICLE SCALES.- *On the approach end or ends of a vehicle scale installed in any one location for a period of six months or more, there shall be a straight approach as follows:*

(a) at least the width of the platform, and
(b) at least one-half the length of the platform but not required to be more than 40 feet, and

(c) *not less than 10 feet 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 may be installed in this portion; and further, where deemed necessary for drainage purposes, the remaining portion of the approach may slope slightly. (Nonretroactive as of 1976)* [Amended 1977]

UR.2.6.2. TO 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. [Added 1975]

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 motor vehicle scales equipped with means for raising the load receiving element from the weighing element for vehicle unloading, suitable means shall be provided so that it is readily apparent to the weigher when the load receiving element is in its designed weighing position. [Added 1973]

UR.3. USE REQUIREMENTS.

UR.3.1. PREPACKAGING SCALE.- A scale marked with the words "For Prepackaging Use Only" or with a statement of similar meaning shall only be used for putting up packages including special customer orders and shall not be used for weighing commodities intended to be delivered to the buyer in any manner other than in a properly labeled random package. [Amended 1975]

UR.3.2. MINIMUM LOAD ON A VEHICLE SCALE.- A vehicle scale shall not be used for weighing a load smaller than 1 000 pounds.

UR.3.2.1. USED FOR WEIGHING LIVESTOCK.- A vehicle scale with a capacity of more than 60 000 pounds that is adapted to weighing livestock shall not be used for weighing net loads of livestock of less than 10 000 pounds when the value of the smallest unit is 20 pounds; or less than 5 000 when the value of the smallest unit is 10 pounds. [Added 1974]

UR.3.3. WET COMMODITIES.- Wet fish and other wet commodities shall be weighed only on scales on which the pans or platforms will drain properly.

UR.3.4. LADING.- A scale shall not be used for weighing a load totaling more than the nominal capacity of the scale.

UR.3.5. SINGLE-DRAFT VEHICLE WEIGHING.- A vehicle or a coupled vehicle combination shall be commercially weighed on a vehicle scale only as a single draft. That is, the total weight of such a vehicle or combination shall not be determined by adding together the results obtained by separately and not simultaneously weighing each end of such vehicle or individual elements of such coupled combination. However,

(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, and
(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.

[Amended 1979]

UR.3.6. FOR WHEEL-LOAD WEIGHERS ONLY.

UR.3.6.1. USE IN PAIRS.- When wheel-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 on combination.

UR.3.6.2. LEVEL CONDITION.- A vehicle, for which either an axle-load determination or a gross-load determination is being made utilizing wheel-load weighers, shall be in a reasonably level position at the time of such determination.

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-indicating means, the scale shall be maintained in level.

UR.4.3. SCALE MODIFICATION.- Neither the length nor the width of the load-receiving element of a scale shall 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.

[Footnote] 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.

DEFINITION OF TERMS

The terms defined here have a special and technical meaning when used in the Scale Code.

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

animal scale. A livestock scale designed for weighing single heads of livestock.

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" as defined.)

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.)

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

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

balance, zero-load. See zero-load balance.

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

beam. See weighbeam.

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.

bench scale. See counter scale.

checkweighing scale. One used to verify perdetermined weight within prescribed limits.

coal-mine scale. One used at a coal mining operation for determining the basic wages of miners on a production basis.

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.

construction-material hopper scale. A scale adapted to weighing construction materials such as sand, gravel cement, and hot oil.

2.20. Scales

counter scale. One which, 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.

Counterbalance weight. One intended for application near the butt of a weighbeam for zero-load balancing purposes.

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.

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

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.

decreasing-load test. A special supplementary test for automatic-indicating scales only, during which the performance of the scale is tested when the load is being reduced. In this test, an observation is made with a test weight load equal to one-half of the maximum applied test load.

direct sale. A sale in which both parties in the transaction are present when the quantity is being determined.

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 ("side bar").

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

grain hopper scale. One adapted to the weighing of individual loads of grain of varying magnitude.

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

hopper scale. A scale designed for weighing bulk commodities whose load-receiving element is a tank, box, or hopper mounted on a weighing element. See also automatic hopper scale, grain hopper scale, and construction material hopper scale.

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

indicator, balance. See balance indicator.

jewelers scale. One adapted to weighing gems and precious metals.

livestock scale. A scale of 60 000 pounds capacity or less equipped with stock racks and gates and adapted to weighing livestock standing on scale platform.

load cell. The basic weighing element of a load-cell scale. The load cell, whether electric, hydraulic, or pneumatic, produces a signal proportional to the load applied.

load-receiving element. That element of a scale which is designed to receive the load to be weighed. For example, platform, deck, rail, hopper, platter, plate, scoop.

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.)

main-weighbeam elements. The combination of a main bar and its fractional bar, or a main bar alone if this has no fractional bar associated with it.

minimum tolerances. Minimum tolerances are the smallest 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. (Scale also General Code definition for basic tolerances.)

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.)

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.

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. (See also nominal capacity, batching scale; nominal capacity, hopper scale.)

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.

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.

nose-iron. A slidably-mounted, manually-adjustable pivot assembly for changing the multiple of a lever.

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.)

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.)

prepackaging scale. A computing scale specially designed for putting up packages of random weights in advance of sale.

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.

ranges, weight. See weight ranges.

ratio test. A test to determine the accuracy with which the actual multiple of a scale agrees with its designed multiple. This test is utilized in the case of 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 utilize this test in the case of some scales not employing counterpoise weights.)

reading-face. That element of an automatic-indicating scale on which weight values are automatically indicated.

reading-face capacity. The largest weight that may be indicated on the reading face, exclusive of the application of any unit weights, weight ranges, or other elements.

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.

scale. See specific type of scale.

scale divisions, number of (n). Quotient of the capacity divided by the value of the scale division

$$n = \frac{Cap}{d} \text{ or } \frac{Cap}{d_d}.$$

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 (d) or the difference between two consecutively indicated or printed values for digital indication or printing (d_d).

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, or the test-weight load on the load-receiving element of the scale.

shift test. A test intended to disclose the weighing performance of a scale under off-center loading.

tare mechanism. A mechanism (including a tare bar) that is 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.

tare-weighbeam elements. The combination of a tare bar and its fractional bar, or a tare bar alone if this has no fractional bar associated with it.

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.

vehicle scale. A scale adapted to weighing highway, farm, or other large industrial vehicles (except railroad freight cars), loaded or unloaded.

weighbeam. An element comprising one or more bars, equipped with movable poises or means for applying counterpoise weights or both.

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.

weight, unit. See unit weight.

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.

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 non- automatic-indicating scale, zero-load balance for a recording scale.)

zero-load balance for an 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.

zero-load balance for a 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. Scales

zero-load balance for a recording scale. A condition in which the scale will record a representation of zero load.

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:

manual zero setting mechanism. Nonautomatic means provided to attain a zero balance indication by the direct operation of a control.

semi-automatic zero setting mechanism. Automatic means provided to attain a direct zero balance indication requiring a single initiation by an operator.

automatic zero setting mechanism. Automatic means provided to maintain a zero balance indication without the intervention of an operator.

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.

SEC. 2.21. BELT-CONVEYOR SCALES

A. APPLICATION

A.1.- This code applies to devices installed on belt conveyors for the purpose of weighing bulk materials carried by conveyors.

A.2.- This code does not apply to equipment for the discrete weighing of objects moving on conveyors, to weigh feeders that measure quantity on a time basis, to check-weighers, to rate indicators or controllers, or to other auxiliary devices except as they may affect the weighing performance of the device.

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 may also be equipped with a primary recording element. An auxiliary vernier counter used for scale calibration shall not be considered part of the master weight totalizer.

S.1.2. UNITS.- A belt-conveyor scale shall indicate or record weight units in terms of pounds or tons or decimal multiples or subdivisions thereof.

S.1.3. PRINTER.- A recording element, if provided, shall be of the digital type.

S.1.4. VALUE OF THE SMALLEST UNIT.- The value of the smallest unit of the primary indicating or recording element shall not be greater than 1/1200 of the rated capacity of the device. However, provision shall be made so that compliance with the requirements of the zero-load test as prescribed in N.3.1. may be readily and accurately determined in 20 minutes operation.

S.1.5. ADVANCEMENT OF PRIMARY INDICATING OR RECORDING ELEMENTS.- The primary indicating and recording elements shall advance only when the belt conveyor is in operation and running. The most sensitive indicating element of the master weight totalizer may advance continuously or intermittently; all other elements shall advance intermittently.

S.2. DESIGN OF WEIGHING ELEMENTS.- A belt-conveyor scale shall be so designed as to combine automatically belt travel with belt load in order to provide a determination of the weight of the material that has passed over the scale.

S.2.1. ADJUSTABLE WEIGHING ELEMENTS.- An adjustable element that can affect the balance or the calibration of the device shall be held securely in adjustment and shall not be adjustable from outside the device unless a tool is required to make the adjustment.

S.3. MARKING REQUIREMENTS.- A belt-conveyor scale shall be marked with the following (Item (d) to be marked after calibration):

(a) The rated capacity in terms of units of weight per hour.
(b) The belt speed in terms of feet per minute at which the belt will deliver the rated capacity.

(c) The value of the smallest unit on the master weight totalizer.
(d) Number of weight units totalized for a specific chain (pounds per foot) for a specific number of feet of belt travel, or for a specific load of test weights for a specific number of feet of belt travel, or for a specific calibrating plate (pounds per foot) for a specific number of feet of belt travel.

N. NOTES

N.1. GENERAL.- Belt-conveyor scales are capable of very accurately weighing a statically applied test load, yet their ability to accurately weigh bulk material carried on a moving loaded belt conveyor may be detrimentally affected by the conditions of the installation. Calibration to theoretical weight figures derived from designed capacity and actual belt speed may have to be adjusted to compensate for effects of belt stiffness and tension. Whenever such a calibration adjustment is made, a simulated test, as described in N.3.3., will confirm that the device is performing satisfactorily. The first test of the device should be a Material Test in accordance with N.3.2. and the correlation with the Simulated Test (N.3.3.) suitable for the device should be established at this time. Subsequent tests may then be made following one of the simulated test procedures described under N.3.3. [Amended 1980]

N.2. CONDITIONS OF TESTS.- A belt-conveyor scale shall be tested after it is installed on the conveyor with which it is to be used and under such environmental conditions as may normally be expected. The scale shall be tested at between 50 and 100 percent of rated capacity. Each test shall be not less than:

(a) 10 minutes duration,
(b) 3 circuits (revolutions) of the belt, and
(c) 500 significant figures on the master weight totalizer.

N.3. TESTING PROCEDURES.

N.3.1. ZERO LOAD TEST.- If a belt conveyor has been idle for a period of two hours or more, before the start of the test the conveyor shall be run empty for not less than 15 minutes. The test shall then be conducted with the belt conveyor empty for an interval of not less than 10 minutes and not less than three circuits of the belt. The counter shall be read when a marked spot on the belt passes a marked spot on the conveyor at the beginning and conclusion of the test. The zero-load test error shall not exceed 0.05 percent of the rated capacity per hour of test.

N.3.2. MATERIAL TEST.- Use bulk material, preferably that material for which the device is normally used. Either pass a preweighed quantity of material over the belt-conveyor scale in a manner as similar as feasible to actual loading conditions, or statically weigh (on a suitable scale) all material that has passed over the belt-conveyor scale during a Material Test. 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 followed. To assure that the test load is accurately weighed and determined, the following precautions shall be observed:

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

(b) Actual empty or tare weight of containers shall be determined at the time of the test. Stencilled tare weight of railway cars or trucks shall not be used.
(c) When a pre-weighed test load is passed over the scale, the belt-loading hopper shall be examined before and after the test to assure that the hopper was empty and that only the material of the test load is passed over the scale.
(d) Any scale used to calibrate a test load of product should, as a prerequisite, be tested first with test weights with a sufficient number of known test loads to permit the compensation for any apparent ratio errors during the Material Test.
(e) When a railway track scale is used to weigh the test load, not more than 24 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 eight hours.
(f) The test shall not be conducted when it is raining or snowing unless adequate precautions are taken to assure that the weight of the test load is not affected.

