



Standard Test Method for Apparent Porosity in Cemented Carbides¹

This standard is issued under the fixed designation B 276; 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 Department of Defense.

ε¹ NOTE—Corrected adjunct information in November 2006.

1. Scope*

1.1 This test method specifies procedures for the metallographic determination of apparent porosity in cemented carbides.

NOTE 1—The term “apparent porosity” is construed to mean all microstructures observed on a properly prepared, unetched surface, including structures resulting from uncombined carbon, non-metallic inclusions, etc., as well as true, inherent porosity.

1.2 *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 243 Terminology of Powder Metallurgy

B 665 Guide for Metallographic Sample Preparation of Cemented Tungsten Carbides

2.2 *ASTM Adjunct:*³

ADJB0276A Apparent Porosity (4 prints of 4 photomicrographs each)

3. Terminology

3.1 *Definitions*—Definition of powder metallurgy terms can be found in Terminology **B 243**.

4. Significance and Use

4.1 Cemented carbide materials may contain small voids that, depending on the application, may affect the performance

of the product. To assist users in specifying the maximum acceptable level of porosity, this test method illustrates a broad range of porosity levels for each of three porosity types. This test method is not intended to be used as a specification, but the levels shown here may be cited in specifications written by producers and users of cemented carbides.

5. Interferences

5.1 Lack of adequate pressure on the specimen during polishing may result in material being torn from the surface of the specimen. This condition may be erroneously interpreted as porosity.

6. Apparatus

6.1 A metallographic microscope permitting observation and measurement up to a magnification of 200×.

6.2 Equipment for the metallographic preparation of test specimens.

7. Specimen Preparation

7.1 Where possible, specimens should be metallographically mounted in a plastic material, so that they can be polished without rounding the edges. Larger specimens may be polished without mounting. When the specimens are too large, they shall be sectioned using a diamond cut-off wheel or by fracturing (appropriate safety precautions shall be utilized when fracturing a specimen). The area selected for examination should represent, as nearly as possible, the entire cross section.

7.2 The specimen shall be prepared for metallographic examination. A suitable procedure is described in Practice **B 665**. The surface to be examined shall be unetched and free of grinding and polishing marks.

8. Procedure

8.1 Pore size shall be defined as the maximum dimension of the pore. Make special reference to the presence of cracks and slits, as well as nonmetallic inclusions.

8.2 Classification of Type “A” and “C” apparent porosity is based entirely on comparison of the microstructures found with the illustrations in Figs. 1, 3 and 4 of ADJB0276A³ with due

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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.

³ Available from ASTM International Headquarters. Order Adjunct No. ADJB0276A.

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

consideration to the difference in field of view of the microscope compared to the area of the illustrations. This can be accomplished by scanning the specimen surface under the microscope at the appropriate magnification, and noting which of the illustrations most nearly represents the fields observed. Choose an area fully representative of the specimen surface for comparison with the illustrations.

NOTE 2—The illustrations in Figs. 1–4 of ADJB0276A represent only a portion of the field of view typically observed in modern microscopes. Typically, the field of view of a microscope is ~6.5× larger than the area in these figures. The exact relationship between the area observed at any given magnification in the microscope and the area of the illustrations can be determined using the method in Annex A1.

8.2.1 Classify pores $\leq 10 \mu\text{m}$ as Type A (see Fig. 1 of ADJB0276A), and examine at a magnification of 200×. Report the porosity level by reference to the appropriate illustration with consideration to the relationship of area between the illustration and that observed in the microscope, and designate as A02, A04, A06, or A08. If the level of Type A pores is less than 50 % of that shown in the illustration for A02, then designate this as A00. If the porosity is not uniform over the area of the test-piece section being examined, identify the location of the section, for example, as top, bottom, edge, rim (case), core, and so forth.

8.2.2 Classify pores in the range from >10 to $\leq 25 \mu\text{m}$ as Type B (see Fig. 2 of ADJB0276A), and examine at a magnification of 100×.

8.2.2.1 If the number of “B” pores appears to be less than or equal to that represented by B02, with consideration to the relationship of area between the illustrations in Fig. 2 of ADJB0276A and that observed in the microscope (see A1.3), count the number of “B” pores in a representative area ($\geq 0.25 \text{ cm}^2$). Divide this count by the area examined (see A1.3) to obtain the number of “B” pores/ cm^2 . If this number is less than 70 pores/ cm^2 , designate this as B00-#, where # is the number of “B” pores/ cm^2 so obtained. If the number is greater than or equal to 70 pores/ cm^2 , designate this as B02. If no “B” pores are observed, designate this as B00-0.

