Withdrawn NIST Technical Series Publication

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NIST HANDBOOK 105-1
(Revised 1990)

Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures

1. Specifications and Tolerances for Field Standard Weights (NIST Class F)

Specifications and Tolerances for Reference Standards and Field Standards Weights and Measures

1. Specifications and Tolerances for Field Standard Weights (NIST Class F)

Office of Weights and Measures
National Institute of Standards and Technology
Gaithersburg, MD 20899

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Preface

The 1990 revision of Handbook 105-1 includes the following major changes since it was last published in 1972:

1. Additional tolerances for weights less than 10 g, which have been in use informally since 1975, have been incorporated into the tolerance tables. The formula used to calculate the tolerances for weights less than 10 g is included in the text.
2. The appendix which gave separate requirements for field standard weights used by service companies has been deleted. The weights used by service companies should meet all specifications and tolerances described in this handbook.
3. Several changes address materials and manufacturing practices and designs. Some of these were made to meet current manufacturing practices, while other changes address designs which have been shown to be unacceptable.
    a. Brass is no longer an acceptable material for weights: the metal is too soft for maintaining the required tolerances.
    b. Fabricated (filled shell) and laminated weight designs are no longer acceptable. These types of weight have not shown the necessary stability for maintaining tolerances during test cycles.
    c. Current standards for surface finish and hardness have been formally adopted, consistent with current use and good manufacturing practices. Surface finish modifications, using non-similar material (e.g., filler, putty), are unacceptable.
    d. The cavity opening design, counterbore sizes, and cavity location have been specified to provide a consistent and practical basis for the manufacture and evaluation of Class F weights. Screw knobs and threaded closures are no longer acceptable due to lack of stablity and adjustment difficulties.

Contents

SPECIFICATIONS AND TOLERANCES FOR REFERENCE STANDARDS AND FIELD STANDARD WEIGHTS AND MEASURES

Specifications and Tolerances for Field Standard Weights (NIST Class F)

These specifications and tolerances are minimum requirements for standards used primarily to test weighing devices.

Key words: Field standard weights; specifications; test weights; tolerances; weights and measures inspection.

Introduction

A class F field standard weight (after this, simply called "weight") is intended to be used primarily to test commercial weighing devices for compliance with the requirements of NIST Handbook 44.[1] Class F weights may be used to test most accuracy class[2] III scales, all scales of class III L or IIII, and scales not marked with a class designation.

A weight shall be verified to be within tolerance prior to use. The within-tolerance status of a weight shall be rechecked as often as regulations or circumstances require, especially when damage to it is known or suspected.

General

These specifications apply to new weights placed in service after the publication of this standard; the tolerances apply to all weights in service.

A weight in service prior to the publication of this standard that has maintained Class F tolerances between verification tests shall continue to be acceptable.

The specifications permit the use of a weight at its nominal value in normal testing operations, where the tolerance on the item under test is at least three times as great as the tolerance of the weight.[3]

Specifications

1. Material

1.1. A weight made of brass or a fabricated weight (such as a laminated weight or a weight of nonuniform density) shall not be placed in service after the publication date of this standard.

1.2. A weight smaller than 5 grams/0.01 lb shall be constructed of stainless steel, tantalum, nickel-chromium alloy, aluminum alloy, or other material sufficiently resistant to corrosion and oxidation that the surface need not be protected or coated.

[1]NBS Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. (See current edition.)
[2]See Handbook 44, Section 2. Scales Code.
[3]See Handbook 44, Appendix A, par. 3.2.

1.3. A weight of 5 grams/0.01 lb up to and including 5 kg/10 lb shall be constructed of material having a hardness of Rockwell B 80 or greater (such as 300-series stainless steel), and be resistant to abrasion, corrosion, denting, and chipping.

