INTERNATIONAL

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Standard Test Method for Transverse Rupture Strength of Cemented Carbides[1]

This standard is issued under the fixed designation B406; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method[2] covers the determination of the transverse rupture strength of cemented carbides.

1.2 The values stated in inch-pound units are to be regarded as the standard. The SI values in parentheses are provided for information only.

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:*[3]

B276 Test Method for Apparent Porosity in Cemented Carbides

2.2 *ISO Standard:*[4]

ISO-3327 Hardmetals—Determination of Transverse Rupture Strength

3. Significance and Use

3.1 This test method is used as a means of determining the quality of cemented carbide grade powders by measuring their sintered strength. It is performed on test specimens prepared to specified shape, dimensions, and surface finish; test specimens may be prepared from finished parts if size permits. There is no known standard material for this test method. The transverse rupture strength of cemented carbides is not a design value.

3.1.1 Most commercial cemented carbides have mechanical behavior that is best classified as brittle (negligible ductility). Fracture strengths are dependent on internal or surface flaws. Examples of incoherent internal flaws are macropores, Type B porosity (see Test Method B276), and inclusions of foreign particles. Such flaws are randomly distributed spatially and in size within the sintered material. This imparts a statistical nature to any transverse rupture strength measurement.

3.1.2 The stress distribution in a beam in three-point loading is non-uniform. It increases linearly along the span to a maximum at the center, and varies linearly through any section from compression on the top to tension on the bottom. The maximum tensile stress therefore occurs at center span in the bottom most fibers of the sample, and is defined as the transverse rupture strength at failure. Failure is initiated at a random flaw site, which is most probably not coincident with the maximum stress. This imparts an additional statistical nature to transverse rupture strength measurements.

4. Apparatus

4.1 Either a specially adapted machine for applying the load or a special fixture suitable for use with a conventional load-applying machine may be used. In either case, the apparatus shall have the following parts:

4.1.1 Two ground-cemented-carbide cylinders 0.250 ± 0.001 in. (6.35 ± 0.02 mm) in diameter, at least 0.500 in. (13 mm) in length with the long axes parallel, and center to center spacing of 0.563 ± 0.005 in. (14.3 ± 0.1 mm).

4.1.2 A movable member (free to move substantially only in a line perpendicular to the plane established by the axes of the two cylinders) containing a 0.4 ± 0.05-in. (10 ± 1.3-mm) cemented-tungsten-carbide ball or a ground-cemented-carbide cylinder of the same dimensions as, and with axis parallel to, those of the two previously mentioned cylinders (see 4.1.1). This ball or cylinder shall be so positioned that movements of the member will cause the ball or cylinder to contact a specimen placed on the two lower cylinders at the midpoint of the span between them.

[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 B09.06 on Cemented Carbides.

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[2] This test method is comparable to ISO-3327.

[3] 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.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

4.1.3 The apparatus shall be so constructed that the application of a sufficient load to the movable member to effect breaking of a specimen will not cause appreciable deflection of the line of movement of the movable member and the plane established by the two fixed cylinders. The apparatus shall be capable of applying sufficient load to break the specimen. The apparatus shall be capable of registering the load required (within ±1 % of the load) to break the specimen. The cemented-tungsten-carbide ball and cylinders shall not show permanent deformation after use.

5. Specimen Size

5.1 The cemented carbide specimens shall be ground to the following dimensions: 0.200 ± 0.010 in. (5.00 ± 0.25 mm) thick by 0.250 ± 0.010 in. (6.25 ± 0.25 mm) wide by 0.750 in. (19.0 mm) minimum long.

6. Specimen Preparation

6.1 Specimens shall be ground to a surface finish of 15 µin. (0.381 µm) rms maximum on four sides, and to the tolerances specified in Section 5. All grinding marks shall be parallel to the length, 0.750 in. (19.05 mm), axis. Opposite ground faces shall be parallel within 0.001 in. (0.0254 mm). The two faces that are perpendicular to the length axis need not be ground. Careful grinding techniques should be used to prevent various forms of surface cracking (flaws) that will degrade the measured strength. Long-established practice recommends the use of soft resin bonded diamond wheels, and copious quantities of coolant. For surface grinding, no pass shall exceed 0.0005 in. (0.0127 mm) in depth.

6.2 The four edges of the specimen representing the intersection of the ground faces shall be chamfered or honed to a maximum of 0.010 in. (0.25 mm) by 45 degrees. Any grinding marks shall be parallel to the long axis of the specimen.

6.3 Each specimen shall be measured to within 0.001 in. (0.02 mm) in both directions perpendicular to the length axis. Adjacent ground sides shall be at right angles to each other within 2 degrees.

6.4 Each specimen shall be visually inspected after grinding. Any specimen on which cracks, chips, or obvious structural defects appear on the ground surfaces shall be eliminated from the test.

7. Procedure

7.1 Visually examine the cylinders and ball in the fixture for cracks, chips, deformation, or misalignment and check the movable member for freedom of movement. Correct any defects prior to use.

7.2 Place a properly prepared and measured specimen on the fixture with the long axis perpendicular to the cylinders and with the 0.250-in. (6.25-mm) face resting on the two cylinders. Then adjust the movable member so that the ball or upper cylinder contacts the specimen without substantial impact. If a ball is used, place the specimen so that the ball touches the midpoint of the specimen width. Apply the load at a rate not exceeding 350 lbf/s (1.5 kN/s). Fracture should occur within the middle one third of the span between the supporting cylinders on the tension side of the specimen. Record the number of pounds required to cause fracture.

7.3 Perform all tests at room temperature but not lower than 65 °F (18 °C).

7.4 Five specimens shall be tested.

8. Calculation

8.1 Calculate the transverse rupture strength as follows:

$$S = 3PL/2bh^2 \quad (1)$$

where:

S = transverse rupture strength, psi (MPa),
P = load, lb (N) required to fracture,
L = length of span, in. (mm),
b = specimen width, in. (mm), and
h = specimen thickness, in. (mm).

9. Report

9.1 One, but only one, of the five values obtained will be considered invalid if its deviation from the mean of the other four values is excessive as determined by the following:

9.1.1 Take the average of the other four values.

9.1.2 Find the deviation of the values from the average.

9.1.3 Total the four deviations.

9.1.4 If the value omitted has a greater deviation than the total of the four other deviations, it is dropped. Otherwise, all five values must be considered valid.

9.1.5 *Example:*

Values Determined, psi		Deviation from Average of 4
180 000		20 000
200 000		0
205 000		5 000
215 000		15 000
150 000	(50 000)	
Average of 5 190 000		40 000
Average of 4 200 000		

The last value is dropped. Had it been 160 000 to 240 000 psi, it would have to be included in the average.

9.2 Report the transverse rupture strength as the mean of the valid values. Also report the standard deviation of these valid values. If less than five valid values are used in calculating the mean, the number of valid values used in the calculation of the mean and the standard deviations of these valid values are to be referenced in the report.

10. Precision and Bias

10.1 The statistical nature of transverse rupture strength in cemented carbide was discussed in 3.1. This causes the precision and bias of the test to be inseparable from statistical nature of the material behavior. This dilemma is compensated for by requiring the reporting of the standard deviation of the test values.

11. Keywords

11.1 cemented carbides; fracture strength; hardmetals; tensile stress; transverse rupture strength