Designation: ~~B796 – 14~~ B796 – 20

Standard Test Method for Nonmetallic Inclusion Content of Ferrous Powders Intended for Powder Forging (PF) Applications[1]

This standard is issued under the fixed designation B796; 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 metallographic method for determining the nonmetallic inclusion level of ferrous powders intended for powder forging (PF) applications.

1.2 The test method covers repress powder forged test specimens in which there has been minimal lateral material flow ~~(< 1%).~~(< 1 %). The core region of the powder forged test specimen shall contain no porosity detectable at 100×.

1.3 This test method is not suitable for determining the nonmetallic inclusion level of powder forged test specimens that have been forged such that the core region contains porosity. At the magnification used for this test method, residual porosity is hard to distinguish from oxide inclusions. Too much residual porosity makes a meaningful assessment of the inclusion population impossible.

1.4 The test method may be applied to materials that contain manganese sulfide (admixed or ~~prealloyed)~~prealloyed), provided the near neighbor separation distance is changed from 30 µm to 15 µm.

NOTE 1—The test method may be applied to powder forged parts where there has been a greater amount of material flow provided:
The near neighbor separation distance is changed, or
The inclusion sizes agreed between the parties are adjusted for the amount of material flow.

1.5 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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]

E3 Guide for Preparation of Metallographic Specimens

E768 Guide for Preparing and Evaluating Specimens for Automatic Inclusion Assessment of Steel

3. Summary of Test Method

3.1 A section representing the core region is cut from the powder forged test specimen, parallel to the direction of forging, to obtain a rectangular section that is mounted for metallographic grinding and polishing.

3.2 The polished sample is examined microscopically at a magnification of 100× and a note made of inclusions larger than a predetermined size.

[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 B09.11 on Near Full Density Powder Metallurgy Materials.

Current edition approved ~~Sept. 1, 2014~~April 1, 2020. Published ~~October 2014~~June 2020. Originally approved in 1988. Last previous edition approved in ~~2002~~2014 as ~~B796 – 07.~~B796 – 14. DOI: ~~10.1520/B0796-14.~~10.1520/B0796-20.

[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**

3.3 The maximum Feret's diameter is used to determine inclusion size. A Feret's diameter is a caliper diameter as illustrated in Fig. 1.

3.4 The fragmented nature of some inclusions means that their size determination is somewhat complicated. The concept of near neighbor separation is used in determining inclusion size. If an inclusion is within a certain distance of its neighboring particles, it is considered a member of an inclusion cluster or agglomerate. Detected features within 30 µm of one another are considered part of the same inclusion. The concept is illustrated schematically in Fig. 2.

3.5 The nonmetallic inclusion level of the test specimen is reported as the number of inclusions per 100 mm^2 greater than or equal to the predetermined size.

4. Significance and Use

4.1 The extensive porosity present in pressed and sintered ferrous materials masks the effect of inclusions on mechanical properties. In contrast, the properties of material powder forged to near full density are strongly influenced by the composition, size, size distribution, and location of nonmetallic inclusions.

4.2 The test for nonmetallic inclusions in powder forged steels is useful as the following:

4.2.1 Characteristic to classify or differentiate one grade of powder from another.

4.2.2 Means of quality comparison of powders intended for powder forging, lot to lot.

4.3 Significant variations in nonmetallic inclusion content will occur if:

4.3.1 The powder used to form the test specimen does not meet powder forging quality standards for nonmetallic inclusion content.

4.3.2 Processing of the powder forged test specimen has been carried out under conditions that do not permit oxide reduction or allow oxidation of the test specimen, or both.

5. Apparatus

5.1 Equipment for the metallographic preparation of test specimens.

5.2 A metallographic microscope permitting observation and measurement up to a magnification of 100× using light with a wavelength of 544 nm (green filter), an objective lens with a magnification of from 8× to 12.5×, and a numerical aperture between 0.16 and 0.20.

NOTE 2—Defining the light optics used is important because this determines the features that will be resolved, and all detected features are included in the assessment of inclusion size.

6. Test Specimen Preparation

6.1 Mix the powder that is intended for use in a powder forging application with an appropriate amount of graphite and lubricant.

6.2 Press a cylindrical compact to a specified green density and heat the compact to the desired forging temperature using a furnace with a suitable reducing gas atmosphere.

6.3 Transfer the heated cylindrical compact to a pre-heated die in a fast-acting press and repress forge the cylinder.

6.4 The relationship between the diameter of the green compact and the diameter of the forging die shall be such that the lateral flow during the repress forging operation is < ~~1%.~~1 %.

