Designation: ~~B963 – 11~~ B963 – 13

Standard Test Methods for Oil Content, Oil-Impregnation Efficiency, and Interconnected Porosity of Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle[1]

This standard is issued under the fixed designation B963; 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~~ Scope*

1.1 This standard describes three related test methods that cover the measurement of physical properties of oil-impregnated powder metallurgy products.

1.1.1 Determination of the volume percent of oil contained in the material.

1.1.2 Determination of the efficiency of the oil-impregnation process.

1.1.3 Determination of the percent interconnected porosity by oil impregnation.

1.2 ~~The values stated~~ With the exception of the values for density and the mass used to determine density, for which the use of the gram per cubic centimetre (g/cm^3~~in SI~~) and gram (g) units is the long-standing industry practice, the values in inch-pound units are to be regarded as ~~the~~ standard. The values given in parentheses are ~~converted in accordance with IEEE/ASTM SI 10 and are for information only.~~mathematical conversions to SI units that are provided for information only and are not considered standard.

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

D1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

E456 Terminology Relating to Quality and Statistics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

~~2.2 *IEEE/ASTM Standard:*~~

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

3. Terminology

3.1 Definitions of powder metallurgy (PM) terms can be found in Terminology B243. Additional descriptive material is available in the Related Material section of Vol. 02.05 of the *Annual Book of ASTM Standards*.

4. Summary of Test Method

4.1 The part or test specimen is first weighed in air. It is then oil impregnated to fill the surface-connected porosity and the specimen is reweighed. The test specimen is then weighed when immersed in water and its volume calculated based on Archimedes' principle. The oil is then removed and the specimen is reweighed.

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[1] These test methods are under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and are the direct responsibility of Subcommittee B09.04 on Bearings.

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[2] 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.

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

4.2 The *oil content* of an oil-impregnated part or test specimen is then calculated as a percentage of the volume of the specimen. This may be done for the as-received and the fully oil-impregnated specimen.

4.3 The *oil-impregnation efficiency* is calculated by dividing the as-received oil content by the fully impregnated oil content and expressing the result as a percentage.

4.4 The volume percentage of *interconnected porosity* (as measured by oil impregnation) is then calculated based on the amount of oil in the fully oil-impregnated specimen.

5. Significance and Use

5.1 Oil content values are generally contained in specifications for oil-impregnated PM bearings.

5.2 The oil-impregnation efficiency provides an indication of how well the as-received parts had been impregnated.

5.3 The desired self-lubricating performance of PM bearings requires a minimum amount of interconnected porosity and satisfactory oil impregnation of the interconnected porosity. A minimum oil content is specified.

5.4 The results from these test methods may be used for quality control or compliance purposes.

6. Apparatus

6.1 *Analytical Balance*—Precision single-pan balance that will permit readings within ~~0.01 %~~0.01% of the test specimen mass. See Table 1.

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

NOTE 1—A transparent container makes it easier to see air bubbles adhering to the test specimen and specimen support when immersed in water.

NOTE 2—For the most precise 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.)~~0.10 in. (2.5 mm) when the test specimen is lowered into the water.

6.3 *Water*—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 support when immersed in water.

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, or 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 shown in Table 2.

NOTE 4—For the most precise determinations, it is important that the mass and volume of all supporting wires immersed in water be minimized.

6.5 *Oil for Oil-Impregnation*—The same type of oil that was used to impregnate the parts originally.

6.5.1 If parts are not already impregnated, oil with a viscosity of 20 to 65 cSt or 100 to 300 SSU (20×10^{-6} to 65×10^{-6} m^2/s ~~(20 to 65 cSt or 100 to 300 SSU) at 38 °C (100 °F)~~ /s) at 100 °F (38 °C) has been found to be suitable.

6.6 *Vacuum Impregnation Apparatus*—Equipment for impregnation of the part or test specimen with oil.

6.7 *Thermometer*—A thermometer with an accuracy of ~~0.5 °C (1 °F)~~ 1 °F (0.5 °C) to measure the temperature of the water.

6.8 *Soxhlet Apparatus*—Glass laboratory unit consisting of a condenser, extractor, filter, flask with a suitable solvent for the oil such as petroleum ether, and a heating mantle.

