Designation: B925 – 15

Standard Practices for Production and Preparation of Powder Metallurgy (PM) Test Specimens[1]

This standard is issued under the fixed designation B925; 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 These standard practices cover the specifications for those uniaxially compacted test specimens that are used in ASTM standards, the procedures for producing and preparing these test specimens, and reference the applicable standards.

1.2 Basic tool design and engineering information regarding the tooling that is required to compact the test specimens and machining blanks are contained in the annexes.

1.3 This standard is intended to be a comprehensive one-source document that can be referenced by ASTM test methods that utilize PM test specimens and in ASTM PM material specifications that contain the engineering data obtained from these test specimens.

1.4 These practices are not applicable to metal powder test specimens that are produced by other processes such as cold isostatic pressing (CIP), hot isostatic pressing (HIP), powder forging (PF) or metal injection molding (MIM). They do not pertain to cemented carbide materials.

1.5 Detailed information on PM presses, compacting tooling and sintering furnaces, their design, manufacture and use are not within the scope of these practices.

1.6 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.

1.7 *This standard may involve hazardous materials, operations, and equipment. 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]

A34/A34M Practice for Sampling and Procurement Testing of Magnetic Materials

A341/A341M Test Method for Direct Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods

A596/A596M Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens

A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs

A811 Specification for Soft Magnetic Iron Parts Fabricated by Powder Metallurgy Techniques

A839 Specification for Iron-Phosphorus Powder Metallurgy Parts for Soft Magnetic Applications

A904 Specification for 50 Nickel-50 Iron Powder Metallurgy Soft Magnetic Parts

A927/A927M Test Method for Alternating-Current Magnetic Properties of Toroidal Core Specimens Using the Voltmeter-Ammeter-Wattmeter Method

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

B312 Test Method for Green Strength of Specimens Compacted from Metal Powders

B331 Test Method for Compressibility of Metal Powders in Uniaxial Compaction

B438 Specification for Bronze-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)

B439 Specification for Iron-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)

B528 Test Method for Transverse Rupture Strength of Powder Metallurgy (PM) Specimens

B595 Specification for Sintered Aluminum Structural Parts

B610 Test Method for Measuring Dimensional Changes Associated with Processing Metal Powders

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[1] This practice 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**

B783 Specification for Materials for Ferrous Powder Metallurgy (PM) Structural Parts
B817 Specification for Powder Metallurgy (PM) Titanium Alloy Structural Components (Withdrawn 2013)[3]
B823 Specification for Materials for Copper Base Powder Metallurgy (PM) Structural Parts
B853 Specification for Powder Metallurgy (PM) Boron Stainless Steel Structural Components
B939 Test Method for Radial Crushing Strength, ***K***, of Powder Metallurgy (PM) Bearings and Structural Materials
B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle
B963 Test Methods for Oil Content, Oil-Impregnation Efficiency, and Surface-Connected Porosity of Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle
E8 Test Methods for Tension Testing of Metallic Materials
E9 Test Methods of Compression Testing of Metallic Materials at Room Temperature
E18 Test Methods for Rockwell Hardness of Metallic Materials
E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
E1876 Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio by Impulse Excitation of Vibration

2.2 *MPIF Standard:*
Standard 56 Method for Determination of Rotating Beam Fatigue Endurance Limit in Powder Metallurgy Materials[4]

3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy terms can be found in Terminology B243. Additional descriptive information is available in the Related Materials section of Vol 02.05 of the *Annual Book of ASTM Standards*.

4. Summary of Practice

4.1 These practices describe the production, by pressing and sintering metal powders, and the preparation, by machining sintered blanks, of test specimens used to measure properties of metal powders and sintered materials.

5. Significance and Use

5.1 Test specimens are used to determine the engineering properties of PM materials, for example, tensile strength, ductility, impact energy, etc.; property data that are essential to the successful use of PM material standards. Processing PM test specimens under production conditions is the most efficient method by which to obtain reliable PM material property data since in most cases it is impractical or impossible to cut test bars from sintered parts.

5.2 The performance characteristics of metal powders, for example, compressibility, green strength and dimensional changes associated with processing are evaluated using PM test specimens under controlled conditions. The data obtained are important to both metal powder producers and PM parts manufacturers.

5.3 PM test specimens play a significant role in industrial quality assurance programs. They are used to compare properties of a new lot of metal powder with an established lot in an acceptance test and are used in the part manufacturing process to establish and adjust production variables.

5.4 In those instances where it is required to present equivalent property data for a production lot of PM parts, standard test specimens compacted from the production powder mix to the same green density can be processed with the production PM parts and then tested to obtain this information.

5.5 Material property testing performed for industrial or academic research and development projects uses standard PM test specimens so the test results obtained can be compared with previous work or published data.

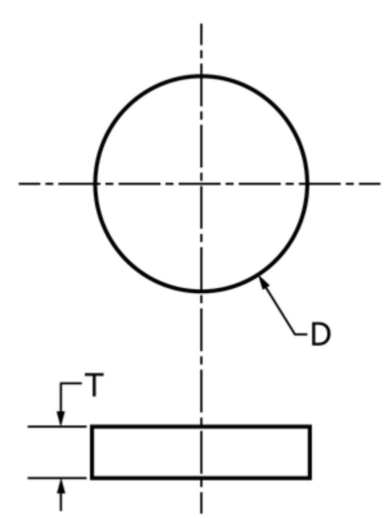
5.6 Powder metallurgy test specimens may have multiple uses. The dimensions and tolerances given in this standard are nominal in many cases. The user is cautioned to make certain that the dimensions of the test specimen are in agreement with the requirements of the specific test method to be used.

6. Powder Metallurgy Test Specimens

POWDER COMPRESSIBILITY TESTING

6.1 *Cylindrical Powder Compressibility Test Specimen:*

6.1.1 *Description and Use*—This solid cylindrical test specimen, see Fig. 1, is produced by compacting a test portion



Dimensions

	in.	mm
D—Diameter	1.00	(25.4)
T—Compact thickness	0.280 ± 0.010	(7.11 ± 0.25)

FIG. 1 PM Cylindrical Powder Compressibility Test Specimen

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from MPIF, 105 College Road East, Princeton, NJ 08540.

of powder mix in laboratory powder metallurgy tooling similar to that shown in Fig. A1.1 in the Annex. An alternative test specimen for measuring powder compressibility is the transverse rupture test specimen. These test specimens are not sintered. The compressibility of the metal powder mix or a compressibility curve showing the green density as a function of compacting pressure is determined according to the procedures in Test Method B331.

6.1.2 *Applicable ASTM Standards:*

6.1.2.1 See Test Method B331.

TRANSVERSE RUPTURE, DIMENSIONAL CHANGE AND GREEN STRENGTH TESTING

6.2 *Transverse Rupture Strength Test Specimen:*

6.2.1 *Description and Use*—The pressed-to-size transverse rupture test specimen, Fig. 2, is produced by compacting metal powder in tooling similar to that shown in Fig A1.2.

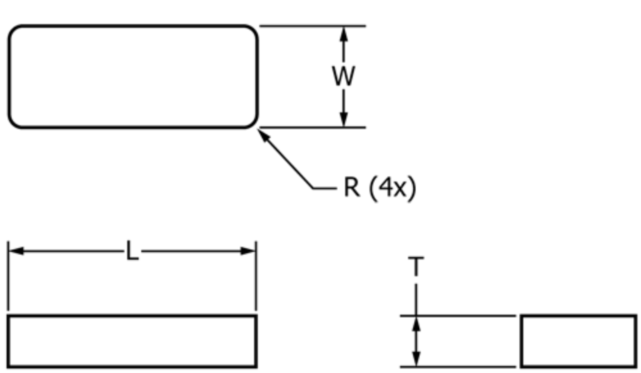
6.2.1.1 This rectangular test specimen has multiple uses in PM. Primarily, it is designed to determine the transverse rupture strength of sintered or heat treated compacts by breaking the test specimen as a simple beam in three-point loading following Test Method B528. But, it is also used to measure the dimensional changes of metal powder mixes due to pressing and sintering or other processing steps according to Test Method B610, and it is used in both a 0.250 and 0.500 in. (6.35 and 12.70 mm) thick version to determine green strength using the procedure in Test Method B312.

6.2.1.2 It is an acceptable alternative test specimen to the cylindrical compact to determine powder compressibility according to Test Method B331. The sintered or heat treated specimen may be used to generate data for the elastic constants. Young's Modulus is determined by impulse excitation of vibration and Poisson's ratio may then be calculated. This test specimen is also a convenient compact on which to measure macroindentation hardness after various processing steps.

6.2.2 *Applicable ASTM Standards:*

6.2.2.1 See the following Test Methods: B312, B331, B528, B610, E18, and E1876.

6.2.2.2 See the following PM Material Specifications: A811, A839, A904, B783, and B823.



Dimensions

	in.	mm
W—Width	0.50	(12.7)
L—Length	1.25	(31.8)
R—Corner radius	0.01	(0.3)
T—Thickness (thin)	0.250 ± 0.005	(6.35 ± 0.13)
T—Thickness (thick)	0.500 ± 0.005	(12.70 ± 0.13)

NOTE 1—Thickness shall be parallel within 0.005 in. (0.13 mm).