N.3.3. SIMULATED TESTS.- One of the following tests, in accordance with the recommendation of the belt-conveyor scale manufacturer, should be used:

(a) CHAIN TEST.- A suitable test chain of the free-roller or wheel type, stamped with a certified weight per foot, may be connected to a stationary part of the structure and allowed to ride on the belt over the scale. The test chain should extend across all scale rollers and, in addition, not less than two idler rollers before and beyond the scale. The length of belt that has passed over the scale during the test must be accurately measured in terms of feet. The test load is the actual belt travel, in terms of feet, divided by the marked belt travel, in terms of feet, times the marked number of weight units totalized.
(b) KNOWN WEIGHT TEST.- Test weights equal to the marked test load may be placed upon or suspended from that portion of the scale which supports the belt. The length of belt which has passed over the scale during the test must be accurately measured, in terms of feet. The test load is the actual belt travel, in terms of feet, divided by the marked belt travel, in terms of feet, times the marked number of weight units totalized.
(c) CALIBRATED PLATE TEST.- For a noncontact scale where mass is determined by absorption of energy, a suitable plate calibrated by the scale manufacturer and marked in equivalent pounds per foot of belt may be used. The length of belt which has passed over the scale during the test must be accurately measured in terms of feet. The test load is the actual belt travel, in terms of feet, divided by the marked belt travel, in terms of feet, times the marked number of weight units totalized.

T. TOLERANCES

T.1. APPLICATION.- The tolerances hereinafter prescribed shall be applied to errors of underregistration and to errors of overregistration.

T.2. TOLERANCE VALUES.- Maintenance and acceptance tolerances shall be 0.5 percent of test load.

T.3. TOLERANCE VALUES-SIMULATED TESTS-REPEATABILITY TESTS.- The variation in the values obtained during the conduct of simulated tests shall not be greater than plus or minus 0.125% (1 part in 800) of the value obtained on the first acceptable simulated test. [Added 1980]

UR. USER REQUIREMENTS

UR.1. SELECTION REQUIREMENTS.- A belt-conveyor scale shall be operated between 50 and 100 percent of its rated capacity.

UR.2. INSTALLATION REQUIREMENTS.

UR.2.1. PROTECTION FROM WIND AND WEATHER EFFECTS.- The scale and the conveyor at the scale shall be protected from wind and weather effects.

UR.2.2. CONVEYOR INSTALLATION.- 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. Unless the scale is the "noncontact" or nuclear type, or 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 installed at least 20 feet or 5 idler spaces, whichever is greater, from loading point, skirting, head or tail pulley, or convex curve in the conveyor, and at least 40 feet from any training idler.
(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 70 feet from the scale.
(d) There shall be no trippers in the conveyor.
(e) The conveyor shall be no longer than 1,000 feet from head to tail pulley.
(f) The angle of the troughing idlers shall not exceed 35 degrees.
(g) The idlers on the scale and at least two before and two after the scale shall be concentric, at 90 degrees to the belt centerline and properly spaced.
(h) Conveyor stringers at the scale and for no less than 20 feet 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.
(i) A conveyor scale shall be so installed that neither its performance or operation will be adversely affected by any characteristic of the foundation, supports, or any other equipment.
(j) The scale area and 3 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 on both sides of the conveyor.
(k) Conveyor belting shall be no heavier than is required for installation. When loaded to 50 percent or more of scale capacity, the belt shall contact the center or horizontal portion of the idlers. [Amended 1980]

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).* [Added 1980]

UR.3. USE REQUIREMENTS.

UR.3.1. LOADING.- Feed of material to the scale shall be controlled, if necessary, to assure that at normal operation the material flow is between 50 percent and 100 percent of the rated capacity.

UR.3.2. MAINTENANCE.- Belt-conveyor idlers and scale shall be maintained in accordance with scale manufacturer's instructions.

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the Belt-Conveyor Scale Code.

belt conveyor. An endless moving belt for transporting material from place to place.

belt-conveyor scale. A device installed on a belt conveyor to measure the weight of bulk material being conveyed.

calibrated plate. A suitable metal plate, provided by the scale manufacturer, determined to have the same effect on a nuclear scale as a specified load or bulk material on the belt conveyor. A calibrated plate is the equivalent of a test chain or test weights used with other types of belt-conveyor scales.

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

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

conveyor stringers. Support members for the conveyor on which the idlers are mounted.

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.

idler space. The center-to-center distance between idler rollers measured parallel to the belt.

idlers or idler rollers. Freely turning cylinders mounted on a frame to support the conveyor belt. For a flat belt the idlers may consist of one or more horizontal cylinders transverse to the direction of belt travel. For a troughed belt, the idler will 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.

loading point. The location at which material to be conveyed is applied to the conveyor.

nuclear type (noncontact) scale. A device consisting of a source of nuclear radiation and a detector for that radiation. Absorption of radiation determines the mass of the material passing between the source and the detector.

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rated capacity. That value representing the weight that can be delivered by the device in one hour.

simulated test. A test using artificial means of loading the scale to determine the performance of a belt-conveyor scale.

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.

tail pulley. The pulley at the opposite end of the conveyor from the head pulley.

take-up. A device to assure sufficient tension in a conveyor belt that the belt will be positively driven by the drive pulley. A counterweighted take-up consists of a horizontal pulley free to move in either the vertical or horizontal direction with dead weights applied to the pulley shaft to provide the tension required.

test chain. A device 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.

totalizer. A device used with a belt-conveyor scale to indicate the weight of material which has been conveyed over the scale. The master weight totalizer is the primary indicating element of the belt-conveyor scale. An auxiliary vernier counter used for scale calibration is not part of the master weight totalizer. Auxiliary remote totalizers may be provided. The totalizer shows the accumulated weight and may be nonresettable or may be reset to zero to measure a definite amount of material conveyed.

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.

tripper. A device for unloading a belt conveyor at a point between the loading point and the head pulley.

SEC. 2.22. 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 100 grains or 6 grams and larger shall be made of a metal, or a metal alloy, not softer than brass.

(b) Weights of less than 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 30 grains or 2 grams 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 grams, 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 abbreviation 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 on 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 25 percent of the smallest tolerance to be applied. (See Sec. 1.11; 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 TOLERANCES FOR AVOIRDUPOIS WEIGHTS

Nominal value	Maintenance tolerance		
	Equal-arm weights	Counterpoise weights	
		For scales with multiples of less than 1 000	For scales with multiples of 1 000 and over
Ounces	Grains	Grains	Grains
1/64	0.1		
1/32	.3		
1/16	.4		
1/8	.5		
1/4	1.0		
1/2	1.5	1.0	
1	1.7	1.0	
2	2.0	1.0	
3	2.0	1.5	
4	3.0	1.5	1.0
5	3.5	1.5	1.0
6	3.5	1.5	
8	4.0	2.0	1.5
10	4.0	2.5	2.0
12	5.0	2.5	2.0
Pounds			
1	5.0	3.0	2.5
2	7.0	6.0	4.0
3	9.0	9.0	5.0
4	11.0	11.0	6.0
5	15	12.0	6.5
6	17		
7	19		
8	21	15.0	9.0
9	23		
10	25	18.0	10.0
15	28		
20	30		
25	35		
30	40		
40	45		
50	50		

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TABLE 2.- MAINTENANCE TOLERANCES FOR METRIC WEIGHTS

Nominal value	Maintenance tolerance
Milligrams	Milligrams
5 or less	0.1
10	.3
20	.4
30	.6
50	.8
100	1.0
200	1.5
300	2.0
500	3.0
Grams	
1	4
2	6
3	8
5	10
10	15
20	20
30	30
50	40
100	70
200	100
300	150
500	175
Kilograms	
1	250
2	400
3	500
5	800
10	1,000
20	1,500
Carats	Milligrams
0.25 (25 points) or less	0.6
5 (50 points)	1.0
1.0	1.5
2.0	2.0
3.0	3.0
5.0	4.0
10.0	6.0
20.0	10.0
30.0	12.0
50.0	15.0
100.0	25.0

TABLE 3.- MAINTENANCE TOLERANCES FOR APOTHECARIES AND TROY WEIGHTS

Nominal value	Maintenance tolerance	
Grains	Grains	Milligrams
1	0.01	0.6
2	.02	1.3
3	.03	2.0
5	.03	2.0
10	.04	2.5
20	.06	4.0
Scruples		
1	0.06	4.0
2	.10	6.5
Drams		
0.5	0.07	4.5
1.0	.10	6.5
2.0	.20	13.0
3.0	.30	20.0
4.0	.40	25.0
5.0	.50	30.0
6.0	.60	40.0
Pennyweights		
1	0.06	4.0
2	.10	6.5
3	.15	10.0
4	.20	13.0
5	.30	20.0
10	.40	25.0
Ounces		
1	0.4	25.0
2	.6	40.0
3	1.0	65.0
4	1.5	100.0
5	1.6	105.0
6	1.8	115.0
7	1.9	125.0
8	2.0	130.0
9	2.1	135.0
10	2.2	145.0
11	2.4	155.0
12	2.5	160.0
20	2.9	190.0
30	3.7	240.0
50	5.4	350.0
100	7.7	500.0
200	12.3	800.0
300	15.4	1000.0
500	23.1	1500.0
1000	38.6	2500.0

SECTION 3

SEC. 3.30. LIQUID-MEASURING DEVICES

A. APPLICATION

A.1.- This code applies to devices used for the measurement of liquids, including liquid fuels and lubricants.

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

(a) Meters mounted on vehicle tanks (for which see Sec. 3.31; Code for Vehicle-Tank Meters).
(b) Devices used for dispensing liquefied petroleum gases (for which see Sec. 3.32; Code for Liquefied Petroleum Gas 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.
(e) Devices used solely for dispensing a product in connection with operations in which the amount dispensed does not affect customer charges.

A.3.- See also Sec. 1.14; 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 liquid-measuring 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 liquid-measuring device shall indicate, and record if the device is equipped to record, its deliveries in terms of gallons, quarts, pints, or binary-submultiple or decimal subdivisions of the gallon.

S.1.1.2.1. ON RETAIL MOTOR FUEL DEVICES.- A retail motor fuel device shall indicate, and record if the device is equipped to record, its deliveries in terms of liters or gallons and decimal subdivisions or fractional equivalents thereof. [Added 1979]

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) one pint on retail devices, and
(b) one gallon on wholesale devices.

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.1.2. 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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 0.06 inch.

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

S.1.4. FOR RETAIL DEVICES ONLY, EXCEPT SLOW-FLOW METERS.

S.1.4.1. INDICATION OF DELIVERY.- A retail liquid-fuel 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.- 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 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. Means shall be provided to prevent the return of primary indicating elements, and of primary recording elements if the device is so equipped, beyond their correct zero position. [Amended 1972]

S.1.4.3. DISPLAY OF UNIT PRICE AND PRODUCT IDENTITY.- In a device of the computing type or of the money-operated 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, means also shall be provided for displaying on each face of the device the identity of the grade, brand, blend, or mixture being dispensed.

