Designation: F 1659 – 95

# Standard Test Method for Bending and Shear Fatigue Testing of Calcium Phosphate Coatings on Solid Metallic Substrates[1]

This standard is issued under the fixed designation F 1659; 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 the procedure for the performance of calcium phosphate ceramic coatings in shear and bending fatigue modes. In the shear fatigue mode this test method evaluates the adhesive and cohesive properties of the coating on a metallic substrate. In the bending fatigue mode, this test method evaluates both the adhesion of the coating as well as the effects that the coating may have on the substrate material. These test methods are limited to testing in air at ambient temperature. These test methods are not intended for application in fatigue tests of components or devices; however, the test method that most closely replicates the actual loading configuration is preferred.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

E 6 Terminology Relating to Methods of Mechanical Testing[2]

E 206 Definitions of Terms Relating to Fatigue Testing and the Statistical Analysis of Fatigue Data[3]

E 466 Practice for Constant Amplitude Axial Fatigue Tests of Metallic Materials[2]

E 467 Practice for Verification of Constant Amplitude Dynamic Loads in an Axial Load Fatigue Testing Machine[2]

E 468 Practice for Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials[2]

## 3. Terminology

3.1 *Definitions:*

3.1.1 The definitions of terms relating to shear and fatigue testing appearing in Terminology E 6 and Terminology E 206 shall be considered as applying to the terms used in this test method.

## 4. Summary of Test Methods

4.1 *Shear Fatigue Testing*:

4.1.1 The intent of the shear fatigue test is to determine the adhesive or cohesive strength of the coating, or both.

4.1.2 This test is designed to allow the coating to fail at either the coating/substrate interface, within the coating, or at the glue/coating interface.

4.2 *Bending Fatigue Testing*:

4.2.1 The intent of the bending fatigue test is to quantify the effect that the coating has on the substrate to which it is applied. It may also be used to provide a subjective evaluation of coating adhesion (that is, spalling resistance, cracking resistance, etc.).

4.2.2 This test method is designed to first provide a substrate fatigue strength to serve as a baseline to assess the effects of the coating on the resulting fatigue strength of the system.

## 5. Significance and Use

5.1 The shear and bending fatigue tests are used to determine the effect of variations in material, geometry, surface condition, stress, etc., on the fatigue resistance of calcium phosphate coated metallic materials subjected to direct stress for up to $10^7$ cycles. These tests may be used as a relative guide to the selection of calcium phosphate coated materials for service under conditions of repeated stress.

5.2 In order that such basic fatigue data be comparable, reproducible, and can be correlated among laboratories, it is essential that uniform fatigue practices be established.

5.3 The results of the fatigue test may be used for basic material property design. Actual components should not be tested using these test methods.

## 6. Equipment Characteristics

6.1 Equipment characteristics shall be in accordance with Section 7 on Adhesive Bonding Materials of Practice E 466.

6.2 *Shear Fatigue Test Grips*:

6.2.1 *General*—Various types of grips may be used to transmit the load to the specimens by the testing machine. To ensure axial shear stress, it is important that the specimen axis coincide with the centerline of the heads of the testing machine

---

[1] This test method is under the jurisdiction of ASTM Committee F-4 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.13 on Ceramic Materials.

Current edition approved Nov. 10, 1995. Published May 1996.

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

[3] Discontinued; see *1987 Annual Book of ASTM Standards*, Vol 03.01.

and that the coating test plane be parallel to the axial load. Any departure from this requirement (that is, any eccentric loading) will introduce bending stresses that are not included in the usual stress calculation (force/cross-sectional area).

