Designation: B934 – 15

Standard Test Method for Effective Case Depth of Ferrous Powder Metallurgy (PM) Parts Using Microindentation Hardness Measurements[1]

This standard is issued under the fixed designation B934; 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 a procedure for determination of the effective case depth of powder metallurgy (PM) parts.

1.2 A microindentation hardness traverse procedure is described to determine effective case depth. This test method may be used to determine the effective case depth for all types of hardened cases.

1.3 The procedure for determining the microindentation hardness of powder metallurgy materials, as described in Test Method B933, shall be followed.

1.4 With the exception of the unit for density, for which the grams per cubic centimeter unit is the long-standing industry practice, the values in SI units are to be regarded as standard.

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]

B243 Terminology of Powder Metallurgy

B933 Test Method for Microindentation Hardness of Powder Metallurgy (PM) Materials

E384 Test Method for Knoop and Vickers Hardness of Materials

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Definitions of powder metallurgy (PM) terms can be found in Terminology B243. Additional descriptive information is available in the Related Material section of Volume 02.05 of the *Annual Book of ASTM Standards*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *case* —that portion of a part, extending inward from the surface that has a microindentation hardness, after hardening, equal to or greater than a specified hardness.

3.2.2 *effective case depth*—perpendicular distance from the surface of the hardened case to the furthest point where a microindentation hardness value equivalent to 50 HRC is maintained, unless otherwise specified.

4. Summary of Test Method

4.1 The powder metallurgy part is sectioned and the surface prepared for examination. Microindentation hardness measurements are taken at various depths below the part surface. The distance where the microindentation hardness falls below the equivalent of 50 HRC is defined as the effective case depth, unless otherwise specified.

5. Significance and Use

5.1 The engineering function of many PM parts may require an exterior portion of the part to have a specified case depth and microindentation hardness. Measurement of effective case depth is used to determine the depth to which the microindentation hardness of the exterior portion of a part has been increased over that of the interior of the part.

6. Apparatus

6.1 *Knoop or Vickers Hardness Indenters,* using 100 gf (0.9807 N) loads are recommended following Test Method E384. The type of hardness indenter and load used shall be agreed upon between customer and producer.

6.2 *Calibrated Optical Instrument, Micrometer Stage,* or other suitable means to measure the distance from the surface of the part to the center of the impression with a precision of 0.025 mm.

7. Test Specimen

7.1 Cut a test specimen from the PM part, perpendicular to the hardened surface at a specified location, being careful to avoid any cutting or grinding procedure that would affect the original microindentation hardness.

[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 B09.05 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.

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

7.2 Mounting of the test specimen is recommended for convenience in surface preparation, edge retention, and microindentation hardness measurement. Edge retention is important for proper depth measurement of the case.

7.3 Grind and polish the test specimen using methods recommended in Appendix X2 of Test Method B933. The area to be traversed should be polished so the microindentation hardness impressions are unaffected, that is, the lighter the indenter load, the finer the finish necessary. 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.

7.4 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.

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

8. Procedure

8.1 Measure microindentation hardness at a series of known intervals from the surface of the test specimen toward the interior. Take a minimum of three acceptable microindentation hardness measurements at each depth. Space the indentations so that adjacent tests do not interfere with each other. The minimum spacing between tests is illustrated in Fig. 1. Use a calibrated optical instrument, micrometer stage, or other suitable means to measure the distance from the surface of the part to the center of the impression.

8.2 Microindentation impressions should not be placed in soft regions such as copper or the center of nickel-rich regions. Randomly encountered upper bainite or fine pearlite in the martensite should not be excluded as a measurement location.

8.3 Plot microindentation hardness versus distance from the part surface (see Fig. 2). The effective case depth shall be the distance at which the microindentation hardness falls below the equivalent of 50 HRC unless a different value is specified (see Note 1). Plot definition will dictate the required number of readings, particularly in the critical region of effective case depth. The procedure described in Appendix X1 of Test Method B933 shall be used for conversion to HRC.

