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Standard Test Method for Compressibility of Metal Powders in Uniaxial Compaction[1]

This standard is issued under the fixed designation B331; 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

~~1.1This test method covers determination of compressibility of metal powders as measured by the extent to which they can be densified in a specified die under controlled conditions.~~

~~1.2The values stated in inch-pound units are to be regarded as the standard. The SI equivalents are in parentheses and may be approximate.~~ *

1.1 This laboratory test method covers the determination of the compressibility of metal powders and metal powder mixtures as measured by the extent to which a sample can be densified under controlled conditions in a specified die.

1.2 With the exception of density values, for which the g/cm^3 unit is the industry standard, the values stated in inch-pound units are to be regarded as the standard. The values shown in parenthesis are mathematical conversions to SI units that are presented for information only and are not to be considered as 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]

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

B~~328Test Method for Density, Oil Content, and Interconnected Porosity of Sintered Metal Structural Parts and Oil-Impregnated Bearings~~ 925 Practices for Production and Preparation of Powder Metallurgy (PM) Test Specimens

B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

E456 Terminology Relating to Quality and Statistics

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to Terminology B243. Additional descriptive PM information is available in the Related Material section of Vol 02.05 of the *Annual Book of ASTM Standards*.

4. Summary of Test Method

~~4.1The test method consists of compacting a sample of metal powder in a confining die, ejecting it from the die, and measuring its green density. The powder is subjected to uniaxial loading in a standardized die of rectangular or of round cross section.~~

4.1 A test sample of metal powder is uniaxially compressed in a specific die under controlled conditions.

4.2 The green density of the resulting compact is determined.

4.3 The compressibility of the powder is defined as the green density of the test compact at the compacting pressure that was used.

5. Significance and Use

~~5.1The compressibility obtained is a measure of a material characteristic inherent in the powder. The test method is useful as a quality control test in the evaluation and manufacturing control of metal powder production, and as an acceptance test for shipment of metal powder lots.~~

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[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 B09.02 on Base Metal Powders.

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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.**

~~5.2Results may be affected by test conditions such as the type amount, and method of lubrication, dwell time, and die material. They may not necessarily agree with results obtained under production conditions.~~

5.1 The compressibility value obtained by this test is a measure of a material characteristic of the powder.

5.2 The test method is useful in research and development projects, as a quality control test in the evaluation and manufacturing control of metal powder production, and as an acceptance test for shipment of metal powder lots.

5.3 In PM production operations, the test is helpful in determining pressing and tooling requirements for high density parts.

5.4 Results may be affected by test conditions such as the type amount, and method of lubrication, dwell time during compaction, and die material. The compressibility values may not necessarily agree with results obtained under production conditions.

6. Apparatus

6.1 ~~*Die and Two Steel Punches*—The die should be made of cemented carbide, or alternatively of tool steel. The set may be designed either for rectangular compacts or round compacts. Fig. 1 illustrates typical rectangular tooling and Fig. 2 illustrates typical round tooling.~~ Compacting Tooling—A cemented carbide die or alternatively, hardened tool steel die and two hardened steel punches capable of producing the compressibility test specimen. The designs shown in Practice B925 for a *cylindrical test specimen* and a *transverse rupture test specimen* are examples of acceptable tooling.

6.2 ~~*Compression Testing Machine or Hydraulic Powder Compacting Press*, capable of applying an adequate load with an accuracy of at least ±1.0%.~~

~~6.3~~*Powder Compacting Press*—A compression testing machine or powder compacting press, capable of applying an adequate load with an accuracy of at least ±1.0 %.

6.3 *Balance*~~, suitable for weighing at least 100 g to the nearest 0.01 g.~~ —A laboratory balance readable to 0.001 g with a minimum capacity of 100 g to be used to determine the mass suitable for weighing at least 100 g to the nearest 0.01 g.

6.4 *Micrometer*~~,~~ —Standard outside micrometers or other suitable measuring ~~device~~instruments for ~~measuring~~determining the dimensions of the green compressibility compacts to the nearest 0.0002 in. (0.005 mm).