S.1.4.4. MONEY-VALUE COMPUTATIONS.- Money-value computations on a retail device 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. Any analog money value indication shall not differ from the mathematically computed money value (Quantity x Unit Price = Sales Price), for any delivered quantity, by an amount greater than one-half the value of the money value division. [Amended 1980]

S.1.4.4.1. 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 $1.00 per gallon or $0.25 per liter.
(b) not more than 2 cents at unit prices greater than $1.00 per gallon or $0.25 per liter up to and including $3.00 per gallon or $0.75 per liter.
(c) not more than 5 cents at all unit prices greater than $3.00 per gallon or $0.75 per liter. [Amended 1981]

S.1.4.4.2. 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 units and 0.02 liter for devices indicating in metric units. [Added 1980]

S.1.4.5. TRAVEL OF INDICATOR ON LUBRICANT DEVICES.- On a lubricant 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 1 pint shall be not less than 1 inch.

S.1.5. FOR WHOLESALE DEVICES ONLY.

S.1.5.1. TRAVEL OF INDICATOR.- A wholesale device shall be readily operable to deliver accurately any quantity from 50 gallons 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 1 gallon shall be not less than 0.20 inch.

S.1.5.2. 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. DESIGN OF MEASURING ELEMENTS.

S.2.1. VAPOR ELIMINATION.- A liquid-measuring device or 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. [Amended 1975]

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 (nonretroactive as of 1965).

S.2.3. DIRECTIONAL FLOW VALVES.- Valves intended to prevent reversal of flow shall be automatic in operation.

S.2.4. STOP MECHANISM.- If stops or other stroke-limiting elements are subject to direct pressure or impact, the security of their position shall be accomplished by positive, nonfrictional engagement of parts, and they shall be adjustable to provide for deliveries within prescribed tolerances. If two or more stops or other elements may selectively be brought into operation to permit deliveries of predetermined amounts, the position for the proper setting of each such element shall be accurately defined, inadvertent displacement from position shall be obstructed, and the delivery for which the device is set at any time shall be conspicuously indicated.

S.2.5. FOR RETAIL DEVICES ONLY.

S.2.5.1. ZERO-SET-BACK INTERLOCK.- A retail motor-fuel device of the meter type shall be so constructed that, after a particular delivery cycle has been completed by movement of the starting lever to any position that shuts off the device, an effective automatic interlock will prevent a subsequent delivery being started until the indicating elements and recording elements, if the device is equipped and activated to record, have been returned to their correct zero positions. *Provision shall be made for the starting*

lever to be in its designed shut-off position and for the zero-set-back interlock to be engaged before the discharge nozzle can be returned to its designed hanging position (nonretroactive as of 1970). In a system with more than one dispenser supplied by a single pump, there shall be incorporated in each dispenser an effective automatic control valve which will prevent product being delivered by a dispenser until the indicating elements on that dispenser have been returned to a correct zero position. [Amended 1981]

S.2.6. FOR WHOLESALE DEVICES EQUIPPED WITH AUTOMATIC TEMPERATURE COMPENSATORS.

S.2.6.1. 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 60 °F.

S.2.6.2. 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 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.2.6.3. PROVISION FOR SEALING AUTOMATIC TEMPERATURE COMPENSATOR.- 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.2.6.4. THERMOMETER WELL WITH AUTOMATIC TEMPERATURE COMPENSATION.- Means shall be provided for inserting, for test purposes, a mecury-in-glass thermometer either

(a) in the liquid chamber of the meter, or
(b) in the meter inlet or discharge line and immediately adjacent to the meter.

S.2.7. FOR LUBRICANT DEVICES ONLY.

S.2.7.1. EXHAUSTION OF SUPPLY.- On a lubricant device other than one of the meter type, means shall be provided for making the device inoperable or for giving a conspicuous and distinct warning when the level of the supply of lubricant becomes so low as to endanger the accuracy of measurement.

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 discharge lines therefrom. However, two delivery outlets may be installed on a motor-fuel device used exclusively in the fueling of trucks if means are provided to insure that liquid can flow from only one such outlet at one time.

S.3.2. PUMP-DISCHARGE UNIT.- If a pump-discharge unit is equipped with a flexible discharge hose, this shall be of the wet-hose type.

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; however, the discharge line may have a shutoff valve at or near the outlet end, provided the line will drain to the same level under all anticipated conditions of product discharge. A 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. 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. 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.

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. AIR PRESSURES.- If a device is operable by air pressure, the air-pressure gage shall show, by special graduations or otherwise, the maximum and minimum working pressures recommended by the manufacturer.

S.4.3. FOR WHOLESALE DEVICES ONLY.

S.4.3.1. DISCHARGE RATES.- A wholesale device shall be marked to show its designed maximum and minimum discharge rates. However, such minimum discharge rate shall not exceed 20 percent of such 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 60 °F.

N. NOTES

N.1. TEST LIQUID.- A liquid-measuring device shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics. A seal or tag should be attached to wholesale devices by the weights and measures official following a satisfactory examination indicating the product used during the test. [Amended 1976]

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.

N.3.1. FOR 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. FOR SLOW-FLOW METERS.- Test drafts shall be equal to at least four times the minimum volume that can be measured by the device and indicated through either a visible indication or an audible signal.

N.3.3. FOR LUBRICANT DEVICES.- Tests shall include a draft of 1 quart, and may include drafts of 1 pint, 4 quarts, and 6 quarts.

N.3.4. FOR OTHER RETAIL DEVICES.- Tests shall include drafts of 1 or more amounts, including drafts of at least 5 gallons.

N.3.5. FOR WHOLESALE DEVICES.- 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 then 50 gallons.

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. If a wholesale device is equipped with an automatic temperature compensator, this test should be conducted with the temperature compensator deactivated.

N.4.1.1. AUTOMATIC TEMPERATURE COMPENSATION ON WHOLESALE DEVICES.- If a device is equipped with an automatic temperature compensator, the compensator shall be tested by comparing the volume indicated or recorded by the device with the compensator connected and operating, with the actual delivered volume corrected to 60 °F.

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. FOR SLOW-FLOW METERS.- A "special" test of a slow-flow meter shall be made at a flow rate at least as small as twice the minimum flow rate, and not smaller than the minimum flow rate, to which the meter is subjected, according to the particular installation.

N.4.2.2. FOR RETAIL MOTOR-FUEL DEVICES.- A "special" test of a retail motor-fuel device shall be made at a minimum discharge rate of

(a) 5 gallons per minute,
(b) the minimum discharge rate marked on the device, or
(c) the minimum discharge rate at which the device will deliver when equipped with an automatic discharge nozzle set at its slowest setting, whichever is least.

N.4.2.3. FOR OTHER RETAIL DEVICES.- "Special" tests of other retail devices shall be made at a minimum discharge rate of

(a) 50 percent of the maximum discharge rate developed under the conditions of installation, or
(b) the minimum discharge rate marked on the device, whichever is less.

N.4.2.4. FOR WHOLESALE DEVICES.- "Special" tests of a wholesale device shall be made as follows:

(a) At a minimum discharge rate of 20 percent of the marked maximum discharge rate or the minimum discharge rate marked on the device, whichever is less.
(b) To develop the operating characteristics of any special elements and accessories attached to or associated with the device.

N.4.3. ELAPSED-TIME TESTS.

N.4.3.1. DURATION.- The duration of an elapsed-time test on a liquid-measuring device shall in no case exceed 24 hours.

N.4.3.2. TEMPERATURE ADJUSTMENT.- In an elapsed-time test, the observed error on the delivery made after the device has stood unused shall be "adjusted," if necessary, by allowing for the unavoidable volume change of the liquid in the device resulting from changes in temperature occurring during the period of nonuse of the device. When adjustments are necessary, appropriate petroleum measurement tables should be used. [Amended 1974]

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 test measure. When adjustments are necessary, appropriate petroleum measurement tables should be used. [Amended 1974]

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.

T.2.1. ON RETAIL DEVICES EXCEPT SLOW-FLOW METERS.-

T.2.1.1. FOR DEVICES INDICATING IN INCH-POUND UNITS.- The maintenance tolerance on normal and special tests, except on elapsed time tests, shall be one cubic inch plus one cubic inch per indicated gallon and never less than 2 cubic inches. The acceptance tolerance shall be 1/2 the maintenance tolerance. [Amended 1981]

T.2.1.2. FOR DEVICES INDICATING IN METRIC UNITS.- The maintenance tolerance on normal and special tests, except on elapsed time tests, shall be 20 milliliters, plus 4 milliliters per indicated liter and never less than 40 milliliters. The acceptance tolerance shall be 1/2 the maintenance tolerance. The tolerance applied to a 19-liter draft shall be that tolerance applicable to a 20-liter draft. [Amended 1981]

T.2.2. ON SLOW-FLOW METERS.- Maintenance tolerances and acceptance tolerances shall be as shown in table 1.

T.2.3. ON WHOLESALE DEVICES.- Maintenance tolerances and acceptance tolerances, except on elapsed-time tests, shall be as shown in table 2.

TABLE 1.- TOLERANCES FOR SLOW-FLOW METERS

Indication	On normal tests				On special tests	
	Maintenance tolerances		Acceptance tolerances		Maintenance and acceptance tolerances	
	Percent	(Minims)	Percent	(Minims)	Percent	(Minims)
1 gill	1.0	(20)	0.75	(15)	1.25	(25)
0.05 gallon	1.0	(30)	.75	(25)	1.25	(40)
1/2 pint	1.0	(40)	.75	(30)	1.25	(50)
0.10 gallon	1.0	(60)	.75	(45)	1.25	(75)
1 pint	1.0	(75)	.75	(60)	1.25	(95)
0.20 gallon	1.0	(120)	.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)	.60	(3)	1.0	(5)
1 gallon and over	.75	(8 per gallon)	.60	(6 per gallon)	1.0	(10 per gallon)

TABLE 2.- MAINTENANCE AND ACCEPTANCE TOLERANCES ON WHOLESALE DEVICES, EXCEPT ON ELAPSED-TIME TESTS.

Indication	On normal tests		On special tests
	Maintenance tolerance	Acceptance tolerance	Maintenance and acceptance tolerances
Gallons	Cubic inches	Cubic inches	Cubic inches
50	50	25	50
Over 50	Add 1/2 cubic inch per indicated gallon	Add 1/4 cubic inch per indicated gallon	Add 1 cubic inch per indicated gallon

T.2.4. ON ELASPED-TIME TESTS.- Maintenance tolerances on elapsed-time tests of liquid-measuring devices shall be as follows:

(a) For a retail device, 2 cubic inches on a test extending over a period of 1 hour or less, plus an additional 1/2 cubic inch for each hour or fractional part thereof beyond the first hour, but in no case more than 6 cubic inches.

(b) For a wholesale device, 5 cubic inches per hour.

Acceptance tolerances shall be one-half the maintenance tolerances. (The error to which these tolerances are applied is the leakage error.)

3.30. Liquid-Measuring Devices

UR. USER REQUIREMENTS

UR.1. SELECTION REQUIREMENTS.

UR.1.1. LENGTH OF DISCHARGE HOSE.- The length of the discharge hose on a retail motor-fuel device shall not exceed 18 feet, measured from the outside of the housing of the device to the inlet 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. (On a hose that is coiled or otherwise retained or connected inside the housing, the measurement shall be made with the hose fully extended.) Unnecessarily remote location of a device shall not be accepted as justification for an abnormally long hose. [Amended 1972].

UR.1.1.1. FOR MARINAS AND AIRPORTS.- The length of the discharge hose shall be as short as practicable, and shall not exceed 50 feet unless it can be demonstrated that a longer hose is essential. Discharge hoses exceeding 18 feet in length shall be adequately protected from weather and other environmental factors when not in use. (Made retroactive as of 1974)

UR.2. INSTALLATION REQUIREMENTS.