NOTE 1—No compositional change occurs in induction hardened materials. The hardness of martensite is affected by the carbon content of the steel. Some lower-carbon steels will not reach the equivalent of 50 HRC when fully hardened. All concerned parties should agree upon the specified effective case depth hardness if other than 50 HRC.

NOTE 2—For routine quality control testing, where the effective case depth is reasonably well known, a somewhat simplified method of estimating effective case depth may be used. This method makes the assumption that the curve that represents microindentation hardness versus depth below the surface of the part may be regarded as a straight line in the region of the effective case hardened depth. Microindentation hardness may be measured at two depths from the surface selected, such that, on the basis of past experience, one will be less than the estimated effective case hardened depth and one will be greater. The two depths selected should lie at about equal distances from the estimated effective case hardened depth. At least five determinations of microindentation hardness shall be carried out at each of the selected depths below the part surface. On a plot of microindentation hardness versus depth from the surface, draw a straight line between the average microindentation hardness value at each of the two depths and read off the distance from the surface of the part at which the specified microindentation hardness value is reached. This is the effective case depth.

NOTE 3—An alternative method may be used for routine quality control testing. Where a minimum effective case depth is specified, measure the microindentation hardness at a distance from the surface of the part that is equal to or greater than the specified minimum depth. At least five determinations of microindentation hardness shall be carried out at the desired location. If the average microindentation hardness at this depth is equal to or greater than the effective case depth hardness, the part meets the specified requirement. Where a maximum effective case depth is specified, measure the microindentation hardness at a distance from the surface of the part that is less than the specified maximum depth in order to confirm that the part has been case hardened. At least five determinations of microindentation hardness shall be carried out at the desired

