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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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# Standard Test Method for Compressibility of Metal Powders in Uniaxial Compaction[1]

This standard is issued under the fixed designation B 331; 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 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.

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

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:*

B 215 Practices for Sampling Finished Lots of Metal Powders[2]

B 243 Terminology of Powder Metallurgy[2]

B 328 Test Method for Density, Oil Content, and Interconnected Porosity of Sintered Powder Metal Structural Parts and Oil-Impregnated Bearings[2]

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to Terminology B 243.

## 4. Summary of Test Method

4.1 The 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.

## 5. Significance and Use

5.1 The 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.

5.2 Results 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.

## 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.

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 *Balance*, suitable for weighing at least 100 g to the nearest 0.01 g.

6.4 *Micrometer*, or other suitable measuring device for measuring the dimensions of the compacts to the nearest 0.0002 in. (0.005 mm).

## 7. Sampling

7.1 A 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 B 215.

## 8. Preparation of Apparatus

8.1 Lubrication 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.

8.1.2 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.

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

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

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[1] This test method is under the jurisdiction of ASTM Committee B-9 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.02 on Base Metal Powders.

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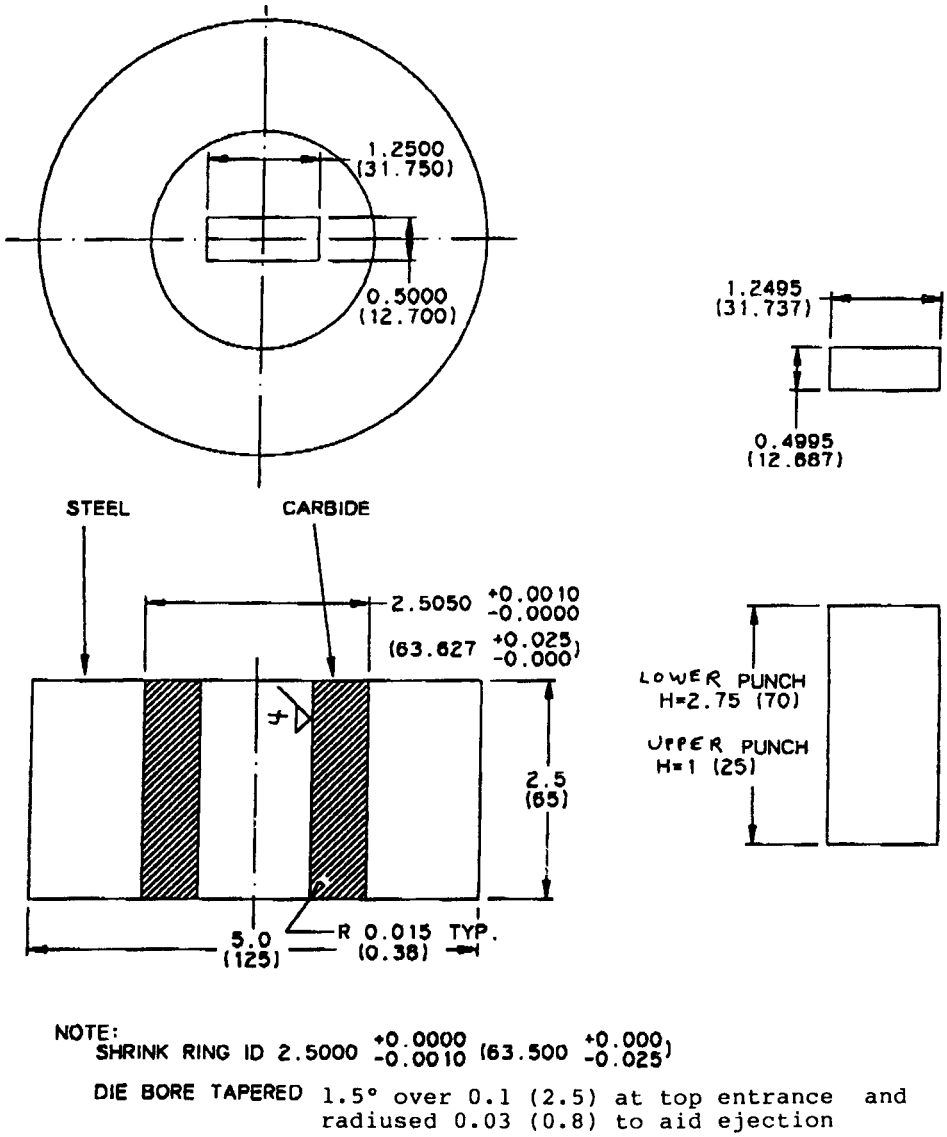
[2] *Annual Book of ASTM Standards*, Vol 02.05.




