

VERIFICATION OF STANDARDS OF MASS

Department of Commerce and Labor

BUREAU OF STANDARDS

Washington

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Under the provisions of the act of Congress approved March 3, 1901, establishing the Bureau of Standards, the Bureau is authorized, among other things, to compare standards of mass used in scientific work, manufacturing, and commerce with the standards of the United States. Work of this character will be limited, for the present, to the verification of masses up to 50 pounds avoirdupois or 25 kilograms.

FUNDAMENTAL STANDARDS.

The fundamental unit of mass of the United States is the International Kilogram, two copies of which are in the possession of the Bureau of Standards. By the use of the relation,

$$1 \text{ lb. avoirdupois} = 0.4535924277 \text{ kilogram,}$$

all units of the customary system are derived. This value for the pound is the result of the joint work of the International Bureau of Weights and Measures and the English Standards Office, London, England. In 1893 the Office of Weights and Measures† was authorized to derive the pound from the kilogram, the reason being that the standard platinum-iridium kilograms in the possession of the United States are much more accurately known and are more permanent standards than the old brass pounds previously used as standards in the United States.

PROTOTYPE KILOGRAMS.

The United States prototype kilograms Nos. 4 and 20, which were received from the International Bureau of Weights and Measures in 1889, are composed of an alloy of 90 per cent platinum and 10 per cent iridium, this having been the composition decided upon as most suitable by the International Committee of Weights and Measures. The shape is that of a cylinder whose height is equal to the diameter, with slightly rounded edges. The values of these standards in terms of the international kilogram are:

$$\text{No. 4} = 1 \text{ kg} - 0.075 \text{ mg}$$

$$\text{No. 20} = 1 \text{ kg} - 0.030 \text{ mg}$$

One of the standards (No. 20) is kept as a standard of reference in a specially constructed fireproof vault, and up to the present time has not been used in any comparisons. The other (No. 4) is occasionally used to verify the secondary or working standards of the Bureau, and in special cases where the highest accuracy is required other kilograms are directly compared with it.

*Superseding the first edition, issued December 10, 1903.

†Now the Bureau of Standards (act of March 3, 1901).

SECONDARY STANDARDS.

For the routine work of testing use is made of secondary, or working, standards, which have either been made at the Bureau or acquired by purchase. The larger weights are made of brass or Tobin bronze, and are gold-plated in order to prevent alteration of value by chemical action of the atmosphere. The smaller weights—e. g., below 1 gram—are made of platinum-iridium or platinum. Every standard is made in one piece, so that possible changes of value, intentionally or accidentally without notice, are reduced to a minimum. The values of these masses are carefully determined in terms of the prototype and checked therewith from time to time to detect any changes.

CLASSIFICATION.

The following three classes of weights will be accepted for regular test and certification: Class A. Reference standards; Class B. Working standards; Class C. Accurate commercial weights.

In special cases weights not falling within the requirements of any one of the above classes will be tested, but in no case will they be stamped with the seal of this Bureau, nor will the regular certificate be given for them.

At the present time it is not practicable to specify minutely requirements as to the shape and material of the weights of each class. The Bureau reserves the right, therefore, to reject any weights showing faults not herein specified but which have a tendency to make them unreliable.

CLASS A. REFERENCE STANDARDS.

This includes standards of the highest type, suitable for reference standards for makers of precision weights, etc., and for use in the most exact scientific investigations.

Requirements.—(1) They must each be of one piece of metal; (2) they must show no trace of porosity; (3) they must either be made of or be plated with a metal that will not readily oxidize or be otherwise chemically affected by the air or the gases ordinarily found in the atmosphere; (4) they must be of such shape and finish as to show any accidental or intentional change in their mass; (5) they must bear distinguishing marks or numbers whenever possible, or be inclosed in a special case bearing such marks; (6) they must be so adjusted that their actual masses differ from their nominal values by less than the amounts specified in the following table of tolerances.

Extent of test.—Tests of weights of this class will include (1) determination of the density and volume, except where they may be assumed with sufficient certainty; (2) determination of the actual mass; (3) adjustment, if necessary and desired. The volumes will be determined by weighing in water.