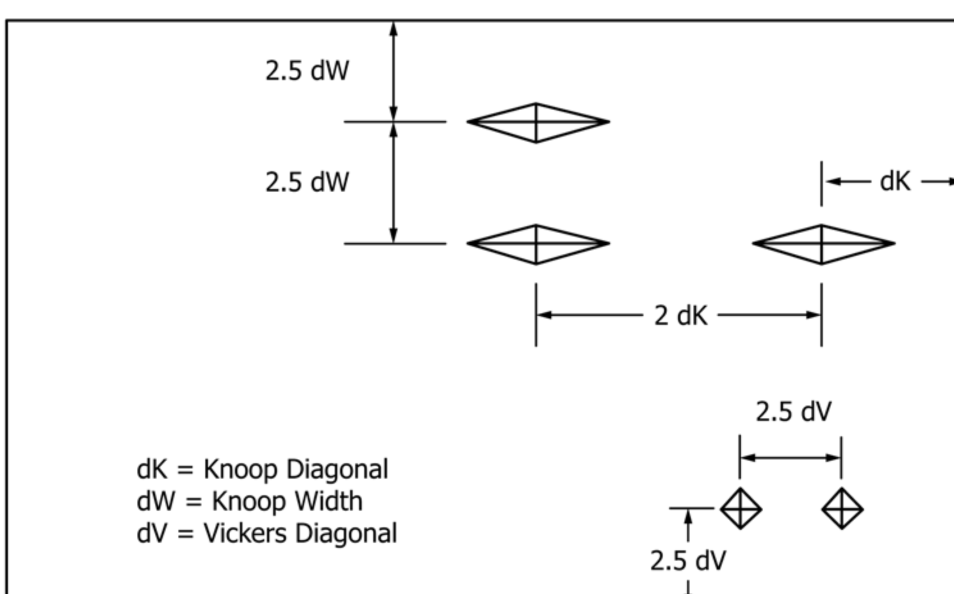

FIG. 1 Minimum Spacing between Indentations

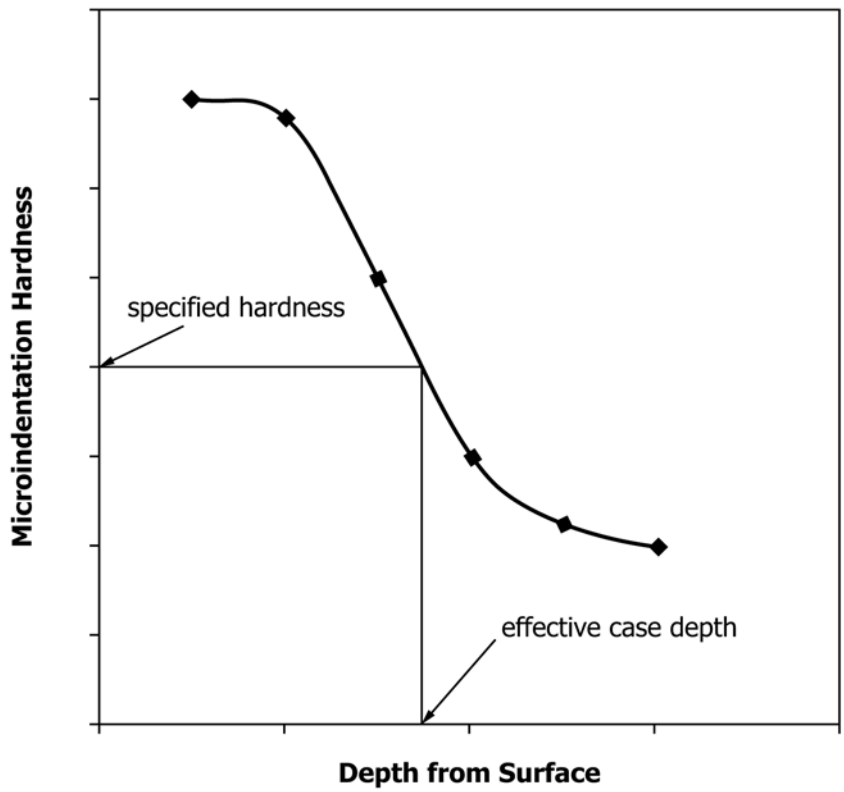

FIG. 2 Schematic Plot of Microindentation Hardness versus Depth from Surface

location. This average microindentation hardness should be equal to or greater than that specified for the effective case hardness. If it is, measure the microindentation hardness at a distance from the surface of the part that is equal to the specified maximum depth. At least five determinations of microindentation hardness shall be carried out at the desired location. If the average microindentation hardness is less than the value specified for the effective case hardness, the maximum effective case depth specification is met. If it is greater than or equal to the specified value, the maximum effective case depth is exceeded.

9. Report

9.1 The report shall include:

9.1.1 The type of material and case measured (and when possible the type of process used to produce the case),

9.1.2 The location of the measurement,

9.1.3 The type of microindentation hardness indenter and the load used,

9.1.4 The load used in testing shall be expressed as the load in grams, for example, HV100 gf or HK 100 gf (preferred method), or the load in kilograms, for example, HV 0.1 or HK 0.1, and

9.1.5 The effective case depth to the nearest 0.1 mm and the microindentation hardness specified.

10. Precision and Bias

10.1 *Precision*—The precision of this test method was developed as part of a Test Methods Assurance Program (TMAP) conducted by the Standards Committee of the Metal Powder Industries Federation (MPIF) and it is published here with the permission of MPIF. The repeatability (r) and reproducibility (R) measurements were determined (1993) according to Practice E691. The test sample was prepared from FL-4605 (no graphite added) at 7.1 g/cm3 and then case-carburized to develop the desired case/core relationship. The effective case depth was determined at 50 HRC after conversion from direct microindentation hardness values by 7 participating laboratories.

The mean case depth was 0.7 mm with a repeatability of 0.1 mm and a reproducibility of 0.5 mm. Duplicate results from the same laboratory should not be considered suspect at the 95% confidence level unless they differ by more than 0.1 mm. For the same test specimen, test results from two different laboratories should not be considered different at the 95% confidence level unless they differ by more than 0.5 mm.

10.2 *Bias*—No bias can be defined since there is no standard case-hardened material for which the effective case depth may be measured.

11. Keywords

11.1 case depth; effective case depth; powder metallurgy; PM

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B934 – 10) that may impact the use of this standard.

(1) Fig. 1 has been updated to match that in the current version of E384.