FIG. 2 PM Transverse Rupture Strength Test Specimen

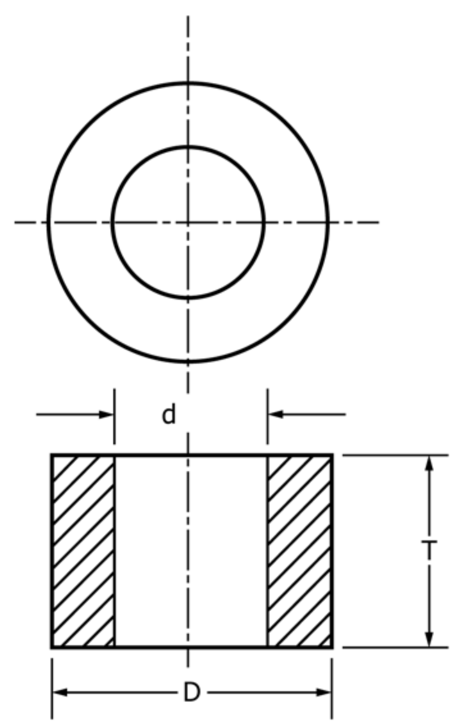
RADIAL CRUSHING STRENGTH TESTING

6.3 *Radial Crushing Strength Test Specimen:*

6.3.1 *Description and Use*—The radial crushing strength test specimen shown in Fig. 3 is compacted to size in tooling (Fig. A2.3) suitable for the production of a thin-walled hollow cylinder within the range of the dimensions listed. The testing procedure involves the application of a compressive force perpendicular to the central axis of the test cylinder and calculating the radial crushing strength from the breaking load and test specimen dimensions. Radial crushing strength is the material property that is used to quantify the mechanical strength of sintered metal bearings, (oil-impregnated).

6.3.1.1 Radial Crushing Strength is determined following the procedure in Test Method B939.

6.3.1.2 This test specimen is widely used in a quality control test to determine the sintered material strength of metal powder mixtures that are to be used for the production of any metal powder product because it is a quick, easy test and gives reliable and reproducible results. Laboratories testing powder mixes intended for the manufacture of porous bearings have recognized that breaking an unsintered test specimen by



Dimensions

	in.	mm
D—Outside diameter	0.80 to 2.00	(20 to 51)
d—Inside diameter	0.50 to 1.00	(13 to 25)
T—Thickness	0.25 to 1.00	(6 to 25)

NOTE 1—Wall thickness (D-d) shall be less than D/3.

FIG. 3 PM Radial Crushing Strength Test Specimen

diametrical loading will give a green strength value that is relevant in production.

6.3.1.3 Laboratories testing powder mixes intended for the manufacture of porous bearings have recognized that using a hollow cylindrical test specimen for dimensional change measurements and determination of green strength will give values that are relevant in production.

6.3.1.4 This specimen finds use in determining oil content, impregnation efficiency and interconnected porosity of PM bearing materials following the procedures in Test Methods B963.

6.3.2 *Applicable ASTM Standards:*

6.3.2.1 See Test Method B939.

6.3.2.2 See the following PM Bearing Specifications: B438 and B439.

TENSION TESTING

6.4 *Flat Unmachined Tension Test Specimen:*

6.4.1 *Description and Use*—The unmachined flat tension test specimen shown in Fig. 4 is commonly referred to in the industry as "the dogbone." It is compacted directly to size and shape using tooling similar to that shown in Fig. A2.4 in the Annex. This test specimen has been designed to have a convenient 1.00 in.^{2} (645.2 mm^2) pressing area to simplify compacting calculations.

6.4.1.1 It is intended for determining the tensile properties and ductility of PM materials that have not been heat treated (not quenched and tempered nor sinter-hardened). The testing procedures for this unmachined PM test specimen can be found in Test Method E8.

6.4.1.2 The flat tension test specimen is not normally used with heat treated PM materials because it may produce unreliable test results and it has a tendency to slip in the grips. Slippage can be prevented by the use of hydraulic grips, but the square corner design of the flat specimen will give rise to stress concentrations that may result in scattered test values. The machined 190-Round tension test specimen, Fig. 5, is recommended for use with heat treated PM materials.

6.4.2 *Applicable ASTM Standards:*

6.4.2.1 See Test Methods E8.

6.4.2.2 See the following PM Material Specifications: A811, A839, A904, B783, B823, and B853.

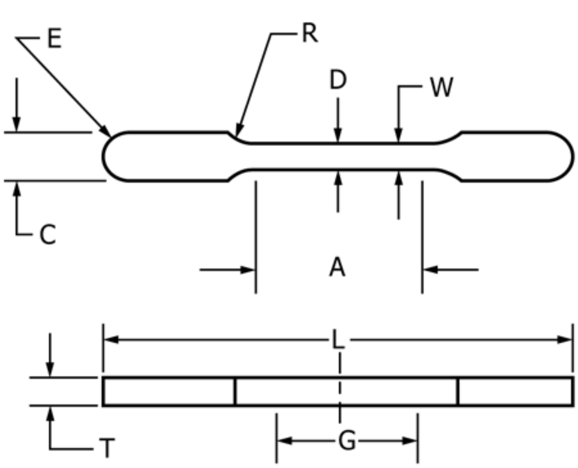
6.5 *Machined 190-Round Tension Test Specimen:*

6.5.1 *Description and Use*—The 190-Round tension test specimen may be prepared by machining a sintered Izod test specimen blank, to the shape and dimensions shown in Fig. 5. The gage section shall be free of nicks, scratches, tool marks or other conditions that can deleteriously affect the properties to be measured. It is primarily used to measure the tensile properties and ductility of heat treated (quenched and tempered or sinter-hardened) PM materials because it gives more consistent test data than those obtained with the flat unmachined tension test specimen, Fig. 4. These tension properties are determined following the testing procedures detailed in Test Method E8.

6.5.2 *Applicable ASTM Standards:*

6.5.2.1 See Test Methods E8.

6.5.2.2 See the following PM Material Specifications: B595, B783, and B817.

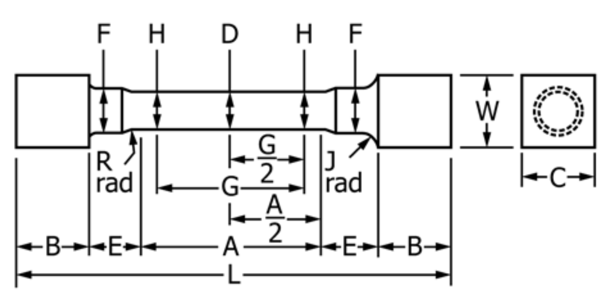


Dimensions

	in.	mm
G—Gage length	1.000 ± 0.003	(25.40 ± 0.08)
L—Overall length	3.53	(89.7)
C—Width of grip section	0.34	(8.6)
E—End radius	C/2	C/2
W—Width of reduced section	0.235	(5.97)
D—Width at center	0.225	(5.72)
A—Length of reduced section	1.25	(31.8)
R—Radius of fillet	1.00	(25.4)
T—Thickness	0.140 to 0.250	(3.56 to 6.35)

NOTE 1—Thickness shall be parallel within 0.005 in. (0.13 mm).

FIG. 4 PM Flat Unmachined Tension Test Specimen



Dimensions

	in.	mm
G—Gage length	1.000 ± 0.003	(25.40 ± 0.08)
D—Diameter at center of gage section	0.187 ± 0.001	(4.75 ± 0.03)
H—Diameter at ends of gage section	0.191 ± 0.001	(4.85 ± 0.03)
R—Radius of gage fillet	0.25	(6.4)
A—Length of reduced section	1.875 ± 0.003	(47.63 ± 0.08)
J—Radius of shoulder fillet	0.05	(1.3)
L—Compact length	3 nominal	(75 nominal)
B—Length of end section	0.310 ± 0.005	(7.87 ± 0.13)
W—Compact thickness	0.394 ± 0.005	(10.00 ± 0.13)
C—Compact width	0.39	(10.0)
E—Length of shoulder	0.250 ± 0.005	(6.35 ± 0.13)
F—Diameter of shoulder	0.310 ± 0.001	(7.87 ± 0.03)

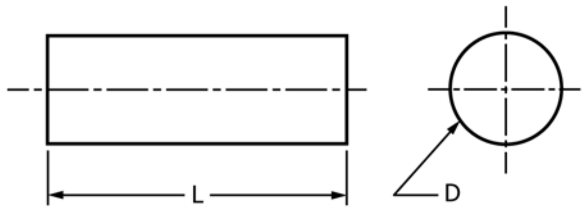
NOTE 1—Specimen diameters, 0.191 and 0.187 in. (4.85 and 4.75 mm), to be concentric within 0.001 in. (0.03 mm) T.I.R.

NOTE 2—Test section shall be free of nicks, scratches, and toolmarks. Polish longitudinally with 00 emery paper and finish with crocus cloth.

