



Standard Test Method for Small Punch Testing of Ultra-High Molecular Weight Polyethylene Used in Surgical Implants¹

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1. Scope

1.1 This test method covers the determination of mechanical behavior of ultra-high molecular weight polyethylene (UHMWPE) by small punch testing of miniature disk specimens (0.5 mm in thickness and 6.4 mm in diameter). The test method has been established for characterizing UHMWPE surgical materials after ram extrusion or compression molding (1,2)²; for evaluating as-manufactured implants after radiation crosslinking and sterilization (3,4); as well as for testing of implants that have been retrieved (explanted) from the human body (5,6).

1.2 The parameters of the small punch test, namely the peak load, ultimate displacement, ultimate load, and work to failure, provide metrics of the yielding, ultimate strength, ductility, and toughness of UHMWPE under multiaxial loading conditions. Because the mechanical behavior of UHMWPE is different when loaded under uniaxial and multiaxial loading conditions (3), the small punch test provides a complementary mechanical testing technique to the uniaxial tensile testing specified for medical grade UHMWPE by Specification F648.

1.3 In addition to its use as a research tool in implant retrieval analysis, the small punch test can be used as a laboratory screening test to evaluate new UHMWPE materials, such as those created by gamma or electron beam irradiation (1). The test method is also well suited for characterization of UHMWPE before and after accelerated aging (for example, Guide F2003), and in that regard it can provide ranking of the mechanical degradation of different UHMWPE samples after oxidative degradation (4,7).

1.4 The small punch test has been applied to other polymers, including polymethyl methacrylate (PMMA) bone cement, polyacetal, and high density polyethylene (HDPE) (8,9). However, the small punch testing of polymers other than UHMWPE is beyond the scope of this standard.

1.5 The values stated in SI units are to be regarded as standard. The units in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*³

D695 Test Method for Compressive Properties of Rigid Plastics

D883 Terminology Relating to Plastics

E4 Practices for Force Verification of Testing Machines

E83 Practice for Verification and Classification of Extensometer Systems

F648 Specification for Ultra-High-Molecular-Weight Polyethylene Powder and Fabricated Form for Surgical Implants

F1714 Guide for Gravimetric Wear Assessment of Prosthetic Hip Designs in Simulator Devices

F1715 Guide for Wear Assessment of Prosthetic Knee Designs in Simulator Devices (Withdrawn 2006)⁴

F2003 Practice for Accelerated Aging of Ultra-High Molecular Weight Polyethylene after Gamma Irradiation in Air

F2102 Guide for Evaluating the Extent of Oxidation in Polyethylene Fabricated Forms Intended for Surgical Implants

3. Terminology

3.1 *Definitions*—The features of a typical small punch test load versus displacement curve for UHMWPE are illustrated in Fig. 1.

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 The boldface numbers in parentheses refer to the list of references at the end of this standard.

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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.