Designation: F 1978 – 00 (2007)$^{\epsilon 1}$

Standard Test Method for Measuring Abrasion Resistance of Metallic Thermal Spray Coatings by Using the Taber Abraser[1]

This standard is issued under the fixed designation F 1978; 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.

ϵ^1 NOTE—Editorial changes were made to Sections 6, 7, and 8 in February 2007.

1. Scope

1.1 This test method quantifies the abrasion resistance of metallic coatings produced by thermal spray processes on flat metallic surfaces. It is intended as a means of characterizing coatings used on surgical implants.

1.2 This test uses the Taber Abraser,[2] which generates a combination of rolling and rubbing to cause wear to the coating surface. Wear is quantified as cumulative mass loss.

1.3 This test method is limited to flat, rigid specimens that do not react significantly with water and do not undergo a phase transformation or chemical reaction between room temperature and 100°C in air.

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 applicable regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *abraser*, *n*—an instrument that is designed to determine the resistance of surfaces to composite rolling and rubbing action.

3.1.2 *particle shedding*, *n*—the loss of surface particles and fragments from a coating.

3.1.3 *thermal spray coating*, *n*—coating produced by spraying melted or softened powder or wire by means of combustible gases, plasma, or two-wire arc.

3.1.4 *weight loss*, *n*—amount of mass removed by the test apparatus over the course of testing.

4. Summary of Test Method

4.1 This test method uses a Taber Abraser with H-22 Calibrade (trademarked) wheels[2] and the 250-g mass of the abrading head without added weights. Specimens are abraded repeatedly and cleaned ultrasonically for a set number of rotational cycles (2 to 100 cycles). The specimens are weighed after each cleaning, and the mass loss is the measure of abrasive wear to the specimen.

5. Significance and Use

5.1 This test method provides a means to evaluate the resistance to particle shedding of a thermal sprayed coating. Such particle shedding might occur during surgical insertion of an implant or as the result of micromotion of the implant after surgical insertion.

5.2 This abrasion test method may be useful for quality control analysis of a coating, and it can be used to evaluate the effects of processing variables, such as substrate preparation before coating, surface texture, coating technique variables, or postcoating treatments, any of which may influence the susceptibility of the coating to particle shedding.

5.3 This abrasion test method is for flat plate-shaped specimens of a size sufficient that the wheels of the abrader do not leave the surface of the specimen. It is not recommended, however, for devices with other shapes or sizes.

6. Apparatus

6.1 *Taber Abraser Model 5150*, or equivalent.

[1] This test method is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.15 on Material Test Methods.

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[2] Trademarked. The sole source of supply of the apparatus known to the committee at this time is Taber Industries, North Tonawanda, NY 14120 USA. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[3] 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.

6.2 *Two H-22 Taber Calibrade Wheels*, or equivalent, with abrading head of 250-g mass and no added weights.

6.3 *Taber Vacuum Unit*, made by Shop-Vac (trademarked),[2] 7.4 amps, or equivalent.

6.4 *Taber Wheel Refacer Model 250*,[2] or equivalent

6.5 *Ultrasonic Cleaning Unit*, for cleaning specimens after abrading.

6.6 *Drying Oven*, capable of operation at 100 ± 2°C, for drying specimens.

6.7 *Analytical Balance*, capable of weighing specimens to an accuracy of 0.0001 g.

7. Test Specimen

7.1 Abrasion test specimens shall be 10-cm (4-in.) squares or 10-cm diameter circles of at least 0.16-cm (0.0625-in.) thickness with a 0.64-cm (0.25-in.) diameter hole through the center to allow the specimen to fit on the specimen table screw of the Taber Abraser. For substrates other than titanium, consideration shall be given to the weight of the test specimen relative to the capacity of the analytical balance.

7.2 The coating shall be applied in a manner representative of that used on the finished surgical implant.

7.3 A minimum of six samples for each coating shall be tested. At least one set shall contain seven samples.

7.4 One specimen, randomly selected, from each group of six specimens shall be reserved to measure weight loss caused by ultrasonic cleaning. This specimen shall be called the "blank" specimen and shall be weighed, cleaned, and re-weighed for an equal number of times to the cleaning and weighing of the abraded specimen.