FIG. 5 Machined 190-Round PM Tension Test Specimen

COMPRESSIVE STRENGTH TESTING

6.6 *Machined Compression Test Specimen:*



Dimensions	in.	mm
L—Length	1.005 ± 0.003	(25.53 ± 0.08)
D—Diameter	0.375 ± 0.003	(9.53 ± 0.08)

FIG. 6 Machined PM Compressive Yield Strength Test Specimen

6.6.1 *Description and Use*—This test specimen, shown in Fig. 6, is usually prepared by machining a sintered Izod test specimen blank. Test specimens that are to be tested in the compacting direction may be prepared from large sintered blanks by sectioning vertically into smaller pieces that are then machined to the required dimensions. This compression test cylinder is not pressed to size because of its excessive length to diameter ratio.

6.6.1.1 The compressive strength of PM materials is measured by use of an extensometer clamped to the gage length during the test following the procedures in Test Method E9. The stress at 0.1 % or 0.2 % permanent offset is usually reported. When reporting the results, it is important that the relationship between the original compacting direction and the testing direction be clearly noted.

6.6.2 *Applicable ASTM Standards:*

6.6.2.1 See Test Method E9.

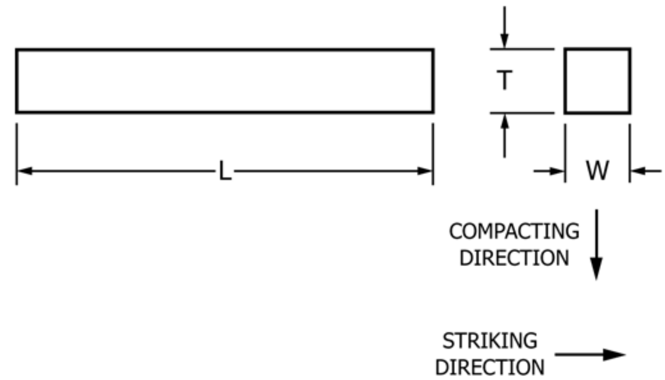
6.6.2.2 See the following PM Material Specifications: B783 and B823.

IMPACT ENERGY TESTING

6.7 *Izod Impact Test Specimen:*

6.7.1 *Description and Use*—This PM impact test specimen, shown in Fig. 7, is produced by compacting and sintering to the shape and dimensions of the standard Izod test bar. Typical tooling is shown in Fig. A2.5.

6.7.1.1 The standard industry practice for PM material specifications is to report Izod impact energy as unnotched impact energy. It is determined in an Izod (cantilever-beam) impact test using a single-blow pendulum-type impact machine. The striking direction is 90 degrees to the original compacting direction. (If for other reasons, the Izod test specimen is to be tested in a notched condition, then refer to Test Method E23 for specifications of notch types and testing procedures for notched bars.)



Dimensions	in.	mm
L—Overall length	2.95	(75.0)
W—Width	0.394 ± 0.005	(10.00 ± 0.13)
T—Thickness	0.394 ± 0.005	(10.00 ± 0.13)

NOTE 1—Adjacent sides shall be 90° ± 10 min.

FIG. 7 PM Izod (Cantilever-Beam) Impact Test Specimen

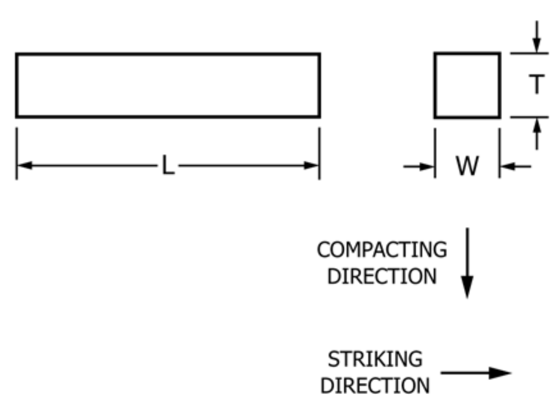
6.7.1.2 This sintered test specimen may also be used as a blank from which the 190-Round tension test specimen, the compression test cylinder, the fatigue test specimen, or the thermal expansion test piece, can be prepared by machining. It can also be shortened to prepare the Charpy test bar.

6.7.2 *Applicable ASTM Standards:*

6.7.2.1 See Test Methods E23.

6.8 *Charpy Impact Test Specimen:*

6.8.1 *Description and Use*—This PM test specimen, shown in Fig. 8, is produced by compacting and sintering to the shape and dimensions of the standard Charpy test bar. Typical tooling is shown in Fig. A2.6. It can also be prepared by shortening a sintered Izod test bar.



Dimensions	in.	mm
L—Overall length	2.16	(55.0)
W—Width	0.394 ± 0.005	(10.00 ± 0.13)
T—Thickness	0.394 ± 0.005	(10.00 ± 0.13)

NOTE 1—Adjacent sides shall be 90° ± 10 min.

FIG. 8 PM Unnotched Charpy (Simple-Beam) Impact Test Specimen

6.8.1.1 The standard industry practice for PM material specifications is to report Charpy impact energy as unnotched impact energy. It is determined in a Charpy (simple-beam) impact test using a single-blow pendulum-type impact machine. The striking direction is 90 degrees to the original compacting direction. (If for other reasons, the Charpy bar is to be tested in a notched condition, then refer to Test Method E23 for specifications of notch types and testing procedures for notched bars.)

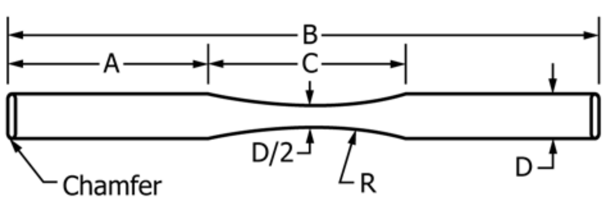
6.8.2 *Applicable ASTM Standards:*

6.8.2.1 See Test Methods E23.

6.8.2.2 See the following PM Material Standards: B783 and B823.

FATIGUE TESTING

6.9 *Machined Fatigue Test Specimen:*



Dimensions	in.	mm
A—Grip length	1.00 ± 0.02	(25.4 ± 0.5)
B—Overall length	3 nominal	(75 nominal)
C—Test section length	1.00 ± 0.02	(25.4 ± 0.5)
D—Grip diameter	0.375	(9.52)
D/2—Test diameter	0.1875 ± 0.0005	(4.763 ± 0.013)
R—Radius	1.38	(35.0)

NOTE 1—Grip diameter and test diameter shall be concentric within 0.001 in. (0.03 mm) T.I.R.

NOTE 2—Test section shall be free of nicks, scratches, and toolmarks. Polish longitudinally progressing through 0, 00, and 000 emery paper. Finish with crocus cloth.

FIG. 9 Machined R. R. Moore (Rotating-Beam) PM Fatigue Test Specimen

6.9.1 *Description and Use*—The rotating beam fatigue test specimen may be prepared by machining a sintered Izod blank, to the shape and dimensions shown in Fig. 9. It is very important that the reduced section be free of nicks, scratches, tool marks or any other conditions that can deleteriously affect the properties to be measured. This test specimen is used to determine the fatigue limit (endurance limit) and the fatigue strength of sintered or heat treated PM materials on an R. R. Moore type testing machine using rotating bending stresses in accordance with MPIF Standard 56.

6.9.2 *Applicable Standards:*

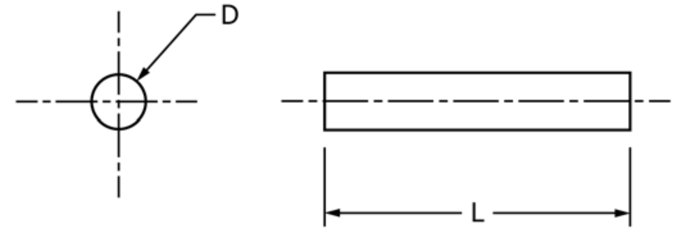
6.9.2.1 See MPIF Standard 56.

6.9.2.2 See PM Material Specification B783.

THERMAL EXPANSION TESTING

6.10 *Machined Thermal Expansion Test Specimen:*

6.10.1 *Description and Use*—This cylindrical test specimen, shown in Fig. 10, may be prepared by machining a sintered Izod test specimen blank, or a sintered Charpy test specimen



Dimensions	in.	mm
L—Length	1.000 ± 0.003	(25.40 ± 0.08)
D—Diameter	0.250 ± 0.003	(6.35 ± 0.08)

FIG. 10 Machined Coefficient of Thermal Expansion PM Test Specimen

blank. It is not compacted directly to size because of the extreme length to diameter ratio. This test specimen is used to determine the coefficient of thermal expansion with a push-rod style differential dilatometer using the procedures in Test Method E228.