6.2.2 A drawing of a typical gripping device for the test assembly is shown in Fig. 1.

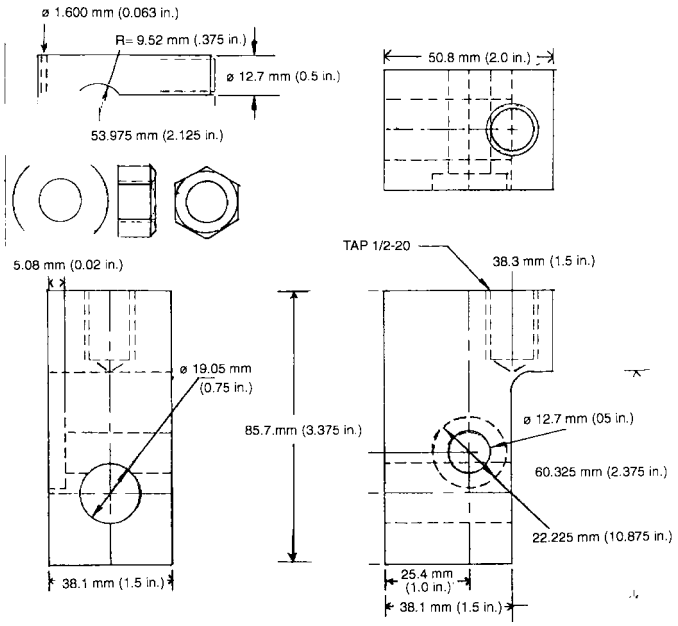


**FIG. 1 Gripping Device for Shear Testing**

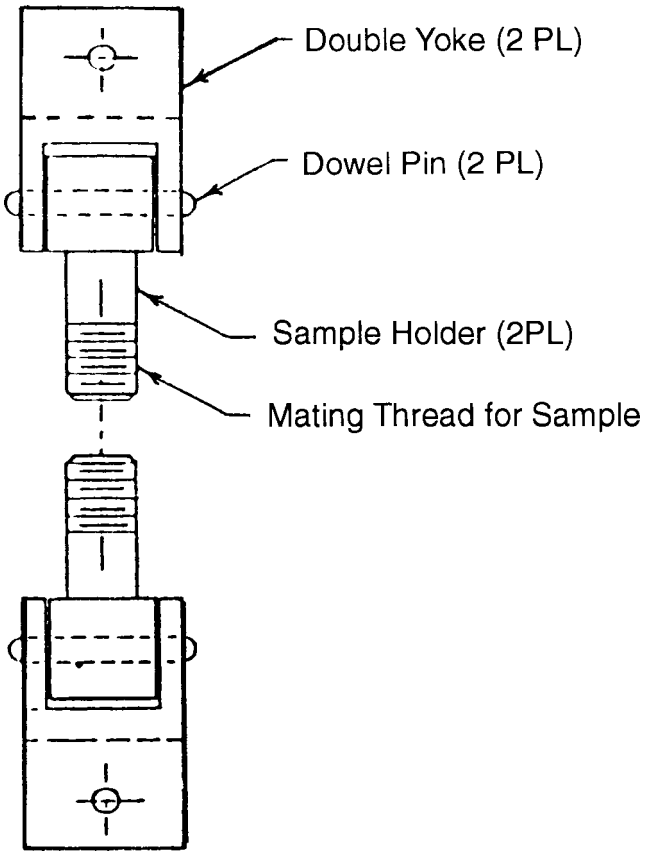


**FIG. 2 Adaptor to Mate the Gripping Device to the Tensile Machine**

6.2.3 Fig. 2 shows a drawing of the adaptor to mate the shear fixture to the tensile machine.

6.2.4 Fig. 3 shows a schematic of the test setup.

6.3 *Bending Fatigue Test Grips*—There are a variety of testing machines that may be employed for this test (that is, rotating beam fatigue machines and axial fatigue machines). The gripping method for each type of equipment shall be determined by either the manufacturer of that equipment (rotating beam machines) or the user.

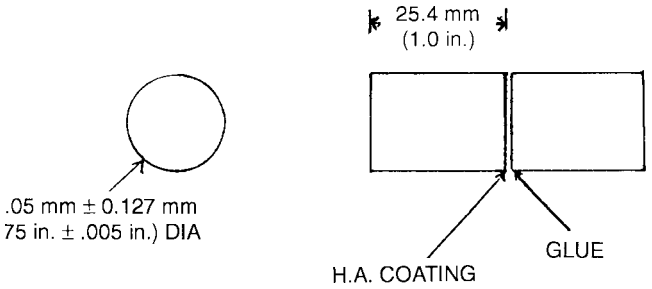


**FIG. 3 Schematic of the Shear Test Set-up**

## 7. Adhesive Bonding Materials

7.1 *Adhesive Bonding Agent*—A polymeric adhesive bonding agent in film form, or filled viscous adhesive cement, shall be identified and shall meet the following requirements.

7.1.1 The bonding agent shall be capable of bonding the coating on the test specimen components with an adhesive shear strength that is at least 34.5 MPa (5000 psi) or as great as the minimum required adhesion or cohesion strength of the coating.

7.1.2 In instances where coating porosity extends to the coating/substrate interface, the bonding agent shall be sufficiently viscous and application to the coating sufficiently detailed, to assure that it will not penetrate through the coating to the substrate. The FM 1000 Adhesive Film[4] with a thickness of 0.25 mm (0.01 in.) has proven satisfactory for this test.

7.1.3 If a material other than FM 1000[4] is used, or the condition of the FM 1000[4] is unknown, it must be tested to establish its equivalence fresh FM 1000.[4] Testing should be performed without the presence of the calcium phosphate coating to establish the performance of the adhesive.

## 8. Test Specimens

8.1 *Shear Fatigue Specimen*:

8.1.1 The recommended shear test specimen and setup is illustrated in Fig. 3 and Fig. 4, respectively. A complete, assembled test assembly, consists of two solid pieces: one with a coated surface and the other with an uncoated surface. The uncoated surface may be roughened to aid in the adhesion of the adhesive bonding agent.

8.1.2 The cross-sectional area of the substrate upon which the coating is applied shall be a nominal 2.85 $cm^2$ (0.44 $in.^2$).

[4] Available from American Cyanamid, Engineering Materials Division, Wayne, New Jersey.