Designation: D3479/D3479M – 19

Standard Test Method for Tension-Tension Fatigue of Polymer Matrix Composite Materials[1]

This standard is issued under the fixed designation D3479/D3479M; 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 determines the fatigue behavior of polymer matrix composite materials subjected to tensile cyclic loading. The composite material forms are limited to continuous-fiber or discontinuous-fiber reinforced composites for which the elastic properties are specially orthotropic with respect to the test direction. This test method is limited to unnotched test specimens subjected to constant amplitude uniaxial in-plane loading where the loading is defined in terms of a test control parameter.

1.2 This test method presents two procedures where each defines a different test control parameter.

1.2.1 *Procedure A*—A system in which the test control parameter is the load (stress) and the machine is controlled so that the test specimen is subjected to repetitive constant amplitude load cycles. In this procedure, the test control parameter may be described using either engineering stress or applied load as a constant amplitude fatigue variable.

1.2.2 *Procedure B*—A system in which the test control parameter is the strain in the loading direction and the machine is controlled so that the test specimen is subjected to repetitive constant amplitude strain cycles. In this procedure, the test control parameter may be described using engineering strain in the loading direction as a constant amplitude fatigue variable.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.3.1 Within the text the inch-pound units are shown in brackets.

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]

D883 Terminology Relating to Plastics
D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D3878 Terminology for Composite Materials
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E83 Practice for Verification and Classification of Extensometer Systems
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E456 Terminology Relating to Quality and Statistics
E467 Practice for Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System
E739 Practice for Statistical Analysis of Linear or Linearized Stress-Life (***S-N***) and Strain-Life (ε-***N***) Fatigue Data
E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application

[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.

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[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.

E1823 Terminology Relating to Fatigue and Fracture Testing

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology E1823 defines terms relating to fatigue. Terminology D883 defines terms relating to plastics. Terminology E6 defines terms relating to mechanical testing. Terminology E456 and Practice E177 define terms relating to statistics. In the event of a conflict between terms, Terminology D3878 shall have precedence over the other standards.

3.2 *Definitions of Terms Specific to This Standard:* The following definitions shall have precedence over Terminology D3878 and over other standards.

3.2.1 *constant amplitude loading, n—in fatigue*, a loading in which all of the peak values of the test control parameter are equal and all of the valley values of the test control parameter are equal.

3.2.2 *fatigue loading transition, n—in the beginning of fatigue loading*, the number of cycles before the test control parameter reaches the desired peak and valley values.

3.2.3 *frequency, f* $[T^{-1}]$*, n—in fatigue loading*, the number of load (stress) or strain cycles completed in 1 s (Hz).

3.2.4 *load (stress) ratio, R [nd], n—in fatigue loading*, the ratio of the minimum applied load (stress) to the maximum applied load (stress).

3.2.5 *peak, n—in fatigue loading*, the occurrence where the first derivative of the test control parameter versus time changes from positive to negative sign; the point of maximum load (stress) or strain in constant amplitude loading.

3.2.6 *replicate (repeat) tests, n*—nominally identical tests on different test specimens conducted at the same nominal value of the independent variable.

3.2.7 *residual stiffness,* $[FL^{-2}]$*, n*—the value of modulus of a specimen under quasi-static loading conditions after the specimen is subjected to fatigue loading.

3.2.8 *residual strength,* $[FL^{-2}]$*, n*—the value of load (stress) required to cause failure of a specimen under quasi-static loading conditions after the specimen is subjected to fatigue loading.

3.2.9 *spectrum loading, n—in fatigue*, a loading in which the peak values of the test control parameter are not equal or the valley values of the test control parameter are not equal (also known as variable amplitude loading or irregular loading.)

3.2.10 *strain ratio,* R_ε *[nd], n—in fatigue loading*, the ratio of the minimum applied strain to the maximum applied strain.

3.2.11 *test control parameter, n*—the variable in constant amplitude loading whose maximum and minimum values remain the same during cyclic loading, in other words, load (stress) or strain.

3.2.12 *valley, n—in fatigue loading*, the occurrence where the first derivative of the test control parameter versus time changes from negative to positive; the point of minimum load (stress) or strain in constant amplitude loading.

3.2.13 *wave form, n*—the shape of the peak-to-peak variation of the test control parameter as a function of time.

3.3 *Symbols:*

3.3.1 S_{max} *(or* ε_{max}*)*—the value of stress (or strain) corresponding to the peak value of the test control parameter in a constant amplitude loading.

3.3.2 S_{min} *(or* ε_{min}*)*—the value of stress (or strain) corresponding to the valley value of the test control parameter in a constant amplitude loading.

3.3.3 S_{mn} *(or* ε_{mn}*)*—the mean value of stress (or strain) as given by $S_{mn} = (S_{max} + S_{min})/2$ or $\varepsilon_{mn} = (\varepsilon_{max} + \varepsilon_{min})/2$.

3.3.4 S_a *(or* ε_a*)*—the difference between the mean value of stress (or strain) and the maximum and minimum stress (or strain) as given by $S_a = (S_{max} - S_{min})/2$ or $\varepsilon_a = (\varepsilon_{max} - \varepsilon_{min})/2$.

3.3.5 N_f—the scalar value of fatigue life or number of constant amplitude cycles to failure.

3.3.6 α—Weibull fatigue life scale parameter.

3.3.7 β—Weibull fatigue life shape parameter.

4. Summary of Test Method

4.1 The tensile specimen described in Test Method D3039/D3039M is mounted in the grips of the testing machine and is tested as follows:

4.1.1 *Procedure A*—The specimen is cycled between minimum and maximum in-plane axial load (stress) at a specified frequency. The number of load cycles at which failure occurs (or at which a predetermined change in specimen stiffness is observed) can be determined for a specimen subjected to a specific load (stress) ratio and maximum stress. For some purposes it is useful to obtain the in-plane stiffness at selected cycle intervals from static axial stress-strain curves using modulus determination procedures found in Test Method D3039/D3039M.

4.1.2 *Procedure B*—The specimen is cycled between minimum and maximum in-plane axial strain at a specified frequency. The number of strain cycles at which specimen failure occurs (or at which a predetermined change in specimen stiffness is observed) can be determined at a given strain ratio and maximum strain. For some purposes it is useful to obtain the in-plane stiffness at selected cycle intervals from static axial stress-strain curves using modulus determination procedures found in Test Method D3039/D3039M or continuously from dynamic axial stress-strain data using similar procedures as found in Test Method D3039/D3039M.

5. Significance and Use

5.1 This test method is designed to yield tensile fatigue data for material specifications, research and development, quality assurance, and structural design and analysis. The primary test result is the fatigue life of the test specimen under a specific loading and environmental condition. Replicate tests may be used to obtain a distribution of fatigue life for specific material types, laminate stacking sequences, environments, and loading conditions. Guidance in statistical analysis of fatigue life data, such as determination of linearized stress life (S-N) or strain-life (ε-N) curves, can be found in Practice E739.