Designation: D 4753 – ~~95~~02

Standard ~~Specification~~ Guide for Evaluating, Selecting, and Specifying Balances and ~~Scales~~ Standard Masses for Use in Soil, Rock, and Construction Materials Testing[1]

This standard is issued under the fixed designation D 4753; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This ~~specification~~ guide provides minimum requirements for general-purpose scales, balances, and standard masses used in testing soil, rock, and related construction materials.

1.2 This ~~specification~~ guide provides guidance for evaluating, selecting, and specifying general purpose scales, balances, and standard masses used in testing soil, rock, and related construction materials.

1.3 The accuracy requirements for balances and scales are specified in terms of the combined effect of all sources of error contributing to overall balance performance. The measurement of specific sources of error and consideration of details pertaining to balance construction have been intentionally avoided.

1.4 This ~~specification~~ guide does not include requirements for balances and scales ~~that have~~ having accuracies greater than those generally required in ~~normal~~ testing soil, rock, and related construction materials.

1.5 This ~~specification~~ guide does not apply to nongraduated balances.

1.6 This ~~specification~~ guide does not address the methods used to verify or quantify specific parameters dealing with balances and scales. For a description of tests used in evaluating balance performance, see NIST Handbook 44.

1.7 This ~~specification~~ guide is not intended to be used as a specification for the purchase of balances and scales.

NOTE 1—The National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS), and the International Organization of Legal Metrology (OIML) publish standards or practices that specify construction requirements as well as performance ~~specifications~~ guides for balances. ASTM, OIML, and NIST publish construction standards and tolerances for standard masses.

NOTE 2—The terms "mass" and "determine the mass of" are used in this standard instead of the more commonly used terms "weight" and "weigh" to comply with standard metric practice. In addition, the term "standard mass(es)" is used instead of standard "standard weight(s)" when referring to a piece of material of known specified mass used to compare or measure the mass of other masses.

1.8 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgement. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged nor should this document be applied without consideration of a project's many unique aspects. The sword "Standard" in the title of this document mans only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

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[1] This ~~specification~~ guide is under the jurisdiction of ASTM Committee D~~-~~18 on Soil and Rock and is the direct responsibility of Subcommittee D18.91 on Standards Development and Review.

Current edition approved ~~April 15, 1995.~~ Jan. 10, 2002. Published ~~June 1995.~~ March 2002. Originally published as D 4753 – 87. Last previous edition D 4753 – 9~~2~~5.

***A Summary of Changes section appears at the end of this standard.**

E 617 Specification for Laboratory Weights and Precision Mass Standards[2]

2.2 *National Institute of Standards and Technology Documents:*

NIST Handbook 44 Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices[3]

~~NIST Handbook 105-1 Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures[3]~~

2.3 *International Organization for Legal Metrology (OIML):*

International Recommendation No. 20 Weights of Accuracy Classes E_1, E_2, F_1, F_2, M_1 from 50 kg to 1 mg[4]

International Recommendation No. 3[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *accurate*—a balance is "accurate" when its performance (its indication as determined by tests made with suitable standards) conforms to the standard within the applicable tolerances and other performance requirements. Balances that fail to conform are "inaccurate."

3.1.2 *balance*—an instrument for determining the mass of an object by the action of gravity on the object. See *scale*. ~~NOTE 3—In~~

3.1.2.1 *Discussion*—In this ~~specification~~ guide and in common usage, the terms balance and scale are used ~~interchangeably as is often done.~~ interchangeably. The term balance is more often used in scientific fields of application. ~~See Note 7.~~ The term scale usually refers to instruments intended for commercial or industrial applications, and when so used, usually implies an instrument of lesser performance than a balance.

3.1.3 *basic condition*—a ~~basic condition is a~~ condition that must be met before a basic measurement for evaluating a balance can be performed.

3.1.4 *basic measurement (of error)*—a basic measurement for evaluating a balance is performed by (*1*) determining the change of indication of the balance when a ~~load of~~ known mass is added to or subtracted from any ~~load~~ mass already on the balance; and (*2*) taking the difference between the change in the indication determined and the known value of the mass.

3.1.5 *basic tolerance*—~~basic tolerances are those tolerances~~—tolerances 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.

3.1.6 *capacity—of a balance*, the maximum ~~load~~ mass recommended by the manufacturer, disregarding any additional capability supplied by a taring device.

3.1.7 *general-purpose balance*—any balance used to make a general purpose determination of mass. See *general-purpose determination of mass*.