8.2.2.2 If the number of “B” pores appears to be greater than that represented by B02, with consideration to the relationship of area between the illustrations in Fig. 2 of ADJB0276A, and that observed in the microscope (see A1.4), classify the “B” porosity as B04, B06, or B08 with reference to the illustrations in Fig. 2 of ADJB0276A. If the porosity is not uniform over the area of the test-piece section being examined, identify the location of the section, for example, as top, bottom, edge, rim (case), core, and so forth.

8.2.3 Count and report pores larger than $25 \mu\text{m}$ as the number of pores per cm^2 . Choose the size ranges as follows: >25 to $\leq 75 \mu\text{m}$, >75 to $\leq 125 \mu\text{m}$, and over $125 \mu\text{m}$.

8.2.4 Classify porosity resulting from uncombined carbon as Type C (see Figs. 3 and 4 of ADJB0276A), and examine at a magnification of 100 or 200×. Report the porosity level by reference to the appropriate illustration with consideration to the relationship of area between the illustrations in Figs. 3 and 4 of ADJB0276A, and that observed in the microscope, and designate as C02, C04, C06, or C08. If the porosity of uncombined carbon is not uniform over the area of the test-piece section being examined, identify the location of the section, for example as top, bottom, edge, rim (case), core, and so forth. If no uncombined carbon is observed, designate this as C00.

9. Report

9.1 The report shall include the following:

9.1.1 Reference to this test method,

9.1.2 Complete identification of the test specimen,

9.1.3 Results obtained, and

9.1.4 Details of any occurrence that may have affected the result.

10. Precision and Bias

10.1 A precision and bias statement cannot be made for this test method.

11. Keywords

11.1 apparent porosity; cemented carbides; hardmetals; microstructure; powder metallurgy

ANNEX

(Mandatory Information)

A1. DETERMINATION OF THE FIELD OF VIEW OF MICROSCOPE

A1.1 Using a metallograph, view a stage micrometer.

A1.2 Determine the diameter (D) of the field of view to a precision of 0.002 cm.

A1.3 Calculate the area of the field of view using the formula:

$$A = \pi(D/2)^2 \quad (\text{A1.1})$$

where:

A = area of field of view, cm^2 , and

D = diameter of field of view, cm.

A1.4 Determine the number of photomicrographs equivalent to the field of view of the microscope at the appropriate magnification using the following:

At 100×:

photographs = $A/0.00676 \text{ cm}^2$ using ADJB0276A

At 200×:

photographs = $A/0.0017 \text{ cm}^2$ using ADJB0276A

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue, B 276 – 91 (2000), that may impact the use of this standard. (Approved Dec. 1, 2005.)

- (1) Removed 6.1, ordinary laboratory apparatus.
- (2) Removed Note 2 and placed this sentence in 7.2.
- (3) Modified 8.2 to specify that porosity type A and C are classified by comparison to ADJB0276A, while considering the relationship of the area of the illustration to the field of view of the microscope. The term photomicrographs and figures have been replaced by the term illustrations.
- (3) The illustrations that were attached to this test method have been removed, as well as all reference to them. Porosity can only be evaluated with reference to the illustrations in ADJB0276A, and all sections of this test method have been so revised. All ratings must consider the relationship of the area of the illustrations in ADJB0276A to that of the field of view of the microscope used.
- (4) The size range of porosity type A, B, and larger have been reclassified as: “A” $\leq 10\ \mu\text{m}$, “B” > 10 to $\leq 25\ \mu\text{m}$, > 25 to ≤ 75 , > 75 to $\leq 125\ \mu\text{m}$, and over $125\ \mu\text{m}$.
- (5) Porosity of type “A” has been reclassified to indicate that a rating of A00 is anything that has less than 50 % of “A” porosity compared to A02 of Fig. 1 of ADJB0276A.
- (6) Porosity of type “B” that is less than 50 % of that compared to B02 of Fig 2 of ADJB0276A is rated as B00-#, where # is the number of “B” pores/cm².
- (7) Section 8.3 has been removed.
- (8) An Annex has been added for determination of the field of view of microscope.
- (9) The illustrations in ADJB0276A have had a micron marker added to each field. The vol% porosity has been removed from each field. The note (this figure is reprinted from ISO 4505) has been removed from all figures.
- (10) Figure 1, Type A Apparent Porosity ($\times 100$) has been removed from ADJB0276A.

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