7. Preparation of Test Specimens

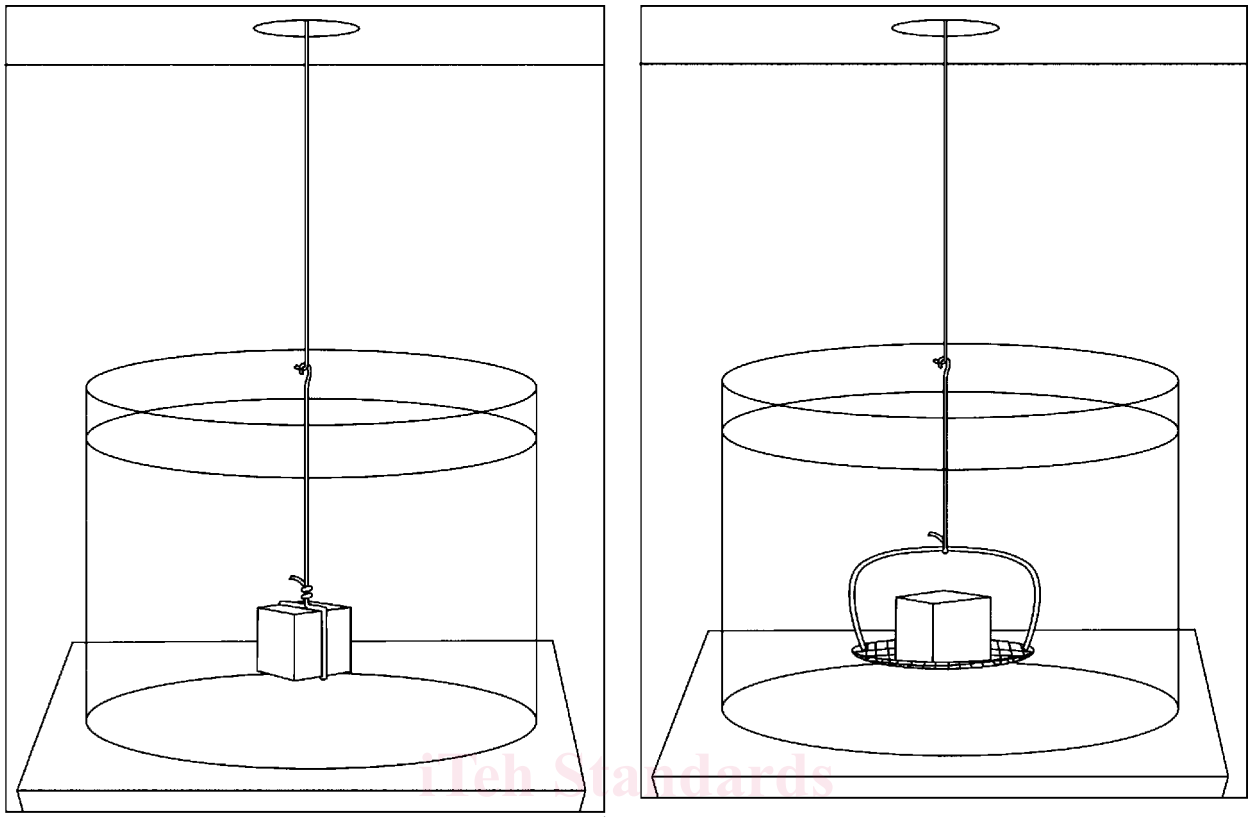
7.1 The mass of the test specimen shall be a minimum of 1.0 g. For small parts, several parts may be combined to reach the minimum mass.

7.2 Thoroughly wipe clean all surfaces of the test specimen to remove any adhering foreign materials such as dirt or oxide scale.

7.3 Take care with cut specimens to avoid rough surfaces to which an air bubble may adhere. A 100-grit sanding or abrasive grinding is recommended to remove all rough surfaces.

TABLE 1 Balance Sensitivity

Mass, g	Balance Sensitivity, g
less than 10	0.0001
10 to less than 100	0.001
100 to less than 1000	0.01
1000 to less than 10 000	0.1



a. Twisted wire arrangement

b. Basket support arrangement

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

TABLE 2 Maximum Recommended Wire Diameters

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)~~

TABLE 2 Maximum Recommended Wire Diameters

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

8. Procedure

8.1 It is important that the part or test specimen, the analytical balance and surrounding air be at a uniform temperature when weighing is performed.

8.2 For the most precise volume determinations, duplicate weighings should be made for all mass measurements. The analytical balance should be adjusted to zero prior to each weighing. Duplicate mass determinations should be averaged before performing any calculations.

8.3 For improved repeatability and reproducibility, the analytical balance should be verified periodically with a standard mass that is approximately equal to the part or test specimen mass.

8.4 *Determination of Oil Content, Oil-Impregnation Efficiency, and Interconnected Porosity:*

8.4.1 Determine the mass of the as-received part or test specimen. This is mass J. This and all subsequent weighings shall be to the precision stated in Table 1.

8.4.2 Oil impregnate the as-received part or test specimen using one of the following procedures:

Vacuum Oil Impregnation—Preferred Procedure

8.4.3 Immerse the part or test specimen in oil at room temperature.

8.4.4 Reduce the pressure over the sample to ~~7 kPa (1 psi)~~1 psi (7 kPa) or less for 30 minutes, then increase the pressure back to atmospheric pressure and keep the sample immersed for at least 30 minutes.

8.4.5 Remove excess oil by wiping gently with an absorbent, lint-free material. Take care not to extract oil absorbed within the part or test specimen.

