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.

Designation: B276 – 21

# Standard Test Method for Apparent Porosity in Cemented Carbides[1]

This standard is issued under the fixed designation B276; 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 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *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:*[2]

B243 Terminology of Powder Metallurgy

B665 Guide for Metallographic Sample Preparation of Cemented Tungsten Carbides

2.2 *ISO Standard:*[3]

ISO 4499-4:2016 Hardmetals — Metallographic Determination of Microstructure — Part 4: Characterisation of Porosity, Carbon Defects and Eta-phase Content

## 3. Terminology

3.1 *Definitions*—Definition of powder metallurgy terms can be found in Terminology B243.

## 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 Guide B665. The surface to be examined shall be unetched and free of grinding and polishing marks.

[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] 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 International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

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

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## 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 with due consideration to the difference in field of view of the microscope or micrographs 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. The operator should take particular care to ensure that the scale markers represented in the field of view of the microscope or printed micrographs are as close as possible to those on the illustrations in the figures. This will minimize any differences due to slight variability in magnification as a result of calibration or duplication/printing of images. Choose an area fully representative of the specimen surface for comparison with the illustrations.

NOTE 2—The illustrations in Figs. 1-4 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 ≤10 µm as Type A (see Fig. 1 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 ≤25 µm as Type B (see Fig. 4 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. 4 and that observed in the microscope (see A1.3), count the number of "B" pores in a representative area (≥0.25 $cm^2$). 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. 4 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. 4. 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 µm as the number of pores per $cm^2$. Choose the size ranges as follows: >25 to ≤75 µm, >75 to ≤125 µm, and over 125 µm.

8.2.4 Classify porosity resulting from uncombined carbon as Type C (see Fig. 2 and Fig. 3 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 Fig. 2 and Fig. 3 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

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## 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 $cm^2$

At 200×:

# photographs = A/0.0017$cm^2$

## SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B276 – 05(2015)) that may impact the use of this standard.

*(1)* Removed all references to ADJB0276A and inserted the images from the adjunct as Figs. 1-4 in this test method.
*(2)* Added language in 8.2 to remind operators to ensure comparable magnifications between the images in the figures of this test method and magnification on the microscope or micrographs being used for comparison.

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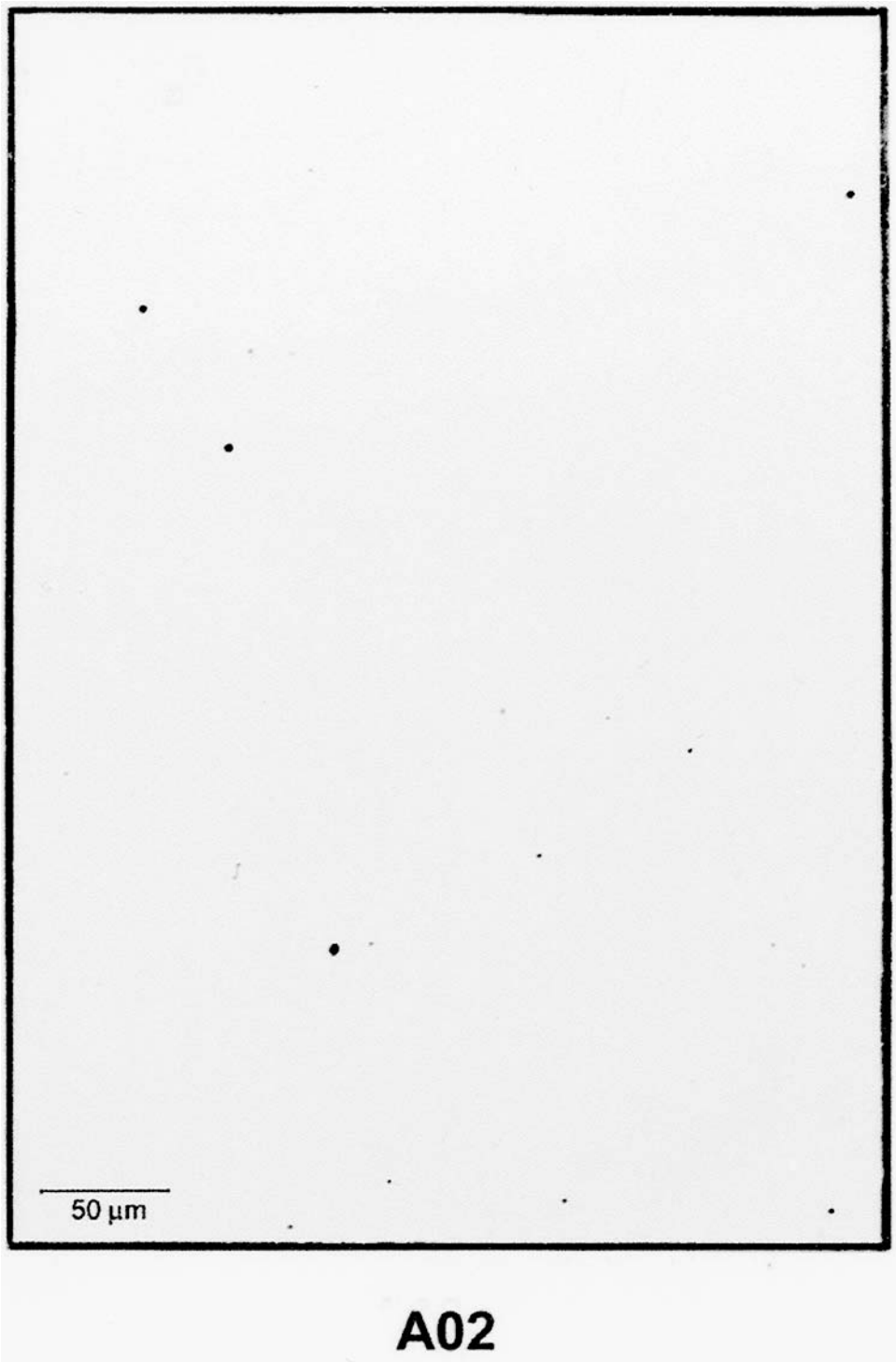


