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Standard Guide for Testing Automotive/Industrial Composite Materials[1]

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INTRODUCTION

A new class of composite materials has been developed to meet the needs of automotive and industrial mass production applications. This new class of materials, referred to as automotive/industrial composites, is comprised of filled and unfilled polymers reinforced with chopped or continuous high modulus, or both (greater than 20.7 GPa (3×10^{6} psi)) fibers.

Automotive/industrial composites possess some of the same advantages as high-performance aerospace composites. However, some aspects of performance are traded off for reduced cost, ease of manufacturing, and high quality appearance. Automotive/industrial composites are also different from materials classified as plastics. This difference arises from the use of high modulus fiber reinforcement to provide substantial improvements in structural properties of the base polymer system.

Currently, ASTM International standard test methods developed for high performance composites or plastics, or both, are used for testing of automotive/industrial composites. In many cases, these standards are quite adequate if proper attention is given to the special testing considerations for automotive/industrial composites covered in this guide. However, in some cases, current standards do not meet the needs for testing of the required properties. In this case, revised standards or new standards specifically for automotive/industrial composites may be desirable.

In addition to covering the special considerations required for automotive/industrial composites testing, this guide points out and compares existing ASTM International standards applicable to these materials. This is done only for some of the more commonly evaluated material properties.

1. Scope

1.1 This guide covers the testing of molded automotive/industrial composite materials. It is intended to increase the users awareness of the special considerations necessary for the testing of these materials. In addition, the user is provided with a comparison of some of the more commonly used ASTM International standard test methods that are applicable for evaluating automotive/industrial composites.

1.2 Areas in which current ASTM International standard test methods do not meet the needs for testing of automotive/industrial composites are indicated. This provides direction for future standardization work.

1.3 It is not the intent of this guide to cover all test methods which could possibly be used for automotive/industrial composites. Only the most commonly used and most applicable standards are included.

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 applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service[2]

D 256 Test Methods for Determining Izod Pendulum Impact Resistance of Plastics[3]

D 543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents[3]

D 618 Practice for Conditioning Plastics for Testing[3]

D 638 Test Method for Tensile Properties of Plastics[3]

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position[3]

D 671 Test Method for Flexural Fatigue of Plastics by Constant-Amplitude-of-Force[3]

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

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[2] *Annual Book of ASTM Standards*, Vol 08.04.

[3] *Annual Book of ASTM Standards*, Vol 08.01.

D 695 Test Method for Compressive Properties of Rigid Plastics[3]
D 696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between − 30°C and 30°C[3]
D 756 Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions[3]
D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[3]
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[3]
D 1822 Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials[3]
D 2289 Test Method for Tensile Properties of Plastics at High Speeds[3]
D 2344 Test Method Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates[4]
D 2584 Test Method for Ignition Loss of Cured Reinforced Resins[5]
D 2734 Test Method for Void Content of Reinforced Plastics[5]
D 2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep Rupture of Plastics[5]
D 3039 Test Method for Tensile Properties of Polymer Matrix Composite Materials[4]
D 3410 Test Method for Compressive Properties of Composite Materials with Unsupported Gage Section by Shear Loading[4]
D 3418 Test Method for Transition Temperatures of Polymers by Thermal Analysis[5]
D 3479 Test Methods for Tension-Tension Fatigue of Polymer Matrix Composite Materials[4]
D 3846 Test Method for In-Plane Shear Strength of Reinforced Plastics[5]
D 4065 Practice for Plastics: Mechanical Properties: Determination and Report of Procedures[5]
D 4255 Guide for Testing In-Plane Shear Properties of Composites Laminates[4]
E 228 Test Method for Linear Thermal Expansion of Solid Materials With a Vitreous Silica Dilatometer[6]

3. Terminology

3.1 *Definitions:*

3.1.1 *automotive/industrial composite*—any filled or unfilled polymer reinforced with chopped or continuous high modulus, or both, (greater than 20.7-GPa (3×10^6 psi)) fibers whose properties are dependent on the process parameters used in mass production manufacturing.

3.1.2 *Plaque*—a flate plate of molded material for evaluation of material properties.

3.1.3 *Part*—a component of a manufactured assembly.

3.2 *Abbreviations:Abbreviations:*

3.2.1 *A/I Composite*, automotive/industrial composite.

4. Significance and Use

4.1 This guide is intended to serve as a reference for the testing of automotive/industrial composite materials.

4.2 The use of this guide assures that proper consideration is given to the unique characteristics of these materials in testing. In addition, this guide also assists the user in selecting the best currently available ASTM International test method for measurement of commonly evaluated material properties.

5. Summary of Guide

5.1 Special testing considerations unique to automotive/industrial composites are identified and discussed. Recommendations for handling these considerations are provided. Special considerations covered are included in Section 7 on Material Definition, Section 8 on Sampling Techniques, Section 9 on Test Specimen Preparation, Section 10 on Test Specimen Conditioning, and Section 11 on Reporting of Results.

5.2 Current ASTM International standard test methods applicable to automotive/industrial composites are compared for commonly evaluated material properties. Areas where revised or new standards are needed are identified. Test methods for commonly evaluated properties in the following test method groups are compared:

Test Methods	Sections
Mechanical Properties	12.4
Fatigue Properties	12.5
Environmental Resistance	12.6
Creep Properties	12.7
Thermal Properties	12.8
Physical Properties	12.9
Impact Properties	12.10

6. Procedure for Use

6.1 Review Sections 7-11 to become familiar with the special testing considerations for automotive/industrial composites.