7. ~~Sampling~~

~~7.1A quantity of powder capable of producing the required number of test specimens (see 9.1 and Section 11) shall be obtained in accordance with Practices~~ Gross Metal Powder Sample

7.1 The gross powder sample is a quantity of powder of sufficient mass to be split into the required number of powder test samples. It shall be taken from the lot of powder that is to be tested in accordance with Practice B215.

8. ~~Preparation of Apparatus~~

~~8.1Lubrication is necessary to assist the ejection of the compacted test specimen from the die. Either die-wall lubrication or powder lubrication may be used.~~

~~8.1.1~~*Unlubricated Powder*~~may be tested in a die with lubricated walls. Apply to the die walls a mixture of a lubricant in a volatile organic liquid. After any excess liquid has drained away, allow the solution adhering to the walls to evaporate leaving a thin layer of lubricant.~~

~~NOTE 1—An example of such a mixture is 100 g of zinc stearate in 1 L of methyl alcohol.~~

~~8.1.2An alternative way of testing powder not containing a lubricant is to use an otherwise unlubricated die after thoroughly mixing into the powder a sufficient amount of a suitable lubricant.~~

~~8.1.3~~*Lubricated Powder*~~, received already mixed with sufficient lubricant should be tested in an otherwise unlubricated die.~~

~~8.2Compressibility may vary according to the method of lubrication, type, and amount of lubricant.~~

~~8.3The parties shall agree on the method, amount, and type of lubricant.~~ Preparation

8.1 This test method contains procedures to be followed for either lubricated or unlubricated metal powders. Lubrication is generally necessary to assist in the compaction and ejection of the compressibility compact.

8.1.1 An alternative way of testing powder not containing a lubricant is to use an otherwise unlubricated die after thoroughly mixing into the powder a sufficient amount of a suitable lubricant.

8.2 *Lubricated Powders*:

8.2.1 Powder mixtures containing a lubricant shall be tested in the as-received condition.

8.3 *Unlubricated Powders*:

8.3.1 The needed lubrication may be supplied either by lubricating the walls of the die or by mixing a powdered lubricant into the metal powder to be tested.

8.3.1.1 Die-wall lubrication consists of coating the walls of the die with a thin film of lubricant prior to each compaction step following the die-wall lubrication procedure in Practices B925.

8.3.1.2 Admixed lubrication consists of thoroughly mixing a small percentage of a powdered lubricant into the gross sample.

8.4 Compressibility test results may vary in accordance with the method of lubrication, type, and amount of lubricant.

8.5 Compressibility test results may vary depending on the rate at which the compacting pressure is applied.

8.6 The parties concerned shall agree on the method of lubrication and the details of the procedure.

9. ~~Procedure~~

~~9.1*Powder Sample Mass*—The powder sample mass shall be such as to result in a rectangular compact 0.240 to 0.260 in. thick (6.1 to 6.6 mm) or a round compact 0.27 to 0.29 in. (6.9 to 7.4 mm) thick. For a powder whose compressibility is not known, it may be necessary to adjust the powder mass based on the specimen thickness obtained in an initial test.~~

~~9.2*Compaction*—The specimen shall be made using a double action pressing process. One example of this type of compaction is as follows:~~

~~9.2.1Insert the lower punch into the die cavity. Position the die cavity to the desired filling height using supporting spacers between the die and the lower press platen. Pour the powder sample into the die cavity taking care to ensure that the powder is uniformly distributed. Insert the upper punch and then apply and release a preliminary pressure of approximately 5000 psi (35 MPa). Remove the spacers supporting the die. If the die is supported by springs, or in some similar way, it is unnecessary to apply the preliminary pressure. Apply the final pressure. In special cases where the results may be affected by the rate of pressure application, a rate not exceeding 60000 psi/min (415 MPa/min) is recommended.~~ Procedure

9.1 *Testing Methods*:

9.1.1 The test for compressibility of metal powder may be conducted in any of three ways:

9.1.1.1 *Method 1*—Compressibility defined as the green density obtained at a selected compacting pressure.

