Designation: B331 – 20

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*

1.1 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 test portion can be densified under controlled conditions in a specified die.

1.2 *Units*—With the exception of the values for density and mass, for which the use of gram per cubic centermetre (g/cm^3) and gram (g) units is the longstanding industry practice, the values stated in inch-pound units are to be regarded as standard. The values given in parentheses are 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

B925 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 under *General Information on PM* on the ASTM B09 web page.

4. Summary of Test Method

4.1 A test portion 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

5.1 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 *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 Practices B925 for a *cylindrical test specimen* and a *transverse rupture test specimen* are examples of acceptable tooling.

6.2 *Powder Compacting Press*—A compression testing machine or powder compacting press, capable of applying an

[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

adequate load with an accuracy of at least ±1.0 % at a rate of approximately 30 tsi/min (400 MPa/min).

6.3 *Balance*—A laboratory balance readable to 0.001 g with a minimum capacity of 100 g.

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

7. 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 portions. It shall be taken from the lot of powder that is to be tested in accordance with Practices B215.

8. 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 *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 mm 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 mm by 12.7 mm by 6.35 ± 0.25 mm), similar to that which is shown in Practices B925 as *Transverse Rupture Strength Test Specimen—Thin*.

9.3 *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 portion 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:*

9.5.1 Determine the mass of each green compressibility test specimen. Record the mass to 0.001 g.

9.5.2 Measure the dimensions of each green compressibility test specimen to the nearest 0.0002 in. (0.005 mm).

10. Calculations

10.1 Calculate the green density of each powder compressibility test specimen as follows:

10.1.1 *For the Cylindrical Test Specimen:*

$$\text{Green Density, } D_G = (0.0777 \times M) / (D^2 \times T) \quad (1)$$

where:

D_G	=	green density of the cylindrical compressibility test specimen, g/cm^3.
0.0777	=	combined conversion factor, in.^{3} to cm^3 and π for the area calculation.
M	=	mass of the green compressibility test specimen, g.
D^2	=	diameter of the compact, squared, in.^{2}.
T	=	thickness of the compact, in.

10.1.2 *For the Rectangular Test Specimens:*

$$\text{Green Density, } D_G = (0.0610 \times M)/(L \times W \times T) \quad (2)$$

where:

D_G = green density of the rectangular compressibility test specimen, g/cm^3.
0.0610 = conversion factor, in.^{3}, to cm^3.
M = mass of the green compressibility test specimen, g.
L = length of the compact, in.
W = width of the compact, in.
T = thickness of the compact, in.

10.2 The density of the green powder compressibility test specimen may also be determined by the water displacement method of Test Methods B962.

11. Report

11.1 *Method 1*—Report the compressibility in g/cm^3 as the arithmetic average of three density measurements, calculated to the nearest 0.01 g/cm^3, at a given compacting pressure (for example, 6.00 g/cm^3 at 30 tsi (400 MPa)).

11.2 *Method 2*—Display the compressibility as a graph of green density as a function of compacting pressure using at least four (4) determinations.

11.3 *Method 3*—Alternatively, report the compressibility in tsi to the nearest 0.5 tsi (10 MPa), as the compacting pressure required to reach the specified green density (for example, 30.0 tsi (400 MPa)) for a green density of 6.50 g/cm^3).

11.4 Report the compact type, thickness, and method of lubrication and the die material.

11.4.1 For lubricated powder tested as-received, report the type and percentage of lubricant, if known.

11.4.2 For unlubricated powder tested using die-wall lubrication, report the type and amount of lubricant as the mass percent dissolved in the solvent.

11.4.3 For unlubricated powder tested after a powder lubricant has been admixed, report the type and percentage of the powder lubricant as well as details of the mixing procedure.

12. Precision and Bias[3]

12.1 The following precision values were developed from data contained in research report RR:B09-1002 collected using *Method 1* of this test standard.

12.1.1 *Precision:*

12.1.1.1 The within-laboratory repeatability limit, *r*, as defined by Terminology E456, is estimated to be 0.025 g/cm^3. Duplicate results from the same laboratory should not be considered different at the 95 % confidence level unless they differ by more than 0.025 g/cm^3.

12.1.1.2 The between-laboratories reproducibility limit, *R*, as defined by Terminology E456, is estimated to be 0.07 g/cm^3. Duplicate results from different laboratories should not be considered different at the 95 % confidence level unless they differ by more than 0.07 g/cm^3.

12.1.2 *Bias:*

12.1.2.1 No information can be presented on the bias of the procedures in this test method for measuring metal powder compressibility because no material having an accepted reference value is available.

12.1.3 *Measurement Uncertainty:*

12.1.3.1 The precision of this test method shall be considered by those performing the test when reporting metal powder compressibility results.

13. Keywords

13.1 compressibility; metal powder

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B09-1002. Contact ASTM Customer Service at service@astm.org.

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B331 – 16) that may impact the use of this standard. (Approved Oct. 1, 2020.)

(1) Deleted "to be used to determine the mass of the compacted test specimen to the nearest 0.01 g" from 6.3.
(2) Deleted "to the nearest 0.01 g" from 9.5.1 and added a sentence to record the mass to 0.001 g.
(3) Updated 3.1.