1.4. A weight larger than 5 kg/10 lb shall be constructed of materials such as iron, steel, or stainless steel, having a hardness of Rockwell B 80 or greater, and be resistant to abrasion, corrosion, denting, and chipping. Cast iron may be used for weights 10 kg/20 lb and larger. Body filler (e.g., fiberglass, putty, or plaster) shall not be used to correct a poor casting or finish.

2. Finish

2.1. The surface finish of a new weight machined from round bar stock shall have a roughness average of 0.80 micrometers[4] (32 microinches) or better, determined by use of a hand-held surface roughness indicator (available from several manufacturers) or more accurate method, and be free of scratches, dents, and chipped corners or edges, determined by visual examination. A beaded or blasted finish (with roughness average 1.25 micrometers (50 microinches) or better) is acceptable on a cube weight to facilitate gripping.

2.2. A weight 5 kg/10 lb or less shall not have a surface coating.

2.3. A weight larger than 5 kg/10 lb constructed of materials susceptible to corrosion or tarnishing shall have a protective surface coating. A light coat of sprayed-on flat aluminum paint is recommended. Lacquer is also acceptable. Epoxy paint or plated surfaces are not acceptable. A coating is recommended for the bottom of a weight, particularly if the bottom is recessed. If paint or lacquer is used, it shall be hard and resistant to chipping. Cast metric and avoirdupois field standards shall be color coded (i.e., gold for metric and silver for avoirdupois) to differentiate the weights.

2.4. The surface finish of a cast weight shall have a roughness average of between 12.5 and 25 micrometers (500 and 1000 microinches), determined by use of a hand-held surface roughness indicator or more accurate method, and be free of sharp surface irregularities such as scabbing (as defined in ASTM A 802)[5], visible cracks or holes which affect the surface finish average. Surface imperfections corrected by machining or welding are acceptable.

2.5. For a cast weight with a pipe handle, the casting near the handle must not be heavily cracked; the visible space between the handle and casting shall be as small as possible, consistent with good manufacturing practices. For a cast weight with a handle welded in place, the welded seam shall be continuous and show no obvious air holes or cracks as determined by visual examination.

2.6. Plating or coating shall not be used on a sheet metal type weight.

3. Density

3.1. The density of a weight smaller than 5 grams/0.01 lb shall be 2.7 g/cm^3 or greater.

3.2. The density of a weight equal to or greater than 5 grams/0.01 lb shall be not less than 7.0 and not more than 9.0 g/cm^3.

4. Design

4.1. Representative weight designs are shown in figures 1-5; variations of these designs are permitted. Prior to production, manufacturers should get the approval of the Office of Weights and Measures for new weight designs. New designs should be submitted to the Office of Weights and Measures, National Institute of Standards and Technology, Gaithersburg, MD 20899.

[4]American National Standard ANSI/ASME B46.1-1985, Surface Texture.
[5]American Society for Testing and Materials (ASTM) Standard Practice A 802, Surface Acceptance Standards