9.1.1.2 *Method 2*—Compressibility as a graph relating density as a function of at least four compacting pressures.

9.1.1.3 *Method 3*—Compressibility defined as the compacting pressure required to attain a target green density.

9.2 *Test Specimens for Powder Compressibility*:

9.2.1 Either of two compressibility test specimens may be selected to determine compressibility.

9.2.1.1 *Cylindrical Compressibility Test Specimen*—A short cylindrical compact 1.000 in. in diameter by 0.280 ± 0.010 in. thick (25.4 in diameter by 7.11 ± 0.25 mm thick), as shown in Practice B925 as *Cylindrical Powder Compressibility Test Specimen*.

9.2.1.2 *Rectangular Compressibility Test Specimen*—A short rectangular compact 1.250 in. long by 0.500 in. wide by 0.250 ± 0.010 in. thick. (31.8 by 12.7 by 6.35 ± 0.25 mm), similar to that which is shown in Practices B925 as *Transverse Rupture Strength Test Specimen—Thin*.

9.2.2 Release the pressure as soon as the maximum pressure is attained, because pressure dwells of as little as 10 s can increase iron powder compressibility by 0.3 %.

9.3 ~~*Ejection*—the compact is then either ejected from the die or exposed via a withdrawal process, in accordance with the type of apparatus used. For the commonly used punch and die systems described in 9.2, the part is ejected by pushing back the die with the aid of two spacer blocks, or the like. The blocks should be longer than the combined length of the upper punch and the formed part. If possible, remove the upper punch by hand. If not possible, perform ejection with blocks until the punch clears the die, remove the punch, and continue to eject the test piece until it clears the die. Carefully deburr test pieces with fine emery paper.~~ Powder Test Sample:

9.3.1 The thickness of the compressibility test specimen is critical as the area of die wall contact has a strong effect on the green density and the thicknesses specified have been determined to give equivalent results between the two powder compressibility test specimens.

9.3.2 The powder test sample shall be a powder charge of sufficient mass to produce either a cylindrical test specimen 0.280 ± 0.010 in. (7.11 ± 0.25 mm) thick or a rectangular test specimen 0.250 ± 0.010 in. (6.35 ± 0.25 mm) thick.

9.3.3 For a powder whose compressibility is not known, it may be necessary to adjust the mass of the powder charge based upon the thickness obtained in an initial test.

9.4 *Compacting*:

9.4.1 Compact and identify three (3) duplicate compressibility test specimens of the shape that has been selected following the compacting procedure listed in Practice B925.

9.4.2 Be careful to release the load as soon as the maximum pressure is reached as a pressure dwell of as little as 10 s may increase compressibility by as much as 0.3 %.

9.4.3 Note the load used, then calculate and record the compacting pressure based on the pressing area of the selected compressibility test specimen.

9.4.4 The compressibility compacts may be lightly sanded on fine emery paper to remove any flash.

9.5 ~~*Measurements*—Weigh the compact to the nearest 0.01 g. Measure its dimensions to the nearest 0.0002 in. (0.005 mm). Compacts may not have top and bottom surfaces that are exactly parallel and care must be taken in determining an average thickness.~~

~~9.5*Compacting Pressures*—Samples of powder may be pressed either at a single specified pressure or at a series of specified pressures. In the latter case, the densities obtained can be utilized for drawing the compressibility curve of the powder, such as, a graph of density as a function of the compacting pressure. Alternatively, by trial and error, the powder may be compacted to a specified green density and the compacting pressure taken as a measure of its compressibility.~~

~~9.6For the method selected in 9.5, repeat 9.2-9.4 twice more.~~ :

9.5.1 Determine the mass of each green compressibility test specimen to the nearest 0.01 g.

9.5.2 Measure the dimensions of each green compressibility test specimen to the nearest 0.0002 in.