INTERNATIONAL

Designation: D3552 – 24

Standard Test Method for Tensile Properties of Fiber Reinforced Metal Matrix Composites[1]

This standard is issued under the fixed designation D3552; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of the tensile properties of metal matrix composites reinforced by continuous and discontinuous high-modulus fibers. Nontraditional metal matrix composites as stated in 1.1.6 also are covered in this test method. This test method applies to specimens loaded in a uniaxial manner tested in laboratory air at either room temperature or elevated temperatures. The types of metal matrix composites covered are:

1.1.1 Unidirectional laminates (all fibers aligned in a single direction) containing either continuous or discontinuous reinforcing fibers. Both longitudinal and transverse properties may be obtained.

1.1.2 0°/90° balanced crossply laminates containing either continuous or discontinuous reinforcing fibers.

1.1.3 Angleply laminates containing continuous reinforcing fibers, with layups that do not include 0° reinforcing fibers (that is, $(\pm 45)_{ns}$, $(\pm 30)_{ns}$, and so forth).

1.1.4 Multidirectional laminates containing continuous reinforcing fibers, with layups including 0° reinforcing fibers (that is, $(0/\pm 45/90)_{ns}$ quasi-isotropic laminates, $(0/\pm 30)_{ns}$ laminates, and so forth).

1.1.5 Laminates containing unoriented and random discontinuous fibers.

1.1.6 Directionally solidified eutectic composites.

1.2 The technical content of this standard has been stable since 1996 without significant objection from its stakeholders. As there is limited technical support for the maintenance of this standard, changes since that date have been limited to items required to retain consistency with other ASTM D30 Committee standards. The standard therefore should not be considered to include any significant changes in approach and practice since 1996. Future maintenance of the standard will only be in response to specific requests and performed only as technical support allows.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

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

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3878 Terminology for Composite Materials
E4 Practices for Force Calibration and Verification of Testing Machines
E8 Test Methods for Tension Testing of Metallic Materials [Metric] E0008_E0008M
E83 Practice for Verification and Classification of Extensometer Systems
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E456 Terminology Relating to Quality and Statistics
E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology E6 defines terms relating to mechanical testing. Terminology E456 and Practice E177 define terms relating to statistics. In the

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.04 on Lamina and Laminate Test Methods.

Current edition approved April 15, 2024. Published April 2024. Originally approved in 1977. Last previous edition approved in 2017 as D3552 – 17. DOI: 10.1520/D3552-24.

[2] 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.

event of a conflict between terms, Terminology D3878 shall have precedence over the other standards.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *continuous fiber, n*—a polycrystalline or amorphous fiber that is continuous within the sample or component or that has ends outside of the stress fields under consideration.

4. Summary of Test Method

4.1 A tension specimen is mounted in the grips of a mechanical testing machine and monotonically loaded, in tension, at a constant loading rate until specimen failure occurs. The ultimate strength of the material can be determined from the maximum force carried before failure. If the coupon strain is monitored with strain or displacement transducers, then the stress-strain response of the material can be determined, from which the ultimate tensile strain, proportional limit, and tensile modulus of elasticity can be derived.

5. Significance and Use

5.1 This test method is designed to produce tensile property data for material specifications, research and development, quality assurance, and structural design and analysis. Factors that influence the tensile response and should be reported include the following: material, methods of material preparation and lay-up, specimen stacking sequence, specimen preparation, specimen conditioning, environment of testing, specimen alignment and gripping, speed of testing, time at temperature, and volume percent reinforcement. Properties, in the test direction, which may be obtained from this test method include the following:

5.1.1 Ultimate tensile strength,

5.1.2 Ultimate tensile strain,

5.1.3 Tensile modulus of elasticity, and

5.1.4 Poissons ratio.

6. Interferences

6.1 Tension test data are used as the principal criteria for the engineering design in actual structural applications. Therefore, it is important to define test conditions that will produce realistic tensile properties, including statistical variation. Such data will allow the design engineer to determine the most appropriate and meaningful margin of safety. The following test method issues will cause significant data scatter:

6.1.1 *Material and Specimen Preparation*—Poor material fabrication practices, lack of control of fiber alignment, and damage induced by improper coupon machining are known causes of high material data scatter in composites.

6.1.2 *Gripping*—A high percentage of grip-induced failures, especially when combined with high material data scatter, is an indicator of specimen gripping problems.

6.1.3 *System Alignment*—Excessive bending will cause premature failure, as well as highly inaccurate modulus of elasticity determination. Every effort should be made to eliminate excess bending from the test system. Bending may occur as a result of misaligned grips or from specimens themselves if improperly installed in the grips or out of tolerance as a result of poor specimen preparation. If there is any doubt as to the alignment inherent in a given test machine, then the alignment should be checked.

7. Apparatus

7.1 *Micrometers and Calipers*—A micrometer with a 4 mm to 8 mm [0.16 in. to 0.28 in.] nominal diameter ball-interface or a flat anvil interface shall be used to measure the specimen thickness. A ball interface is recommended for thickness measurements when at least one surface is irregular (for example, a coarse surface which is neither smooth nor flat). A micrometer or caliper with a flat anvil interface shall be used for measuring length, width, diameter, and other machined surface dimensions. The use of alternative measurement devices is permitted if specified (or agreed to) by the test requestor and reported by the testing laboratory. The accuracy of the instrument(s) shall be suitable for reading to within 1 % of the specimen dimensions. For typical specimen geometries, an instrument with an accuracy of ±0.0025 mm (±0.0001 in.) is adequate for thickness measurement, while an instrument with an accuracy of ±0.025 mm (±0.001 in.) is adequate for measurement of length, width, diameter, and other machined surface dimensions.

7.2 *Testing Machine,* comprised of the following:

7.2.1 *Fixed Member*—A fixed or essentially stationary member carrying one grip.

7.2.2 *Movable Member*—A movable member carrying a second grip.

7.2.3 *Loading Mechanism*—A loading mechanism for imparting to the movable member a controlled velocity with respect to the stationary member, this velocity to be regulated as specified in Section 11.

7.2.4 *Force Indicator*—A suitable force-indicating mechanism capable of showing the total force carried by the test specimen. This mechanism shall be essentially free of inertia lag at the specified rate of testing and shall indicate the force with an accuracy of ±1 % of the indicated value, or better. The accuracy of the testing machine shall be verified in accordance with Practice E4. Further, the calibrated force range used for a particular test shall be chosen to ensure the anticipated maximum forces are between 20 % to 80 % of the calibrated force range. This is to ensure a linear calibrated force response and protect the force indicator from overload conditions.

7.2.5 *Grips:*

7.2.5.1 *General*—Grip designs shall be suited to the specimens being tested. The grip designs described in Test Methods E8 shall be applicable but should be sized according to the specimen dimensions.

7.2.5.2 *Grips for Round Specimen*—The grips for round specimens shall be standard threaded grips or split-shoulder grips with shoulder surfaces designed to mate with corresponding specimens described in Section 8. The grips shall be self-aligning.

7.2.5.3 *Grips for Flat Specimens*—The grips shall be wedge-type grips or lateral pressure grips with serrated or knurled surfaces for contact with the specimen. The grips shall be self-aligning; that is, they shall be attached to their respective fixed and movable members in such a manner that when any force is applied, the grips will place the axis of a correctly mounted specimen in coincidence with the applied force direction such that no significant moment is placed on the specimen test section, either in the thickness or width direction.