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Standard Practice for Calculating Property Retention Index of Plastics[1]

This standard is issued under the fixed designation D5870; 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 practice covers procedures for the calculation of a property retention index (PRI) of thermoplastic and thermoset plastics after exposure to thermal aging, natural or artificial accelerated weathering, or chemical exposures.

1.2 This practice is not intended to establish a fixed procedure for conducting the exposure test, but it is intended to provide a set of specific procedures used to calculate the retention index of a characteristic property of the material after it has been exposed. Selection of the specific exposure test conditions depends on the material being tested and the property being measured. It is up to the user to determine which exposure test conditions are most relevant to the specific material and the service condition being used. The exposure test used must be conducted in accordance with conditions described in specific exposure standards.

1.3 This practice does not describe procedures for sampling the materials to be tested. These procedures are described in the standards and specifications applicable to the material being evaluated.

1.4 The procedure used to calculate the PRI depends on whether the test used to characterize the materials being exposed is destructive or nondestructive. The PRI can be useful in describing short-term mechanical, electrical, and other properties of plastics at specified temperatures after the materials have been subjected to an exposure test.

1.5 *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.*

NOTE 1—There is no similar or equivalent ISO standard. ISO DIS 11248 is significantly different since it pertains only to thermosetting resins.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1435 Practice for Outdoor Weathering of Plastics
F1499 Specification for Coextruded Composite Drain, Waste, and Vent Pipe (DWV)
D1898 Practice for Sampling of Plastics[3]
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
D3045 Practice for Heat Aging of Plastics Without Load
D4329 Practice for Fluorescent UV Exposure of Plastics
D4364 Practice for Performing Outdoor Accelerated Weathering Tests of Plastics Using Concentrated Sunlight
D4459 Practice for Xenon-Arc Exposure of Plastics Intended for Indoor Applications
D4674 Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments
D6360 Practice for Enclosed Carbon-Arc Exposures of Plastics
G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

2.2 *ISO Standards:*[4]

ISO 291 Plastics—Standard Atmospheres for Conditioning and Testing
ISO 877 Plastics—Methods of Exposure to Direct Weathering, to Weathering Using Glass Filtered Daylight, and to Intensified

[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.50 on Durability of Plastics.

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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.

[3] Withdrawn.

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

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

Weathering by Daylight Using Fresnel Mirrors
ISO 4892 Plastics—Methods of Exposure to Laboratory Light Sources Part 1: General Guidance, Part 2: Xenon Arc Exposures, Part 3: Fluorescent UV Exposures, and Part 4: Filtered Open Flame Carbon Arc Exposures
ISO DIS 11248 Plastics—Thermosetting Molding Materials, Evaluation of Short-Term Performance at Elevated Temperatures

3. Terminology

3.1 *Definitions:* The terminology given in Terminologies D883 and G113 is applicable to this practice.

4. Significance and Use

4.1 The property retention index (PRI) determined by this practice is intended primarily to provide relative durability performance information on materials for design engineers. It is up to the user to ensure that appropriate sampling procedures are used for the selection of specimens to be exposed so that the PRI data obtained is actually representative of the material being evaluated.

4.2 The PRI obtained depends on the material being tested, property being evaluated, and exposure condition used. A PRI obtained for one property will probably not be the same as the PRI for a different property of the same material, even if the same exposure test is used.

4.3 Plastics exposed to a combination of environmental and thermal treatments may undergo a change in functional performance. Any laboratory-accelerated aging procedure, especially those that use only a single stress, may not realistically indicate the changes a plastic may undergo in actual use conditions. This practice provides a means for expressing the changes in properties as a function of time exposed in a wide variety of tests. The PRI data obtained is best used for comparing the performance of materials subjected to the same exposure test simultaneously.

4.3.1 Both laboratory-accelerated and outdoor exposure testing can be highly variable, and the PRI data will be influenced by this variability. For example, PRI data from outdoor exposures can vary depending on the exposure location and the time of year when the exposure is conducted. Variability in laboratory-accelerated exposure tests can result in large differences in PRI data from two laboratories running supposedly identical tests. PRI data obtained from exposure to laboratory-accelerated tests cannot be used to predict the PRI for exposure to natural weathering or actual use conditions unless there is a sufficient amount of data from both types of exposure to allow valid statistical comparisons.