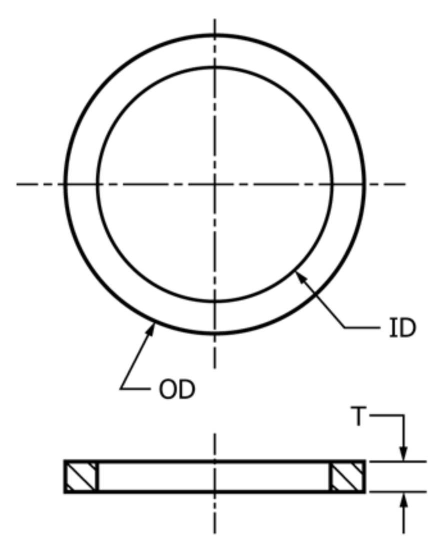
6.10.2 *Applicable ASTM Standard:*

6.10.2.1 See Test Method E228.

MAGNETIC TESTING

6.11 *Magnetic Ring Test Specimen:*

6.11.1 *Description and Use*—This ring shaped test specimen, shown in Fig. 11, has been designed with a diameter and cross-section that allow easy winding and will give reliable and reproducible test data. It is generally compacted directly to size in tooling similar to that shown in Fig. A2.7.



Dimensions	in.	mm
ID—Inside diameter	1.61	(41.0)
OD—Outside diameter	1.96	(50.0)
T—Thickness	0.177 ± 0.005	(4.50 ± 0.13)

FIG. 11 Typical PM Ring Test Specimen for Measuring Magnetic Properties

6.11.1.1 Magnetic properties are a function of the state of the material and are adversely affected by machining, tumbling or cold working. PM magnetic properties are generally measured on as-sintered material, but if the testing is being done to verify the magnetic properties of production parts, the testing shall be done on test specimens in the same state as that of the production parts. If a machined or repressed test specimen is intended to simulate as-sintered material, then the test specimen shall be annealed to eliminate stresses.

6.11.1.2 Permeability, coercivity and other magnetic properties are determined using standard ASTM test methods for magnetic properties. These test methods require a ring test specimen that has a ratio of the mean diameter to the radial width of not less than 10 to 1.

6.11.2 *Applicable ASTM Standards:*

6.11.2.1 See the following Test Methods: A34/A34M, A341/A341M, A596/A596M, A773/A773M, and A927/A927M.

6.11.2.2 See the following PM Material Specifications: A811, A839, and A904.

7. Procedure

7.1 Obtain a test sample from the powder lot that is to be tested following the procedures in Practices B215.

7.2 Record the following information about the powder lot or mix, as required:

7.2.1 Brand, grade and lot number of base metal powder,

7.2.2 Chemical composition of the alloy if not an elemental powder,

7.2.3 Brand, name, grade and percentage of all additives, and

7.2.4 Type, brand, grade and percentage of admixed lubricant.

7.3 The test specimens or blanks are produced by uniaxially compacting a test portion of the powder using double-action pressing. Information on the required test specimen tooling is presented in the Annexes.

7.3.1 *Laboratory Tooling*—Insert the lower punch into the die cavity. Position the die and lower punch on the lower press platen so that the die is supported on blocks and the lower punch is at the desired filling height. Follow the sequence in Fig. 12. Pour the powder test portion into the die cavity taking care to ensure that the powder is uniformly and evenly distributed. Insert the upper punch and apply and then release a pre-compacting pressure of approximately 5000 psi (35 MPa).

NOTE 1—If the powder mix does not contain an admixed lubricant, the die walls shall be coated with a lubricant prior to each pressing. A suspension of 100 g of zinc stearate in 1 L of methyl alcohol painted on the die walls and allowed to dry has been found to be satisfactory for this purpose. (This suspension is flammable and should be used in a suitable ventilated area.)

7.3.1.1 Remove the spacer blocks that have supported the die. (If the die is supported on springs, then the pre-compacting step is not needed.) Next, apply the final compacting pressure, typically 60 000 to 120 000 psi (415 to 830 MPa) depending upon the compressibility of the powder mix and the required green density of the test specimen. 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.

7.3.1.2 Release the pressure as soon as the maximum pressure is attained, because pressure dwells of as little as 10 s can increase the green density of the test specimen by 0.3 %. Place two spacer blocks between the top of the die and the upper press platen. These ejection blocks should be longer than the combined lengths of the upper punch and the formed test specimen. If possible, remove the upper punch by hand. If not possible, apply pressure so that the ejection blocks push the die down. Then remove the upper punch when it clears the die. Continue to eject the green test specimen until it can be picked

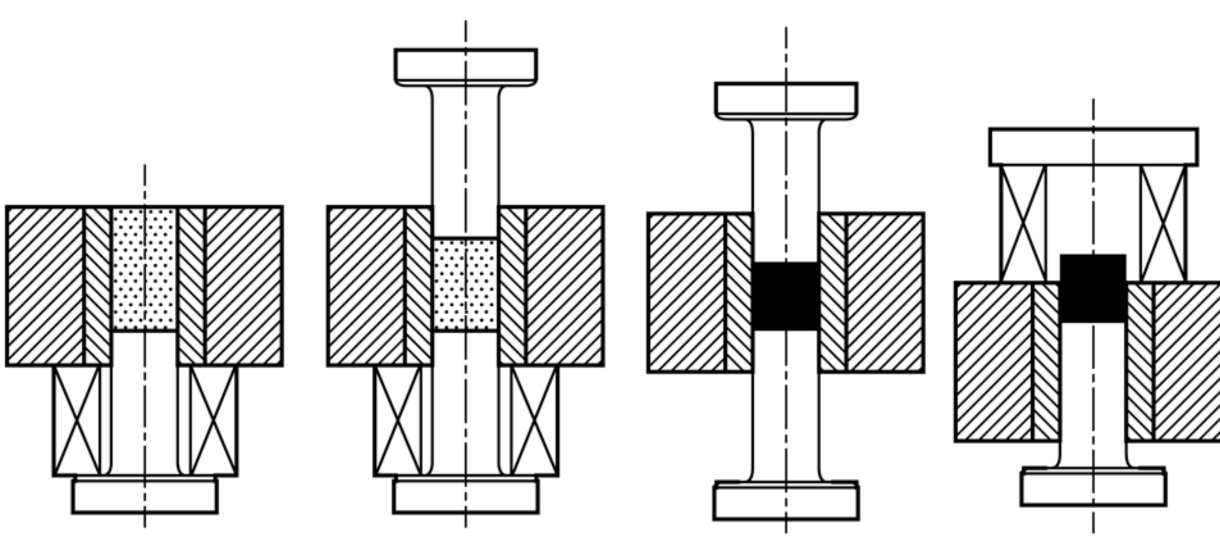


FIG. 12 Sequence of Operations to Produce a Green Test Specimen in a Manually Operated Laboratory Tool Set

off the lower punch. Repeat these steps to obtain the desired number of test specimens.

7.3.2 *Production Tooling*—When compacting in a tool set adapted to a production PM press, the die filling, pressing and ejection operations are all controlled by the programmed actions of the press. It usually is necessary for the powder mix to contain an admixed lubricant. A large number of identical test specimens can be rapidly produced when compacting in a production press.

7.4 Carefully deburr each test specimen with fine emery paper and determine the green density following the procedures in Test Method B331. When producing multiple test specimens care should be taken to ensure that the green densities are held as uniform and consistent as possible. To indicate the density uniformity in a group of test specimens, the arithmetic mean green density $(\bar{x})$ and the standard deviation (σ) shall be calculated and noted.

7.5 Record the following information about each green test specimen, as required:

7.5.1 Green dimensions,

7.5.2 Green mass,

7.5.3 Green density,

7.5.4 Type of press and compacting pressure, and

7.5.5 Lubricant system used.

7.6 If required, sinter the test specimens for the prescribed time at a temperature suitable for the material composition. See Table 1. This shall be done in a protective atmosphere or vacuum laboratory furnace capable of controlling the required sintering cycle or in a production PM sintering furnace. See Fig. 13. Cool the test specimens to room temperature in the protective atmosphere before removing from the furnace and exposing to air.

7.7 Determine the sintered density of each test specimen following the procedure in Test Method B962.

7.8 Record the following information about each sintered test specimen, as required:

7.8.1 Sintered dimensions,

7.8.2 Sintered mass,

7.8.3 Sintered density,

TABLE 1 Typical Sintering Temperatures for Powder Metallurgy Materials

PM Material	°F	°C
Aluminum	1100-1200	(600-650)
Brass	1600-1800	(870-980)
Bronze	1500-1600	(815-870)
Copper	1600-1900	(870-1040)
Copper Infiltrated Iron and Steel	2050-2200	(1120-1200)
Iron-Bronze	1600-1800	(870-980)
Iron and Carbon Steel	2050-2200	(1120-1200)
Iron-Copper and Copper Steel	2050-2200	(1120-1200)
Iron-Nickel and Nickel Steel	2050-2300	(1120-1200)
Low Alloy Steel	2050-2300	(1120-1260)
Magnetic Iron	2100-2400	(1150-1320)
Nickel Silver	1600-1800	(870-980)
Stainless Steel	2100-2400	(1150-1320)
Titanium Alloy	2100-2400	(1150-1320)

7.8.4 Sintering furnace, atmosphere and dew point, and

7.8.5 Heating rate, sintering time and temperature and cooling rate.

7.9 When preparing PM test specimens by machining sintered blanks, single-point cemented carbide cutting tools with sharp cutting-point-radii are typically used. Machine using high turning speeds, fine feed rates and spray mist lubrication. Grinding may also be used to remove material when preparing a test specimen. Polish the machined test specimens longitudinally with progressively finer emery paper to remove tool marks and finish lap with crocus cloth.

