Designation: B 933 – 04

Standard Test Method for Microindentation Hardness of Powder Metallurgy (P/M) Materials[1]

This standard is issued under the fixed designation B 933; 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 This test method covers the determination of the microindentation hardness of powder metallurgy (P/M) materials. The test method differs from the approach used for pore-free materials in terms of the precautions required to deal with the porosity.

1.2 A method for converting the directly measured indentation lengths to other hardness scales, for example, HRC is described in Appendix X1.

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 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

E 384 Test Method for Microindentation Hardness of Materials

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Definitions of powder metallurgy (P/M) terms can be found in Terminology B 243. Additional descriptive information is available in the Related Materials section of Vol 02.05 of the *Annual Book of ASTM Standards*.

4. Summary of Test Method

4.1 Microindentation hardness testing uses a calibrated machine to force a pyramidal-pointed diamond indenter into the surface of the test material under a known test load. The microindentation hardness value is calculated from the indenting force divided by the projected area of the resulting indentation.

NOTE 1—This test method is designed specifically for use on porous P/M materials. It is intended to be a companion to Test Method E 384. There are specific differences that are intentional; otherwise, the details on equipment and procedures in Test Method E 384 shall be adhered to. The specific differences relate to the presence of porosity in the P/M materials. Special precautions are required during sample preparation to reveal pores and heterogeneous microstructural features so that appropriate test locations may be selected.

5. Significance and Use

5.1 Microindentation hardness testing provides a measure of the hardness of the microstructural constituents of a porous material. It indicates the hardness the material would have if there were no pores present and the material was tested using macroindentation hardness methods.

5.2 Microindentation hardness tests allow the evaluation of specific phases, microstructural constituents, and regions or gradients too small for macroindentation hardness testing.

6. Apparatus

6.1 *Microindentation Hardness Testing Machine*, capable of applying the required load, equipped with a Knoop or Vickers indenter, and provision for measuring the length of the diagonals of the indentation.

6.2 Apparatus requirements are summarized in method Test Method E 384.

7. Reagents and Materials

7.1 *Metallographic Etchants*, suitable for the material being tested.

8. Test Specimen

8.1 *Specimen Mounting*:

8.1.1 Sample mounting is recommended for convenience in surface preparation, edge retention, and ease of testing. The sample should be supported adequately in the mounting medium.

8.2 *Specimen Preparation*:

[1] This test method is under the jurisdiction of ASTM Committee B09 on Metal Powder and Metal Powder Products and is the direct responsibility of Subcommittee B09.05 on Structural Parts.

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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.

8.2.1 Guidelines for grinding and polishing specimens are provided in Appendix X2.

8.2.2 Care should be taken to ensure that the true area fraction of porosity is revealed throughout the entire cross section of the specimen. It is essential in surface preparation to remove all smeared metal and to identify pores clearly so that they may be avoided during testing.

8.2.3 The specimen should be lightly etched prior to microindentation hardness testing. Careful etching is necessary as heavy etching obscures features and interferes with the measurement of the diagonals of the indentation.

8.2.4 For heat treated steels, swabbing with or immersion in 2 % nital for 4 to 7 s gives an appropriate structure.

9. Procedure

9.1 Support the specimen so that its surface is perpendicular to the axis of the indenter.

9.2 Select a suitable location for testing and an appropriate load and magnification for the test. A 100 gf load is recommended for hardened materials. Lower loads may be used for softer materials or when small regions need to be tested. For the best precision, use the highest load compatible with the feature to be tested. Magnification ranges for various indentation lengths are as follows:

Indentation Length (μm)	Magnification	
	Max	Min
<76	. . .	400
76 to 125	800	300
>125	600	200

9.3 Apply the test load.

9.4 Examine the indentation for possible sources of error such as distorted or unusually large indentations. The two sections of each diagonal should agree within 20 % of each other. Discard any distorted or unusually large indentations. Unusually large indentations sometimes occur due to the presence of pores directly under the indentation.

9.5 Measure the length of the diagonals of the indentation, taking care to avoid backlash by moving only in one direction. For Knoop microindentation hardness, read the length of the larger diagonal to 0.1 μm. For Vickers microindentation hardness, measure both diagonals to the nearest 0.1 μm and calculate the average.

9.6 Make additional indentations. Space the indentations, so that adjacent tests do not interfere with each other. The minimum spacing between tests is illustrated in Fig. 1.

9.7 Discard any value if by including this value the hardness range of the other points is more than doubled. In all cases of a discarded value, make a replacement.

10. Calculation or Interpretation of Results

10.1 The Knoop or Vickers microindentation hardness numbers may be calculated using the following formulae or by using tables in Test Method E 384.

10.1.1 *Knoop*—Using the units of force and length commonly employed, that is, for force P in gf, and a long diagonal d in micrometres, the Knoop hardness is calculated:

$$HK = 14229\ P/d^2$$

10.1.2 *Vickers*—Using the units of force and length commonly employed, that is, for force P in gf, and the mean of the two diagonals d in micrometres, the Vickers hardness is calculated:

$$HV = 1854.4\ P/d^2$$

10.1.3 For indentation diagonals measured in millimetres, tables of *HK* and *HV* values are tabulated in Test Method E 384.

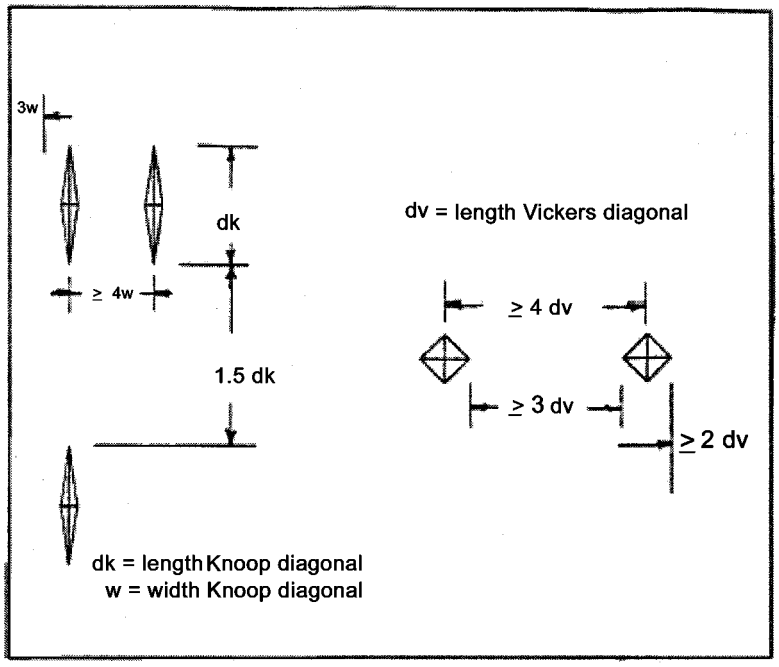

FIG. 1 Minimum Spacing Between Indentations