NOTE 1—The dimensions for the cavity shall be 0.500 ± 0.004 in. wide (12.70 ± 0.10 mm) by 1.250 ± 0.004 in. long (31.75 ± 0.10 mm). The mating parts shall fit freely and should be finished to 4 RMS, or better, to dimensions of 0.0005 in. (0.013 mm) to 0.001 in. (0.025 mm) smaller than the bottom of the die cavity, in each dimension. The dimensions given in the drawing typify the die cavity and punch within the stated tolerance, at the nominal width and length dimensions, permitting die wall to punch clearances of 0.00025 to 0.0005 in. (0.006 mm to 0.013 mm) at each of the four sides of the die, at the bottom of the die. The outer ring may be AISI H-11 steel hardened to 45 to 48 HRC. The punches may be AISI A-7 steel hardened to 60 to 62 HRC. The die insert should be die grade tungsten carbide.

**FIG. 1 Example of Tooling to Produce Rectangular Test Piece**

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

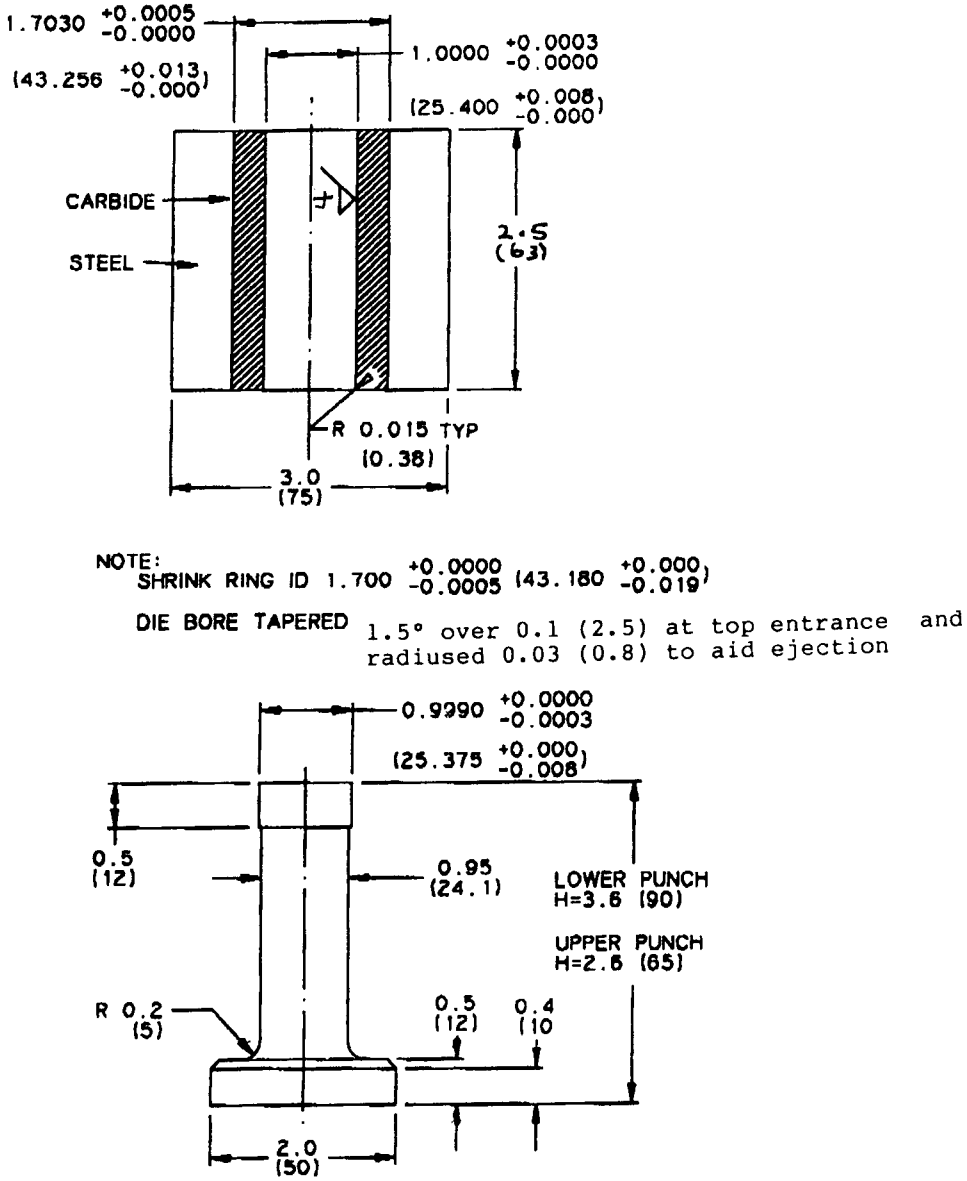
## 9. Procedure

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:

9.2.1 Insert 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 60 000 psi/min (415 MPa/min) is recommended.

9.2.2 Release the pressure as soon as the maximum pressure is attained, because pressure dwells of as little as 10 s can




NOTE 1—The outer ring may be AISI H-11 steel hardened to 45 to 48 HRC. The punches may be AISI A-7 steel hardened to 60 to 62 HRC. The die insert should be die grade tungsten carbide. Mating parts should be fitted and lapped to 4 RMS or better.

**FIG. 2 Example of Tooling to Produce Round Test Piece**

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.

9.4 *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.

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

## 10. Calculations

10.1 Calculate the density of the green compact as follows:

10.1.1 For round compacts:

$$\rho_g = \text{Green density, g/cm}^3 = (4/(\pi \times (2.54)^3) \times M/d^2 \times t)$$

$$= 0.0777\ (M/d^2 \times t) \quad (1)$$

where:
$M$ = mass of compact, g,
$d$ = diameter of compact, in., and
$t$ = thickness of compact, in.

Where the test specimen is measured in mm, the equation is:

$$\rho_g = \text{Green density, g/cm}^3 = ((4/\pi) \times 1000 \times M)\ (d^2 \times t)$$

$$= 1273\ (M/d^2 \times h) \quad (2)$$

10.1.2 For rectangular compacts:

$$\rho_g = \text{Green density, g/cm}^3 = (1/2.54)^3 \times M/(L \times W \times t)$$

$$= 0.0610\ (M/L \times W \times T) \quad (3)$$

where:
$M$ = mass of compact, g,
$L$ = length of compact, in.,
$W$ = width of compact in., and
$t$ = thickness of compact, in.

Where the test specimen is measured in mm, the equation is:

$$\rho_g = \text{Green density, g/cm}^3 = 1000\ (M/L \times W \times t) \quad (4)$$

10.2 Alternatively, the density of the green compact may be calculated by the water immersion method of Test Method B 328.

## 11. Report

11.1 Report the compressibility as the average of three density measurements, calculated to the nearest 0.01 g/cm$^3$. Report also the individual density measurements and the compacting pressure rounded to the nearest 0.5 tsi.

11.2 Alternatively, report the compressibility curve of the powder as a graph drawn through points representing a single determination, at not less than four compacting pressures or, draw the line through points representing the average of three determinations at three compacting pressures.

11.3 If the alternative method of compacting to a specified green density is used, report the compressibility as the compacting pressure, with its precision, and the individual pressures. Report also the specified green density used.

11.4 Report the compact thickness, and type, amount, and method of lubrication. (For die wall lubrication, specify the amount of lubrication as the weight percent dissolved in the solvent. Where admixed lubricant is used, the type and amount used shall be indicated).

11.5 Report whether the method used for determination of density was as prescribed in 10.1 or 10.2.

## 12. Precision and Bias [3]

12.1 For the density determination method of 10.1, ferrous and nonferrous powders, the repeatability interval, *r*, is 0.025 g/cm$^3$. On the basis of test error alone, the difference in absolute value of individual test results obtained in the same laboratory on the same material will be expected to exceed 0.025 g/cm$^3$ only about 5 % of the time.

12.2 For the density determination method of 10.1, the reproducibility interval, *R*, for ferrous and nonferrous powders is 0.07 g/cm$^3$. On the basis of test error alone, the difference in absolute value between individual test results obtained in two different laboratories on the same material will be expected to exceed *R* only about 5 % of the time. Thus, if a larger difference is found, there is reason to question one or both test results.

12.3 No precision data for this test method are available, based on 10.2, the use of Test Method B 328 for density determination.

12.4 No statement can be made about bias, because there are no accepted standard or reference powders for compressibility testing.

## 13. Keywords

13.1 compressibility; metal powder

[3] Supporting data are available from ASTM Headquarters. Request RR:B09-1002.