



Designation: B931 – 23

# Standard Test Method for Metallographically Estimating the Observed Case Depth of Ferrous Powder Metallurgy (PM) Parts<sup>1</sup>

This standard is issued under the fixed designation B931; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 A metallographic method is described for estimating the observed case depth of ferrous powder metallurgy (PM) parts. This method may be used for all types of hardened cases where there is a discernible difference between the microstructure of the hardened surface and that of the interior of the part.

1.2 With the exception of the values for grit size for which the U.S. standard designation is the industry standard, the values stated in SI units are to be regarded as standard.

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:*<sup>2</sup>

[B243 Terminology of Powder Metallurgy](#)

[E407 Practice for Microetching Metals and Alloys](#)

[E456 Terminology Relating to Quality and Statistics](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

2.2 *MPIF Standards:*

[MPIF Standard 70 Guide to Sample Preparation of Ferrous Powder Metallurgy \(PM\) Materials for Cross-Sectional Metallographic Evaluation](#)

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

## 3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy (PM) terms can be found in Terminology [B243](#). Additional descriptive information is available under “General Information on PM” on the B09 web page.

3.2 The metallographically estimated observed case depth is defined as the distance from the surface of the part to the point where, at a magnification of 100 $\times$ , there is a discernible difference in the microstructure of the material.

## 4. Summary of Test Method

4.1 The powder metallurgy part is sectioned and the surface prepared for metallographic evaluation. The metallographic specimen is etched and the distance is measured from the surface of the part to the point at which a discernible difference in the microstructure of the material is observed.

## 5. Significance and Use

5.1 The engineering function of many PM parts may require an exterior portion of the part to have a hardened layer. Where case hardening produces a distinct transition in the microstructure, metallographic estimation of the observed case depth may be used to check the depth to which the surface has been hardened.

## 6. Apparatus

6.1 Equipment for the metallographic preparation of test specimens—see MPIF Standard 70.

6.2 *Metallographic Microscope*, permitting observation and measurement at a magnification of 100 $\times$ .

## 7. Reagents and Materials

7.1 Etchants such as 2 % to 5 % nital, nital/picral combinations, or other suitable etchants. For more information on suitable etchants refer to Practice [E407](#).

## 8. Test Specimens

8.1 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 microstructure.

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

8.2 Mounting of the test specimen is recommended for convenience in surface preparation and edge retention. Edge retention is important for proper measurement of the observed case depth.

**9. Procedure**

9.1 Guidelines for grinding and polishing specimens are provided in MPIF Standard 70.

9.2 Etch the specimen with etchants such as 2 % to 5 % nital or nital/picral combinations.

9.2.1 *Observed Case Depth:*

9.2.1.1 Examine the surface region of the part at a magnification of 100x.

9.2.1.2 Measure the distance from the surface of the part to the point where there is a discernible difference in the microstructure of the material.

NOTE 1—The nature and amount of intermediate transformation products will depend on the material being heat treated, its density, and the type of surface hardening treatment being used. The sharpness of the change in the microstructure at the point of transition will therefore vary. The microstructure expected at this transition point should be agreed between the producer and purchaser of the part. Magnifications higher than 100x may be used to check the microstructure of the part in the region of the transition zone. However, the metallographic estimate of the observed case depth shall be made at a magnification of 100x.

**10. Report**

10.1 Report the following information:

- 10.1.1 The type of material and case measured,
- 10.1.2 The type of etchant used,
- 10.1.3 The location of the measurement, and
- 10.1.4 The metallographically estimated observed case depth to the nearest 0.1 mm.

**11. Precision and Bias**

11.1 The precision of this test method is based on an intralaboratory study of ASTM B931, Standard Test Method for Metallographically Estimating the Observed Case Depth of Ferrous Powder Metallurgy (PM) Parts, conducted in 2013. A single laboratory participated in this study, testing two different induction-hardened PM parts. Every “test result” represents an individual determination. The laboratory reported 40 replicate test results for each of the materials. Except for the use of only

one laboratory, Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. B09-1021.<sup>3</sup>

11.1.1 The 95 % repeatability limit, *r*, as defined by Terminology E456, is listed in Table 1. The repeatability was determined based on 40 individual tests in a single laboratory.

11.1.2 Reproducibility limits cannot be calculated from a single laboratory’s results. The reproducibility of this test method is being determined and will be available on or before December 2025.

11.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

11.3 The precision statement was determined through statistical examination of 80 results, from a single laboratory, on two different PM parts described below:

PM sprocket A: induction-hardened case depth of approximately 900 μm

PM sprocket B: induction-hardened case depth of approximately 500 μm

**12. Measurement Uncertainty**

12.1 The precision of Test Method B931 shall be considered by those performing the test when reporting metallographically estimated case depth results.

**13. Keywords**

13.1 case depth; observed case depth; PM; powder metallurgy

<sup>3</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B09-1021. Contact ASTM Customer Service at service@astm.org.

**TABLE 1 Observed Case Depth (μm)**

|            | Average <sup>A</sup> | Repeatability Standard Deviation | Repeatability Limit |
|------------|----------------------|----------------------------------|---------------------|
|            | $\bar{x}$            | $s_r$                            | $r$                 |
| Sprocket A | 880                  | 39.2                             | 110                 |
| Sprocket B | 560                  | 42.3                             | 120                 |

<sup>A</sup>The average of the laboratories’ calculated averages.

**SUMMARY OF CHANGES**

Committee B09 has identified the location of selected changes to this standard since the last issue (B0931–14 (2018)<sup>E1</sup>) that may impact the use of this standard. (Approved Feb. 1, 2023.)

(1) Deleted the Appendix X1 and reference to it in 9.1, and made reference to MPIF Standard 70 for sample preparation.

(2) Changes made to Section 11 on Precision and Bias to comply with B09 Form & Style.