UR.2.1. 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.2.2. 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.2.3. SUCTION HEAD.- A piston-type device shall be so installed 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 from either of the delivery outlets will be readily apparent.

UR.2.5. PRODUCT STORAGE IDENTIFICATION.- 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. When the device is marked by means of a color code, the code key shall be conspicuously displayed at the place of business. [Added 1975 and amended 1976]

UR.3. USE REQUIREMENTS.

UR.3.1. RETURN OF INDICATING ELEMENT TO ZERO.- On any device used in making individual retail deliveries to individual consumers, the primary indicating element, except totalizers on key-lock or other self-operated devices, and the primary recording element if the device is equipped to record, shall be returned to zero before each such delivery.

UR.3.2. UNIT PRICE AND PRODUCT IDENTITY.- On a retail device there shall be displayed on each face of the device the price at which the product is offered for sale, and in the case of a computing type or money-operated type the unit price at which the device is set to compute and deliver. There shall also be conspicuously displayed on each face

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, there shall be displayed on each face of the device, at any time the device is in service, the identity of the grade, brand, blend or mixture which the device is set to dispense. [Amended 1972]

UR.3.3. PRINTED TICKET.- Any printed ticket issued by a device of the computing type an which there is printed the total computed price, the total volume of the delivery or the price per gallon, shall have shown thereon also the other two values (either printed or in clear hand script).

UR.3.4. ACTIVATION OF ZERO-SET-BACK INTERLOCK AND POSITION OF STARTING LEVER AND DISCHARGE NOZZLE.- On a retail motor-fuel device the starting lever shall be returned to its shutoff position and the zero-set-back interlock engaged following each delivery to a customer. The discharge nozzle shall be returned to its designed hanging position following each delivery to a customer unless the primary indicating and recording elements, if the device is equipped and activated to record, have been returned to a definite zero indication.

UR.3.5. TEMPERATURE COMPENSATION-WHOLESALE.

UR.3.5.1. USE OF AUTOMATIC TEMPERATURE COMPENSATORS.- If a wholesale 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.3.5.2. WRITTEN INVOICES.- Any written invoice based on a reading of a wholesale device that is equipped with an automatic temperature compensator shall have shown thereon that the volume delivered has been adjusted to the volume at 60 °F.

UR.3.5.3. NONAUTOMATIC TEMPERATURE COMPENSATION.- If the volume of the product delivered is adjusted to the volume at 60 °F, the product temperature shall be taken during the delivery in the liquid chamber of the meter or in the meter inlet or discharge line adjacent to the meter, or shall be taken in the compartment of the receiving vehicle at the time it is loaded. The accompanying invoice shall indicate that the volume of the product has been adjusted for temperature variations to a volume of 60 °F and shall also state the product temperature used in making the adjustment.

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the Code for Liquid-Measuring Devices.

dry hose. A discharge hose intended to be completely drained at the end of each delivery of liquid. (See dry-hose type.)

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.)

elapsed-time test. One to determine the leakage error that results solely from nonuse of a liquid-measuring device.

gravity type. A type of device designed for discharge by gravity.

leakage error. On an elapsed-time test of a liquid-measuring device, the difference between the error on a normal delivery of a given nominal amount and the temperature-corrected error on a delivery of the same nominal amount made after the device has stood unused.

liquid fuel. Any liquid used for fuel purposes, that is, as a fuel, including motor fuel.

liquid-fuel device. A device designed for the measurement and delivery of liquid fuels.

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.

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).

motor fuel. Liquid used as fuel for internal-combustion engines.

motor-fuel device. A device designed for the measurement and delivery of liquids used as fuel for internal-combustion engines.

pressure type. A type of device designed for operation with the liquid under pressure artificially produced.

retail device. A device designed for single deliveries of less than 100 gallons and, in addition, any device designed or used for retail deliveries of motor fuels to individual highway vehicles.

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.

test liquid. The liquid used during the test of a device.

visible type. A type of device in which the measurement takes place in a visible glass measuring chamber.

wet hose. A discharge hose intended to be full of liquid at all times.

wet-hose type. A type of device designed to be operated with the discharge hose full of liquid at all time.

wholesale device. Any device other than a retail device. (See retail device.)

SEC. 3.31. VEHICLE-TANK METERS

A. APPLICATION

A.1.- This code applies to meters mounted on vehicle tanks.[1]

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 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. 1.14; 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 meter shall indicate, and record if the meter is equipped to record, its deliveries in terms of gallons. Fractional parts of the gallon shall be in terms of either decimal or binary subdivisions.

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) one pint on milk-metering systems and on meters used for retail deliveries of liquid fuel for domestic use, and
(b) one gallon on other meters.

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

[1] Requirements for milk-metering systems were added in 1972. See also Sec. 3.35; Milk Meters (Tentative Code).

(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 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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is associated with the graduation.

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 0.04 inch.

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 0.06 inch.

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 0.20 inch.

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 gallon at which the device is set to compute.

S.1.4.2. 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 volume of the delivery in terms of gallons and the appropriate fraction of the gallon and the price per gallon.

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 0.1 gallon. [Amended 1979]

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 one 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 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.

The adjusting mechanism shall be readily accessible for purposes of affixing a security seal (nonretroactive as of 1965).

S.2.2.1. MILK-METERING SYSTEMS.- Adequate provision shall be made for applying security seals to the adjustment mechanism and the register.

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.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 20 feet 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 REQUIREMENT.

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, such minimum discharge rate shall not exceed 20 percent of such maximum discharge rate.

S.5.3. MEASURING COMPONENTS--MILK-METERING SYSTEM.- All components that affect the measurement of milk which 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.

N. NOTES

N.1. TEST LIQUID.- A measuring system shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics. A seal or tag should be attached by the weights and measures official following a satisfactory examination indicating the product used during the test. [Amended 1975]

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 one minute at its maximum discharge rate, and shall in no case be less than 50 gallons.

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.

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 tests 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 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 table 1 and table 2.

TABLE 1.- TOLERANCES FOR VEHICLE-TANK METERS EXCEPT MILK METERS

Indication	On normal tests		On special tests
	Maintenance tolerance	Acceptance tolerance	Maintenance and acceptance tolerances
Gallons	Cubic inches	Cubic inches	Cubic inches
50	50	25	50
Over 50	Add 1/2 cubic inch per indicated gallon	Add 1/4 cubic inch per indicated gallon	Add 1 cubic inch per indicated gallon

TABLE 2. TOLERANCES FOR MILK METERS

Indication	Maintenance tolerance	Acceptance tolerance
Gallons	Gallons	Gallons
100	0.5	0.3
200	0.7	0.4
300	0.9	0.5
400	1.1	0.6
500	1.3	0.7
Over 500	Add 0.002 gallon per indicated gallon	Add 0.001 gallon per indicated gallon

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 so installed as to permit complete drainage and that all available product is measured following each pickup.

3.31. Vehicle-Tank Meters

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 LIQUID-MEASURING DEVICES

A. APPLICATION

A.1.- This code applies to devices used for the measurement of liquefied petroleum gas 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. 1.14; 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, or binary-submultiple or decimal subdivisions of the gallon.

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) one pint on retail devices, and
(b) one gallon on wholesale devices.

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 on a motor-fuel device, which must be to the nearest one cent of money value. (See Sec. 1.13; G-S.5.5.)

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 gallons and the appropriate fraction of the gallon and the price per gallon. [Added 1979]

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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 0.06 inch.

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.- Primary indicating elements shall be readily returnable to a definite zero indication. Primary recording elements on a retail motor-fuel device, 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 primary indicating elements, and of primary recording elements if these are returnable to zero, beyond their correct zero position.

S.1.4.3. 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, means also shall be provided for displaying on each face of the device the identity of the grade, brand, blend, or mixture being dispensed.

S.1.4.4. MONEY-VALUE COMPUTATIONS.- Money-value computations on a retail device 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 0.1 gallon. [Amended 1979]

S.1.5. FOR WHOLESALE DEVICES ONLY.

S.1.5.1. TRAVEL OF INDICATOR.- A wholesale device shall be readily operable to deliver accurately any quantity from 50 gallons 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 1 gallon shall be not less than 0.20 inch.

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 (nonretroactive as of 1965).

S.2.3. DIRECTIONAL FLOW VALVES.- Valves intended to prevent reversal of flow shall be automatic in operation.

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.- Means shall be provided for inserting, for test purposes, a mercury-in-glass thermometer either

(a) in the liquid chamber of the meter, or
(b) in the meter inlet or discharge line and immediately adjacent to the meter.

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 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 gallons compensated 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. FOR RETAIL MOTOR-FUEL DEVICES ONLY.

S.2.7.1. ZERO-SET-BACK INTERLOCK.- A retail motor-fuel device of the meter type shall be so constructed that, after a particular delivery cycle has been completed by movement of the starting lever to its shut-off position, or to what would appear to be its normal shutoff position from some reasonable "customer" position, an effective automatic interlock will prevent a subsequent delivery being started until the indicating elements have been returned to their correct zero positions.

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 conjuction 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) 5 gallons per minute for motor-fuel devices, or
(b) 20 percent of the marked maximum discharge rate for other retail devices and for wholesale devices.

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 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 maximum discharge rate, and shall in no case be less than 10 gallons for a retail motor-fuel device and 50 gallons for any other device.

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. If the device is equipped with an automatic temperature compensator, this test should be conducted with the compensator deactivated.

N.4.1.1. AUTOMATIC TEMPERATURE COMPENSATION.- If a device is equipped with an automatic temperature compensator, the compensator shall be tested by comparing the volume indicated or recorded by the device with the compensator connected and operating, with the actual delivered volume corrected to 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. 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) 5 gallons 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) 10 gallons per minute for a device with a rated maximum discharge less than 50 gallons per minute.
(b) 20 percent of the marked maximum discharge rate for a device with a rated maximum discharge of 50 gallons per minute or more, or
(c) the minimum discharge rate marked on the device, whichever is least.

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.

T.2.1. ON NORMAL TESTS.- The maintenance tolerance on "normal" tests shall be 4 cubic inches per indicated gallon on underregistration and 2 cubic inches per indicated gallon on overregistration. The acceptance tolerance on "normal" tests shall be 2 cubic inches per indicated gallon on underregistration and 1 cubic inch per indicated gallon on overregistration.

T.2.2. ON SPECIAL TESTS.- The maintenance and acceptance tolerances shall be 4 cubic inches per indicated gallon on underregistration and 2 cubic inches per indicated gallon on overregistration.

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 motor-fuel device shall not exceed 15 feet, 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.

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 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. (see also 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. WRITTEN INVOICES.- Any written invoice based on a reading of a device that is equipped with an automatic temperature compensator shall have shown thereon that the volume delivered has been adjusted to the volume at 60 °F.

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.

DEFINITION OF TERMS

The terms defined here have a special and technical meaning when used in the Code for Liquefied Petroleum Gas Liquid-Measuring Devices.

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.

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 volume, 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.

motor-fuel device. A stationary device primarily used for retail deliveries of liquefied petroleum gas as motor fuel to the fuel tanks of individual highway vehicles.

retail device. A device used for single deliveries of liquefied petroleum gas for domestic or non-resale use.

wholesale device. Any device other than a retail device.

SEC. 3.33. LIQUEFIED PETROLEUM GAS VAPOR-MEASURING DEVICES

A. APPLICATION

A.1.- This code applies to positive displacement, low-pressure (5 psi or less) devices used for the measurement of liquefied petroleum gas in the vapor state.

