



Standard Test Method for Radial Crushing Strength, K , of Powder Metallurgy (PM) Bearings and Structural Materials¹

This standard is issued under the fixed designation B939; 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 the equipment and laboratory procedure for the determination of the radial crushing strength of materials using either a plain powder metallurgy (PM) bearing or a thin-walled hollow cylindrical test specimen. This is a destructive test that produces quantitative results.

1.2 Limitations:

1.2.1 The principle of this procedure is based on the material being tested having minimal ductility. The permanent deflection of the cylinder during the test should not exceed 10 % of the outside diameter.

1.2.2 The radial crushing strength test results should be used only as a guide if the test specimen has a wall thickness that is greater than one-third of the outside diameter. These test results should then only be used for comparison with data from the test specimens of like materials and similar dimensions.

1.3 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) and gram (g) units are the industry standard, 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.

1.4 *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](#)

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 B09.04 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.

[B438 Specification for Bronze-Base Powder Metallurgy \(PM\) Bearings \(Oil-Impregnated\)](#)

[B439 Specification for Iron-Base Powder Metallurgy \(PM\) Bearings \(Oil-Impregnated\)](#)

[B925 Practices for Production and Preparation of Powder Metallurgy \(PM\) Test Specimens](#)

[E456 Terminology Relating to Quality and Statistics](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

2.2 *MPIF Standard*:³

[MPIF Standard 55 Determination of Radial Crush Strength \(\$K\$ \) of Powder Metallurgy \(PM\) Test Specimens](#)

3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy (PM) terms can be found in Terminology [B243](#). Additional descriptive information is available in the related material section of Vol 02.05 of the *Annual Book of ASTM Standards*.

4. Summary of Test Method

4.1 Radial crushing strength is determined by subjecting a plain sleeve bearing or a thin-walled cylindrical test specimen to a controlled compressive force applied perpendicular to its central axis under uniformly increasing load until fracture occurs.

4.2 The term “radial crushing strength,” as used in this test method is the stress at fracture calculated from the breaking load and the dimensions of the test specimen.

5. Significance and Use

5.1 The radial crushing strength test is a destructive procedure used to determine a material strength characteristic of PM bearings and hollow cylindrical test specimens. These data can be used to grade, classify, and evaluate the materials.

5.2 The PM bearing Specifications [B438](#) and [B439](#) require the use of this test method as an acceptance test for the strength of oil-impregnated sintered bearings.

³ Available from Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540, <http://www.mpif.org>.

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

5.3 This test method may be used by powder producers and parts manufacturers as a lot acceptance test for metal powders and lubricated powder mixtures intended for the production of porous parts.

5.4 Companies in the PM industry use this test as a manufacturing control test because it is appropriate for production practices.

5.5 Radial crushing strength is a property of the PM material but is not a design value. However, experience has shown that the radial crushing strength of a material is approximately twice the ultimate tensile strength.

6. Apparatus

6.1 *Measuring Equipment*—Micrometers, calipers, and plug gages capable of measuring the inside and outside diameters and length of the test specimen to the nearest 0.001 in. (0.03 mm).

6.2 *Compression Testing Machine*—A compression machine readable to 0.1% of the full scale reading, and capable of applying a controlled breaking force to the test specimen. Use the lowest range that can produce a measurable result.

6.3 *Loading Plates*—Two loading plates—ground, flat, hardened steel of a hardness greater than the microindentation hardness of the material being tested and large enough to encompass the entire length of the specimen.

7. Test Specimens

7.1 The test specimen shall be a hollow right circular thin-walled cylinder.

7.1.1 When PM bearings are to be tested, the test specimen shall be a plain sleeve bearing taken from a production lot or another bearing that has been machined to a plain cylindrical shape.

7.1.2 When metal powders are to be evaluated, the test specimen shall be produced according to the procedure in Practices B925.

8. Procedure

8.1 Measure the outside diameter, inside diameter, and the length of the test specimen to the nearest 0.001 in. (0.025 mm).

8.2 The test specimen shall be round within 0.003 in./in. (0.08 mm/mm) of the outer diameter.

8.3 Clean any surface oil or other contaminants from the test specimen and the flat surfaces of the loading plates.

8.4 Position the test specimen in the central region of the lower loading plate in the compression testing machine.

8.5 Bring the upper plate into contact with the test specimen and slowly apply the diametric load at a constant crosshead closure rate that does not exceed 0.2 in./min (5.0 mm/min) (see Fig. 1).

8.6 Use a scale on the compression testing machine that has a precision of 0.1% or better of the crushing load and record, to the precision listed in Table 1, the load at which the test specimen fractures or the first reading at which the applied load drops.

