Designation: B 796 – 00

Standard Test Method for Nonmetallic Inclusion Level of Powder Forged (P/F) Steel Parts[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 in a prescribed manner so that the core region where the assessment is to be carried out contains no porosity.

1.3 This test method is not suitable for determining the nonmetallic inclusion level of powder forged parts that have been forged such that the core region contains porosity or of those parts that contain additions of manganese sulphide. 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 *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:*

E 3 Methods for Preparation of Metallographic Specimens[2]

E 768 Practice 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 and mounted for metallographic grinding and polishing.

3.2 The polished sample is examined microscopically at a magnification of 100X 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.

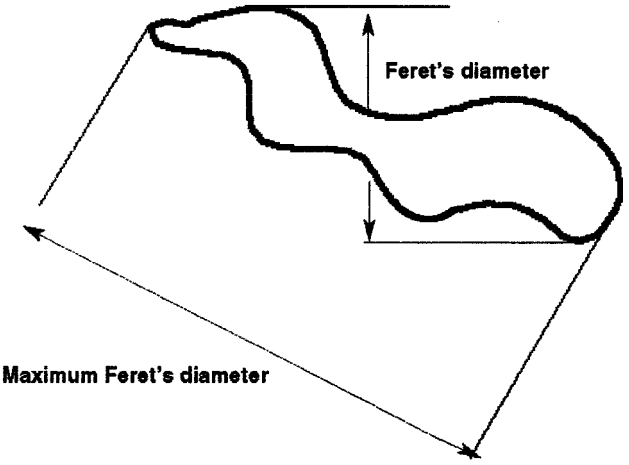

FIG. 1 Schematic illustration of Feret's diameter.

3.4 The fragmented nature of some inclusions means that their size determination is somewhat complicated. The concept of near neighbour separation is used in determining inclusion size. If an inclusion is within a certain distance of its neighbouring 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 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 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 powder forged parts, lot to lot.

4.3 Significant variations in nonmetallic inclusion content will occur if:

4.3.1 The powder used to form the parts does not meet

[1] This test method is under the jurisdiction of ASTM Committee B-9 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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[2] *Annual Book of ASTM Standards*, Vol 03.01.

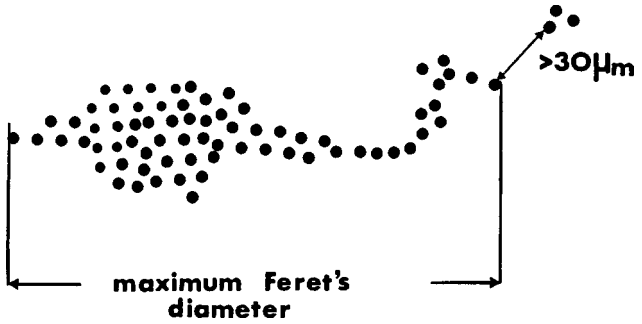

FIG. 2 Schematic illustration of the "near neighbor" concept and maximum Feret's diameter.

powder forging quality standards for nonmetallic inclusion content.

4.3.2 Processing of the powder forged parts has been carried out under conditions that do not permit oxide reduction or allow oxidation of the part, 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 100X using light with a wavelength of 544 nm (green filter), an objective lens with a magnification of from 8X to 12.5X, and a numerical aperture between 0.16 and 0.20.

NOTE 1—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 shall be removed from the powder forged part, austenitized, and quenched.

6.2 The polished surface of the specimen 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.

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.

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 E 3 and Practice 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 100X using light with a wavelength of 544 nm (green filter), an objective lens with a magnification of from 8X to 12.5X, 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 neighbour separation, and sized using the maximum Feret's diameter that are as follows:

7.2.5.1 Greater than or equal to 30 μm in length,

7.2.5.2 Greater than or equal to 100 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:

8.1.1 Greater than or equal to 30 μm in length.

8.1.2 Greater than or equal to 100 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

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

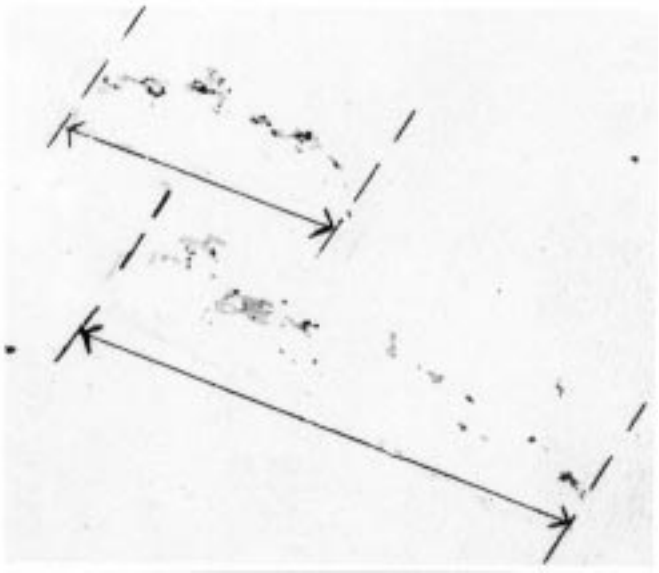

FIG. 4 Example of a discontinuous sulphide inclusion. The maximum Feret's diameter is indicated.