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. 3.22; Code for Liquefied Petroleum Gas 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. 1.14; 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 cubic feet or cubic meters or multiple or decimal subdivisions of these units. [Amended and made nonretroactive as of 1972. To become retroactive January 1, 1987, provided that individual marketers shall bring into compliance existing equipment in service as of the effective date of this requirement at the rate of 15 percent every two years.]*

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 100 cubic feet or 1 cubic meter (1 000 cubic decimeters). [Amended 1972]

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.- A device shall be equipped with a proving indicator measuring 1, 2, 5, or 10 cubic feet per revolution, or 0.025, 0.05, 0.1, 0.2, or 0.25 cubic meters per revolution, for testing the meter. The test circle of proving indicator shall be divided into ten equal parts. Additional subdivisions of one or more of such equal parts may be made. [Amended 1973]

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 0.04 inch for indicating elements and 0.02 inch for proving circles.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is 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 0.06 inch.

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.- The vapor should be measured at a gage pressure of 11 inches of water (0.40 psi) ± 2.75 inches of water (0.10 psi). Where vapor is being measured at a pressure other than 11 inches, a volume multiplier shall be applied based on the following equation:

Volume Multiplier =

$$\frac{\text{atmospheric pressure (psia) + gage pressure (psi)}}{\text{atmospheric pressure (psia) + 0.40 psi}}$$

[Amended 1980]

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 device may be equipped with an adjustable automatic means for adjusting the indication and registration of the measured volume of vapor product to the volume at 60 °F.

S.3. DESIGN OF DISCHARGE LINES AND SHUTOFF VALVES.

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.3.2. SHUTOFF VALVES.- The shutoff valve shall be located in the input line to the meter.

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 device shall be marked to show its rated gas capacity (cubic feet or cubic meters per hour). [Amended 1973]

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.

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 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.- Test drafts should be at least equal to one complete revolution of the largest capacity proving indicator, and shall in no case be

less than 2 cubic feet or 0.05 cubic meter. All flow rates should be controlled by suitable outlet orifices. [Amended 1973]

N.4. TEST PROCEDURES.- If a device is equipped with an automatic temperature compensator, the proving device reading shall be corrected to 60 °F, using an approved table. [Amended 1972]

N.4.1. NORMAL TESTS.- The normal test of a device shall be made at the capacity rate given on the badge of the meter.

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 60 °F.

N.4.2. SPECIAL TESTS.- "Special" tests, to develop the operatng 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 20 percent of the marked capacity rate, or the check rate if marked on the device, whichever is less.

N.4.2.2. LOW-FLAME TEST.- The device shall be tested at an extremely low-flow rate as given in table 1.

TABLE 1.- CAPACITY OF LOW-FLOW TEST RATE ORIFICES WITH RESPECT TO DEVICE CAPACITY

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

[Amended 1973]

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 liquefied petroleum 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 liquefied petroleum 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]

T.1.1. ON LOW-FLAME TESTS.- The maintenance and acceptance tolerances shall be 20 percent on underregistration and 10 percent on overregistration.

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.- Any invoice on which the charge is based on units other than cubic feet or cubic meters shall have shown thereon the cubic foot or cubic meter equivalent of the unit on which the charge is based.

Any invoice shall also include the altitude correction factor utilized in determining the quantity on which the charges are based. [Amended 1975]

UR.2.3. CORRECTION FOR ALTITUDE.- An approved multiplier table of corrections shall be used to correct for changes in the atmospheric pressure with respect to altitude. The multiplier for a particular installation shall be affixed on the front of the device near the badge. [Added 1972]

DEFINITION OF TERMS

The terms defined here have a special and technical meaning when used in the Code for Liquefied Petroleum Gas Vapor-Measuring Devices.

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.

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.

base pressure. The absolute pressure used in defining the gas measurement unit to be used, and is the gage pressure at the meter plus an agreed atmospheric pressure.

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

check rate. A rate of flow usually 20 percent of the capacity rate.

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 which 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 gage mark which partially surrounds tne gage glass in the upper neck.

cubic foot, metered. That quantity of gas which occupies one cubic foot when under pressure and temperature conditions existing in the meter.*

cubic foot, standard. That quantity of gas which occupies a volume of one cubic foot when under a pressure of 14.73 psia and at a temperature of 60 °F.*

ft^3/h. Cubic feet per hour.

gage pressure. The difference between the pressure at the meter and the atmospheric pressure (psi).

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*Source: American National Standards Institute, Inc. "American National Standard for Gas Displacement Meters (500 Cubic Feet per Hour Capacity and Under)," First Edition, 1974.

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.

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.

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

m^3/h. Cubic meters per hour.

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. Where two proving circles are present the circle representing the smallest volume per revolution is referred to as the "leak-test circle."

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.

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.

proving indicator. The test hand or pointer of the proving or leak-test circle on the meter register or index.

rated capacity. The rate of flow in cubic meters per hour of a liquefied petroleum 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.

SEC. 3.34. CRYOGENIC LIQUID-MEASURING DEVICES

A. APPLICATION

A.1.- This code applies to devices used for the measurement of cryogenic liquids, whether such devices are installed in a permanent location or mounted on a vehicle. 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.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 Liquid-Measuring Devices).
(b) Devices used soley 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. 1.14; 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 gallons or liters (NBP); pounds or cubic feet of gas (NTP), or decimal subdivisions or multiples thereof.

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) One-tenth gallon
    (2) One-half liter
    (3) One pound
    (4) One-half kilogram
    (5) Ten cubic feet of gas

(b) For Large Delivery Devices
    (1) One gallon
    (2) Five liters
    (3) Ten pounds
    (4) Five kilograms
    (5) One hundred cubic feet 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 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 of these are returnable to zero, 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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is associated with the graduation.

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 0.04 inch.

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 0.06 inch.

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 0.20 inch.

S.1.4. COMPUTING-TYPE DEVICES.

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 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 0.1 gallon. [Amended 1979]

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 passage of vapor through the device where such vapor will cause over-registration of or tend to damage or degrade the device. Vent lines from the vapor eliminator shall be made of metal tubing or some other suitably rigid material. [Amended 1978]

S.2.2. DIRECTIONAL FLOW VALUES.- 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 may be equipped with an adjustable automatic means for adjusting the indication and registration of the measured quantity of product to the quantity at the normal boiling point of the specific cryogenic product.

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, or for the purpose of precooling 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. MARKING REQUIREMENTS.

S.4.1. 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.4.2. DISCHARGE RATES.- A meter shall be marked to show its designed maximum and minimum discharge rates.

S.4.3. 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 quantity at the normal boiling point of the specific cryogenic product.

N. NOTES

N.1. TEST LIQUID.- A meter shall be tested with the liquid to be commercially measured or with a liquid or the same general physical characteristics.

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 vending 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 pounds.

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 50 gallons 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. Liquid Density and Volume Correction Factors (with respect to temperature and pressure) published in NBS Technical Note 361, Revised, Liquid Densities of Oxygen, Nitrogen, Argon, and Parahydrogen, shall apply.

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 which 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 COMPENSATION.- If 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. [Added 1978]

T. TOLERANCES

T.1. BASIC TOLERANCE VALUES.- Maintenance and acceptance tolerances for cryogenic liquid-measuring devices, whether or not a device is equipped with an automatic temperature or density compensator, shall be as follows:

T.1.1. ON NORMAL TESTS.- The maintenance tolerance on "normal" tests shall be four percent (4%) per indicated unit on underregistration and two percent (2%) per indicated unit on overregistration. The acceptance tolerance on "normal" tests shall be two percent (2%) per indicated unit on underregistration and one percent (1%) per indicated unit on overregistration.

T.1.2. ON SPECIAL TESTS.- The maintenance and acceptance tolerances shall be four percent (4%) per indicated unit on underregistration and two percent (2%) per indicated unit on overregistration.

T.2. 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, if these are returnable to zero, shall be returned to zero before each delivery.

UR.2.2. CONDITION OF DISCHARGE SYSTEM.- The discharge system, up to and including the meter, shall be precooled to liquid temperatures before a "zero" condition is established prior to the start of a commercial delivery, where vapor will cause overregistration of or tend to damage or degrade the meter.

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) one minute for small delivery devices, and
(b) three 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 OF VALUES.- When the metered cryogenic liquids are expressed in terms of pounds, kilograms, or cubic feet in addition to gallons or liters, liquid density, pressure, temperature, and unit conversion values of NBS Technical Note 361, Revised, Liquid Densities of Oxygen, Nitrogen, Argon, and Parahydrogen, shall be used. For unit conversions:

(a) lb/gal values shall be used as the pound equivalent when converting from gallons to pounds;
(b) NTP Volume Correction Factor Value shall be used as the gas equivalent at NTP when converting from liquid volume (gallons) to the equivalent gas volume (cubic feet); and
(c) Liquid Volume Correction Factor Values shall be used to adjust the measured liquid volume to NBP.

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. WRITTEN 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 normal boiling point of the specific cryogenic product.

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 have shown thereon also the other two values (either printed or in clear hand script).

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.

3.34. Cryogenic Liquid-Measuring Devices

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 35 psia, a correction shall be applied to the written invoice or printed ticket using the appropriate tables provided in NBS Technical Note 361, Revised; or the saturation pressure shall be reduced to 30 psia (if this can be safely accomplished) prior to making a delivery. [Added 1976].

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the Code for Cryogenic Liquid-Measuring Devices.

cryogenic liquids. Fluids whose normal boiling point is below 123 kelvins (-238 °F).

cryogenic liquid-measuring device. A system including a mechanism or machine of the meter type designed to measure and deliver cryogenic liquids in the liquid state by 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.

cubic foot. A cubic foot of a cryogenic liquid in gaseous state is defined as that volume of gas which, at a temperature of 70 °F and under a pressure of 14.696 pounds per square inch absolute, occupies one cubic foot.

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.

large-delivery device. Devices used primarily for single deliveries greater than 100 gallons, 1 000 pounds, or 10 000 cubic feet.

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.

NBP. Normal boiling point of cryogenic liquid at 14.696 psia.

NTP. Normal temperature and pressure of 70 °F and 14.696 psia respectively.

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.

small-delivery device. Any device other than a large-delivery device.

transfer standard. A measurement system designed for use in proving and testing cryogenic liquid-measuring devices.

1977
SEC. 3.35. TENTATIVE CODE
MILK METERS

(This Tentative Code has only a trial or experimental status and is not intended to be rigidly enforced. The requirements are designed for observation and study prior to the development and final adoption of a Code for 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. 1.14; 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 meter shall indicate and record if the meter is equipped to record, its measurements in terms of gallons. Fractional parts of these units shall be in terms of decimal or binary subdivisons.

S.1.1.3. VALUE OF SMALLEST UNIT.- The value of the smallest unit of indicated volume and recorded volume, if the meter is equipped to record, shall not exceed 0.1 gallon or 1 pint.

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.

3.35. Milk Meters (tentative)

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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 0.06 inch.

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 0.20 inch.

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.- 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 volume of the delivery in terms of units and the appropriate fraction of the unit and the price per unit.

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 indication or representation to within one 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.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 20 feet in length unless it can be demonstrated that a longer hose is essential to permit transfer from a supply tank,

(d) sufficiently clear so product in the hose is visible, and
(e) connected to the pump at horizontal or above to permit complete drainage of the hose.

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, such minimum discharge rate shall not exceed 20 percent of such maximum discharge rate.

S.4.3. MEASURING COMPONENTS.- All components that affect the measurement of milk which 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.

N. NOTES

N.1. TEST LIQUID.- A meter shall be tested with the liquid to be commercially measured or with a liquid of the same general physical characteristics.

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 100 gallons.

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 the 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.