FIG. 1 (a) Type A Apparent Porosity
(This figure is reprinted from ISO 4499-4:2016.)



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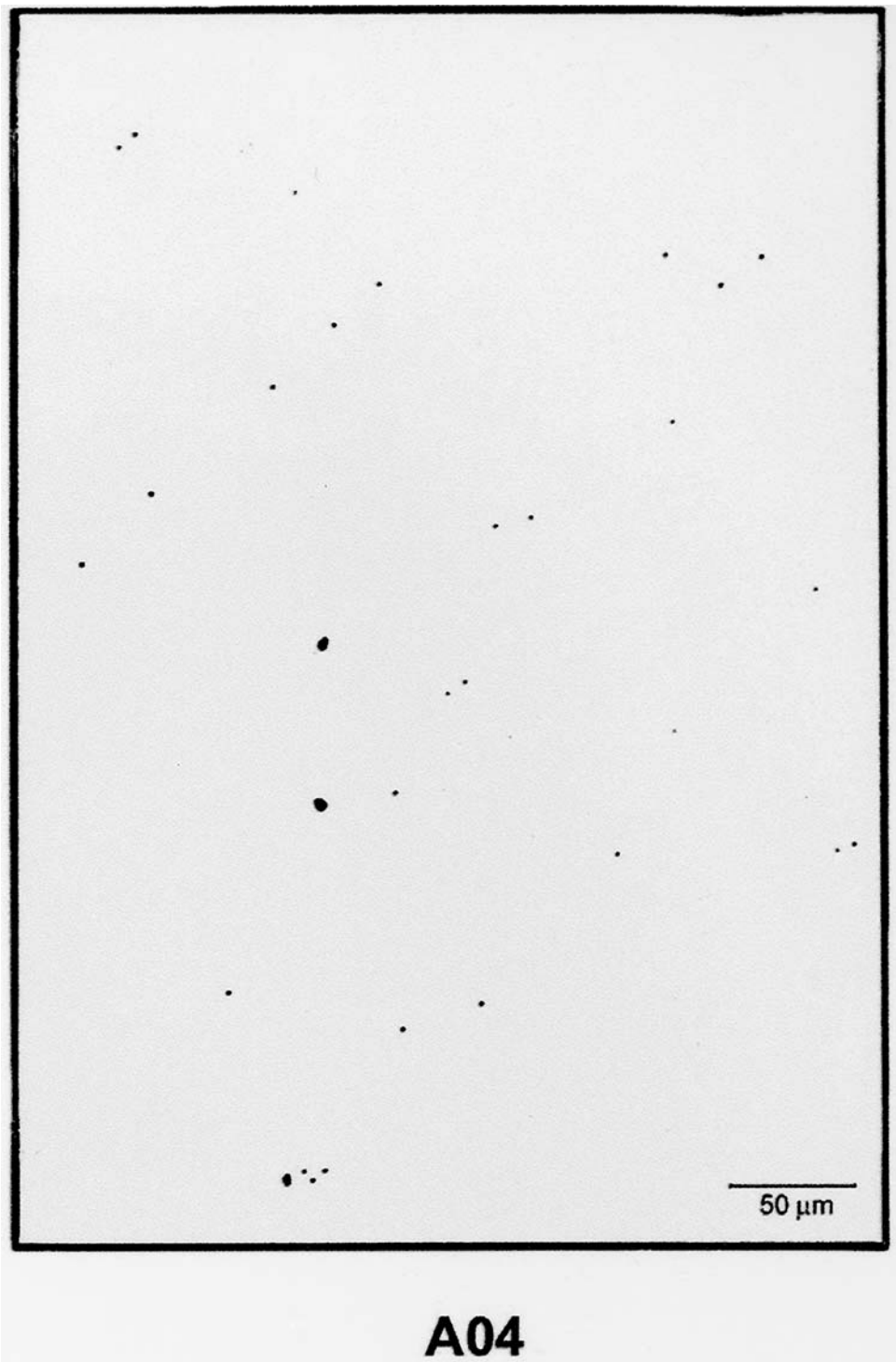


