Designation: B 796 – 00~~2~~

Standard Test Method for Nonmetallic Inclusion ~~Level~~ Content of Powders Intended for Powder ~~Forged~~ Forging (P/F) ~~Steel Parts~~ Applications[1]

This standard is issued under the fixed designation B 796; 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 ~~recognized~~ metallographic method for determining the nonmetallic inclusion level of ~~powder forged steel parts.~~

~~1.2 This test method also may be used to determine the nonmetallic inclusion content of~~ powders intended for powder forging ~~applications after they have been consolidated~~ (P/F) applications.

1.2 The test method covers repress powder forged test specimens in ~~a prescribed manner so that the~~ which there has been minimal lateral material flow (< 1%). The core region ~~where~~ of the ~~assessment is to be carried out contains~~ 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 ~~parts~~ test specimens that have been forged such that the core region contains ~~porosity or of those parts that contain additions of manganese sulphide.~~ 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) 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 *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:*

[1] This test method is under the jurisdiction of ASTM Committee ~~B-9~~ B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.11 on Near Full Density Powder Metallurgy Parts.

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E ~~3 Methods~~ 3 Practice for Preparation of Metallographic Specimens[2]
E ~~768 Practice~~ 768 Guide for Preparing and Evaluating Specimens for Automatic Inclusion Assessment of Steel[2]

3. Summary of Test Method

3.1 A section representing the core region ~~of the part~~ is cut from the powder forged ~~part~~ test specimen and mounted for metallographic grinding and polishing.

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

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 neighbo~~u~~r separation is used in determining inclusion size. If an inclusion is within a certain distance of its neighbo~~u~~ring 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 ~~part~~ 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 ~~steel parts~~ steels is useful as the following:

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

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

4.3 Significant variations in nonmetallic inclusion content will occur if:

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

4.3.2 Processing of the powder forged ~~parts~~ test specimen has been carried out under conditions that do not permit oxide reduction or allow oxidation of the ~~part,~~ 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~~X~~× using light with a wavelength of 544 nm (green filter), an objective lens with a magnification of from ~~8X~~ 8× to 12.5~~X~~×, and a numerical aperture between 0.16 and 0.20.

NOTE ~~1~~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. Sampling

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

[2] *Annual Book of ASTM Standards,* Vol 03.01.

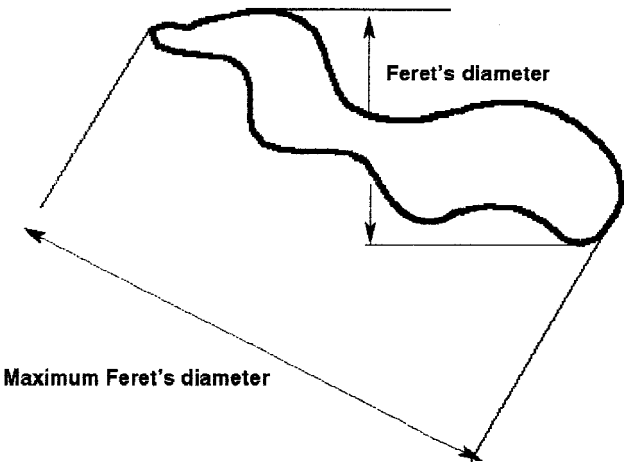

FIG. 1 Schematic illustration of Feret's diameter.

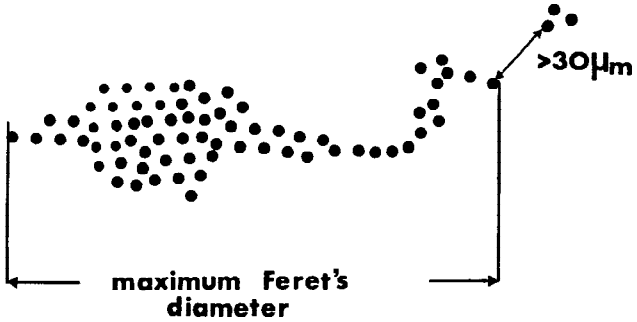

FIG. 2 Schematic illustration of the "near neighbor" concept and maximum Feret's diameter.

6.2 The polished surface of the ~~specimen~~ sample to be examined shall be not less than 350 mm^2 (0.54 $in.^2$) in area. Multiple sections are permitted in order to obtain the necessary area for ~~measurement on small parts.~~ measurement.

6.3 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 ~~part.~~ test specimen.

7. Procedure

7.1 *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 ~~Methods~~ Practice E 3 and ~~Practice~~ Guide E 768 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.

7.2 *Measurement of Nonmetallic Inclusion Content*:

7.2.1 Survey at least 350 mm^2 (0.54 in^2) of the surface of the polished specimen at a magnification of 100~~X~~× using light with a wavelength of 544 nm (green filter), an objective lens with a magnification of from ~~8X~~ 8× to 12.5~~X~~×, and a numerical aperture between 0.16 and 0.20.

7.2.2 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.

7.2.3 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.

7.2.4 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. 3 and 4.

7.2.5 Measure and record the number of inclusion particles~~,~~ according to the principle of near neighbo~~ur~~ separation~~,~~ and sized using the maximum Feret's diameter that are as follows:

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

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

7.2.5.3 Greater than or equal to 150 μm in length.

8. Report

8.1 Report the number of nonmetallic inclusions per 100 mm^2 that are as follows:

FIG. 3 Example of a spotty oxide inclusion. The maximum Feret's diameter is indicated.

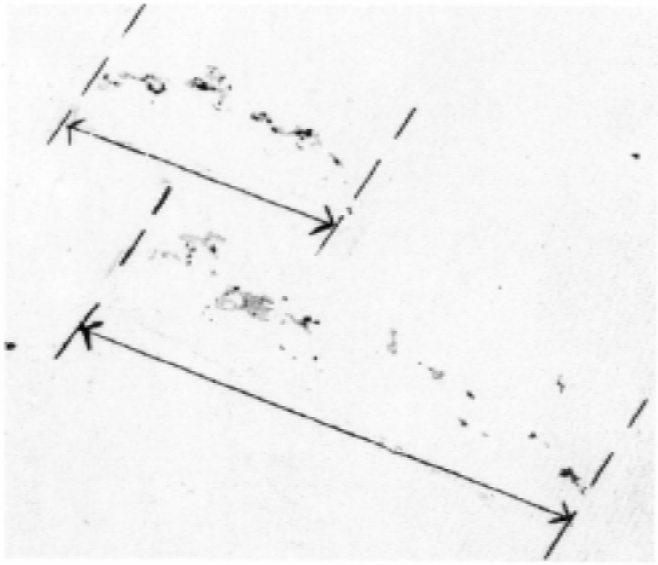

FIG. 4 Example of a discontinuous sulphide inclusion. The maximum Feret's diameter is indicated.

8.1.1 Greater than or equal to 30 µm but less than 100 µm in length.
8.1.2 Greater than or equal to 100 µm but less than 150 µm in length.
8.1.3 Greater than or equal to 150 µm in length.
8.2 The total area examined.

9. Precision and Bias

9.1 The precision and bias that can be expected through the use of this test method is currently under review by Subcommittee B09.11.

10. Keywords

10.1 nonmetallic inclusions; powder forged (P/F) steel parts