TABLE 1.- TOLERANCES FOR MILK METERS

Indication	Maintenance tolerance	Acceptance tolerance
Gallons	Gallons	Gallons
100	0.5	0.3
200	0.7	0.4
300	0.9	0.5
400	1.1	0.6
500	1.3	0.7
Over 500	Add 0.002 gallon per indicated gallon	Add 0.001 gallon per indicated gallon

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.

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.

3.35. Milk Meters (tentative)

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 volume, or the price per gallon, shall have shown thereon also the other two values (either printed or in clear script).

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

(From 1975 to 1979 this was a Tentative Code)

A. APPLICATION

A.1.- This code applied 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. 1.14; 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 gallons or cubic feet or binary or decimal subdivisions thereof except batch plant meters, which shall indicate deliveries in terms of gallons or decimal subdivisions of the gallon only.

S.1.1.3. VALUE OF SMALLEST UNIT.- The value of the smallest unit of indicated delivery and recorded delivery, of the device is equipped to record, shall not exceed the equivalent of:

(a) 10 gallons on utility type meters,
(b) 1/10 gallon on batching meters delivering less than 100 GPM, or
(c) 1 gallon on batching meters delivering 100 GPM or more.

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.

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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall not be less than 0.04 inch. If the graduations are not parallel the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 0.06 inch.

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 in temperature of the test liquid.

N.3. TEST DRAFTS.- Testing 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 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.

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, Section T.

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.

3.36. Water Meters

TABLE 1.

Meter size (inches)	Normal tests			
	Maximum rate			
	Rate of flow (gpm)	Meter indication		Tolerance on over- and under-registration
		gal	ft^3	
5/8	15	50	5	1.5%
3/4	25	50	5	
1	40	100	10	
1-1/2	80	300	40	
2	120	500	40	
3	250	500	50	
3	350	1000	100	
6	700	1000	100	

TABLE 2.

Meter size (inches)	Special Tests								
	Intermediate rate				Minimum Rate				
	Rate of flow (gpm)	Meter indication		Tolerance on over- and under-registration	Rate of flow (gpm)	Meter indication		Tolerance	
		gal	ft^3			gal	ft^3	Under-registration	Over-registration
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		
3	40	100	10		7	50	5		
6	60	100	10		12	50	5		

3.36. Water Meters

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.

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 top of meter, to prevent siphoning of meter and permit rapid drainage of 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. The valving, piping or hose shall not be smaller than the size of the actual discharge line.

DEFINITONS OF TERMS

The term defined here has a special and technical meaning when used in the Code for Water Meters.

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

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.- See also Sec. 1.14; 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 1/2 pint per 200 gallons, or fraction thereof, of the nominal compartment capacity, or to more than 1 pint, 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.- Effective venting of a compartment shall be provided to permit air to escape, during filling operations, from all areas 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 7-5/8 inches, or, if other than circular, have an effective area of less than 45 square inches.

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 length or 6 inches, whichever is less.
(c) So that it shall not extend into, nor more than 6 inches 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 18 inches for fill openings of less than 15 inches in diameter, or, if other than circular, an effective area of less than 175 square inches, and not lower than 24 inches for larger fill openings.
(e) To provide a clearance of not less than 2 inches 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 0.04 inch 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 insure

(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 another is automatically prevented, or
(b) that all compartments will discharge simultaneously.

If the discharge valves from two or more compartments are automatically so controlled that they can only be operated together, thus effectively connecting these compartments each to the other, 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.

4.40. Vehicle Tanks Used as Measures

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 gaged "to deliver." If the compartment is gaged by measuring the test liquid into the tank, the inside tank walls shall first be thoroughly wetted.

N.4. GAGING OF COMPARTMENTS.- When a compartment is gaged 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, incl	3	0.75
401 to 600, incl	4	1.0
601 to 800, incl	5	1.25
801 to 1 000, incl	6	1.50
Over 1 000	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. 1.14; General Code requirements.

S. SPECIFICATIONS

S.1. UNITS.- The capacity of a liquid measure shall be 1 gill, 1/2 liquid pint, 1 liquid pint, 1 liquid quart, 1/2 gallon, 1 gallon, 1-1/4 gallons, 1-1/2 gallons, 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.

TABLE 1.- MINIMUM THICKNESSES OF METAL FOR LIQUID MEASURES

Nominal capacity	Minimum thickness	
	For iron or steel, plated or unplated	For copper or aluminum
	Inch	Inch
1 pint or less	0.010	0.020
1 quart, 1/2 gallon, 1 gallon	.014	.028
Over 1 gallon	.016	.032

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.

4.41. Liquid Measures

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 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. LUBRICATING-OIL BOTTLES

A. APPLICATION

A.1.- This code applies to any rigid (inflexible) container used for the measurement of lubricating oil for direct delivery to the crankcase of a motor vehicle, whether or not the bottle is sealed with a cap or some other device.

A.2.- See also Sec. 1.14; General Code requirements.

S. SPECIFICATIONS

S.1. UNITS.- The capacity of a lubricating-oil bottle shall be 1 liquid pint, 1 liquid quart, 1/2 gallon, or 1 gallon, when the temperature of the bottle is 20 °C (68 °F), and the bottle shall not be subdivided.

S.2. MATERIAL.- Bottles shall be made of clear, uncolored glass.

S.3. CAPACITY POINT.- The capacity point shall be defined by a permanent, clearly defined graduation not more than 0.1 inch in width, extending at least halfway around the bottle, and the words "Fill to line" or a similar and suitable statement clearly referring to this graduation shall be permanently marked on the bottle. An auxiliary, undesignated graduation less prominent than the capacity graduation may be placed above the capacity graduation to serve as a guide in filling the bottle with an excess measure of oil.

S.4. HEADSPACE.- The capacity of that portion of the bottle above the capacity graduation shall not be less than 3 cubic inches.

S.5. CLEARANCE ABOVE CAPACITY GRADUATION.- When any opaque top or spout that is provided is screwed firmly in place or is otherwise securely attached, the lower edge of such top or spout shall be at least 1/4 inch above the capacity graduation.

S.6. DRAINAGE.- A bottle, and any top or spout that is provided, shall be so constructed as to permit free and unobstructed drainage of the contents of the bottle.

S.7. MARKING REQUIREMENTS.- A bottle shall be permanently marked on its side with a statement of its capacity. (See also S.3.)

N. NOTES

N.1. TO DELIVER.- A lubricating-oil bottle shall be tested "to deliver" with a 10-second drain period.

N.2. TEST LIQUID.- Water shall be used as the test liquid for lubricating-oil bottles.

N.3. TEMPERATURE CONTROL.- During the test of a lubricating-oil bottle, appropriate precautions shall be exercised to reduce to the practicable minimum any detrimental temperature effects.

N.4. LEVEL OF TEST LIQUID.- During the test of a lubricating-oil bottle, the top of the meniscus of the water shall be brought into coincidence with the bottom of the capacity graduation.

4.42. Lubricating-Oil Bottles

T. TOLERANCES

T.1.- Maintenance and acceptance tolerances in excess shall be as shown in table 1. There shall be no tolerance in deficiency.

TABLE 1.- MAINTENANCE AND ACCEPTANCE TOLERANCES, IN EXCESS ONLY, FOR LUBRICATING-OIL BOTTLES

Nominal capacity	Tolerance	
	Fluid drams	Cubic inches
1 pint	6	1.4
1 quart	8	1.8
1/2 gallon	12	2.7
1 gallon	20	4.5

UR. USER REQUIREMENTS

UR.1. DRAINAGE.- Lubricating-oil bottles shall be permitted to drain into the oil-fill pipe for such period of time as is necessary to provide for the accurate delivery. [Amended 1976]

SEC. 4.43. 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. 1.14; 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 gage rod or surface gage, 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 utilized 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 500 gallons, or 2000 liters, 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 so as to facilitate an accurate level determination in both directions of the tank's horizontal plane. (Nonretroactive as of 1969.)* [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 gage rod or surface gage, 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 which can be agitated without overflowing and which can be measured accurately with the liquid at rest. (Nonretroactive as of 1979.)*

S.3. DESIGN OF INDICATING MEANS.

S.3.1. GAGE-ROD BRACKET OR SUPPORTS.- If a tank is designed for use with a gage rod, a substantial and rigid gage-rod bracket or other suitable supporting elements for positioning the gage rod shall be provided. A gage 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 gage rod is properly seated on its brackets or supports, there shall be a clearance of at least 3 inches between the graduated face of the rod and any tank wall or other surface that it faces.

S.3.2. GAGE 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. The graduated face of the rod shall have a dull finish.

S.3.3. SURFACE-GAGE BRACKET OR SUPPORTS.- If a tank is designed for use with a surface gage, a substantial and rigid surface-gage bracket or other suitable supporting elements for positioning the surface gage shall be provided. A surface gage and its brackets or other supporting elements shall be so construced that, whenever the gage 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.3.4. SURFACE GAGE.- When properly engaged with its bracket and set to its lowest position, a surface gage shall not touch the bottom of the tank. The gage shall be graduated throughout an interval corresponding to the volume range within which readings of liquid level are to be made.

S.3.5. EXTERNAL GAGE ASSEMBLIES [Added 1977]

S.3.5.1. DESIGN AND INSTALLATION.- The gage assembly shall be designed to meet sanitary requirements and shall be readily accessible for cleaning purposes. The gage assembly shall be mounted in a vertical position and equipped with a sliding mechanism to assist in determining the liquid level.

S.3.5.2. GAGE TUBE.- The gage tube shall be borosilicate glass or approved rigid plastic with a uniform internal diameter not less than 3/4 inch i.d. It shall be designed and constructed so that all product in the gage can be discarded in such a manner that no product in the gage tube will enter the discharge line or tank.

S.3.5.3. SCALE PLATE.- The scale plate shall be mounted adjacent to and parallel with the gage tube and be no more than 1/4 inch from the tube.

S.3.5.4. SCALE GRADUATIONS.- The graduation lines shall be clear and easily readable and shall comply with the requirements of paragraphs included under S.3.6. Graduations.

S.3.6. GRADUATIONS.

S.3.6.1. SPACING AND WIDTH OF GRADUATIONS.- On a gage rod or surface gage, the spacing of the graduations, center to center, shall be not more than 0.0625 (1/16) inch and not less than 0.03125 (1/32) inch. The graduations shall be not less than 0.005 inch in width, and the clear interval between adjacent edges of successive graduations shall be not less than 0.015625 (1/64) inch.

S.3.6.2. VALUES OF GRADUATIONS.- On a gage rod or surface gage, the graduations may be designated in inches or centimeters and fractions thereof, or may be identified in a numerical series without reference to inches or centimeters or fractions thereof. In either of these cases there shall be provided for each such rod or gage and each tank with which it is associated, a volume chart showing values in terms of the volume of liquid in the tank, corresponding to each graduation on the rod or gage. If a rod or gage 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 gage.

S.3.6.3. VALUE OF GRADUATED INTERVAL.- The value of a graduated interval on a gage rod or surface gage (exclusive of the interval from the bottom of the tank to the lowest graduation) shall not exceed

(a) 1/2 gallon for a tank of a nominal capacity of 250 gallons or less; 2 liters for a tank of a nominal capacity of 1000 liters or less,
(b) 1 gallon for a tank of a nominal capacity of 251 to 500 gallons, inclusive; 4 liters for a tank of a nominal capacity of 1001 to 2000 liters, inclusive,
(c) 1-1/2 gallons for a tank of a nominal capacity of 501 to 1500 gallons, inclusive; 6 liters for a tank of a nominal capacity of 2001 to 6000 liters, inclusive,
(d) 2 gallons for a tank of a nominal capacity of 1501 to 2500 gallons, inclusive; 8 liters for a tank of a nominal capacity of 6001 to 10 000 liters, inclusive, and
(e) add 1 gallon for each 2500 gallons or fraction thereof of nominal tank capacity above 2500 gallons; add 4 liters for each 10 000 liters or fraction thereof of nominal tank capacity above 10 000 liters.