3.1.8 *general-purpose determination of mass*— a single determination of mass using a balance (not a special purpose determination of mass involving repeat determinations of mass, averages, standard deviations, corrections etc.).

3.1.9 *general-purpose standard mass*—a standard mass used with a balance to make a general purpose determination of mass. See *general-purpose determination of mass*.

3.1.10 *hysteresis*—the difference between indications obtained when the value of the applied ~~load~~ mass is reached by adding mass or by removing mass from ~~the load receiving element of~~ a balance.

3.1.11 *linearity error*—plus or minus deviation from the theoretically straight-lined (linear) course of two interdependent values. In balances, this expression is applied to the plus or minus deviation of the indicated measurement value from the true (actual) value of the ~~load.~~

~~NOTE 4—The term linearity~~ mass.

3.1.11.1 *Discussion*—Linearity implies that the deviation from the true values are a continuous function of the applied ~~load.~~ mass. Thus, obtaining enough values of the true applied ~~load~~ mass versus balance reading to establish a relation between applied ~~load~~ mass and output should give the error that will occur at any applied ~~load.~~ mass. Linearity, then, is a statement about the systematic (nonrandom) error of a balance. Superimposed on the linearity are precision and other effects, such as off-center errors, temperature effects, etc. Linearity is a measure of balance performance over its full range, and on most balances adjustments can be made to alter the useableness of a balance with a given linearity for ~~weighings~~ measurements within a particular range of use.

3.1.12 *nongraduated balance*—balances not fitted with a scale numbered in units of mass.

3.1.13 *off-center error—of a top loading or platform balance*, the difference in indicated value when a mass is shifted to various positions on the loading area (pan or platform); eccentric load error. ~~NOTE 5—The~~

3.1.13.1 *Discussion*—The test for off-center error is called the shift test, or offcenter-load test. Information about balance performance under eccentric loadings is not normally found in product literature but such information can usually be obtained by contacting the manufacturers directly.

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[2] *Annual Book of ASTM Standards*, Vol 14.02.

[3] Available from the International Standards, National Institute of Standards and Technology, US Department of Commerce, Gaithersburg, MD 20899.

[4] Available from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

3.1.14 *precision of a balance*—the degree of agreement between the indications of a balance for repeated determinations of mass of the same mass under essentially the same conditions. It is usually expressed quantitatively as a standard deviation of a series of ~~weighings,~~ mass determinations, or as a function of the range of several ~~determinations of mass.~~ mass determinations. See *repeatability type II*, *reproducibility*.

3.1.15 *readability type I*—the value of the smallest unit of mass that can be read without estimation over the given range of measurement either directly or by use of a vernier or micrometer.

3.1.16 *readability type II*—the value of the smallest unit of mass that can be read *with* estimation over the given range of measurement.

3.1.17 *readability type III*—the value of the smallest unit of mass that can be read ~~while the balance is in use, but not smaller than readability Type I.~~

~~NOTE 6—Readability Type III refers to the smallest unit of mass that can be read~~ when in-service conditions such as draft, vibration, and other environmental conditions affect the balance while the balance is in use, but not smaller than readability Type I.

3.1.18 *repeatability type I*—the degree of agreement between the indications of a balance for repeated determinations of the same mass under essentially the same conditions. The degree of agreement (qualitatively).

3.1.19 *repeatability type II*—see *precision of a balance*.

3.1.20 *reproducibility*—see *precision of a balance*.

3.1.21 *scale*—see *balance*. ~~Note 7—The term scale usually refers to instruments intended for commercial or industrial applications, and when so used, usually implies an instrument of lesser performance than a balance.~~

3.1.22 *sensitivity*—the ratio of the deflection (ΔL) of the balance indicator or self-indicating display to the ~~load~~ mass (ΔM) causing the deflection; $S = \Delta L/\Delta M$ at a given ~~load.~~ mass.

NOTE ~~8~~3—Values for sensitivity are sometimes seen expressed in terms of mass units. When used in this way in reference to a nonself-indicating balance, sensitivity refers to the reciprocal of sensitivity or the change in mass required to change the position of equilibrium (rest point) a specified amount, usually one division on the balance indicator. When used in reference to self-indicating balances, it refers to the change in mass required to change the indication by one scale division.

3.1.23 *standard mass*—an object of specified mass and construction used with balances, and for the verification of balances and other masses.

3.1.24 *taring range*—a range within which it is possible to reset the indicator or display to zero by ~~means~~ use of the tare device.

3.1.25 *tolerance*—a value fixing the limit of allowable error or departure from true performance or value.

