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Standard Guide for Material Properties Needed in Engineering Design Using Plastics[1]

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INTRODUCTION

Plastics are increasingly being used in durable applications as structural components on a basis comparable with traditional materials such as steels and aluminum, as well as high performance composite systems. Unlike many consumer-goods applications, where plastics typically serve as enclosures, these durables applications primarily involve load-bearing components exposed to rather broad varying operating environments over the life cycle of the product. This necessitates access to material property profiles over a wide range of conditions, rather than typical values reported at room temperature. In order to design effectively with plastics, the designer must take into account the effects of time, temperature, rate, and environment on the performance of plastics, and the consequences of failure.

1. Scope

1.1 This guide covers the essential material properties needed for designing with plastics. Its purpose is to raise the awareness of the plastics community regarding the specific considerations involved in using the appropriate material properties in design calculations.

1.2 This guide is intended only as a convenient resource for engineering design. It should be noted that the specific operating conditions (temperature, applied stress or strain, environment, etc. and corresponding duration of such exposures) could vary significantly from one application to another. It is, therefore, the responsibility of the user to perform any pertinent tests under actual conditions of use to determine the suitability of the material in the intended application.

1.3 The applicable ISO and ASTM standard methods for the relevant material properties are listed in this guide for the benefit of design engineers.

1.4 It should be noted that for some of the desired properties, no ASTM or ISO standards exist. These include pvT data, no-flow temperature, ejection temperature, and fatigue in tension. In these instances, relying on available test methods is suggested.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

1.7 *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]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D695 Test Method for Compressive Properties of Rigid Plastics

D883 Terminology Relating to Plastics

D1435 Practice for Outdoor Weathering of Plastics

[1] This guide is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

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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.

***A Summary of Changes section appears at the end of this standard**

D1894 Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
D1999 Guide for Selection of Specimens and Test Parameters from ISO/IEC Standards (Withdrawn 2000)[3]
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
D2991 Test Method for Stress-Relaxation of Plastics (Withdrawn 1990)[3]
D3045 Practice for Heat Aging of Plastics Without Load
D3123 Test Method for Spiral Flow of Low-Pressure Thermosetting Molding Compounds
D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
D3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials
D3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer
D4473 Test Method for Plastics: Dynamic Mechanical Properties: Cure Behavior
D5045 Test Methods for Plane-Strain Fracture Toughness and Strain Energy Release Rate of Plastic Materials
D5279 Test Method for Plastics: Dynamic Mechanical Properties: In Torsion
E6 Terminology Relating to Methods of Mechanical Testing
E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
E1823 Terminology Relating to Fatigue and Fracture Testing

2.2 *ISO Standards:*[4]

ISO 175 Plastics—Determination of the Effects of Immersion in Liquid Chemicals
ISO 294-1 Plastics—Injection Moulding of Test Specimens of Thermoplastic Materials—General Principles, and Moulding of Multipurpose and Bar Test Specimens
ISO 527-1 Plastics—Determination of Tensile Properties—Part 1: General Principles
ISO 527-2 Plastics—Determination of Tensile Properties—Part 2: Test Conditions for Moulding and Extrusion Plastics
ISO 527-4 Plastics—Determination of Tensile Properties—Part 4: Test Conditions for Isotropic and Orthotropic Fibre Reinforced Plastic Composites
ISO 604 Plastics—Determination of Compressive Properties
ISO 899-1 Plastics—Determination of Creep Behaviour - Tensile Creep
ISO 899-2 Plastics—Determination of Creep Behaviour - Flexural Creep by Three-Point Loading
ISO 2578 Plastics—Determination of Time-Temperature Limits After Prolonged Exposure to Heat
ISO 3167 Plastics—Multipurpose Test Specimens
ISO 4607 Plastics—Methods of Exposure to Natural Weathering
ISO 4892-2 Plastics—Methods of Exposure to Laboratory Light Sources—Part 2: Xenon Arc Sources
ISO 6721-2 Plastics—Determination of Dynamic Mechanical Properties—Part 2: Torsion Pendulum
ISO 8295 Plastics—Film and Sheeting—Determination of the Coefficients of Friction
ISO 10350.1 Plastics—Acquisition and Presentation of Comparable Single-Point Data— Part 1: Moulding Materials
ISO 11403-1 Plastics—Acquisition and Presentation of Comparable Multipoint Data—Part 1: Mechanical Properties
ISO 11403-2 Plastics—Acquisition and Presentation of Comparable Multipoint Data—Part 2: Thermal and Processing Properties
ISO 11443 Plastics—Determination of the Fluidity of Plastics Using Capillary and Slit-Die Rheometers

3. Terminology

3.1 *Definitions:*

3.1.1 *aging*—the effect on materials of exposure to an environment for an interval of time (see Terminology D883).

3.1.2 *coefficient of friction*—a measure of the resistance to sliding of one surface in contact with another surface.

3.1.3 *coefficient of linear thermal expansion*—the change in linear dimension per unit of original length of a material for a unit change in temperature.

3.1.4 *compressive strength*—the compressive stress that a material is capable of sustaining. In the case of a material that does not fail in compression by a shattering fracture, the value for compressive strength is an arbitrary value depending upon the degree of distortion that is regarded as indicating complete failure of the material (modified from Terminology E6).

3.1.5 *creep*—the time-dependent increase in strain in response to applied stress (modified from Terminology E6).

3.1.6 *creep modulus*—the ratio of initial applied stress to creep strain (see Test Method D2990).

3.1.7 *creep rupture stress*—stress to produce material failure corresponding to a fixed time to rupture (modified from Test Method D2990).

3.1.8 *critical stress intensity factor*—toughness parameter indicative of the resistance of a material to fracture at fracture initiation (see Test Method D5045).

3.1.9 *engineering stress*—stress based on initial cross sectional area of the specimen.

3.1.10 *fatigue*—the process of progressive localized permanent deleterious change or loss of properties occurring in a material subjected to cyclic loading conditions (modified from Definitions E1823).

3.1.11 *Poisson's ratio*—the absolute value of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material (see Terminology D883).

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.