[Amended 1980]

S.3.7. DESIGN OF INDICATING MEANS ON TANKS WITH A CAPACITY GREATER THAN 2000 GALLONS, OR 8000 LITERS.- *Any farm milk tank with a capacity greater than 2000 gallons, or 8000 liters, shall be equipped with an external gage 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. 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.

S.4.2. FOR A TANK OF 250 GALLONS, OR 1000 LITERS, OR LESS.- The volume chart for a tank of nominal capacity of 250 gallons, or 1000 liters, or less shall show values at least to the nearest 1/4 gallon, or 1 liter.

S.4.3. FOR A TANK OF 251 TO 500 GALLONS, OR 1001 TO 2000 LITERS.- The volume chart for a tank of nominal capacity of 251 to 500 gallons, or 1001 to 2000 liters, inclusive, shall show values at least to the nearest 1/2 gallon, or 2 liters.

S.4.4. FOR A TANK OF GREATER THAN 500 GALLONS, OR 2000 LITERS.- The volume chart for a tank of nominal capacity of greater than 500 gallons, or 2000 liters, shall show values at least to the nearest gallon, or 4 liters.

[Amended 1980]

S.5. GAGING.

S.5.1. LEVEL.- A farm milk tank shall be level, as shown by the level-indicating means, during the original gaging operation.

S.5.2. TO DELIVER.- A farm milk tank shall be originally gaged "to deliver." If the tank is gaged by measuring the test liquid 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.

S.5.3. PREPARATION OF VOLUME CHART.- When a tank is gaged 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 gage rod, surface gage, 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 gaged 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 gaging 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 metering system is capable of operating within 25% 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 metering system is capable of operating within 25% of the applicable tolerance found in T.4. [Added 1975]

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 gallon, or 2 liters, whichever is greater. [Amended 1980]

T.3. BASIC TOLERANCE VALUES.- The basic maintenance and acceptance tolerance shall be 0.2% (2/10%) 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% (4/10%) 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 which can be agitated without overflowing.

DEFINITION OF TERMS

The terms defined here have a special and technical meaning when used in the Code for Farm Milk Tanks.

4.43. Farm Milk Tanks

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.

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

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 gage rod or a surface gage, and (3) a chart for converting level-of-liquid readings to volume; or such a unit in which readings are made on gage rod or surface gage directly in terms of volume. Each compartment of a sub-divided tank shall, for purposes of this code, be construed to be a "farm milk tank."

gage 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.

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

prover test method. A method of testing milk tanks which utilizes approved volumetric prover(s) for measuring the test liquid removed from or introduced into the tank.

surface gage. 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.

SEC. 4.44. MILK BOTTLES

A. APPLICATION

A.1.- This code applies to a container that is designed as a measure container for the measurement and delivery of milk and other fluid dairy products at retail.

A.2.- This code does not apply to containers for milk or other fluid dairy products that are designed to be used as packages and are so labeled as to conform to all requirements for packages.

A.3.- See also Sec. 1.14; General Code requirements.

S. SPECIFICATIONS

S.1. UNITS.- The capacity of a milk bottle shall be 1 gill, 1/2 liquid pint, 10 fluid ounces, 1 liquid pint, 1 liquid quart, 1/2 gallon, 1 gallon, or 2 gallons.

S.2. MATERIAL.- A milk bottle shall be sufficiently transparent that the level of milk easily can be seen under normal lighting conditions without removing the cap or lid, and shall be made of such material that the volumetric capacity of the bottle will not be altered by customary filling and handling operations.

S.3. CAPACITY POINT.- The capacity point of a milk bottle shall relate to the plane of its sealing surface as follows:

(a) On "cap-seat" bottles, the plane established by the under side of the bottle cap (corresponding to the plane of the cap seat).
(b) On "crown-cap" bottles, the plane established by the under side of the crown cap or other cover (corresponding to the top edge of the bottle).
(c) On a bottle designed for optional or multiple types of closures, the plane established by the lowest sealing surface.

S.3.1. POSITION.- The capacity point of a milk bottle shall be

(a) 1/4 inch below the plane of the sealing surface on a bottle with an inside diameter of 2 inches or less, measured immediately below that plane, and
(b) 1/8 inch below the plane of the sealing surface on a bottle with an inside diameter of greater than 2 inches, measured immediately below that plane.

S.4. MARKING REQUIREMENTS.

S.4.1. CAPACITY.- A milk bottle shall be permanently marked with a statement of its capacity. *The marking requirements shall relate to the placement of other written, printed, or graphic matter on the bottle as follows:*

(a) On bottles with no written, printed, or graphic matter, the capacity statement shall be located at or above the shoulder of the bottle.
(b) On bottles with written, printed, or graphic matter, the capacity statement shall be located within the bottom 30 percent of the labeled area.

(Nonretroactive as of 1969.)

4.44. Milk Bottles

S.4.2. IDENTIFICATION.- *A milk bottle manufactured after January 1, 1967, shall be marked with the last two digits of the year in which the bottle was manufactured. (Nonretroactive as of 1966.)*

N. NOTES

N.1. TO CONTAIN.- A milk bottle shall be tested "to contain."

N.2. TEST LIQUID.- Water shall be used as the test liquid for milk bottles.

N.3. TEMPERATURE CONTROL.- The test of a milk bottle shall be conducted with the ambient temperature, the temperature of the bottle, and the temperature of the test liquid at 68 °F % 5 °F.

N.4. SAMPLE SELECTION.- For the test to determine the average error in a lot or delivery of milk bottles, not less than 25 bottles of the same capacity, pattern, make, and ownership shall be selected at random so as properly to be representative of the total lot or delivery.

T. TOLERANCES

T.1. TOLERANCE ON AVERAGE CAPACITY.- Maintenance and acceptance tolerances in excess and in deficiency on the average capacity of milk bottles tested shall be as shown in table 1.

T.2. TOLERANCE ON INDIVIDUAL BOTTLE.- Maintenance and acceptance tolerances in excess and in deficiency on the capacity of an individual milk bottle shall be as shown in table 2.

TABLE 1.- MAINTENANCE AND ACCEPTANCE TOLERANCES, IN EXCESS AND IN DEFICIENCY, ON AVERAGE CAPACITY OF MILK BOTTLES

Nominal capacity	Tolerances on average capacity			
	In excess		In deficiency	
	Fluid drams	Cubic inches	Fluid drams	Cubic inches
10 fluid ounces or less	0.75	0.17	0.25	0.06
1 pint	1.00	0.23	0.50	0.11
1 quart	1.25	0.28	0.75	0.17
1/2 gallon	2.00	0.45	1.00	0.23
1 gallon	3.00	0.68	2.00	0.45
2 gallons	6.00	1.35	3.00	0.68

TABLE 2.- MAINTENANCE AND ACCEPTANCE TOLERANCES, IN EXCESS AND IN DEFICIENCY, ON CAPACITY OF AN INDIVIDUAL MILK BOTTLE

Nominal capacity	Tolerances on individual capacity			
	In excess		In deficiency	
	Fluid drams	Cubic inches	Fluid drams	Cubic inches
10 fluid ounces or less	2.25	0.50	1.25	0.28
1 pint	3.00	0.68	2.00	0.45
1 quart	4.00	0.90	3.00	0.68
1/2 gallon	6.00	1.35	5.00	1.13
1 gallon	10.00	2.26	8.00	1.80
2 gallons	18.00	4.06	12.00	2.71

T.3. TOLERANCE REQUIREMENTS.- A lot or delivery of milk bottles shall be considered as failing to meet tolerance requirements when

(a) The average error of the sample of 25 or more bottles is greater than the appropriate tolerance value (see T.1.), or
(b) The error in 20 percent or more of the individual bottles in the sample is greater than the appropriate tolerance on individual bottles (see T.2.).

SEC. 4.45. 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 Sec. 4.44; Code for Milk Bottles.

A.3.- See also Sec. 1.14; 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 (in inch-pound units) or a liter (in metric units), and the measure shall not be subdivided. However, for prepackaged measure-containers, any capacity less than 1/2 liquid pint or 1/4 liter 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.1.1. or S.1.2.

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 QUART OR ONE LITER OR LESS.- Bulging of the sides of a rectangular measure-container of one-quart or one-liter 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 two-quart or two-liter 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 1/16 inch 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 1/64 inch). [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.

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 mL		add per liter- 5 mL	

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 two quarts or two liters or greater shall be limited to the packaging, in advance of sale, of ice cream, sherbet, or other similar frozen desserts. [Amended 1979]

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 to the practicable minimum any detrimental temperature effects.

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 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	
Inches		Fluid drams Minims	Millimeters		Milliliters
0	9/16	2	0	16	0.1
9/16	13/16	3	16	21	0.2
13/16	1-1/16	6	21	26	0.4
1-1/16	1-5/16	10	26	31	0.6
1-5/16	1-9/16	15	31	36	0.8
1-9/16	1-13/16	20	36	41	1.1
1-13/16	2-1/16	30	41	46	1.4
2-1/16	2-5/16	40	46	51	1.8
2-5/16	2-9/16	50	51	56	2.2
2-9/16	2-13/16	1 and 5	56	61	2.8
2-13/16	3-1/16	1 and 20	61	66	3.4
3-1/16	3-5/16	1 and 35	66	71	4.1
3-5/16	3-9/16	1 and 50	71	76	4.8
3-9/16	3-13/16	2 and 10	76	81	5.6
3-13/16	4-1/16	2 and 30	81	86	6.4
			86	91	7.2
			91	96	8.1
			96	101	9.0

[Amended 1974]

SEC. 4.47. 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 therefor.

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. 1.14; 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. The bottom of a measure, other than a basket, shall be perpendicular to the 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.

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.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.

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 1/8 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.- Rape seed shall be used as the testing medium for nonwatertight dry measures.

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	In deficiency
	Cubic inches	Cubic inches
1/32 pint or less	0.1	0.05
1/16 pint	.15	.1
1/8 pint	.25	.15
1/4 pint	.5	.3
1/2 pint	1.0	.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. 4.48. 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. 1.14; 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 material 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 ten 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 FOR BERRY BASKETS AND BOXES

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. 1.14; General Code requirements.

S. SPECIFICATIONS

S.1. UNITS.- A fabric-measuring device shall indicate lengths in terms of 1/8 yards, 1/4 yards, 1/2 yards, and yards. In addition, lengths may be indicated in terms of any or all of the following sub-divisions: 1/3 yards, 1/16 yards, 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 0.008 inch in width.

S.2.1.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval between graduations shall be at least 1/4 inch for 1/8-yard graduations, and 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 with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 0.015 inch.

S.2.2.4. CLEARANCE.- The clearance between the index of an indicator and the graduations shall in no case be more than 0.06 inch.

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 1/8 yard 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 position.

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.

TABLE 1.- MAINTENANCE AND ACCEPTANCE TOLERANCES FOR FABRIC-MEASURING DEVICES

Indication of device	Maintenance tolerance		Acceptance tolerance	
	On under-registration	On over-registration	On under-registration	On over-registration
Yards	Inches	Inches	Inches	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

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.

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. 1.14; General Code requirements.

S. SPECIFICATIONS

S.1. UNITS.- A wire- or cordage-measuring device shall indicate lengths in terms of feet or feet and inches.

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 0.008 inch, nor more than 0.04 inch, 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 0.03 inch.

S.2.2. INDICATOR.