Certificate and marking.—Weights fulfilling the requirements for this class will be marked with a special seal of the Bureau if it is requested, and the Bureau of Standards test number will be placed on the case containing them.

Fees—Schedule 11.—Class A. Reference standards of mass.

	Per weight.
(a) Determination of density	\$2.00
(b) Verification and certification	2.00
(c) Verification of a connected series of masses	1.00
(d) Adjustment within the tolerance established for Class A.....	1.00

Classes B and C.

Basis of comparison.—It is a common practice to use brass weights for reference standards and to adjust iron or steel weights to them by weighing in air without

correcting for buoyancy. This has placed most commercial weighing on the basis of comparison with brass weights in air. Although the difference between the values determined in this way and by correcting for the buoyancy of the air is almost negligible, to avoid apparent discrepancies between brass and iron weights of these classes, the values as determined by comparison with brass weights in air will be given. For weights of Class B the Bureau will, however, recognize three bases of adjustment and comparison—(1) the actual mass, or the weight in vacuo as calculated from an assumed density; (2) the weight as determined by comparison in air with correct platinum weights whose density is 21.5 at 0° C; (3) the weight as determined by comparison in air with correct brass weights whose density is 8.4 at 0° C. To avoid confusion, the basis for the adjustment of the weights of Class B should be stated when they are submitted for test. When a few of the smaller weights of a set are of aluminum, the large weights being of platinum, the values will be given on the basis (2). All weights of Class C must be adjusted to and all values will be given on the basis (3).

The second and third bases are practically equivalent to assuming the weights to be of brass or of platinum of the specified density. Whenever the volume of a weight is not actually determined, the following densities will be assumed in reducing weighings to vacuo:

Brass or bronze	8.4
Platinum	21.5
Aluminum	2.65
Cast iron	7.4

Forms of certificates.—For weights of Classes B and C this Bureau will give two forms of certificates—(a) certificates of values, which will give the value of each weight; (b) certificates of classification, which will merely certify that the weights are within the tolerance errors established by the Bureau. For example, they will be certified as Class B weights if the errors are within those allowed for that class.

CLASS B. WORKING STANDARDS.

This class includes weights suitable for standards for manufacturers of scales and weights, for city or district sealers, and for the better grades of chemical and other scientific work.

Requirements.—(1) They may be of either one or two pieces of metal. If of two pieces, the smaller one must be the handle which may screw into the body of the weight, or a plug of brass or other suitable material which must be driven securely into the upper side of the weight. In plug weights, the plug should not be driven in until it has been found that the weight does not need further adjusting. (2) If they are of two pieces, the hole left under the handle or plug must be small in proportion to the volume of the weight. (3) They must be made of a metal that will not readily oxidize or be otherwise affected by the air or gases ordinarily in the atmosphere, or they must be plated with such a metal or be coated with lacquer or similarly transparent coatings that will protect the metal from such gases. (4) The surface of the metal must be smooth or polished so as to readily show scratches or other injuries. (5) They must be of such known material that the density may be assumed with a fair degree of accuracy. (6) They must be adjusted to within the limits specified in the tables below.

Extent of test.—For certificate of classification the test will include only a single weighing for each weight, except where the errors are very close to the limit.

For certificate of values a sufficient number of weighings of each weight will be made to insure the accuracy of the corrections.

For both forms of certification the determination of the density if desired or necessary, and adjustment when necessary and desired may be made.

Certificate and marking.—Values for individual weights will be given to the degree of accuracy shown in the tables below. Upon request weights not coated with lacquer or other material liable to be injured by so doing will be marked with the seal of the Bureau and a capital B if they fulfill the requirements for weights of this class.

Fees—Schedule 12.—Class B. Working standards of mass.

	Certificate of value.	Certificate of classification.
	<i>Each.</i>	<i>Each.</i>
For single weights.....	(a) \$0.80	(b) \$0.40
For weights in a connected series.....	(c) .50	(d) .25
For adjustment—(I) when of two pieces; (II) when of one piece but not requiring replating.....	(e) .75	(f) .75

CLASS C. ACCURATE COMMERCIAL WEIGHTS.