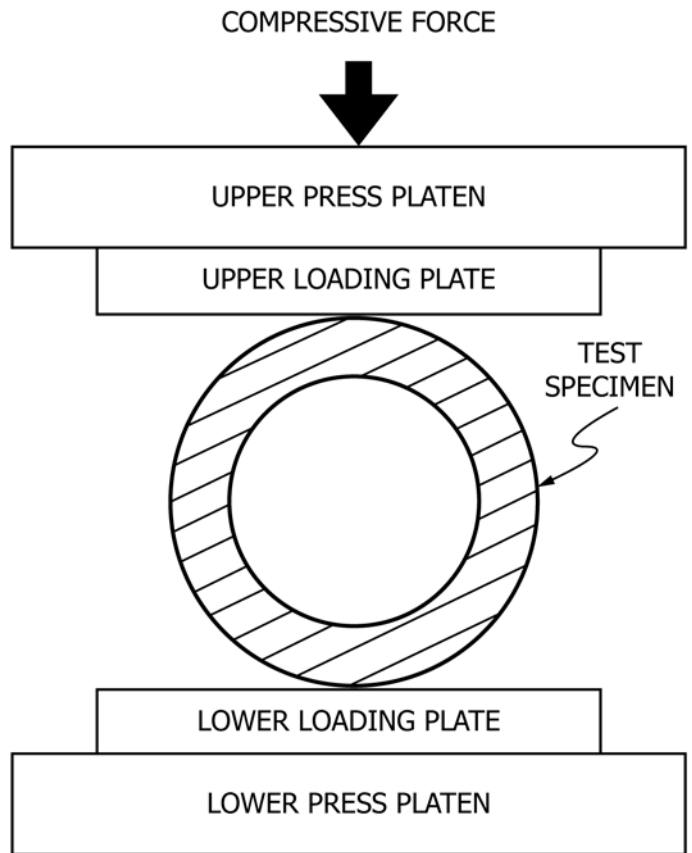


FIG. 1 Diametrical Load Applied to the Upper Plate and Test Specimen

TABLE 1 Precision for the Measurement of the Crushing Load

Inch-Pound (lbf)		SI (N)	
(D-t)/Lt ²	Record Break Load To:	(D-t)/Lt ²	Record Break Load To:
<100	±10	<0.155	±50
>100	±1	>0.155	±5

9. Calculation

9.1 Use the following equation to calculate the radial crushing strength of the material in the specimen.

$$Radial\ Crushing\ Strength,\ K = \frac{P \left(\frac{D+d}{2} \right)}{L \left(\frac{D-d}{2} \right)^2} = \frac{P(D-t)}{Lt^2} \quad (1)$$

where:

- K = radial crushing strength, psi (MPa),
- P = breaking load, lbf (N),
- D = outside diameter, in. (mm),
- d = inside diameter, in. (mm),
- L = length, in. (mm), and
- t = wall thickness [(D - d)/2], in. (mm).

10. Report

10.1 The radial crushing strength, calculated as the average of at least three (3) but preferably five (5) determinations, shall be reported to the nearest 1000 psi (10 MPa).

TABLE 2 Precision Data

Material	Med Graphite Bronze CTG-1001-K23	Iron-Copper FC-1000-K20	Copper-Steel FC-0208-50
Sintered Density (g/cm ³)	6.56	5.96	6.76
Outside Diameter, <i>D</i> in. (mm)	1.00 (25.4)	1.00 (25.4)	2.00 (50.8)
Inside Diameter, <i>d</i> in. (mm)	0.75 (19.1)	0.75 (19.1)	0.875 (22.2)
Length, <i>L</i> in. (mm)	0.75 (19.1)	0.75 (19.1)	0.75 (19.1)
Number of Participating Labs	9	9	10
Radial Crushing Strength, <i>K</i> psi (MPa)	31 000 (215)	58 000 (400)	114 000 (785)
Repeatability, <i>r</i> psi (MPa)	2200 (15)	4900 (35)	6900 (50)
Reproducibility, <i>R</i> psi (MPa)	3300 (25)	6600 (45)	6900 (50)

10.1.1 Report whether the average is from three or five determinations.

10.2 The following information may also be included in the report:

10.2.1 Origin and processing of the test specimen,

10.2.2 Chemical composition of the material,

10.2.3 Density of the bearing or test specimen before testing, and

10.2.4 Details of any deviation from the test method and any conditions or occurrences that may have affected the test results.

11. Precision and Bias

11.1 *Precision*—The precision of this test method (Table 2) was determined by the Standards Committee of the Metal Powder Industries Federation for MPIF Standard 55 using Practice E691.⁴

⁴ The precision data is used herein with the permission of the Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540, <http://www.mpif.org>.

11.1.1 The within-laboratory repeatability interval, (*r*), as defined by Terminology E456, is shown in Table 2. Duplicate results from the same laboratory should not be considered suspect at the 95% confidence level unless they differ by more than *r*.

11.1.2 The between-laboratory reproducibility interval, (*R*), as defined in Terminology E456, is shown in Table 2. Duplicate results from different laboratories should not be considered suspect at the 95% confidence level unless they differ by more than *R*.

11.2 *Bias*—No information can be provided on the bias of the procedure in Test Method B939 for measuring the radial crushing strength of PM bearings and structural materials because no PM material having an acceptable reference value is available.

11.3 *Measurement Uncertainty*—The precision of this test method shall be considered by those performing the test when reporting the results.

12. Keywords

12.1 *K*; material strength; PM bearings; radial crushing strength

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B939–09) that may impact the use of this standard.

- (1) Changed the statement on units in Section 1.3.
- (2) Deleted the reference to SI 10 in Section 2.1.
- (3) Revised subsection 6.2 about the compression testing machine.
- (4) Revised subsection 6.3 on the loading plates.
- (5) Completely revised Section 8 on Procedure and incorporated a new table to indicate the precision for the measurement of the crushing load with respect to the dimensions of the test specimen.
- (6) Changed Section 10, Report, and added a new subsection, 10.1.1.

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