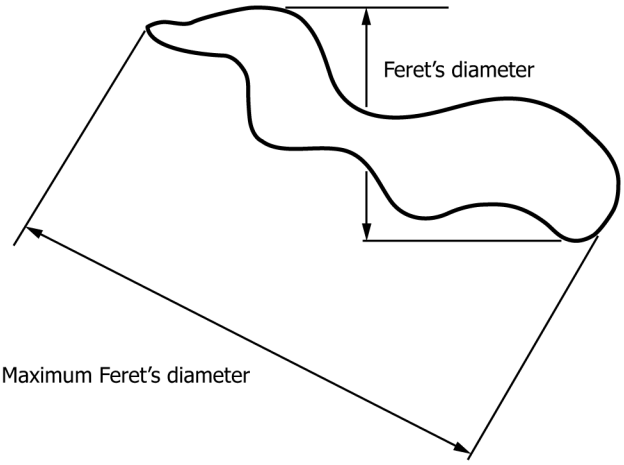

FIG. 1 Schematic ~~illustration~~Illustration of Feret's ~~diameter.~~Diameter

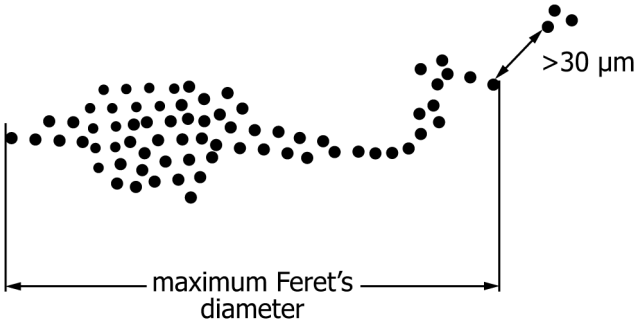

FIG. 2 Schematic ~~illustration~~Illustration of the ~~"near neighbor" concept and maximum Feret's diameter.~~"Near Neighbor" Concept and Maximum Feret's Diameter

7. Sampling

7.1 A metallographic sample shall be removed from the powder forged test specimen, austenitized, and quenched.

7.2 The polished surface of the sample to be examined shall be not less than 350 mm^2 in area. Multiple sections are permitted in order to obtain the necessary area for measurement.

7.3 The polished surface shall be parallel to the direction of forging, that is, parallel to the direction of travel of the forging punch, and shall represent the core region of the test specimen as illustrated in Fig. 3.

8. Procedure

8.1 *Preparation of Specimens*—In polishing the specimens, it is highly important that a clean polish be obtained and that the inclusions not be pitted, dragged, or obscured. It is recommended that the procedures described in ~~Practice~~Guide E3 and Guide E768 be followed. Automated grinding and polishing procedures are recommended. Examine specimens in the as-polished condition, free of the effects of any prior etching, if used.

8.2 *Measurement of Nonmetallic Inclusion Content:*

8.2.1 Survey at least 350 mm^2 of the surface of the polished specimen at a magnification of 100× using light with a wavelength of 544 nm (green filter), an objective lens with a magnification of from 8× to 12.5×, and a numerical aperture between 0.16 and 0.20.

8.2.2 Size detected inclusions on the basis of near neighbor separation. Features within 30 µm of one another are considered to be part of the same inclusion.

8.2.3 For individual features less than 30 µm in size, three such features within 30 µm of one another are required to constitute an inclusion aggregate.

8.2.4 Add an individual feature less than 30 µm in size to an inclusion larger than 30 µm, provided both features are within 30 µm of one another. Examples are given in Figs. 4 and 5.

8.2.5 Measure and record the number of inclusion particles according to the principle of near neighbor separation and sized using the maximum Feret's diameter that are as follows:

8.2.5.1 Greater than or equal to 30 µm but less than 100 µm in length,

8.2.5.2 Greater than or equal to 100 µm but less than 150 µm in length, and

8.2.5.3 Greater than or equal to 150 µm in length.

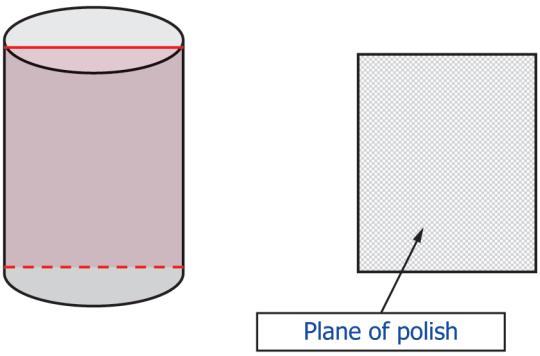

FIG. 3 Schematic of the ~~section~~Section to be ~~taken from the forged cylindrical compact and the surface that~~Taken From the Forged Cylindrical Compact and the Surface That is to be ~~ground~~Ground and ~~polished~~Polished