This class includes weights suitable for “test weights” of city or district sealers, for jewelry and diamond weights, druggists’ weights, etc.

Requirements.—(1) They must be of either one or two pieces of metal. For example, when the handle screws into the body of the weight there must be no plug of lead or other material. If plugged the opening should be on the top of the weight and should be small and so arranged that the surface of the plug is close to the surface of the weight. If the weights are made to pile one upon another, the surface of the plug must be slightly below the surface of the weight. There should be no plugs or cavities on the underside, but for the present weights so constructed will be received if they are reasonably reliable. (2) They must be of such metal or plated with such metal as will not be affected by the atmosphere to a greater extent than good nickel plate or be lacquered or painted with such material as will not chip readily. (3) They must be adjusted to within the limits of error given in the tables of tolerance below.

Extent of test.—The test will be the same as for Class B, but to a less degree of accuracy.

Certificates and marking.—Values for individual weights will be given to the degree of accuracy shown in the tables below.

Weights fulfilling the requirements for weights of this class and so constructed that the seal can be placed upon them without injury will be marked with the seal of the Bureau and a capital C.

Fees—Schedule 13.—Class C. Accurate commercial weights.

	Certificate of value.	Certificate of classification.
	<i>Each.</i>	<i>Each.</i>
Verification, single weights.....	(a) \$0.60	(b) \$0.30
Verification, weights in a connected series.....	(c) .40	(d) .20

Table of Tolerances.

Weight.*	CLASS A.		CLASS B.		CLASS C.	
	Tolerance.	Values given to.	Tolerance.	Values given to.	Tolerance.	Values given to.
20 kg	100 mg	10 mg	200 mg	50 mg	1,500 mg	100 mg
10	50	10	100	10	900	10
5	25	1	50	10	450	10
2	10	1	20	10	225	10
1	5	0.1	10	1	150	10
500 g	3	0.1	5	1	90	1
200	1	0.01	2	0.1	40	1
100	0.5	0.01	1	0.1	25	1
50	0.3	0.01	0.5	0.1	20	0.1
20	0.1	0.01	0.2	0.01	10	0.1
10	0.1	0.01	0.2	0.01	8	0.1
5	0.1	0.001	0.2	0.01	5	0.1
2	0.05	0.001	0.1	0.01	3	0.1
1	0.05	0.001	0.1	0.01	2	0.1
500 mg	0.04	0.001	0.08	0.001	1	0.01
200	0.03	0.001	0.06	0.001	1	0.01
100	0.03	0.001	0.05	0.001	1	0.01
50	0.02	0.001	0.05	0.001	0.5	0.01
20	0.02	0.001	0.04	0.001	0.4	0.01
10	0.02	0.001	0.04	0.001	0.3	0.01
5	0.01	0.001	0.03	0.001	0.2	0.01
2	0.01	0.001	0.02	0.001	0.1	0.01
1	0.01	0.001	0.02	0.001	0.1	0.01
0.5	0.01	0.001	0.01	0.001	-----	-----
0.2	0.01	0.001	0.01	0.001	-----	-----
0.1	0.01	0.001	0.01	0.001	-----	-----

* For weights of other denominations the nearest metric weight here given will determine the tolerance.

No weights, of any class, smaller than 10 milligrams will be stamped with the seal of the Bureau, and other weights to be stamped must be so constructed that the imprint can be readily placed.

CONTINUITY OF SETS.

The method of testing a connected series of weights is to compare one of the set (usually the largest) with the corresponding office working standard and then to derive the values of the remainder by intercomparison. This gives a connected set of values and at the same time diminishes wear on the office standards. Where the continuity of a set submitted for test is broken, or where single weights are submitted for test, the work of testing is relatively greater, and consequently larger fees are charged.

The sets of weights in common use are usually made up of one of the following series:

- (a) 10, 5, 2, 2, 1, 0.5, 0.2, 0.2, 0.1, $\Sigma 0.1$.
- (b) 10, 5, 2, 1, 1, 0.5, 0.2, 0.1, 0.1, $\Sigma 0.1$.
- (c) 10, 4, 3, 2, 1, 0.4, 0.3, 0.2, 0.1, etc.
- (d) 10, 5, 4, 3, 2, 1, 0.5, 0.4, 0.3, 0.2, 0.1, etc.