7.10 If required by the testing program, additional operations, for example, heat treatment, steam treatment or oil-impregnation may be performed on the test specimens to duplicate production practice.

7.11 Refer to the ASTM Standard Test Method or Practice for which the test specimens were prepared and follow the procedures and calculations to obtain the property values.

8. Keywords

8.1 compacting tool set; die; metal powder properties; PM materials; powder metallurgy tooling; powder testing; sintered material properties; test specimens

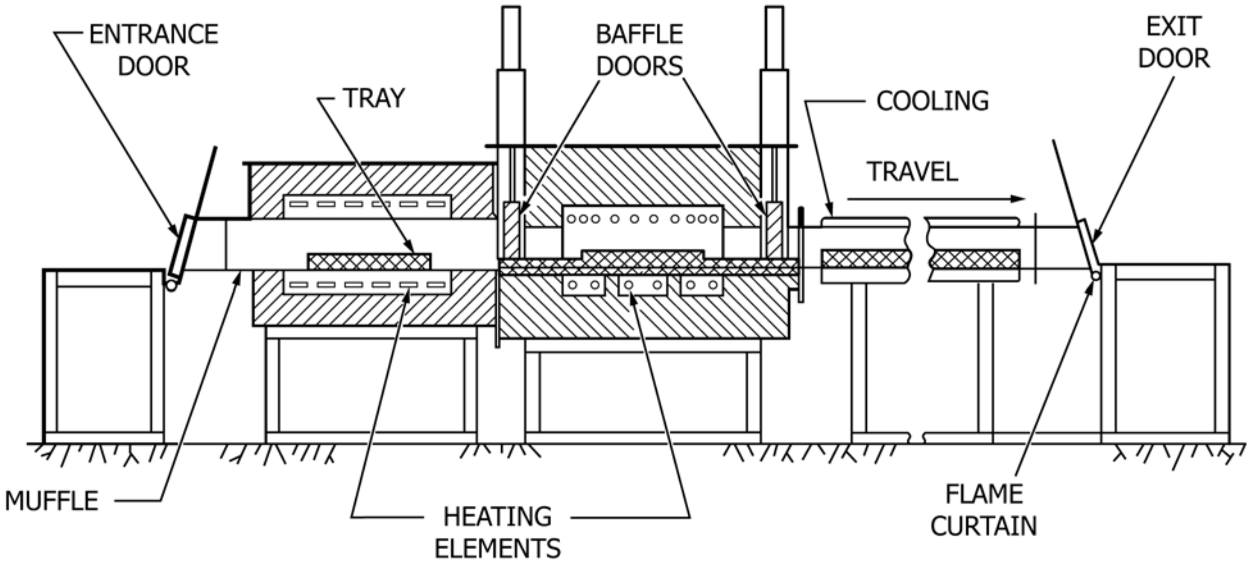


FIG. 13 Example of a Manually Operated Box Type Protective Atmosphere Laboratory Sintering Furnace

ANNEXES

(Mandatory Information)

A1. TEST SPECIMEN TOOLING—GENERAL INFORMATION

A1.1 PM test specimens are produced using the same methods as those used to make PM parts. This annex describes two types of tooling and presses that are used to compact green PM test specimens.

A1.2 *Laboratory Tooling*—If only a few test specimens are needed for the evaluation, they are usually produced using laboratory tooling. This may consist of a simple die supported on blocks and two plain punches or a laboratory tool set made with a spring loaded die and an adjustable lower punch. The compacting force is supplied by an ordinary hydraulic platen press or a compression testing machine. When compacting in laboratory tooling, filling, compacting and ejection are all controlled manually. See Fig. 12 for the sequence of these manual operations.

A1.3 *Production Tooling*—When larger quantities of identical test specimens are required for a test program, they are then usually compacted in a tool set that has been designed and made to fit a production metal powder compacting press. With this system, the powder filling, compression, and ejection operations are automatically controlled by the programmed actions of the press cycle.

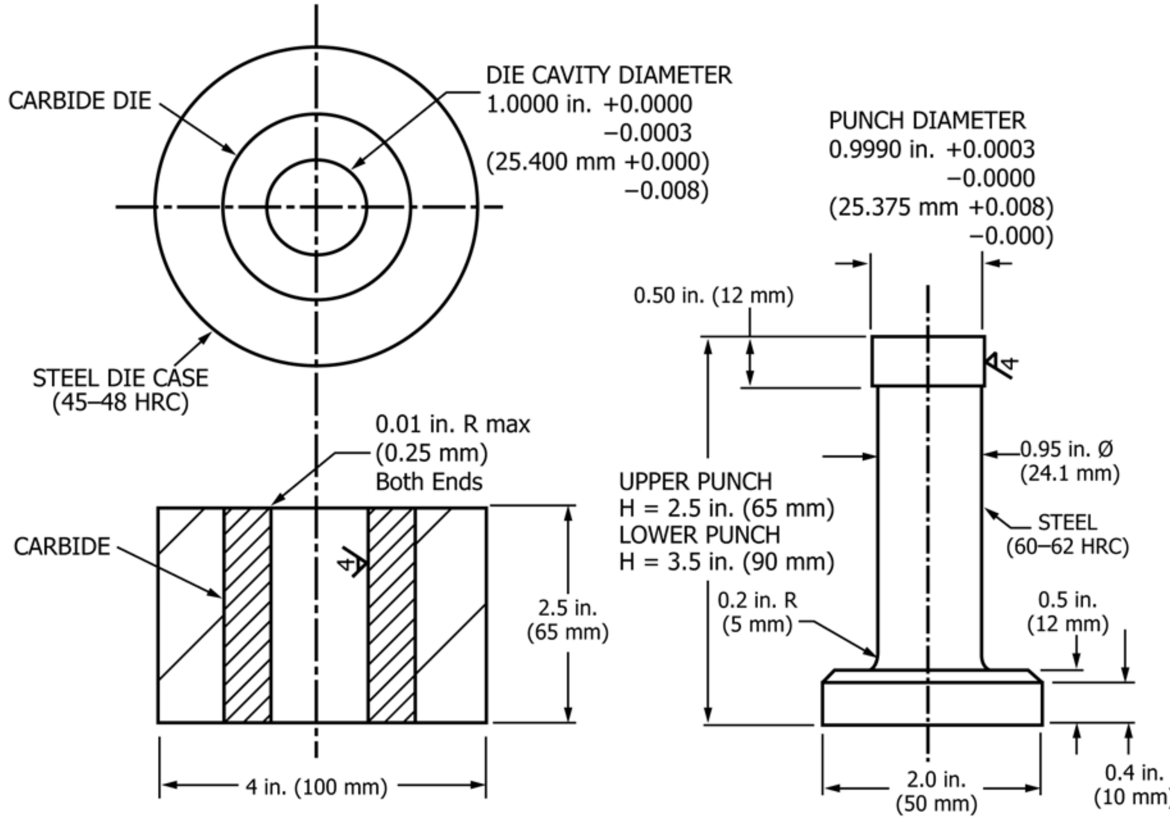


FIG. A1.1 Typical Laboratory Tooling—Cylindrical Powder Compressibility Test Specimen