NOTE ~~9~~4—For additional terms used in this ~~specification~~ guide related to balances and standard masses, see NIST Handbook 44 or OIML IR No. 3 .

4. Significance and Use

4.1 This ~~specification~~ guide provides those ~~writing and~~ using ~~test~~ standards related to soil, rock, and related construction materials, with a means for ~~determining~~ selecting the balance required for a particular standard.

4.2 This guide provides those writing standards pertaining to soil, rock, and related construction materials with a means for specifying the balance capabilities required for a particular ~~test method~~ standard and for describing the balance selected in a uniform fashion.

~~4.2 This specification~~

4.3 This guide provides agencies conducting soil, rock, and related construction materials, testing with guidance for selecting and evaluating general purpose balances and standard masses.

~~4.3 This specification~~

4.4 This guide provides inspection organizations with criteria for evaluating general purpose balances and standard masses.

5. Requirements for General-Purpose Balances

5.1 General-purpose balances shall be judged accurate for a given class if their indications meet the basic tolerances shown in Table 1.

6. Requirements for General-Purpose ~~Weights~~ Masses

6.1 General-purpose standard masses for use in testing of soil and rock ~~should~~ shall conform to the requirements in Specification E 617 for Type I or Type II, Grade S, O, or P standard masses and have tolerance limits equal to or better than those for Class 6 standard masses except that the maintenance tolerances given in Specification E 617 for Class 6 standard masses are to be considered acceptance tolerances for purposes of this ~~specification~~ guide and the maintenance tolerances twice those values. The tolerances values given in Table 2 correspond to the minimum acceptable maintenance tolerances under this ~~specification.~~ guide.

NOTE ~~10~~5—Former NIST Class J, M, S, S-1, P, and Q standard masses meet this ~~specification,~~ guide, as do OIML Class M_1 standard masses (IR No. 20).

7. Evaluation of General-Purpose Balances

7.1 *Basic Tolerance*—Table 1 shows the basic tolerances for all classes of general-purpose balances used in soil or rock testing

TABLE 1 Requirements for General-Purpose Balances

Class	Test Mass,[A] g	Basic Tolerance	Readability Type I,[B] g
GP1	≥20	±0.1 %	0.01
	<20	±0.02 g	0.01
GP2	≥200	±0.1 %	0.1
	<200	±0.2 g	0.1
GP5	≥2000	±0.1 %	1
	<2000	±2 g	1
GP10	≥5000	±0.1 %	5
	<5000	±5 g	5
GP100	≥50 000	±0.1 %	50
	<50 000	±50 g	50

[A] The known mass which is added to or subtracted from any ~~lo~~ mad~~ss~~ already on the balance when making a basic measurement (of error).
[B] Not readability Type II.

TABLE 2 Maintenance Tolerances for General-Purpose Standard Masses

Denomination	Tolerance,[A] mg
20 kg	4000
10 kg	2000
5 kg	1000
3 kg	600
2 kg	400
1 kg	200
500 g	100
300 g	60
200 g	40
100 g	20
50 g	14
30 g	10
20 g	6
10 g	4
5 g	4
3 g	4
2 g	4
1 g	4
500 mg	2
300 mg	2
200 mg	2
100 mg	2

[A] Acceptance tolerances on new general-purpose standard masses are one-half the ~~maintenance~~ tolerances shown in this table.

that are covered by this ~~specification.~~ guide. The basic tolerances shown apply to basic measurements made when evaluating a balance.

7.1.1 A basic measurement for evaluating a balance is performed by determining the change of indication of the balance when a known mass is added to or subtracted from any ~~load~~ mass already on the balance, and then taking the difference between the change in the indication determined and the known value of the mass. To evaluate a balance, the basic tolerances shown in Table 1 are applied to the known value of the mass used in the basic measurement. The result of a basic measurement must fall within the error allowed by the basic tolerance.

NOTE ~~11—For~~ 6—For nearly all determinations of mass encountered in soils testing, the value of interest is the difference between two determinations of mass. In cases where the difference between the two determinations of mass is small, relative to the total masses determined, it is desirable to specify a tolerance based on the difference between the two determinations of mass to relieve what might otherwise be an excessively stringent tolerance.

NOTE ~~12—A~~ 7—A no load condition may be treated as a ~~load~~ mass of 0.0 g and may be considered a ~~load~~ mass on the balance.

7.1.2 The basic tolerance for a balance should apply to all values of loading within the range of the balance without regard to whether the balance is properly zeroed or a tare mass is being used, and should apply under all usual and customary methods of operation. Furthermore, the basic tolerance must be met in the environment in which the balance is to be used.