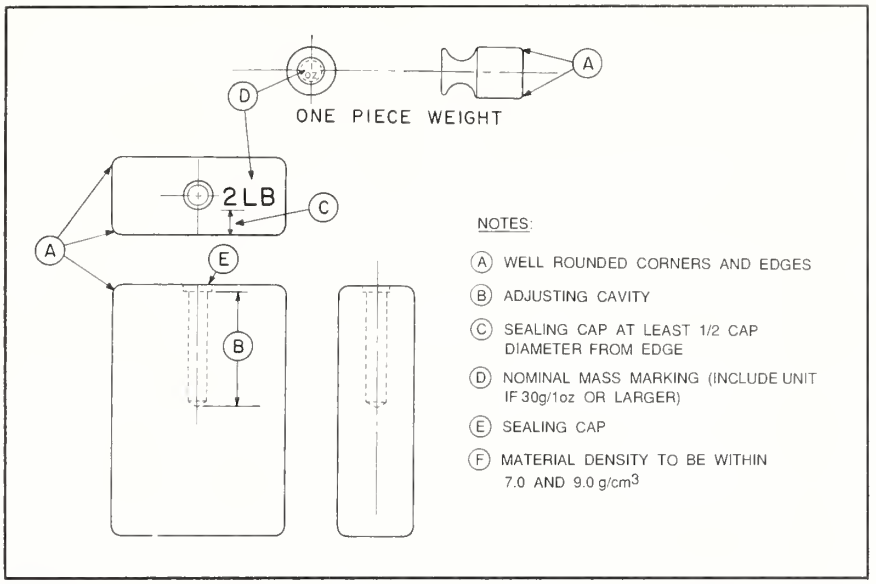

Figure 1. Typical small field standard weight, with sealing cavity (For weights: 50 g (2 oz) < W ≤ 5 kg (10 lb)).

4.2. After the publication date of this standard, a new fabricated weight (either laminated or of nonuniform density) or a new weight with a removable screw knob is not acceptable. Weights shall be made entirely of material of uniform density and cast or machined in a single piece, with allowance for an adjusting cavity and a handle of a different density. A weight with an adjusting cavity shall have the cavity protected by a seal that is destroyed or defaced by removal.

4.3. All corners and edges of a weight shall be uniformly chamfered (45° angle) or rounded with a well defined radius to reduce the likelihood of chipping. Sharp edges and corners shall not be acceptable.

4.4. A weight smaller than 50 g/0.125 lb (2 ounces) shall not be lighter than its nominal value when new, and shall not deviate from its nominal value by more than the tolerance shown in tables 2, 3, 4, or 5.

4.5. The bottom surface of a weight may be recessed, e.g., as illustrated in figure 3. A weight with a convex bottom surface is not acceptable.

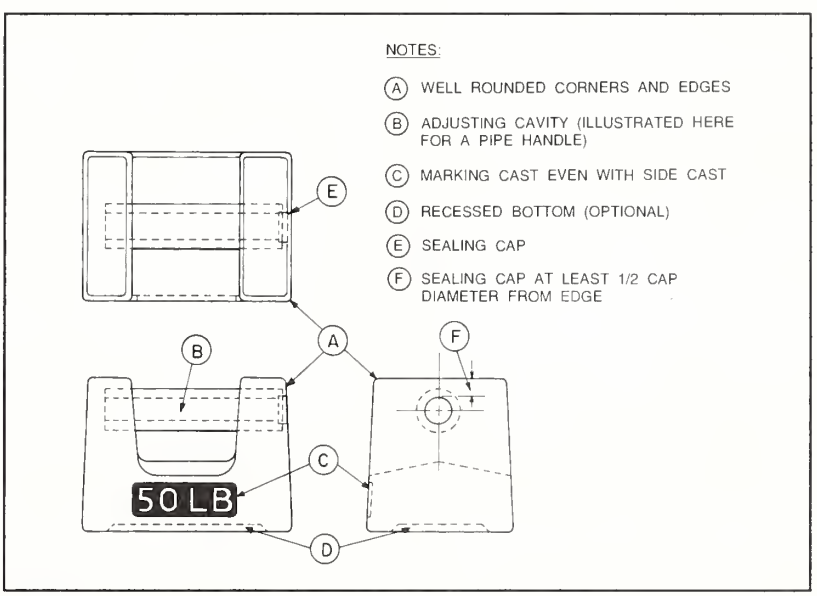

Figure 2. Large field standard weights (Cast weights: 10 kg (20 lb) ≤ W).