7.5 Of the seven sample set, one sample shall be selected to determine the time required for ultrasonic cleaning.

8. Procedure

8.1 *General Test Conditions*:

8.1.1 Prepare a fresh cleaning solution for the ultrasonic cleaner by adding 0.1 ± 0.005 g of reagent grade NaCl to each litre of deionized water.

8.1.2 Resurface the abrading wheels using Taber Wheel Refacer Model 250 for each new specimen. Check the radius of the wheel, it is essential that the radius of the abrading wheels not fall below the marked minimum level over the course of the test. Should the wheel radius fall below the labeled mark, the test run shall be discarded and a new specimen shall be run in its place.

8.1.3 Mount the wheels by placing the wheel marked "Left Wheel" on the left hand abrading head and the wheel marked "Right Wheel" on the right hand abrading head.

8.1.4 Before running the battery of tests, the ultrasonic cleaner shall be evaluated. This shall be done by by selecting the coated extra coated sample from Step 7.3, 7.5, and abrading.

8.1.4.1 Using the analytical balance, weigh the sample no fewer than three times and record the average weight of these measurements.

8.1.4.2 Place the sample on the Taber Abraser, as described in 8.2.5

8.1.4.3 Set the Taber Abraser for ten cumulative cycles and start the turntable.

8.1.4.4 Clean the sample for ten minutes with a fresh saline solution, using the ultrasonic cleaner to be used for the coating analysis.

8.1.4.5 Place the cleaned sample in a 100°C oven and dry for 10 min.

8.1.4.6 Allow the sample to cool to room temperature before weighing

8.1.4.7 Using the analytical balance, weigh the sample no fewer than three times and record the average weight of these measurements.

8.1.4.8 Repeat Steps 8.1.4.4-8.1.4.7 until the same mass (within balance error) is recorded for two consecutive cleanings.

8.1.4.9 Record the total number of cleanings used in 8.1.4.4-8.1.4.8.

8.1.4.10 Determine the required cleaning time necessary to obtain a stable mass, as $(10\cdot(n\text{-}1))$ min, where n is the total number of cleanings determined in 8.1.4.9.

8.1.5 Abrasion shall be done with only the 250-g mass of the abrading head assembly. No extra weights shall be added to the abrading head.

8.1.6 If there is more than one set of specimens to test, the specimens shall be tested in a random sequence.

8.1.7 A single complete specimen run shall consist of a series of partial runs, commencing with an initial two-cycle partial run and continuing until 100 cycles have been completed. Once a specimen run is initiated, no other specimens shall be tested using the same wheel until the specimen run is finished.

8.1.8 At the start of each new complete specimen run, the display indicating the number of cycles run shall be reset. This is done by pressing the "reset cycles completed" button. The Taber Abraser counts cumulative cycles (cycles completed) and so the number of cycles set for each partial run shall be the cumulative number of cycles (2, 5, 10, or 100) designated as the end of that partial run.

8.1.9 *Reference Standards*—Each group of six specimens shall include one unabraded "blank" specimen, as specified in 7.4. Once in every six tests, an unabraded specimen shall be used as a control to determine the weight loss caused by the ultrasonic cleaning. This specimen shall be weighed, cleaned, and reweighed for as many cycles as would normally be used if abrasion testing were being performed. These values shall be logged as "blank" weight loss values.

8.2 *Operation*:

8.2.1 Clean the specimen for the time determined in 8.1.4.10 using an ultrasonic cleaner with saline solution. This solution shall be changed to a fresh solution before the first cleaning done that day.

8.2.2 Place the cleaned specimen in a 100°C oven for 10 min to dry.

8.2.3 Allow the specimen to cool to room temperature before weighing.

8.2.4 Using the analytical balance, weigh the specimen no fewer than three times, and record the average of these weight measurements on a data sheet.

8.2.5 Place the specimen on the Taber Abraser, coating side up such that the specimen screw projects through the hole in