7.1.3 A balance shall not be considered acceptable if the result of basic measurements involving any combination of poise locations, counterpoise masses, pan loading, and scale positions, or unit masses are not within the basic tolerances shown in Table 1.

7.1.4 When evaluating top loading balances, results of basic measurements under off-center loading must also meet basic tolerances.

NOTE ~~13—The~~ 8—The possibility of off-center error and linearity error should be considered when making basic measurements.

7.1.5 Standard masses meeting or exceeding the requirements given in Specification E 617 for weights of Type I or Type II,

Grades S or O, and Class 2 are suggested in Specification E 617 for use as working standards for calibration and precision analytical work and are recommended in this ~~specification~~ guide for use in evaluating general purpose balances. The use of standard masses of lesser quality for calibration purposes is discouraged because of the tendency to think of them as accurate once they are labeled "standard masses for calibration."

7.2 *Balance Classification*—A balance is classified by reference to its readability Type I (see Table 1).

NOTE ~~14~~9—Capacity is not to be considered when classifying a balance. Balance classification in this ~~specification~~ guide is based on balance performance, not on use requirements. When selecting a balance, the anticipated ~~loads~~ masses which the balance is expected to measure will dictate the capacity required.

7.3 *Basic Conditions*—A basic condition is a condition which must be met before a basic measurement for evaluating a balance can be performed. In general, basic conditions require that a balance give a clear and stable indication under any condition of loading including the indication at no load. Both the useable readability (readability Type III) and the repeatability Type I must be adequate to perform the basic measurements described in 7.1.

NOTE 15~~0~~—For example, when a determination of mass is made with a beam balance, if the smallest poise is moved by an amount equal to the readability Type I, the indicating pointer must move clearly off balance (usually at least one division on the pointer scale). This is an indication of the adequacy of the sensitivity of a balance.

7.3.1 Readability Type I (not Type II) establishes the balance's class for determining the appropriate basic tolerance. If environmental or other factors cause the usable readability (readability Type III) to be poorer than the readability Type I then the balance cannot meet the basic tolerance for its class.

7.3.2 The repeatability Type I of the balance being evaluated must be such that the difference between the highest and lowest values in a group of several determinations of a mass ~~of the same load~~ shall not be greater than twice the balance's readability Type I.

7.4 *Balance Testing*—Two types of testing may be performed when evaluating the performance of a balance.

7.4.1 *Maintenance Testing*—Maintenance testing should be performed on balances in service. The basic measurement for evaluating a balance is performed in an environment that meets the manufacturer's recommendations. Maintenance testing is performed to determine whether a balance should be repaired. A tolerance equal to or better than the basic tolerance should apply to all basic measurements for this test.

7.4.2 *In-Use Testing*—In-use testing should be performed on balances in service. The basic measurement for evaluating a balance should be performed as and where the balance is used to make general purpose determinations of mass. In-use tests are intended to indicate the quality of usual and customary mass determinations that are made or may be made when using a general-purpose balance. The basic tolerance should apply to basic measurements for this test.

7.5 *Rejection*—If a balance fails when in-use tests are performed then maintenance tests should be performed. If a balance fails both in-use and maintenance tests, it should be removed from service and repaired or replaced. If a balance fails the in-use test but passes the maintenance test, the environment in which the balance is located must be improved.

8. Evaluation of General-Purpose Standard Masses

8.1 General-purpose standard masses should be tested on a precision balance. Standard masses meeting or exceeding the requirements given in Specification E 617 for standard masses of Type I or Type II, Grades S or O, and Class 2 are suggested in Specification E 617 for use as working standards for calibration and precision analytical work and are recommended in this ~~specification~~ guide for use in evaluating general purpose standard masses. The use of standard masses of lesser quality for calibration purposes is discouraged because of the tendency to think of them as accurate once they are labeled "standard masses for calibration."

8.2 General-purpose standard masses that fail to meet the requirements specified in Section 6 should be removed from service and either adjusted to meet acceptance tolerances or replaced.

9. Selecting and Specifying Balances

9.1 *Selecting Balances*—The selection of a balance is based on the proposed use. A balance must have a capacity sufficient to accommodate all anticipated test ~~loads,~~ masses, and its performance must be good enough so as not to be a cause of test error. The accuracy desired in test results should be used to establish the allowable balance tolerances.

9.1.1 The precision of a balance (a term frequently found in manufacturer's specifications), expressed as a standard deviation, shall not be greater than twice the readability Type I (not Type II).