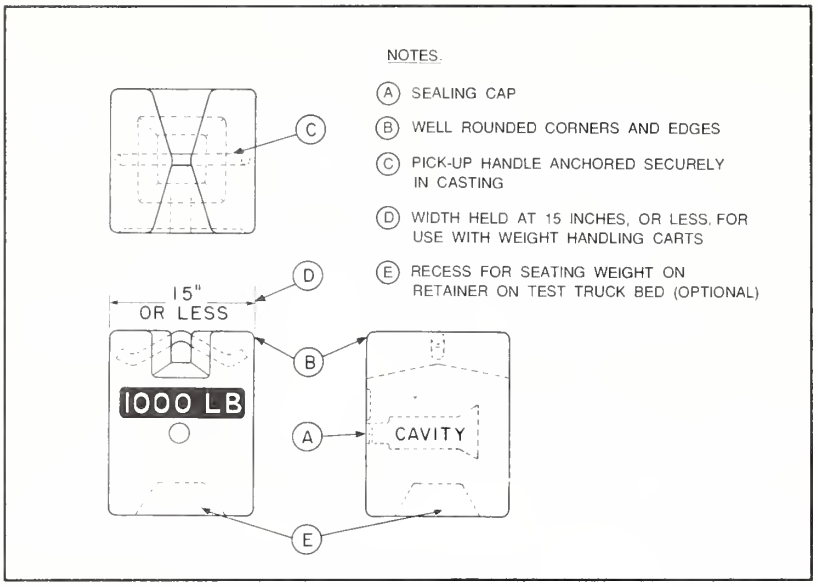

Figure 3. Large field standard weight.

5. Adjusting Cavity

5.1. A weight smaller than 50 g/0.125 lb (2 ounces) shall be of one-piece construction without an adjusting cavity.

5.2. A weight 50 g/0.125 lb (2 ounces) and larger may have a single adjusting cavity.

5.3. A weight with an adjusting cavity shall have its opening on a flat side of the weight and not on the bottom surface; however, a cylinder weight or cube weight shall have the opening of its adjusting cavity on the top. For weights larger than 5 kg/10 lb, the adjusting cavity shall be located in the upper half of the weight, where possible.

5.4. The outer rim of the recess that holds the sealing cap shall not be closer to the edge of the weight than the radius of the recess, with the exception of a weight of 50 g/2 oz, where it may be closer because of the size of the weight. See figure 1.

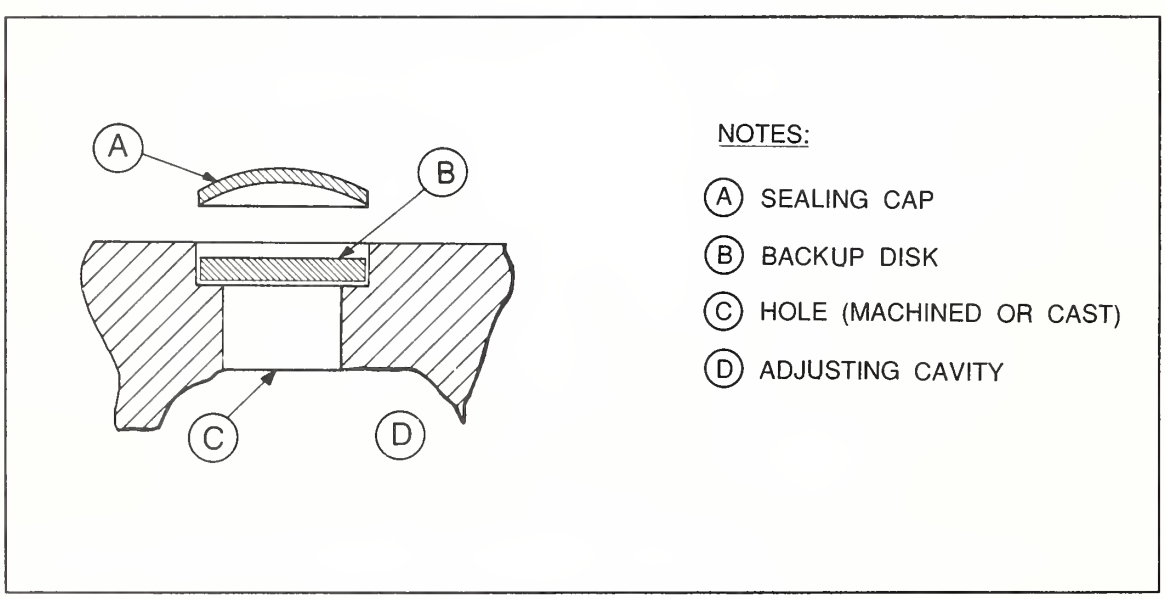

Figure 4. Adjusting cavity closure (field standard weight).

