Designation: D8132/D8132M – 23

Standard Test Method for Determination of Prepreg Impregnation by Permeability Measurement[1]

This standard is issued under the fixed designation D8132/D8132M; 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 determines the in-plane permeability of composite prepreg (pre-impregnated) materials as a measure of level of impregnation. Permissible prepreg materials include those reinforced with carbon, glass, aramid, thermoplastic and other fibers impregnated with a thermoset or thermoplastic matrix resin, creating a single ply sheet material. The reinforcements may be unidirectional or woven fabrics.

1.2 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.

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

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

1.4 *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:*

D883 Terminology Relating to Plastics

D3878 Terminology for Composite Materials

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

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology D883 defines terms relating to plastics. 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 terminologies.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *as cast*—pertaining to the transparent and smooth surface of an acrylic block.

3.2.2 *acrylic block assembly*—the acrylic blocks nested together or clamped together but that are otherwise oriented or joined together only for a temporary process.

3.2.3 *cut side*—machined surface of an acrylic block.

3.2.4 *permeability*—material property that determines flow through a porous medium. Within this standard, used to determine the air transport of prepreg materials in the in-plane directions.

3.2.5 *permeability test apparatus*—the vacuum test chamber with known volume where the permeability test specimen is mounted and tested to determine permeability.

3.2.6 *permeability test specimen*—specimen prepared for the permeability test.

3.3 *Symbols*

A = cross-sectional area of the prepreg test specimen

CV = coefficient of variation of a sample population for a given property (in percent)

FAW = fiber areal weight

H = prepreg thickness

ID = inner diameter

K = permeability

K_n = normalized permeability (independent of prepreg thickness)

L = length of prepreg sample

OD = outer diameter

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.03 on Constituent/Precursor Properties.

Current edition approved Sept. 1, 2023. Published October 2023. Originally approved in 2017. Last previous edition approved in 2017 as D8132/D8132M – 17. DOI: 10.1520/D8132_D8132M-23.

P = absolute pressure in vacuum chamber (P as a function of time)

P_{atm} = actual atmospheric pressure

P_i = initial absolute pressure in vacuum chamber (P_{iabs} at time 0)

RH = relative humidity

S_{n-1} = standard deviation of a sample population for a given property

x_1 = test result for an individual specimen from the sample population for a given property

$\bar{x}$ = mean or average (estimate of mean) of a sample population for a given property

4. Summary of Test Method

4.1 This test method consists of imparting a pressure differential across a single ply of prepreg to determine the permeability of the material by exposing one side to the atmosphere and the other to known volume of reduced pressure. The initial reduced pressure, created by a vacuum pump, increases after the pump is shut off as a function of air flow through the prepreg. To create the test specimen, a single ply of prepreg is sandwiched and bonded between acrylic blocks. This test specimen is then attached to the surface of the known volume with vacuum tape. This assembly provides a leak-free seal and no applied compaction pressure on the prepreg surface during testing.

4.2 This standard defines a test method to determine the air transport capacity of a prepreg composite material in the plane of the fiber; in unidirectional materials, this means either parallel to or orthogonal to the fiber direction and in woven fabric materials, in the warp or fill direction.

4.3 A successful test is dependent on proper handling and mounting of the prepreg material sample. A leak-free seal is required between the prepreg and acrylic block adherends and the surface of the test apparatus.

5. Significance and Use

5.1 It is well known that the prepreg impregnation level affects handling characteristics, tack and drape, and final part quality. Resin impregnation level is the dominant factor in the ability of removing air and volatiles from the layup during processing. Partially impregnated prepreg materials can in some applications provide higher quality, lower void content composite parts, and are becoming increasingly more common due to the desire to cure out-of-autoclave, using vacuum bag-only processes. This test can identify small changes in the material impregnation level which can assist in definition of production processes or shipping and handling procedures. The value of permeability can be used for specifying ranges as acceptance requirements for prepreg materials, thus enabling the prepreg manufacturer and user greater confidence in the ability to produce repeatable and high quality parts. This test directly determines the actual air flow propensity of the material tested without any applied compaction pressure during testing.

5.2 Factors that influence the permeability of the tested prepreg material shall be reported including: prepreg material, orientation, location on roll, width, length, thickness, and actual atmospheric pressure.

6. Interferences

6.1 *Material and Specimen Preparation*—Poor material fabrication practices, lack of control of fiber alignment, and damage induced by improper specimen cutting are known causes of high data scatter in composites in general. Specific factors that affect the prepreg test specimen permeability results include compression and bending of prepreg, handling, sharpness of cutting blades, and control of fiber alignment and orientation when cutting. Measuring prepreg thickness is very difficult and subjective due to the viscoelastic material and non-uniform surface and can cause significant permeability calculation error. When comparing values at different laboratories, a normalized permeability value that does not take into account prepreg thickness may be more applicable.

6.2 *Permeability Test Specimen Preparation*—To maintain a high quality seal to the prepreg material it is important to have clean bonding surfaces on the acrylic blocks. Also the viscosity, gel, and cure time of adhesive, time to apply adhesive and mount specimen, and adhesive quantity can affect the seal or cause undesired impregnation of areas of the prepreg. The adhesive must fill in the bond line between the two acrylic block adherends or there can be a gap that is difficult to seal from the environment. Control of the orientation of the prepreg between the acrylic blocks is necessary for repeatable results. Once the prepreg is mounted and adhered between the acrylic blocks, the test specimen should be allowed to cure without pressure on the prepreg. Ends of the mounted prepreg should never be touched except for cutting immediately before testing.

6.3 *Mounting Blocks and Adhesive*—The mounting blocks that are specified are based on cast clear acrylic which enables inspection of the bond line. Other clear polymer blocks may be used but adhesion would need to be evaluated with the mounting adhesive.

6.4 *Mounting Permeability Test Specimen to Apparatus*—The completed test specimens must be mounted with the prepreg centered so as not to touch the sides of the apparatus. An air-tight seal must be maintained throughout the testing.

6.5 *Barometric Pressure*—The barometric pressure that is used for the calculation of permeability must be the actual barometric pressure in the ambient testing environment and not a corrected barometric pressure. All pressure units used for calculations must be in absolute values.

6.6 *Geometry*—Specific geometric factors that affect permeability results include prepreg thickness, width, length, and orientation.

6.7 *Environment*—Results can be affected by large variations in environmental conditions under which the tests are conducted. Sample preparation and testing in relative humidity (RH) over 70% and temperatures above 24 °C [75 °F] or below 15 °C [60 °F] are not recommended.