The first two series are recommended as preferable to the others, as they require fewer weights and are therefore more convenient to test and in use.

REJECTED WEIGHTS.

When weights are not sufficiently accurate or otherwise fail to conform to the requirements of the Bureau for weights of the class to which they are intended to belong, the

Bureau will, unless previously requested to do otherwise, notify the one who submitted the weights, and will await further instructions. If the only fault is that they are not sufficiently accurate, they may be either (1) reclassified, if they come within the requirements of a lower class, or (2) readjusted, or (3) returned. Sets of weights will be treated as a whole. Incorrect weights belonging to a set may be replaced before a test is completed, but the Bureau will not give a classification certificate for part of a set.

TEST BEFORE CLEANING.

In some cases the persons sending weights to the Bureau have special reasons for wishing to know the values of the weights as they are sent to the Bureau; for example, when they have been used in some investigation and the corrections are desired. In such cases the Bureau should be notified, as, otherwise, the weights will be carefully cleaned, duplicates given identification marks, etc., thus possibly changing their values. A regular certificate will not be given in such cases unless the weights are free from foreign material.

GENERAL STRUCTURE AND RELIABILITY OF WEIGHTS.

This Bureau will not be responsible for the value of weights after they have been in the hands of other people. The restrictions as to construction are simply to prevent or detect accidental or intentional changes in the weights. Weights made in two pieces, especially where the handle screws into the body of the weight and there are loose particles in the cavity, might readily be changed without detection.

Weights with openings into a cavity on the underside, in which loose material is placed and which are closed with a screw, are objectionable for the same reason. Those with plugs or holes partly filled with lead on the underside are not safe unless made with special care to prevent the filling becoming loose. It is advisable, therefore, that adjustment be made on the top of the weight where any change will be readily noticed. It is also advisable, if the handle screws into the body of the weight, that a pin be provided for a seal that will prevent the handle from unscrewing. When weights of Class B are made with an adjusting plug it is better that no loose material be placed in the cavity, the final adjusting being done by filing the plug. Careful attention to these details as well as to the "requirements" for each class will do much to produce reliable weights. On many points of design and material there are several satisfactory possibilities. As an aid both to manufacturers and purchasers this Bureau will be glad to receive from any manufacturer specifications as to design and material for weights of each class and of the various sizes in order to have as large a variety as possible from which to select those that are satisfactory.

With the best of construction the constancy of a standard after it leaves this Bureau depends on the care it receives. Proper boxes, proper lifters, the avoidance of rubbing, and careful handling will do much to preserve the values of the weights.

SEAL FOR BOXES CONTAINING WEIGHTS.

On account of the difficulty of marking individual weights, especially the small ones, the Bureau will hereafter seal boxes containing weights. This will assure the person receiving the weights that they have not been handled since leaving the Bureau. By this means manufacturers or dealers desiring to furnish customers with weights tested at the Bureau can have them tested in advance and thus avoid the delay caused by sending them for test after they have been ordered.

SPECIAL DIRECTIONS.

Application for test.—Written request should be made for all tests, even when the weights are delivered in person or by messenger. This request should state explicitly the class to which the weights belong and which form of certificate is desired, also the marks or numbers that serve to identify the weights.

Identification marks.—When practicable the weights themselves, otherwise the case containing them, should bear marks or numbers that will serve to identify them.

Shipping directions.—All weights should be carefully packed in cases that can be used in returning them. They should be directed simply to the “Bureau of Standards, Department of Commerce and Labor, Washington, D. C.” Delays may be caused by other forms of address. Packages will be returned by express “collect” except where sufficient postage is sent to cover return by mail.

Remittances.—Fees should be sent with the weights in accordance with the schedules of fees shown on the previous pages, and should be remitted by money order or check drawn to the order of the “Bureau of Standards.” Delays in forwarding fees involve corresponding delays in the return of the weights.

S. W. STRATTON,
Director.

Approved:

OSCAR S. STRAUS,
Secretary.