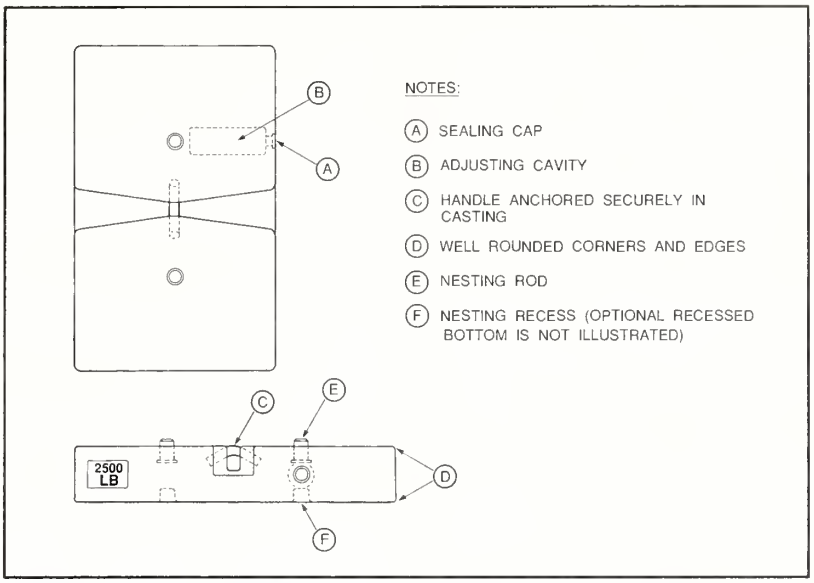

Figure 5. Large field standard weight (nesting weight).

5.5. A weight with an adjusting cavity shall, when empty, be lighter than its nominal value by at least five times the tolerance shown in tables 2, 3, 4, or 5. When a new weight is adjusted to nominal value and sealed, the cavity must be large enough to accept additional material equal to at least five times the tolerance, to increase the useful lifetime of the weight. The cavity design shall allow adjusting material to be easily removed.

6. Adjusting Cavity Closure

6.1. A weight shall have a cavity closure similar to the design shown in figure 4. The cavity shall have a recessed opening (counterbore), larger than the cavity hole, machined if necessary, to hold a backup disk and sealing cap, (as shown at the outer edge of the cavity in fig. 4). A backup disk may either be solid or have a hole in its center no larger than 1/4-inch diameter. The backup disk may be made of aluminum. A backup disk must be sufficiently sturdy so it does not deform and get driven into the adjusting cavity, and it must be easily removed when adjusting a weight. The depth of the counterbore shall be at least twice the thickness of the sealing cap. When applied, the sealing cap shall not protrude above the surface of the weight.

A weight having a threaded plug shall not be placed in service after the publication date of this standard.

6.2. The sealing cap shall be of soft, noncorrosive material so that it can easily be removed when adjusting a weight. Lead sealing caps are recommended for weights larger than 5 kg/10 lb. Aluminum is recommended for smaller weights. For weights above 50 kg/100 lb the sealing cap shall be at least 1/8 inch thick.

6.3. The dimensions or range of dimensions given in table 1 are recommended for counterbore recess diameters and depths. The diameter of the cavity hole, through which adjusting material is entered into the cavity, may range between 50% and 80% of the counterbore diameter. On weights with a pipe handle, the diameter of the cavity hole cannot exceed the diameter of the pipe.

7. Adjusting Material

7.1. Any metal in the form of shot or solid, may be used to adjust weights. Lead is preferred. Molten, poured metal is not acceptable. A grit size of 32 or larger is permitted for adjusting material.