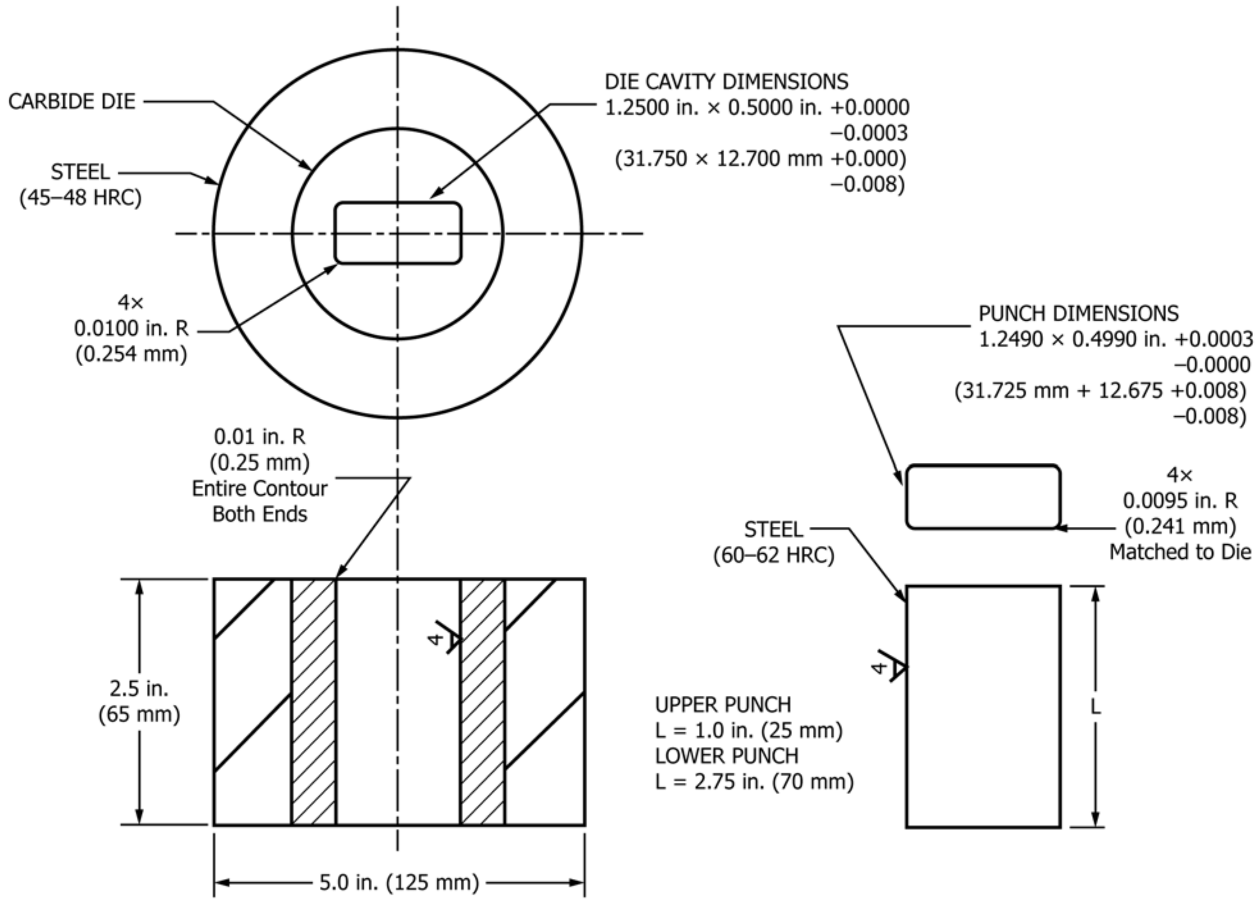


FIG. A1.2 Typical Laboratory Tooling—Transverse Rupture Test Specimen

A2. TEST SPECIMEN TOOLING—MATERIALS AND MANUFACTURE

A2.1 Powder metallurgy tooling shall be made from materials that will resist the abrasive action resulting from compacting metal powder and ejecting green parts, but still have the mechanical strength to withstand the hoop stresses resulting from high compacting pressures. The tooling shall be precisely made and be capable of producing multiple identical test specimens. Before being used, all components of the tooling shall be free of grease or oil and be fully demagnetized. This annex describes the requirements of the components of the tooling used to compact PM test specimens.

A2.2 *Test Specimen Dies*—The die cavity for the test specimen is usually wire cut from a nonmachining grade of cemented carbide rated for light-impact applications (U.S. Carbide Industry Grade C-12). The die body length or thickness is dependent on the compression ratio of the powder being tested. Generally, 2 to 3 in. (50 to 75 mm) is adequate for dies that are used to compact PM test specimens. The walls of the die cavity are finish lapped to a 4 µin. (0.1 µm) or better surface finish preferably parallel to the pressing direction. The perimeter of the die cavity at both the top and bottom of the die body shall have a 0.01 in. (0.25 mm) radius to facilitate punch entrance. The die body insert is securely contained within a steel die case. The series of drawings starting with Fig. A2.1 show the specifications for the dies that are needed to produce the PM test specimens referenced in ASTM standards.

A2.3 *Die Cases*—The ring to hold the carbide die insert is usually made of AISI H-11 chromium hot-work tool steel hardened to 40 to 48 HRC. The amount of shrink between the die case and the die insert is typically 0.0015 to 0.0025 in. per in. (mm per mm) of insert diameter. The outside diameter of the die case shall be machined to fit the clamping system in the press table or die set platen in which the tooling is to be used.

A2.4 *Punches*—The upper and lower punches may be made of AISI A-2 or A-7 air hardening, medium-alloy, cold-work tool steel hardened to 60 to 62 HRC. The punches should fit the die with 0.0003 to 0.0005 in. (0.008 to 0.013 mm) clearance on each side and be lapped to a surface finish of 4 µin. (0.1 µm) or better. The punches shall move smoothly in the die cavity. The corner between the punch face and side is kept sharp to minimize flash on the green compact. The lower punch should

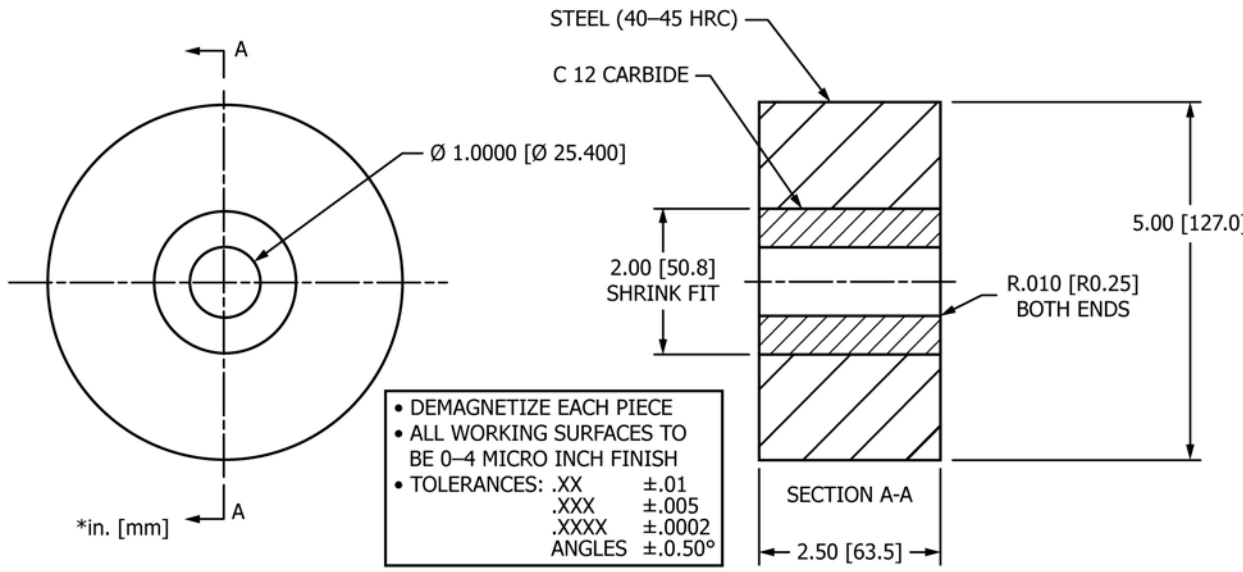


FIG. A2.1 Die—Cylindrical Powder Compressibility Test Specimen

be 0.25 in. (6 mm) longer than the thickness of the die to allow complete ejection of the green specimen. The upper punch is usually shorter. The ends of the punches may be machined to fit in the upper and lower punch clamps of the tool set or compacting press.

A2.5 *Core Rods*—For small diameter and long core rods, AISI M-2, molybdenum high-speed steel, in the form of centerless ground drill rod blanks is routinely used. For irregular core rods, various grades of tool steel hardened to 58 to 60 HRC or cemented carbide are the materials of choice. Core rods are lapped in the longitudinal direction to a 4 µin. (0.1 µm) or better surface finish. They shall move freely and smoothly in both upper and lower punches and are attached to the core rod support by means of a core rod adapter and core rod clamp.