S.2.2.1. SYMMETRY.- The index of an indicator shall be symmetrical with respect to the graduations with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 0.015 inch.

S.2.2.4. CLEARANCE.- The clearance between the index of an indicator and the graduations shall in no case be more than 0.06 inch.

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.

5.51. Wire- and Cordage-Measuring Devices

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 1 foot shall be not less than 1/4 inch.

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 devise 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. (Nonretroactive as of 1969.)*

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, its 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 3/8 inch in width and at least 50 feet 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 25% 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 20 feet and appropriate increments up to at least 50 feet.

T. TOLERANCES

T.1. TOLERANCE VALUES.- Maintenance and acceptance tolerances shall be as shown in table 1.

TABLE 1.- MAINTENANCE AND ACCEPTANCE TOLERANCES FOR WIRE AND CORDAGE-MEASURING DEVICES

Indication of device	Acceptance and maintenance tolerances	
	On underregistration	On overregistration
Feet	Inches	Inches
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

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.

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. 1.14; General Code requirements.

S. SPECIFICATIONS

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 feet, 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-fourth the width of the smallest graduated interval on the measure, and shall in no case be wider than 0.03 inch.

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.

5.52. Linear Measures

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 25 feet or over shall be tested at a tension of 10 pounds. Tapes less than 25 feet shall be tested at a tension of 5 pounds. However, flexible metal tapes of 25 feet 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, incl.	1/16
31 to 55, incl.	1/8
56 to 80, incl.	3/16
81 to 100, incl.	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. 1.14; 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 of 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].

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 three 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 5 miles, or 8 kilometers, 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 LADING.

(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 when the truck is loaded with one-half of the maximum cargo load. [Amended 1977]

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.- Maintenance and acceptance tolerances on odometers shall be 4 percent of the interval under test. [Amended 1977]

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]

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the Odometer Code.

cold tire pressure. The pressure in a tire when the tire is at ambient temperature.

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.

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.

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.

operating tire pressure. The pressure in a tire when the vehicle has been driven for at least 5 miles or 8 kilometers.

passenger vehicles. Vehicles such as automobiles, recreational vehicles, limousines, ambulances, and hearses.

road test. A distance test, over a measured course, of an odometer assembly when installed on a vehicle, the mechanism being actuated as a result of vehicle travel.

rolling circumference. The rolling circumference is the straight line distance traveled per revolution of the wheel (or wheels) that actuates the odometer. In the case where more than one wheel actuates the odometer, the rolling circumference is the average distance traveled per revolution of the wheels.

simulated-road test. A distance test during which the 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.

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. 1.14; General Code requirements.

S. SPECIFICATIONS

S.1. DESIGN OF INDICATING ELEMENTS.

S.1.1. GENERAL.- A taximeter shall be equipped with a primary indicating element.

S.1.2. ADVANCEMENT OF INDICATING ELEMENTS.- Except when a taximeter is being cleared, the primary indicating elements shall be susceptible of advancement only by the rotation of the vehicle wheels or by the time mechanism.

S.1.3. VISIBILITY OF INDICATIONS.- Except when a taximeter is being cleared, indications of fare and extras shall be clearly visible at all times and at least 10 mm high for the fare and 4 mm high for all other indications. [Amended 1977]

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.- Whenever the indicating elements of a taximeter are set to indicate a charge for the hire of the vehicle, the character of the fare indication shall be clearly shown on the taximeter face. When a taximeter is cleared, the indication "Not Registering," "Vacant," or an equivalent expression shall be shown.

S.1.5.2. SINGLE-TARIFF TAXIMETER.- Whenever a single-tariff taximeter is set so as to register charges, the indication "Registering," "Hired," or an equivalent expression shall be shown.

S.1.5.3. MULTIPLE-TARIFF TAXIMETER.- Whenever a multiple tariff taximeter is set so as to register charges, the basis for the particular tariff for which it is set shall be shown. The indication "Registering," "Hired," or an equivalent expression may be shown for the lowest tariff. For any tariff rate higher than the lowest, there shall be shown the type of tariff that actually is being charged ("3 or more persons," for example).

S.1.5.4. TIME NOT RECORDING.- While a taximeter is set for fare registration but with the time mechanism inoperative with respect thereto, the indication "Time Not Recording" or an equivalent expression shall appear. This indication may replace the indication specified for a single-tariff taximeter and for the lowest rate on a multiple-tariff taximeter, but shall be in addition to the indication specified for the higher rates on a multiple-tariff taximeter.

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.- If an extras mechanism is provided, 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.

S.1.7.1. NONUSE OF EXTRAS.- If and when taximeter extras are prohibited by legal authority or are discontinued by a vehicle operator, with respect to all taximeters involved 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.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.3. DESIGN OF OPERATING CONTROL.

S.3.1. MEANS OF CONTROL.- A control lever-arm, knob, handle, or other convenient and effective means shall be provided to set the taximeter mechanism for the desired operating condition and to "clear" the taximeter.

S.3.2. POSITIONS OF CONTROL.- The several positions of the control lever shall be mechanically defined, and displacement from any one of these positions shall be sufficiently obstructed that the accidental or inadvertent changing of the operating condition of the taximeter is improbable. Possible movement of this control to an operating position immediately following its movement to the cleared position shall automatically be delayed enough to permit the taximeter mechanism to come to complete rest in the cleared condition.

S.3.3. 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.3.4. 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 construction of a taximeter shall be such that there will be no interference between the time and the distance portions of the mechanism at any speed of operation corresponding to a vehicle speed faster than the speed at which the basic rate of distance revenue equals the basic waiting-time rate. Specifically, the registration of a taximeter in the "hired" condition shall agree with its performance in the "time not recording" condition within 1 percent. [Amended 1977]

S.5. PROVISION FOR SECURITY SEALS.- Adequate provision shall be made for affixing lead-and-wire 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 in any way the 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.

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 two kilometers, 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, 150 pounds or 70 kilograms 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 mechanism through which charges are made for time intervals, this mechanism shall be tested at least through the first 5 time intervals.

N.3. INTERFERENCE TEST.- If a taximeter is equipped with a mechanism through which charges are made for time intervals, a test shall be conducted to determine whether there is interference between the time and distance mechanisms. During the interference test, the vehicle is operated at a speed of 2 or 3 mi/h or, 3 or 4 km/h faster than the speed at which the basic distance rate equals the basic time rate.

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 100 ft or 30 m 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 seconds per minute (5 percent).
(b) ON UNDERREGISTRATION: 9 seconds per minute (15 percent) on the initial interval, and 6 seconds per minute (10 percent) on subsequent intervals.

T.1.2.2. ON AVERAGE TIME INTERVAL COMPUTED AFTER EXCLUDING THE INITIAL INTERVAL.- Maintenance and acceptance tolerances on the average time interval excluding the initial interval shall be as follows:

(a) ON OVERREGISTRATION: No tolerance.
(b) ON UNDERREGISTRATION: 3 seconds per minute (5 percent).

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.- When mounted upon a vehicle, a taximeter shall be so located that its face can be seen by a passenger from the rear compartment of the vehicle. Adequate lighting facilities shall be provided for so illuminating the face of the taximeter that the indications thereof may be conveniently read by the passenger, and the face of the taximeter shall be so illuminated whenever the taximeter is in operation and artificial illumination is necessary for the convenient reading of its indications. [Amended 1973]

UR.3. STATEMENT OF RATES.- The distance and time rates for which a taximeter is adjusted, and the schedule of extras when an extras mechanism is provided, shall be conspicuously displayed inside the vehicle. 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]

UR.4. REINSPECTION.- Whenever a taximeter has been damaged, or repairs that might in any way affect the accuracy of its indications have been made, or any of the official security seals have been mutilated, such device shall not thereafter be used until it has been officially examined and reapproved.

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the Taximeter Code.

basic distance rate. The charge for distance for all intervals except the initial interval.

basic time rate. The charge for time for all intervals except the initial interval.

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.

cold tire pressure. The pressure in a tire when the tire is at ambient temperature.

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.

face. That side of a taximeter upon which passenger charges are indicated.

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 or time mechanism.

5.54. Taximeters

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.

flag. A plate at the end of the lever arm or similar part by which the operating condition of a taximeter is controlled.

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.

initial distance or time interval. The interval corresponding to the initial money drop.

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

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

operating tire pressure. The pressure in a tire when the vehicle has been driven for at least 5 miles or 8 kilometers.

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.

rolling circumference. The rolling circumference is the straight line distance traveled per revolution of the wheel (or wheels) that actuates the taximeter. In the case where more than one wheel actuates the taximeter, the rolling circumference is the average distance traveled per revolution of the wheels.

simulated-road test. A distance test during which the taximeter 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.

single-tariff taximeter. One that calculates fares at a single rate only.

subsequent distance or time intervals. The intervals corresponding to money drops following the initial money drop.

taximeter. A device that automatically calculates, at a predetermined rate or rates, and indicates the charge for hire of a vehicle.

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. 1.14; 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 two hours.
(b) Six minutes on parking meters indicating time in excess of one but not greater than two hours.
(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 of 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 operable 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 for a minimum of one minute for times less than one hour and a minimum of two minutes for times of one hour or more at the time the meter is activated. 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 0.008 inch in width.

S.1.2.3. CLEAR INTERVAL BETWEEN GRADUATIONS.- The clear interval shall be not less than 0.03 inch. If the graduations are not parallel, the measurement shall be made

(a) along the line of relative movement between the graduations and 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 with which it is associated and at least throughout that portion of its length that is 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 0.04 inch.

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 effects shall be reduced to a practicable minimum.

S.1.4. PRINTED TICKETS.- A printed ticket issued or stamped by a timing device shall have printed clearly thereon the time when service begins and when service ends. The time indication shall be designated as follows:

(a) Date (month and day).
(b) Time of day (hour and minute, and a.m. or p.m. designation when not in terms of 24-hour time).

S.2. MARKING REQUIREMENTS.

S.2.1. 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 one hour or less, stopwatches with a minimum divison of not greater than one-fifth second shall be used. In the test of timing devices with a nominal capacity of more than one hour, the value of the minimum division on the timepiece shall be not greater than one second. Timepieces and stopwatches shall be calibrated with standard time signals as described in National Bureau of Standards Special Publication 432, NBS Time and Frequency Dissemination Services, or any superseding publication. [Amended 1978]

T. TOLERANCES

T.1. TOLERANCE VALUES.- Maintenance and acceptance tolerances for timing devices shall be as follows:

T.1.1. FOR LAUNDRY DRIERS AND CAR-WASH TIMERS.- The maintenance and acceptance tolerances shall be:

(a) on overregistration, no tolerance; and
(b) on underregistration, six seconds per indicated minute.

[Amended 1975]

T.1.2. FOR TIME CLOCKS AND TIME RECORDERS.- The maintenance and acceptance tolerances on overregistration and underregistration shall be three seconds per hour, not to exceed one minute per day. [Amended 1975]

T.1.3. ON PARKING METERS.- The maintenance and acceptance tolerances shall be as shown in table 1.

TABLE 1.- MAINTENANCE AND ACCEPTANCE TOLERANCES FOR PARKING METERS

Nominal time capacity	Maintenance and Acceptance Tolerances	
	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

[Amended 1975]

5.55. Timing Devices

T.2. 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 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 two minutes of the correct time in effect in the area, except 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]

DEFINITIONS OF TERMS

The terms defined here have a special and technical meaning when used in the Code for Timing Devices.

car-wash timers. 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.

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

laundry-drier timers. A timer used in conjunction with a coin-operated device to measure the period of time during which a laundry drier is in operation.

parking meter. A coin-operated device for measuring parking time for vehicles.

time recorders. 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.

timing devices. 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.

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