~~Designation:B312–96 (Reapproved 2002)~~ Designation: B 312 – 09

Standard Test Method for ~~Green Strength for Compacted Metal Powder Specimens~~Green Strength of Specimens Compacted from Metal Powders[1]

This standard is issued under the fixed designation B 312; 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 the green strength of unsintered compacted metal powder specimens by subjecting them to a uniformly increasing transverse loading under controlled conditions. The term green strength, as used herein, defines the stress, calculated from the flexure formula, required to break a specimen as a simple beam supported near the ends and applying the force midway between the fixed line center of the supports.~~

~~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.~~

~~1.3~~*

1.1 This standard covers a test method that may be used to measure the transverse rupture strength of a compacted but unsintered (green) test specimen produced from lubricated or unlubricated metal powders or powder mixtures.

1.2 Green strength is measured by a quantitative laboratory procedure in which the fracture strength is calculated from the force required to break an unsintered test specimen supported as a simple beam while subjected to a uniformly increasing three-point transverse load under controlled conditions.

1.3 This test method is a companion standard to Test Method B 528 that covers the measurement of the transverse rupture strength of sintered PM test specimens.

1.4 With the exception of density values, for which the g/cm^3 unit is the industry standard, and mass measurements used to calculate density, the values stated in inch-pound units are to be regarded as the standard. The SI equivalents shown in parentheses have been converted in accordance with IEEE/ASTM Standard SI 10, may be approximate and are only included for information.

1.5 *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]

B 215 Practices for Sampling Metal Powders
B 243 ~~Terminology of Powder Metallurgy~~ Terminology of Powder Metallurgy
B 528 Test Method for Transverse Rupture Strength of Metal Powder Specimens
B 925 Practices for Production and Preparation of Powder Metallurgy (PM) Test Specimens
B 962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 *Definitions*—the definitions of powder metallurgy ~~(P/M)~~(PM) terms used in this test method can be found in Terminology B 243. Additional descriptive PM information is available in the Related Material section of Vol 02.05 of the *Annual Book of ASTM Standards*.

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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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Current edition approved May 1, 2009. Published July 2009. Originally approved in 1956. Last previous edition approved in 2002 as B 312 – 96 (2002).

[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* ~~, Vol 02.05.~~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.**

4. Summary of Test Method

~~4.1The powder to be tested is pressed in a die to the configuration of a bar having a standard rectangular shape in the pressing direction and to one of two thicknesses. Either the powder to be pressed contains lubricant or the surfaces of the die are lubricated at each pressing.~~

~~4.2The pressed test specimen's width, thickness, and density are determined. The load necessary to fracture the bar is determined by applying a uniformly increasing force to the specimen while supporting it in the prescribed three-point bend test fixture.~~

~~4.3Green strength or maximum fiber stress of the material under test is determined by calculation using the equation for a simply supported beam with a concentrated load.~~

4.1 Three rectangular test specimens are compacted to a predetermined green density from test portions of the metal powder or powder mixture that is to be tested.

4.2 Each unsintered bar is placed, in turn, in a test fixture and subjected to a uniformly increasing transverse load under controlled conditions until fracture occurs.

4.3 The green strength or maximum flexural stress of each specimen is determined by calculation using the stress equation for a simply supported beam with a concentrated mid-point load.

4.4 The green strength of the material being tested is reported as the arithmetic mean of the results of three individual tests at the measured green density rounded to the nearest 100 psi (0.5 MPa).

5. Significance and Use

~~5.1The test for green strength of a compacted metal powder is useful as a:~~

~~5.1.1Method to relate the resistance of a pressed compact to breakage or damage due to handling.~~

~~5.1.2Means of quality comparison of metal powder, lot to lot.~~

~~5.1.3Method of determining the effect of additions to a base powder.~~

~~5.2Significant variations in green strength will occur if the density tolerance of the pressed bar is exceeded.~~

5.1 The green strength value determined under the conditions specified by this test method is influenced by the characteristics of the powder, how it compacts under the specified conditions (i.e., the particle to particle bonding that exists following compacting), and the lubrication system used.