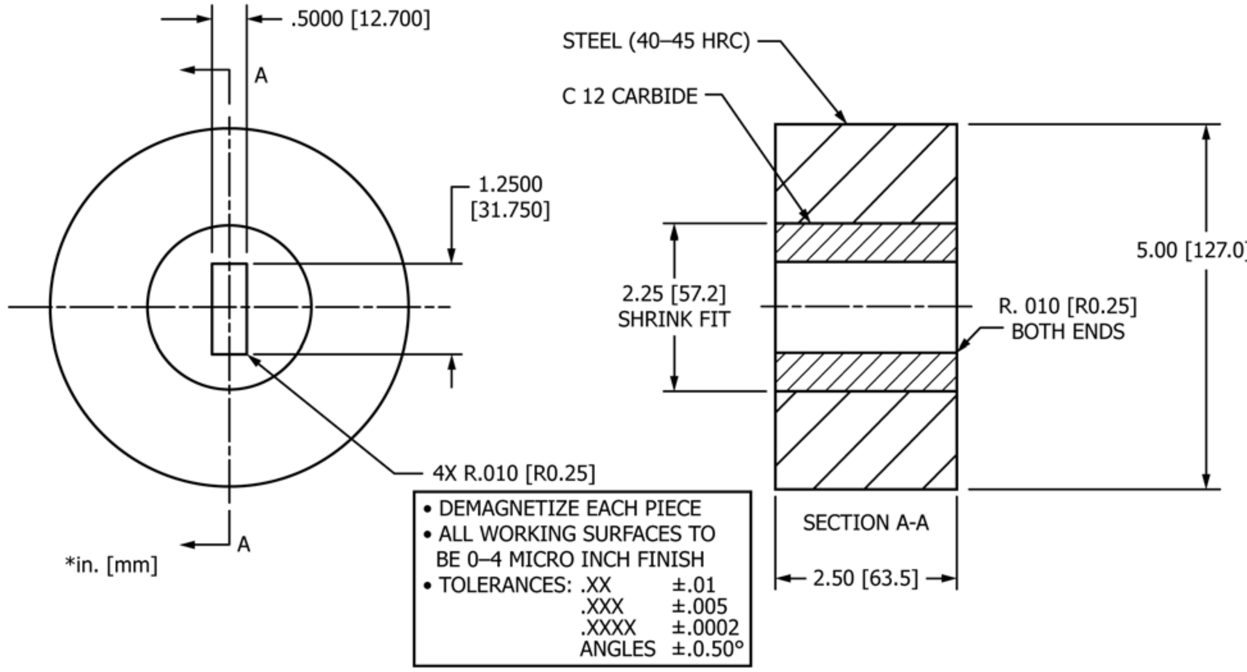


FIG. A2.2 Die—Transverse Rupture Test Specimen

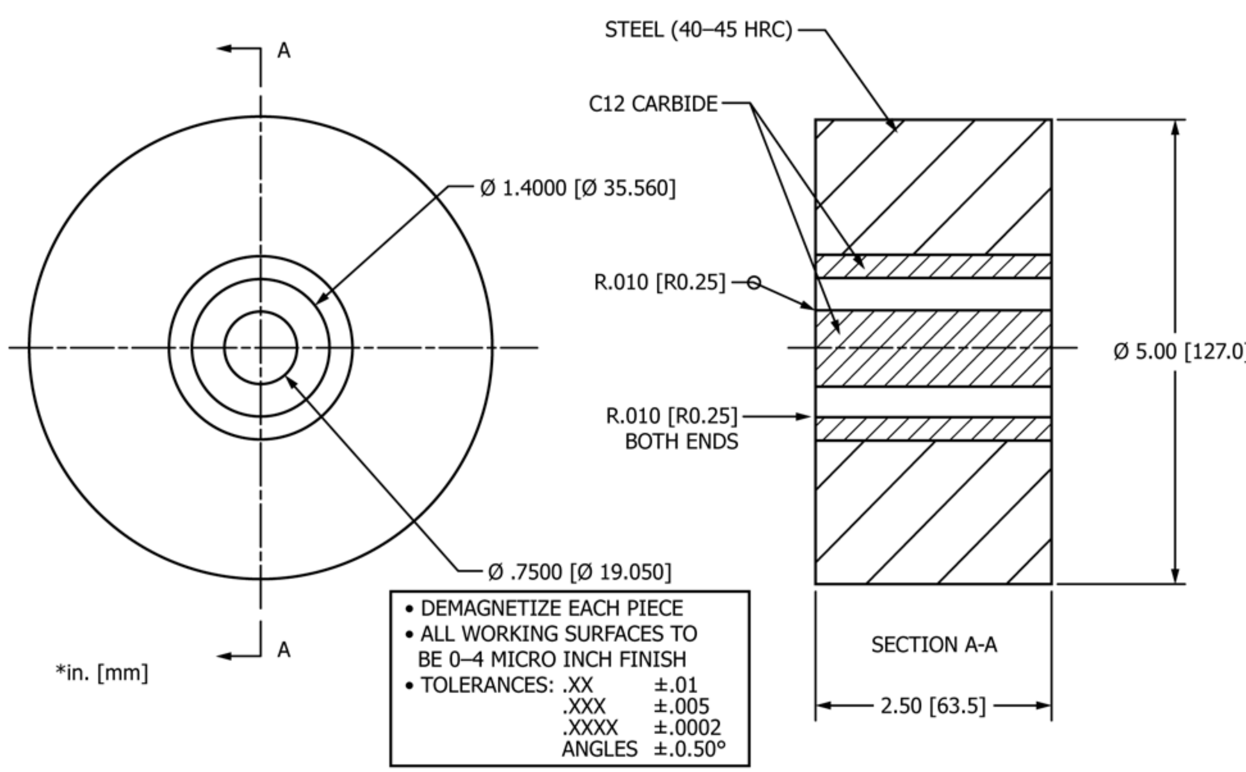


FIG. A2.3 Die and Core Rod—Typical Radial Crushing Strength Test Specimen

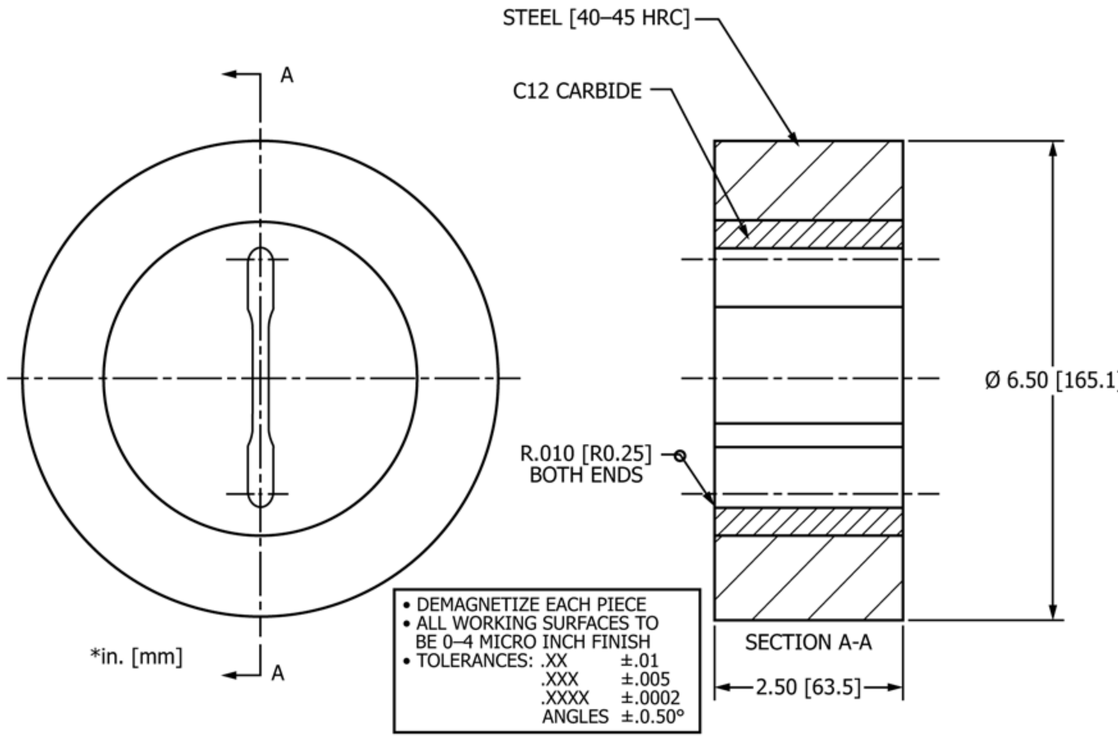
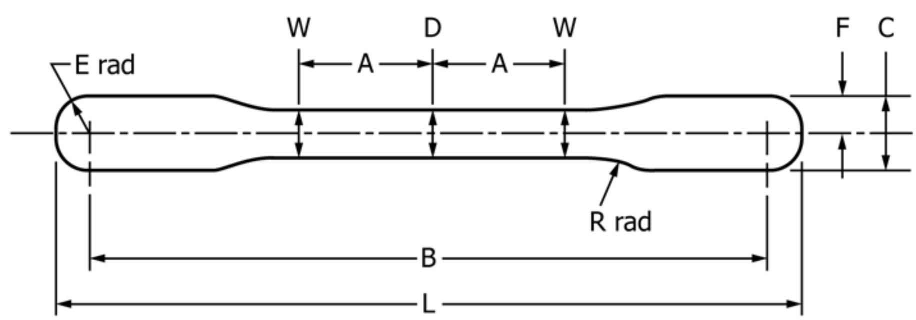


FIG. A2.4 (a) Die—Flat Unmachined Tension Test Specimen



Die Dimensions

	in.	mm
A—Half length of reduced section	0.625	(15.88)
B—Grip length between centers	3.187 ± 0.001	(80.95 ± 0.03)
C—Width at grip section	0.342 ± 0.001	(8.69 ± 0.03)
D—Width at center	0.225 ± 0.001	(5.72 ± 0.03)
E—End radius	C/2	C/2
F—Half width at grip section	0.171 ± 0.001	(4.34 ± 0.03)
L—Overall length	3.529 ± 0.001	(89.64 ± 0.03)
R—Fillet radius	1.00	(25.4)
W—Width at end of reduced section	0.235 ± 0.001	(5.97 ± 0.03)

FIG. A2.4 (b) Die Cavity Detail—Flat Unmachined Tension Test Specimen *(continued)*