8. Markings

8.1. A weight shall be clearly marked with its nominal mass value. Weights 30 g/0.0625 lb (1 oz) and larger shall also be clearly marked with a weight unit e.g., 1 lb.

8.2. Markings shall be located on a flat surface of a weight, either on the top or on a side. The markings shall be shallow, relatively broad, and free from burrs and sharp angles or edges. They shall not perforate or crack a sheet metal weight, or cause any raised area on the bottom surface of the weight. Markings may be raised above the surface only for a sheet metal type weight.

8.3. Markings cast in a cast weight shall be located on the side of the weight and shall lie even with or below the surface of the weight. A serial number may be stamped on a weight of 10 kg/20 lb and above.

8.4. No markings other than nominal value and weight unit shall be used on weights 5 kg/10 lb and smaller.

8.5. Markings such as trade marks or name of the manufacturer on a weight, if used, shall be limited to the shortest name or initials by which the firm is commonly known. Letters in the identification marking shall be no larger than those of the denomination.

9. Carrying Case

9.1. Field standard weights up to and including 5 kg/10 lb shall be carried in a rigid covered case designed to restrict movement and prevent damage to the weights. Separate pockets shall be lined with nonabrasive noncorrosive material (e.g., soft, non-shredding plastic, wood). A separate box may be inserted into the larger box to house smaller denomination weights (e.g., 8 oz. to 1/16 oz).

10. Special Weights

10.1 In rare instances, weights with unusual forms or materials, mainly for use indoors or in a controlled environment, may be accepted as suitable for specific purposes, without satisfying the general specifications of this standard. Designs for such weights or sample weights should be submitted to the Office of Weights and Measures, National Institute of Standards and Technology (NIST). The NIST will examine the designs to determine their suitability for the intended use, and inform the requester in writing of their decision. A weight documented to have an acceptable design may be submitted to a State laboratory for tolerance testing or calibration. A weight certified as class F, Special shall satisfy the class F tolerance.

Tolerances

1. Adjustment

1.1. A class F weight shall be maintained so that its actual value does not differ from the nominal value by more than the prescribed tolerance of tables 2, 3, 4, or 5.

1.2. A new weight or newly adjusted weight shall be adjusted as near to the nominal value as practicable. (See Specifications 4.4.)

2. Basis for Adjustment

2.1. Class F tolerances are established as applying to the apparent mass as determined at 20 °C in air having a density of 0.0012 g/cm^3, against standards having a density of 8.0 g/cm^3 (called apparent mass vs 8.0).

3. Class F Tolerances for Field Standard Weights

3.1 The tolerances applied to a weight have been chosen to be small enough to be negligible when testing a device, be a small fraction of the nominal value of the weight, and yet large enough to be practical for manufacturing a weight. These considerations are conflicting so that it is impossible to have the same fractional tolerance (e.g., 1 part in 10^4) over the entire span of nominal values from 500 kg to 1 mg.

3.2. The tolerances are one part in 10,000 for weights 1 kg (2 lb) and larger, 70 mg for weights between 1 kg and 300 grams, and one part in 5,000 for weights 300 g down to and including 10 g. Tolerances for weights below 10 g are determined from the equation:

$$T(W) \text{ in mg} = 0.9\ W^{0.31795}$$

where W is the nominal value in grams. For other units, first convert the nominal value of the weight to grams, calculate the tolerance, and then convert the tolerance value back to the other unit.

Enough digits are used in the formula to avoid errors in the tolerances, when rounded to two significant digits. The formula was deduced by assuming a practical tolerance of 0.1 mg for the 1-mg weight and relating it to the tolerance of 1.5 mg for a 5-g weight.

3.3. Tolerances given in tables 2, 3, 4, and 5 have been rounded to two significant digits. For mass units other than metric, tolerances have first been calculated in metric units, converted to the other units, and then rounded. This has resulted, in some instances, in the same numerical value for tolerances for adjacent nominal values in a table.