5.2 Knowledge of the green strength value is useful to the production, characterization and utilization of metal powders in the manufacture of PM structural parts and bearings.

5.3 The test for green strength of a compacted metal powder can be used to:

5.3.1 Relate the resistance of a pressed compact to breakage or damage due to handling.

5.3.2 Compare the quality of a metal powder or powder mixture from lot to lot.

5.3.3 Determine the effect of the addition of a lubricant or other powders to a base powder.

5.3.4 Evaluate powder mixing or blending variables.

5.4 Factors that are known to influence the green strength of a metal powder are particle shape, particle size distribution and compressibility of the metal powder.

5.5 The amount and type of lubricant or other additives and the mixing procedures have a strong effect on the green strength of specimens produced from metal powder mixtures.

6. Apparatus

6.1 ~~*Punches and Die* (see Fig. 1), for producing a test specimen having a nominal die dimension of 0.500 in. (12.70 mm) wide by 1.250 in. (31.75 mm) long.~~ Analytical Balance—a laboratory instrument with a capacity of at least 100 g suitable for determining the mass of both the test portion of powder and the green test specimen to an accuracy of 0.001 g.

6.2 ~~*Compression Testing Machine or Powder Press*, capable of applying the required pressure to produce, and break if desired, the standard test specimen.~~ PM Tool Set— a compacting die and punches capable of producing the test specimens; an example of which is shown in Practices B 925 as *Laboratory Tooling –Transverse Rupture Test Specimen*.

6.3 ~~*Balance*, suitable for weighing to an accuracy of 0.01 g.~~ Universal Testing Machine or PM Compacting Press—a press with the ability to hold the PM tooling and apply the force necessary to compact the test specimens to the target green density.

6.4 *Outside Micrometers or Calipers* ;—instruments capable of measuring from 0.000 to 1.250 in. (0.00 to ~~31.8~~31.75 mm) with an accuracy of 0.001 in. (0.03 mm).

6.5 Either of the following sets of testing apparatus:

6.5.1 ~~*Constant Loading Beam Device* as shown in~~ Transverse Rupture Test Fixture and Compression Testing Machine —a fixture (Fig. 1) for locating the test specimen and a press capable of applying a breaking load at a controlled rate of approximately 20 lbf/min (~90 N/min), and on which the force can be read to the nearest 0.1 lbf (0.5 N), or

6.5.2 *Constant Loading Beam Device, Metal Shot and Scale*—— a lever-arm laboratory device (Fig. 2~~, capable of measuring the breaking force on the test specimen to the nearest 0.1 lbf (0.5 N).~~

~~6.5.2*Transverse Rupture Test Fixture* as shown in Fig. 3, for use with a compression testing machine to locate the test bar so the breaking force can be measured to the nearest 0.1 lbf (0.5 N).~~), designed to collect a controlled flow of metal shot that will produce a force with a loading rate of approximately 20 lbf/min (~90 N/min) on a pre-positioned test specimen until fracture