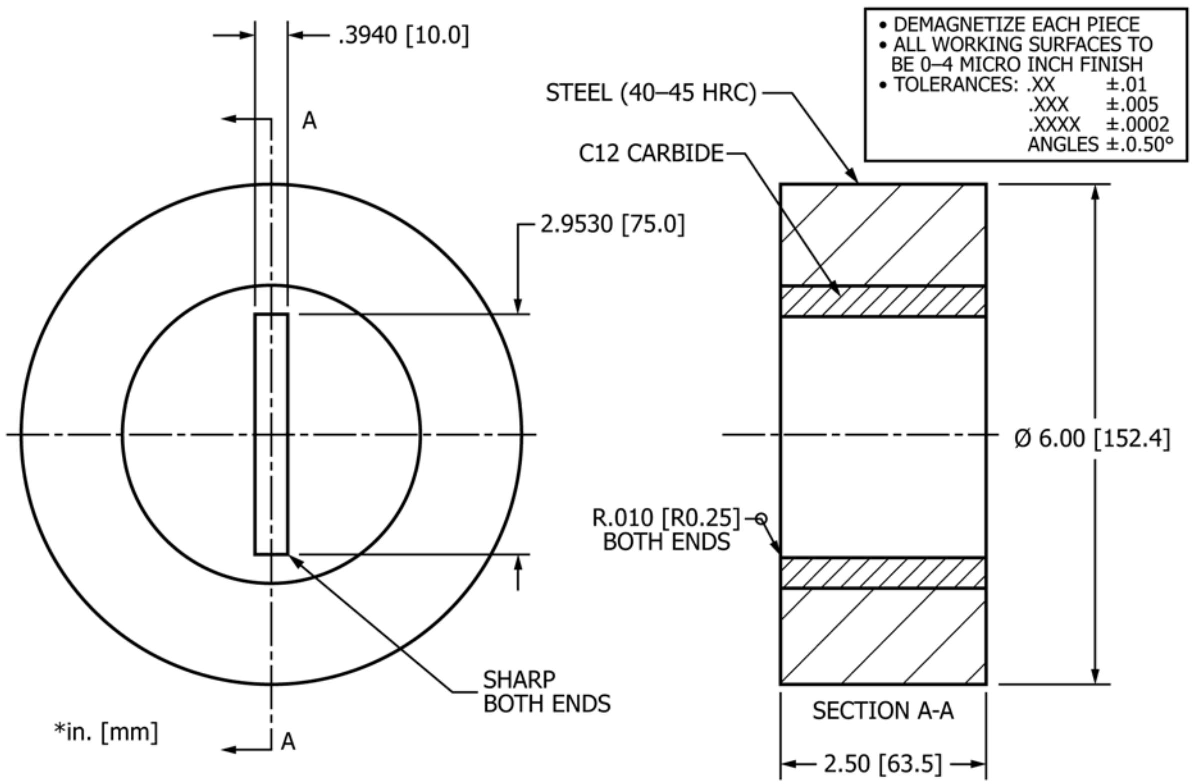


FIG. A2.5 Die—Izod Impact Energy Test Specimen

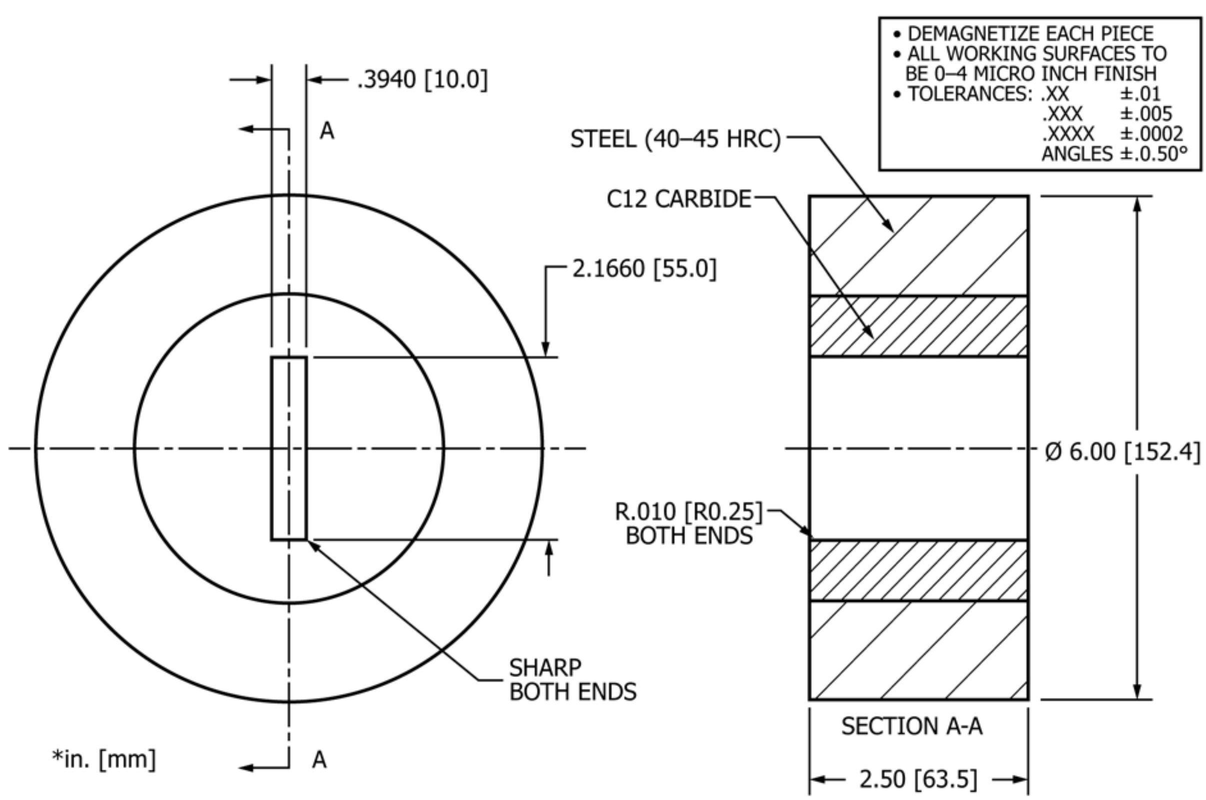


FIG. A2.6 Die—Charpy Impact Energy Test Specimen

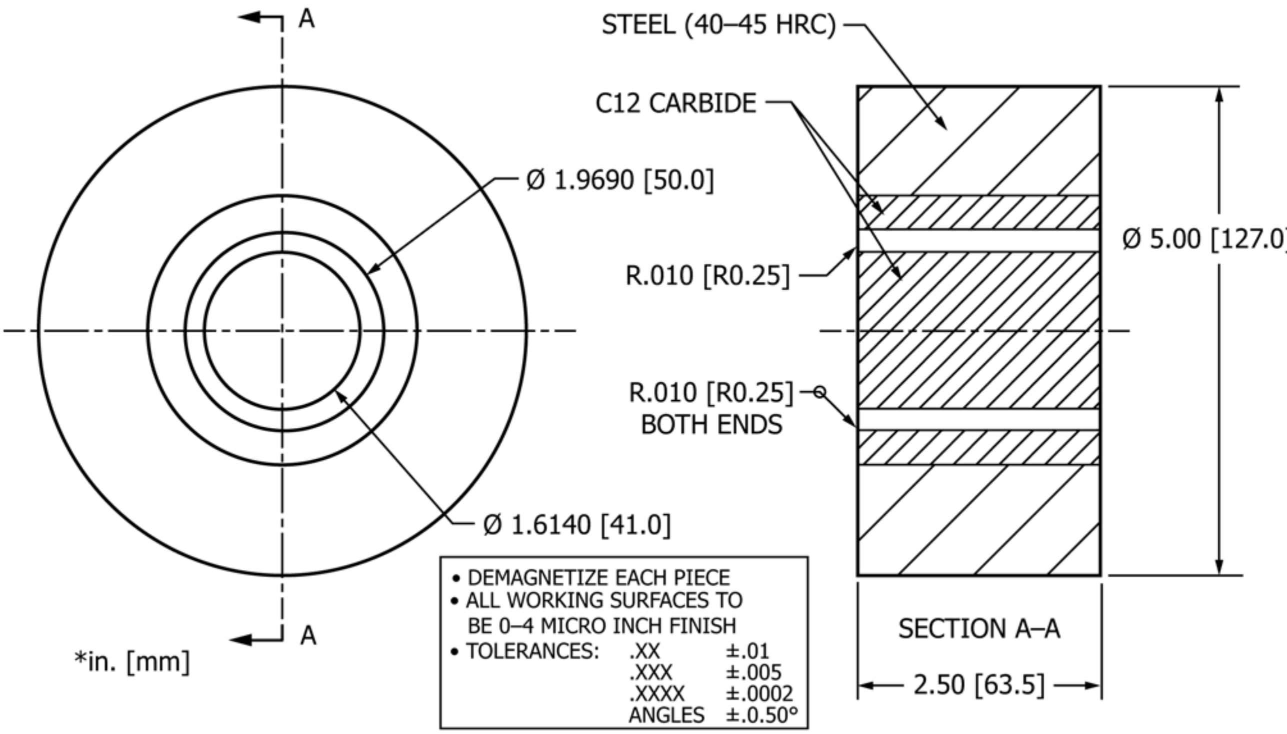


FIG. A2.7 Die and Core Rod—Typical Ring Test Specimen for Magnetic Properties

SUMMARY OF CHANGES

Committee B09 has identified the location of these selected changes, made to this standard since issue B925-08 that may impact the use of this standard.

(1) Changed units statement to comply with B09 Policy Guide.
(2) Removed reference to ASTM SI10 in Section 2.2 and renumbered Section 2.3 to 2.2.
(3) Removed all reference to B328. Standard has been superseded.
(4) Removed reference to B715. Standard has been withdrawn with no replacement.
(5) Added reference to B962 where applicable.