**FIG. 1 (b )Type A Apparent Porosity**
**(This figure is reprinted from ISO 4499-4:2016.)** *(continued)*



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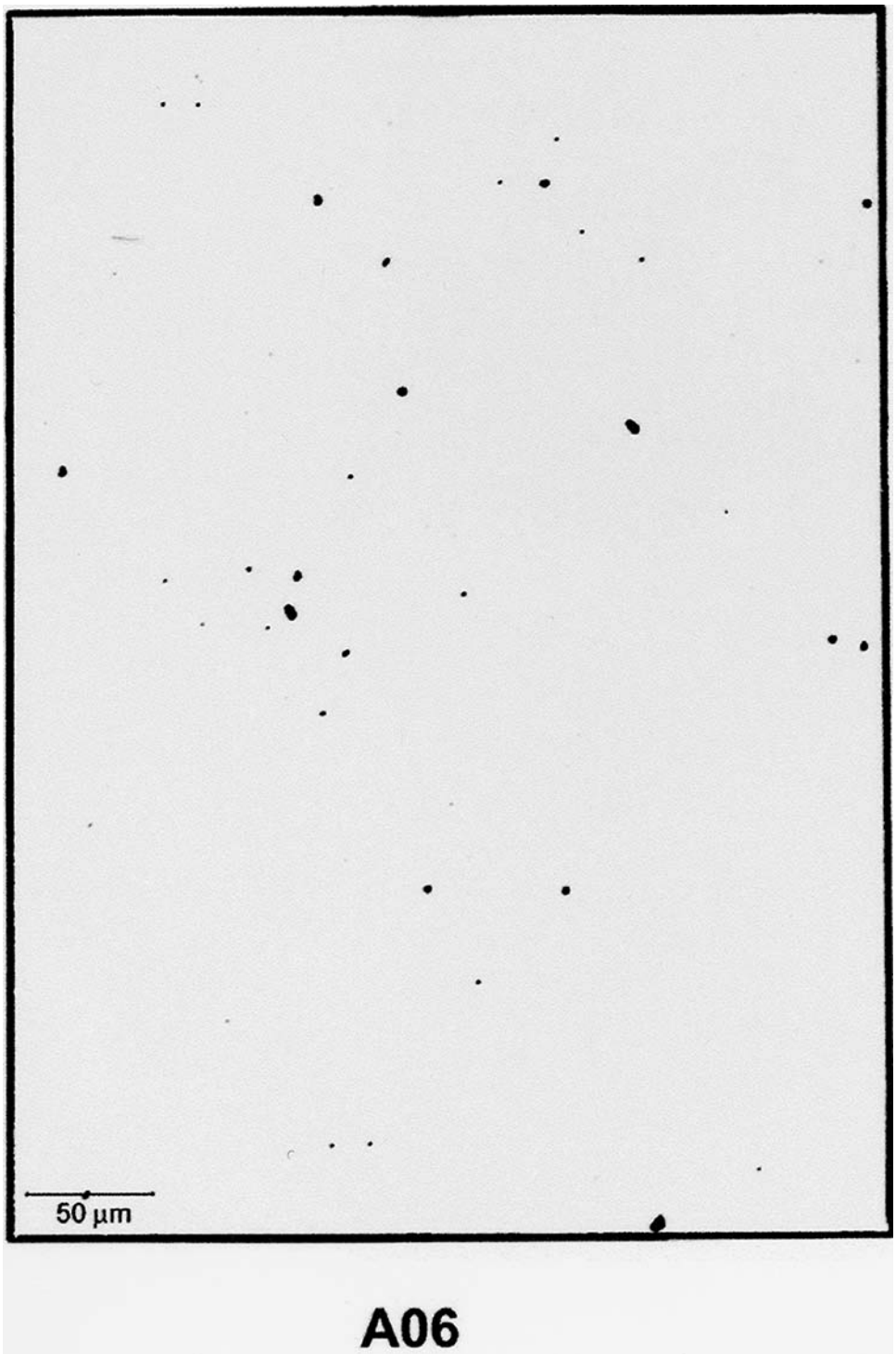


**FIG. 1 (c) Type A Apparent Porosity**
**(This figure is reprinted from ISO 4499-4:2016.)** *(continued)*



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