Table 1. Dimensions of Cavity Openings

Weight/ Weight Range	Recess(Counterbore) Diameter	Depth
W≤ 2 oz	1/4 to 3/8 in	-
2 oz <W< 20 lb	1/2 to 5/8	-
20 lb ≤W< 100 lb	1	1/4 in
W≥ 100 lb	2	3/8
W ≤ 50 g	7 - 10 mm	-
50 g < W < 10 kg	13 - 16	-
10 kg ≤ W < 50 kg	25	7 mm
W ≥ 50 kg	50	10

Class F Tolerances for Field Standard Weights

TABLE 2. Metric

Denomination	Tolerance
500 kg	50 g
300	30
200	20
100	10
50	5.0
30	3.0
20	2.0
10	1.0
5	.50
3	.30
2	.20
1	.10
500 g	70 mg
300	60
200	40
100	20
50	10
30	6.0
20	4.0
10	2.0
5	1.5
3	1.3
2	1.1
1	0.90
500 mg	0.72
300	0.61
200	0.54
100	0.43
50	0.35
30	0.30
20	0.26
10	0.21
5	0.17
3	0.14
2	0.12
1	0.10

TABLE 3. Avoirdupois

Denomination	Tolerance	
10 000 lb	1.0 lb	450 g
5 000	0.50	230
3 000	0.30	140
2 500	0.25	110
2 000	0.20	91
1 000	0.10	45
500	0.050	23
100	0.010	4.5
50	0.0050	2.3
30	0.0030	1.4
25	0.0025	1.1
20	0.0020	0.91
10	0.0010	0.45
5	500 µlb	230 mg
3	300	140
2	200	91
1	150	70
0.5	100	45
0.3	60	27
0.2	40	18
0.1	20	9.1
0.05	10	4.5
0.03	6.0	2.7
0.02	4.0	1.8
0.01	3.2	1.5
0.005	2.6	1.2
0.003	2.2	0.99
0.002	1.9	0.87
0.001	1.5	0.70

TABLE 3. Continued

Denomination	Tolerance	
8 oz	100 µlb	45 mg
4	50	23
2	25	11
1	12	5.4
0.5 (1/2)	6.2	2.8
0.3	3.9	1.8
0.25 (1/4)	3.7	1.7
0.2	3.4	1.6
0.125 (1/8)	3.0	1.3
0.1	2.8	1.3
0.0625 (1/16)	2.4	1.1
0.05	2.2	1.0
0.03125 (1/32)	1.9	0.87
0.03	1.9	0.85
0.02	1.7	0.75
0.015625 (1/64)	1.5	0.69
0.01	1.3	0.60

TABLE 4. Apothecary

Denomination	Tolerances	
12 oz ap	150 µlb	70 mg
10	140	62
6	82	37
5	69	31
4	55	25
3	41	19
2	27	12
1	14	6.2
6 dr ap	10	4.7
5	8.6	3.9
4	6.9	3.1
3	5.1	2.3
2	3.8	1.7
1	3.1	1.4
0.5	2.5	1.1
2 s ap	2.7	1.2
1	2.2	0.98
0.5	1.7	0.78

TABLE 5. Grains

Denomination	Tolerance	
10 000 grains	150 µlb	70 mg
5 000	150	70
3 000	86	39
2 000	57	26
1 000	29	13
500	14	6.5
300	8.6	3.9
200	5.7	2.6
100	3.6	1.6
50	2.9	1.3
30	2.5	1.1
20	2.2	0.98
10	1.7	0.78
5	1.4	0.63
3	1.2	0.53
2	1.0	0.47
1	0.83	0.38
0.5	0.67	0.30
0.3	0.57	0.26
0.2	0.50	0.23
0.1	0.40	0.18

* 1 µlb = 0.000001 lb

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This handbook provides minimum requirements for field standard weights used to test commercial weighing devices. It supersedes Handbook 105-1 (1972 edition.)

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)
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