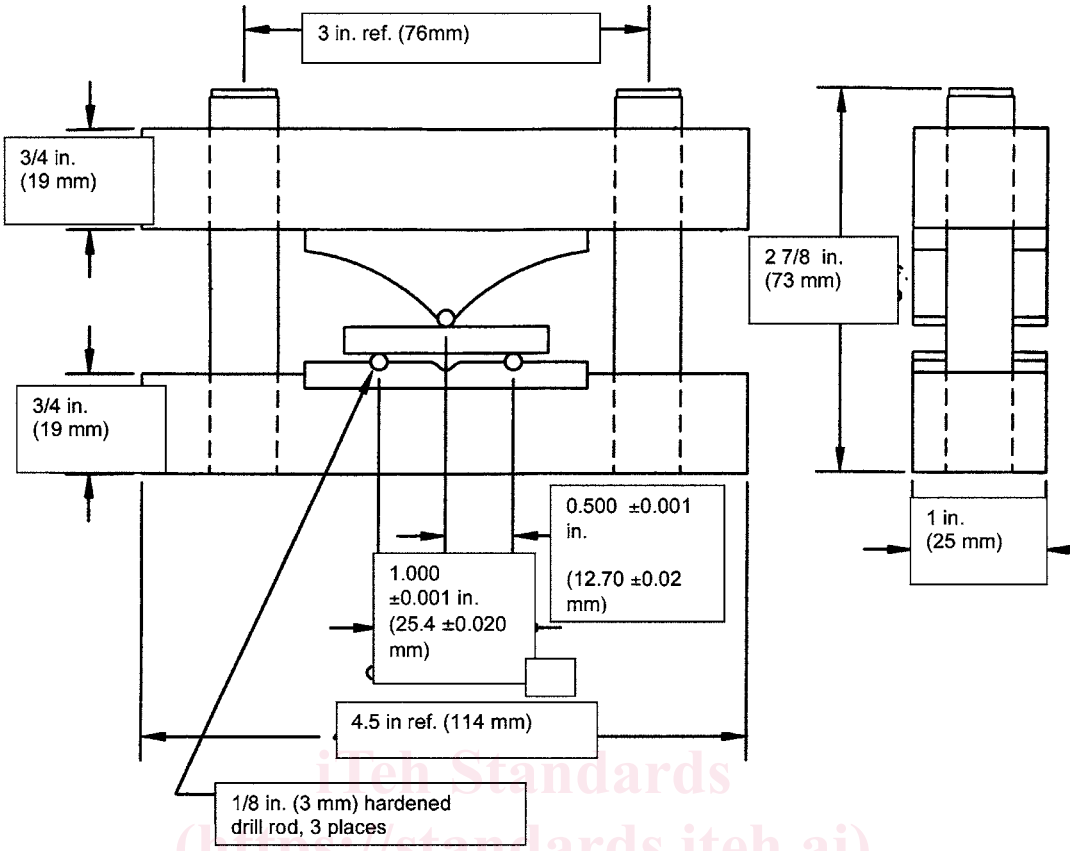

FIG. 1 Example of Constant Loading Beam Device

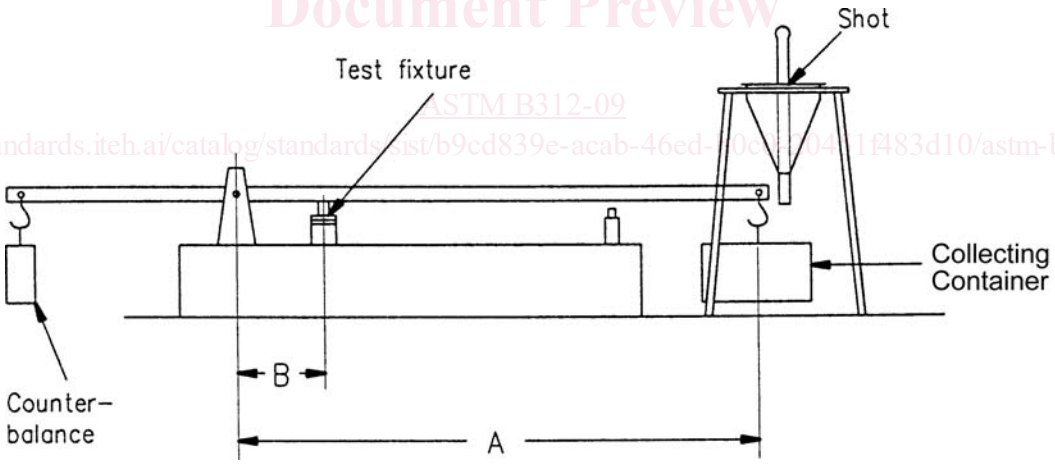

FIG. 2 Transverse Rupture Test Fixture

occurs, and a scale with a capacity of at least 25 lb (10 kg) to determine the mass to the nearest 0.01 lb (0.005 kg) of the shot that was required.

7. Test Specimen

~~7.1The test specimen has nominal dimensions of 0.500 in. (12.70 mm) wide by 1.250 in. (31.75 mm) long by either 0.250 in. (6.35 mm) or 0.500 in. (12.70 mm) thick. The green density shall be within ±0.05 g/cm~~

7.1 The recommended test specimen is an unsintered, (green), rectangular compact having dimensions of 0.500 in. (12.70 mm) wide by 1.250 in. (31.75 mm) long as specified in Practices B 925 as *Transverse Rupture Strength Test Specimen*.