6.2 Locate the table for the property that you would like to determine in Section 12. Use the table to help in selecting the best ASTM International standard test method for determining that property.

6.3 Follow the selected ASTM International standard, but refer back to the guide for recommendations on material definition, sampling procedures, test specimen preparation, test specimen conditioning, and reporting of results.

7. Material Definition

7.1 *Constituent Definition*—Variations in the type and content of fiber, filler, and resin can have a significant influence on material property test results. Each constituent material should be carefully defined and documented before testing to avoid misinterpretation of test results.

7.1.1 Fiber, filler, and resin content should be measured and recorded at least one location in each part or plaque from which test specimens are machined. In 12.9, techniques for measuring these values are covered.

7.1.2 The following items should be documented each time a material is tested: fiber type, dimensions, and surface treatment; filler type, dimensions, and surface treatment; and resin type and component breakdown.

[4] *Annual Book of ASTM Standards*, Vol 15.03.
[5] *Annual Book of ASTM Standards*, Vol 08.02.
[6] *Annual Book of ASTM Standards*, Vol 14.02.

7.2 *Process Definition*—Processing techniques can affect fiber orientation, void content, and state of polymerization. These factors can in turn influence material property test results significantly. Each of these items should be defined and documented before testing to avoid misinterpretation of test results.

7.2.1 Fiber orientation should be quantitatively measured and documented for each part or plaque from which test specimens are machined. Both overall and local variations in fiber orientation should be documented. Unfortunately, a practical test method for measuring and quantifying local fiber orientation has not yet been developed and standardized.

7.2.2 Void content should be measured for each material tested in at least three different parts or plaques from which test specimens are taken. Methods for measuring void content are reviewed in 12.9.

7.2.3 State of polymerization should be measured quantitatively and documented for at least three different parts or plaques from which test specimens are machined. Although a specific test is not standardized for measuring state of polymerization, other auxilliary tests are often used. One such measurement is determination of glass transition temperature by Test Method D 3418.

7.2.4 As a minimum, the following process conditions should be documented for each material tested: compound preparation, charge preparation, molding technique, molding temperature, molding pressure, molding time, and part or plaque dimensions.

7.3 *History Definition*—Load and environmental history after molding and before testing can have a significant influence on A/I composite materials property test results. These history factors should be fully defined before testing to avoid misinterpretation of test results.

7.3.1 Load history, if any, should be documented for each test specimen. Information on the loading mode, magnitude, rate, and number of times that the load was applied should be included.

7.3.2 Environmental history should be documented for each test specimen. Time, temperature, and humidity conditions from molding to testing should be fully documented.

8. Sampling Techniques

8.1 *Test Plaques and Parts*—Either parts or test plaques may be used as a source of test specimens. Flat plaques tend to produce optimum and more uniform material property results than complex parts if the plaques are molded under carefully controlled conditions. If complex parts are used, the effects of local flow and molding conditions are much more likely to affect test results. The objectives of the testing to be done dictate the choice of parts or flat plaques for sampling.

8.1.1 A complete description of the part or plaque dimensions, molding source, and molding date should be documented.

8.2 *Mix of Parts*—Sampling from several parts (or plaques) produces average test results which are less influenced by part-to-part material or process variation. In addition, part-to-part variation may be evaluated when several parts are used.

8.2.1 A minimum of three parts should be used for sampling for each material property evaluated. An equal number of test specimens should be taken from each part.

8.2.2 Each test specimen should be labeled so that the part from which it was cut can be identified.

8.3 *Test Specimen Orientation*—Overall and local fiber orientation effects can have a significant influence on material property test results.

8.3.1 Test specimen orientation should be mixed to determine average properties of a nominally planar isotropic material. A minimum of two perpendicular directions should be selected for test specimens within each part (or plaque). These orientations should be selected to produce the maximum and minimum material property test results if possible.

8.3.2 Maximum and minimum properties should be measured independently for materials with oriented fiber reinforcement. Test results for minimum and maximum properties should not be averaged.

8.3.3 Each test specimen should be marked so that its orientation within the original part can be identified.

8.4 *Test Specimen Location*—The location of test specimens within a part (or plaque) can influence material property test results.

8.4.1 Areas near the edges of parts should be avoided for test specimen location unless the properties in these areas are specifically desired.

8.4.2 Areas near or over local geometric conditions such as ribs, bosses, molded holes, corners, and flanges should be avoided for routine material property testing. Test specimens may be taken from these areas when properties are needed for the analysis of these specific geometric conditions.

8.4.3 Test specimen location within each part should be documented with a drawing or photograph. Each test specimen should be identified so that its location within the original part can be traced. Special identification should be used for test specimens taken from part edges or from an area near or over any local geometric variation.

8.5 *Number of Test Specimens*—The more test specimens that are used to determine each material property, the less local and part to part variations in properties will affect average test results.

8.5.1 A minimum of six test specimens for each material property to be measured is suggested for a nominally planar isotropic material. These six should be from three separate parts with two from each part. Each two should be perpendicularly oriented so that fiber orientation effects are averaged in each part. More test specimens may be required depending on the variability of test data and the desired confidence level in the value of the property being measured.

8.5.2 When testing oriented fiber reinforced materials, at least six test specimens should be used for evaluating both minimum and maximum property values. These six should be from three separate parts with two specimens from each part. More specimens may be necessary for measurement of materials properties to specific statistical levels of confidence.