9.1.2 When listed by the manufacturer, the linearity error of a balance shall not be greater than twice the readability Type I (not Type II).

9.1.3 If the maximum error of indication contributed by off-center loading can be obtained from the manufacturer, it should be no greater than twice the readability Type I (not Type II).

9.1.4 In cases where a test requires that more than one test result be determined, several balances having different capabilities may be required. ~~Note 16—The following example explains how a balance is selected: assume that a test method requires that a sample of soil be graded and that the fractions be reported to the nearest 0.1%. If the sample mass is 1000 g, then a balance having a minimum capability of determining the mass of each fraction to the nearest 1.0 g (0.1% of the total sample mass) will be required.~~

~~If the sample mass is 5000 g, then a balance having a minimum capability of determining the mass of each fraction to the nearest 5.0 g (0.1% of the total sample mass) will be required.~~

9.2 *Specifying Balances*—An example of the wording that may be used to specify balances in ASTM standards is as follows:

9.2.1 *Balance*—A balance having a minimum capacity of ___ g or kg and meeting the requirements of ~~Specification~~ Guide D 4753 for a balance of ___ g readability.

9.2.2 *Balance*—A balance or scale conforming to the requirements of ~~Specification~~ Guide D 4753 readable (with no estimation) to 0.1 % of the test mass, or better.

NOTE 1~~7~~1—Special consideration may be required when specifying the readability of balances used to determine masses of less than 20 g.

10. Keywords

10.1 balance; scale; standard masses

ANNEXES

(Mandatory Information)

A1. Annex Examples of Selecting a Specified Balance

A1.1 Assume that a test method requires that the particle sizes of a specimen be determined and that the size fraction be reported to the nearest 0.1%. If the specimen mass is 1000 g, then a balance having a minimum readability of determining the mass of each fraction to the nearest gram (0.1 % of the total mass) will be required. If the specimen mass is 5000 g, then a balance having a minimum readability of determining the mass of each fraction to the nearest 5 grams (0.1 % of the total mass) will be required.

A1.2 Assume that a test method requires that the dry unit weight of a specimen be determined to four significant digits. The test method states that the balance be readable with no estimation to 0.1 of the test mass. If the mass of the specimen is 100 g, the balance must be readable to 0.1 g. If the mass of the specimen is 500 g, the balance must be readable to 0.1 g. The mass of the specimen would have to be 1000 g before the readability of the balance would be 1 g.

A2. Annex Examples of Specifying a Balance When Writing Standards

A2.1 Assume that a test method requires that a specimen of soil be graded and that the fractions be reported to the nearest 0.1 %. If the specimen mass is 1000 g, then a balance having a minimum readability of determining the mass of each fraction to the nearest gram (0.1 % of the total mass) will be required. If the specimen mass is 5000 g, then a balance having a minimum readability of determining the mass of each fraction to the nearest 5 grams (0.1 % of the total mass) will be required. Depending on the specimen size, either a GP5 or a GP10 would be required. The balance statement would be as specified in 9.2.2.

A2.2 Assume that a test method requires that the dry unit weight of a specimen be determined to four significant digits, therefore, the test method will require that the balance be readable with no estimation to 0.1 % of the test mass (i.e., 1 part in 1000). If the mass of the specimen is 100 g, the balance must be readable to 0.1 g. If the mass of the specimen is 500 g, the balance must be readable to 0.1 g. The mass of the specimen would have to be 1000 g before the readability of the balance would be 1 g. The balance statement would read “A balance having a minimum capacity of 500 g and meeting the requirements of Guide D 4753 readable (with no estimation) to 0.1 % of the test mass, or better.” This is in accordance with the balance statement specified in 9.2.1

SUMMARY OF CHANGES

~~This~~

In accordance with Committee D18 policy, this section identifies the location of changes to this ~~specification that have been incorporated~~ standard since the ~~last issue. Committee D-18 has highlighted those changes~~ 1999 edition that ~~affect~~ may impact the ~~technical interpretation or~~ use of this ~~specification.~~

~~(1) Section 7.4.1 on acceptance testing~~ standard.
(1) Annex A1 and Annex A2 were added.
(2) Some notes contained mandatory information and were included into the text.
(3) Some notes were discussions and the classification of those notes were changed to discussions.
(4) Most references to load were changed to mass.
(5) The standard was ~~deleted.~~
~~(2) The requirement was~~ changed ~~in Sections 9.1.1, 9.1.2, and 9.1.3~~ from ~~"one-half the readability"~~ a specification to ~~"twice the readability."~~ guide.
(6) Minor editorial changes were made.