7.2 Either the *thin* test specimen with a thickness 0.250 ± 0.005 in. (6.35 ± 0.13 mm) or the *thick* test specimen having a thickness of 0.500 ± 0.005 in. (12.70 ± 0.13 mm) may be used as agreed to by the concerned parties.

7.3 The top and bottom faces of the green compact shall be parallel within 0.001 in. (0.03 mm).

7.4 The green density shall be within ± 0.05 g/cm^3 ~~of the target.~~ of the target green density that has been agreed to between the concerned parties.

8. Procedure

~~8.1For lubricated powders follow the instructions starting in Section 8.2. The method of lubrication of the powders shall be standardized since green strength, green density, and compactibility will vary with the method chosen and the care with which it is applied. The method of lubrication shall be a matter of agreement between the parties concerned. Unlubricated powder may be tested in a die with lubricated walls. Apply to the die walls a lubricant mixture (for example, a mixture of 100 g of zinc stearate in one liter of methyl alcohol. Warning: This mixture is flammable and should be used in a suitable, well ventilated area.) After any excess liquid has drained away, allow the die walls to dry, and fill with the powder being tested, as described in 8.2 and 8.3~~

8.1 *Lubrication Method*—The lubrication system to be used when compacting the test specimen shall be a matter of agreement between the concerned parties. Compactibility and green density will vary with the method chosen as well as the care with which it is applied and affect the green strength value.

8.1.1 Lubricated metal powder mixtures should be tested in the as-received condition.

8.1.2 Unlubricated metal powder or powder mixtures may be compacted with the aid of die-wall lubrication or an admixed powder lubricant.

8.1.2.1 If die-wall-lubrication is chosen, it shall be applied prior to the compacting of each test specimen following the procedures in Practices B 925.

~~8.2Determine from Table 1 the approximate mass of powder to be used to make a test specimen 0.250 ± 0.005 in. (6.35± 0.13 mm) or 0.500 ± 0.005 in. (12.7 ± 0.13 mm) thick by 0.500 in. (12.7 mm) wide by 1.250 in. (31.7 mm) long. See Fig. 4. Weigh this charge to ±0.02 g.~~

~~8.3The specimen is prepared using a double action pressing process. One example of this type of compaction is as follows: With the lower punch inserted in the die cavity, pour the powder into the die cavity taking care that the powder is uniformly distributed.~~

TABLE 1 ~~MaPrecissiof Pn owdf Green Strengto Obth Meain Gsuremen Dets Using the Test Fixty fure and Compression Test Speing Machimene~~

~~Green Density, g/cm^3~~			
~~P6 I 0.250in. Thickness3~~	~~or 0.500in. Thickness6.015.5~~		~~31.0~~
Material	Nominal thickness, in. (mm)	Number of Laboratories	~~31.0~~
~~6.2~~ 6.2 Mean strength psi[A]	16.0 Repeatability, r psi	32.0 Reproducibility, R, psi	
~~6.4~~	~~1 6.5~~	~~33.0~~	
water atomized pre-alloyed powder + 0.5% wax lubricant (green density = 6.8 g/cm^3)	0.250 (6.35)	~~33.0~~	
~~6.6~~	17.0	3 4.06	452
6.62	1301	246	452
~~6.8~~	~~17 .5~~	~~35.0~~	
	0.500 (12.70)	~~35.0~~	
~~7.0~~	18.0	36.	0
7.02	1685	436	540
~~7.2~~	~~18 .5~~	~~37.0~~	
	0.250 (6.35)	~~37.0~~	
~~7.4~~	1 9.0	38.0 727	1941
7.42	4979	727	1941
~~7.6~~ sponge iron + 0.5% wax lubricant (green density = 7.2 g/cm^3)	~~19 .5~~ 0.500 (12.70)	~~39.02~~ 32	~~5432 648 1814~~ 5432 648 1814

[A] Strength values listed are the arithmetic averages of the test data and have not been rounded