



Designation: B 311–93(Reapproved 2002)^{ε1}

~~Test Method for Density Determination for Powder Metallurgy (P/M) Materials Containing Less Than Two Percent Porosity~~ Designation: B311 – 08

Standard Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity¹

This standard is issued under the fixed designation B311; 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.

This standard has been approved for use by agencies of the Department of Defense.

^{ε1}Note—Paragraphs 3.1, 4.1, 4.2, 5.4, and 6.1 were revised editorially in June 2002.

1. Scope*

1.1 This test method covers the determination of density for powder metallurgy ~~(P/M)~~(PM) materials containing less than two percent porosity and for cemented carbides. This test method is based on the water displacement method.

NOTE 1—A test specimen that gains mass when immersed in water indicates the specimen contains surface-connected porosity. Unsealed surface porosity will absorb water and cause density values higher than the true value. This test method is not applicable if this problem occurs.

~~1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.~~

1.2 With the exception of density values, for which the g/cm^3 unit is the industry standard, the values stated in SI units are to be regarded as the standard. Values in inch-pound units are shown in parentheses and result from conversion in accordance with IEEE/ASTM Standard SI 10.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B243 [Terminology of Powder Metallurgy](#)

2.2 *IEEE/ASTM Standard:*

SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

2.3 *ISO Standard:*

3369 Impermeable Sintered Metal Materials and Hardmetals—Determination of Density³

NOTE 2—The water density table in ISO 3369 differs from the table contained in this test method.

3. Summary of Test Method

~~3.1 Using an analytical balance, the test specimen is first weighed in air and then in water. The density is determined by calculation.~~ Terminology

3.1 Definitions of powder metallurgy (PM) terms can be found in Terminology B243. Additional descriptive material is

¹ This test method is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.11 on Near Full Density Powder Metallurgy Materials.

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² Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

^{ε1} Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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

available in the Related Material section of Vol. 02.05 of the *Annual Book of ASTM Standards*.

4. Significance and Use

4.1 For P/M materials containing less than two percent porosity, a density measurement may be used to determine if the part has been densified, either overall or in a critical region, to the degree required for the intended application. Density alone cannot be used for evaluating the degree of densification because chemical composition and heat treatment affect the pore-free density.

4.2 For cemented carbides, a density measurement is normally used to determine if there is any significant deviation in composition of the carbide grade. For straight tungsten carbide-cobalt grades, the relationship is straightforward. For complex carbide grades (for example, grades containing tantalum carbide or titanium carbide, or both, in addition to tungsten carbide-cobalt), the situation is more complicated. If the measured density is beyond the specified limits, the composition is outside of the specified limits. A measured density within the specified limits does not ensure correct composition; compensation between two or more constituents could result in the expected density with the wrong composition. Density alone cannot be used for evaluating a cemented carbide grade.

Summary of Test Method
4.1 Using an analytical balance, the test specimen is first weighed in air and then in water. The density is determined by calculation using Archimedes' principle.

5. Significance and Use

5.1 For PM materials containing less than two percent porosity, a density measurement may be used to determine if the part has been densified, either overall or in a critical region, to the degree required for the intended application. Density alone cannot be used for evaluating the degree of densification because chemical composition and heat treatment affect the pore-free density.

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6. Apparatus

6.1

6.1 Analytical Balance— precision single-pan analytical balance that will permit readings within 0.01 % of the test specimen mass. The analytical balance shall be supported in a manner to eliminate mechanical vibrations and be shielded from air drafts. See Table 1.

5.26.2 Weighing Liquid—Distilled or deionized water to which 0.05 to 0.1 volume percent of a wetting agent has been added to reduce the effects of surface tension.

NOTE 3—Degassing the water by evacuation, boiling, or ultrasonic agitation helps to prevent air bubbles from collecting on the test specimen and specimen support when immersed in water.

6.3

6.3 Water Container—A glass beaker or other suitable transparent container should be used to contain the water.

NOTE 4—A transparent container makes it easier to see air bubbles adhering to the test specimen and specimen support when immersed in water.

NOTE 5—For the most precise density determination, the water container should be of a size that the level of the water does not rise more than 2.5 mm (0.10 in.) when the test specimen is lowered into the water.