8.4.6 Do not place or store parts on porous surfaces such as paper, cloth, or cardboard as these will absorb oil.

8.4.7 Proceed to 8.4.13.

Immersion Oil Impregnation—Alternative Procedure

8.4.8 Immerse the part or test specimen in oil at a temperature of ~~82 ± 5 °C (180 ± 10 °F)~~ 180 ± 10 °F (82 ± 5 °C) for at least 4 hours.

8.4.9 Cool by immersing in a bath of the same oil held at room temperature and keep in this oil for at least 30 minutes.

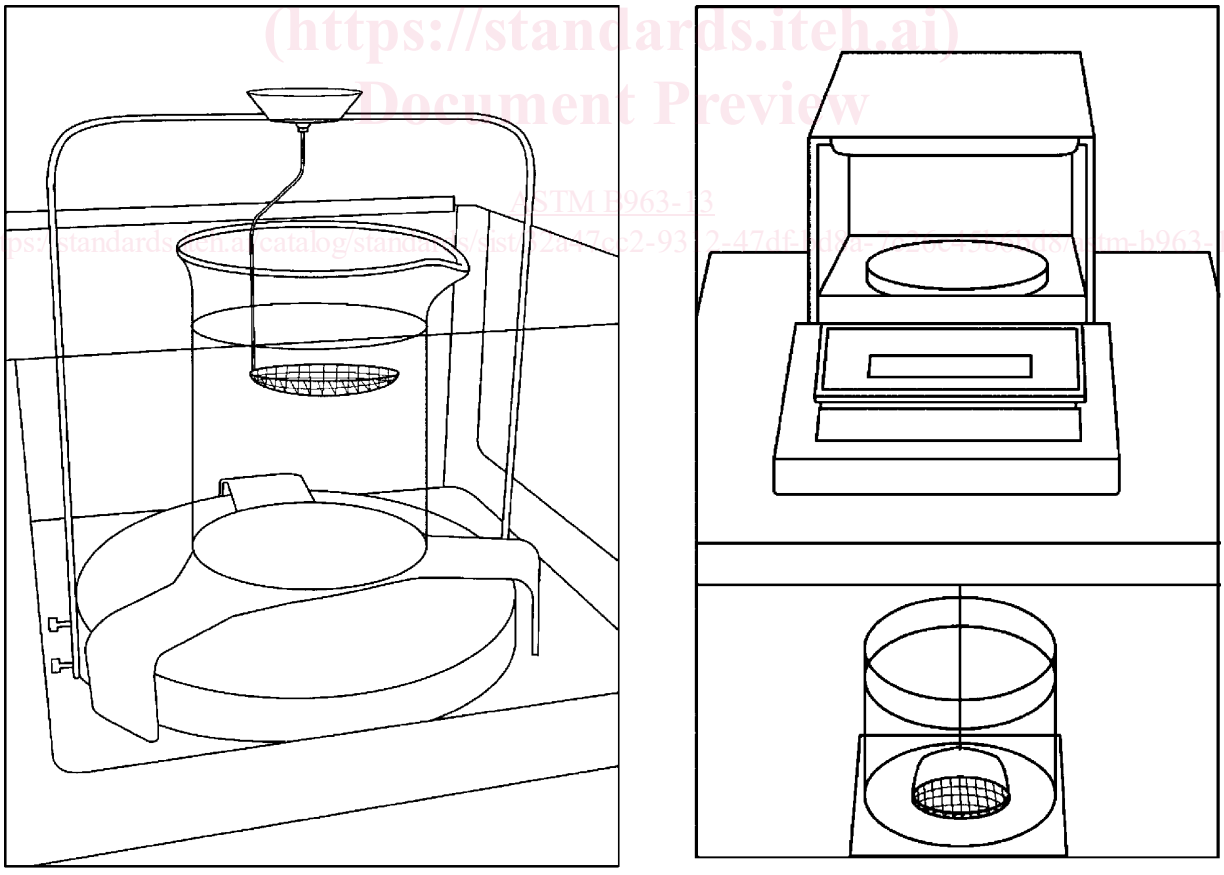
8.4.10 Remove excess oil by wiping gently with an absorbent, lint-free material. Take care not to extract oil absorbed within the part or test specimen.

8.4.11 Do not place or store parts on porous surfaces such as paper, cloth, or cardboard as these will absorb oil.

8.4.12 Proceed to 8.4.13.

8.4.13 Determine the mass of the oil-impregnated part or test specimen to the precision stated in Table 1. This is mass B.

8.4.14 Support the container of water over the pan of the balance using a suitable bridge as shown in Fig. 2a. Take care to ensure that the bridge does not restrict the free movement of the balance pan. The container of water may also be supported below the balance for weighing larger specimens if the balance has a lower beam hook for this purpose. See Fig. 2b. If this arrangement is used, shield the weighing system, including the wire, from the effect of air drafts.



a. Beaker support above balance pan

b. Weighing arrangement below the balance pan

FIG. 2 Methods for Weighing in Water