6.4

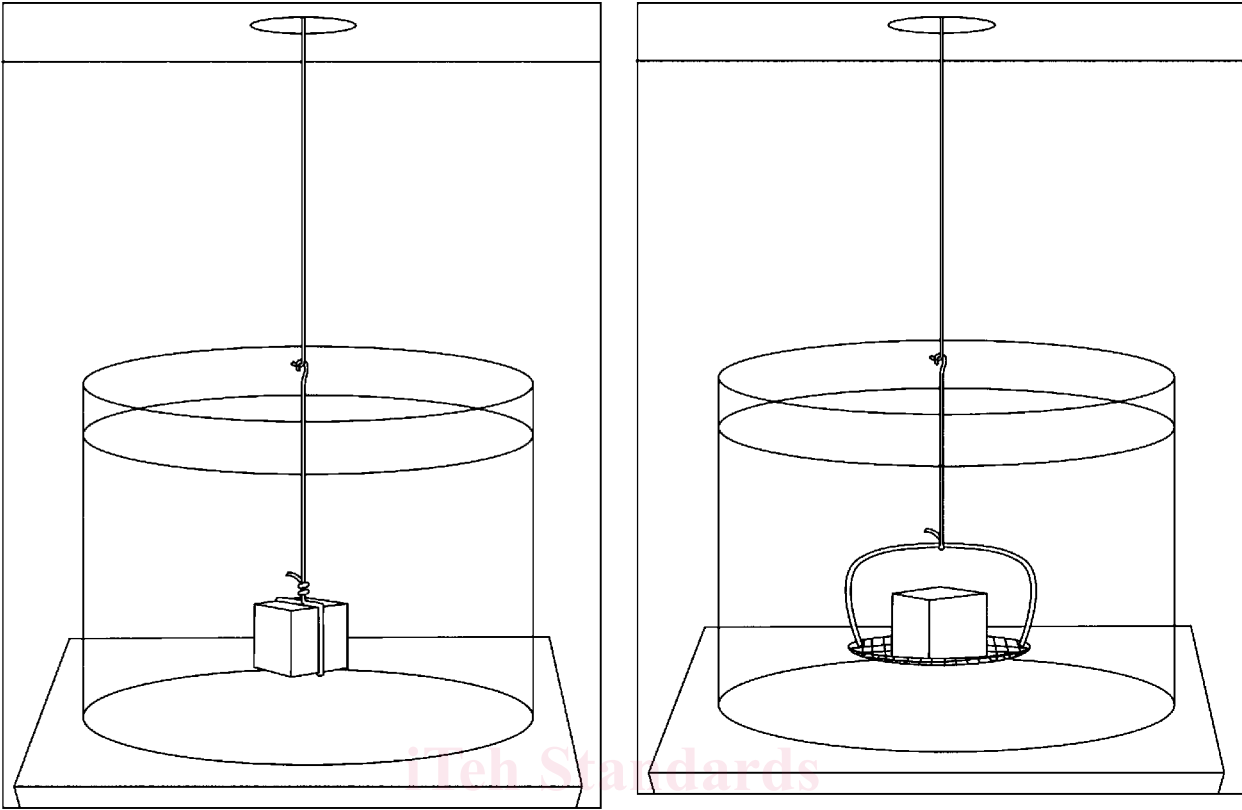
6.4 Test Specimen Support for Weighing in Water—Two typical arrangements are shown in Fig. 1. The suspension wire may be twisted around the test specimen or the test specimen may be supported in a wire basket that is attached to the suspension wire. For either arrangement, a single corrosion resistant wire—for example, austenitic stainless steel, copper, nichrome—shall be used for the basket and suspension wire. The maximum recommended diameter of suspension wire to be used for various mass ranges is:

| Mass, g | Wire Diameter, mm (in.) |
|----------------------|-------------------------|
| less than 50 | 0.12 (0.005) |
| 50 to less than 200 | 0.25 (0.010) |
| 200 to less than 600 | 0.40 (0.015) |
| 600 and greater | 0.50 (0.020) |

The suspension wire may be twisted around the test specimen or the test specimen may be supported in a wire basket that is attached to the suspension wire. For either arrangement, a single corrosion resistant wire—for example, austenitic stainless steel, copper, nichrome—shall be used for the basket and suspension wire. For the maximum recommended diameter of suspension wire to be used for various mass ranges see Table 2.

NOTE 6—For the most precise density determinations, it is important that the mass and volume of all supporting wires immersed in water be minimized.

6.5



a. Twisted wire arrangement

b. Basket support arrangement

FIG. 1 Methods for Holding the Test Specimen When Weighing in Water

TABLE 1 Density of Air-Free Water^A

| Temperature (°C) | Density (g/cm ³) |
|--------------------------|------------------------------|
| 18.0 | 0.99986 |
| 18.5 | 0.99985 |
| less than 10 | 0.0001 |
| 19.0 | 0.99984 |
| 10 to less than 100 | 0.001 |
| 19.5 | 0.99983 |
| 100 to less than 1000 | 0.01 |
| 20.0 | 0.99982 |
| 1000 to less than 10 000 | 0.9982 |
| 20.5 | 0.998121 |
| 21.5 | 0.9979 |
| 22.0 | 0.9978 |
| 22.5 | 0.9976 |
| 23.0 | 0.9975 |
| 23.5 | 0.9974 |
| 24.0 | 0.9973 |
| 24.5 | 0.9972 |
| 25.0 | 0.9970 |
| 25.5 | 0.9969 |
| 26.0 | 0.9968 |
| 26.5 | 0.9966 |
| 27.0 | 0.9965 |
| 27.5 | 0.9964 |
| 28.0 | 0.9962 |
| 28.5 | 0.9961 |
| 29.0 | 0.9959 |
| 29.5 | 0.9958 |
| 30.0 | 0.9956 |

^AMetrological Handbook 145, "Quality Assurance for Measurements," National Institute of Standards and Technology, 1990, p. 9-10.