4.4 A number of different exposure techniques can be used to provide information on the effects of environmental stresses such as light, heat, and water on plastics (see Practices D1435, F1499, D2565, D4329, D4364, and D4459; Test Method D4674~~; and ISO 4892 and~~ ; and ISO 877 and ISO 4892). When it is desirable to evaluate the effects of heat alone, exposures should be conducted in accordance with Practice D3045. When it is desirable to evaluate the effects of chemical exposures, the exposures should be conducted in accordance with Test Method D543.

4.5 There are a number of factors influencing the physical properties and the retention of these properties after exposure. In addition to a complete description of the exposure test conditions used, the following information shall be included in any report referencing this practice: (*1*) complete description of the material tested, including the type, source, manufacturer's code number, form, and previous history; (*2*) methods of preparation for the material and individual test specimens; (*3*) procedure used for specimen conditioning prior to and after exposure; (*4*) complete description of the environment in which the physical properties were determined (for example, temperature and relative humidity); (*5*) complete description of the procedure used to determine the physical properties tested, including the rate at which specimens were tested, if applicable; (*6*) if applicable, void content of the specimens tested and the method used to measure void content.

NOTE 2—It is not the intent of this practice to require users to divulge proprietary information regarding composition. To avoid divulging proprietary information, generic descriptions may be used to provide information on material composition.

4.6 When destructive tests are used to determine a physical or chemical change, or both, which occurs as a result of exposure, the amount of change is expressed as a function of the value obtained for the material tested at a specified test environment (for example, temperature and humidity). The exposed and reference specimens are measured at the same time in the specified test environment.

4.7 When nondestructive tests are used to determine a physical or chemical change, or both, which occurs as a result of exposure, the amount of change is expressed as a function of the value obtained on the specimens prior to exposure. Property measurement tests on the specimens before and after exposure shall be conducted at the same conditions (for example, temperature and humidity).

4.8 The property or properties to be measured may be specified in an ASTM, ISO, or other appropriate standard for the material being tested, or by any prior agreement between interested parties. If the method used to measure the property being evaluated is not described in an ASTM, ISO, or other appropriate standard, a description of the test method shall be included in the report of test results.

4.9 It is realized that a material cannot be tested without specifying the method of preparation. To have any meaning in comparative testing, specimens of each material being evaluated by these test procedures should be prepared or molded from the same lot under identical processing conditions and randomized prior to testing at the conditions desired. It must be realized that lot-to-lot variation in the material may cause additional variability in results.

NOTE 3—For those plastics with a *Tg* greater than ambient, the slow collapse of free volume, with attendant significant changes in mechanical properties such as fatigue resistance, impact resistance, yield stress, and vapor transmission, etc. will be accelerated at elevated temperatures below the *Tg* but will be reversed at temperatures above the *Tg*. Therefore, incubation at elevated temperatures in the *Tg* range may be erratically susceptible to oven fluctuation effects.

4.10 The results depend on which side of the test specimen is exposed with some tests. In bending tests, for example, different results are obtained in accordance with whether the exposed surface or the unexposed surface of the test specimen is placed under tension. Care must be taken to ensure that all specimens being exposed have the same orientation in the test fixture used to hold the specimens during exposure. In addition, the results also depend on the orientation of test specimens during the procedure used to measure the property being monitored. This is especially true with impact tests. During the procedure used to measure the characteristic property, care must be taken to ensure that all specimens are oriented the same way in the test fixture.

4.11 Before proceeding with this practice, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, or dimensions, or some combination thereof, and testing parameters covered in the material's specification shall take precedence over those mentioned in this practice. The default conditions described in this practice apply if there are no material specifications.

5. Apparatus

5.1 The apparatus used for exposure and measurement of the property desired will depend on the particular exposure used and property being measured. Refer to the appropriate ASTM or ISO standards for requirements on the apparatus needed.

6. Sampling

6.1 Sampling of materials for testing is covered under applicable standards or specifications for the material being tested.

6.2 It is important to select samples for testing that are representative of the material being evaluated. Procedures for sampling plastics are described in Practice D1898.

7. Test Specimens

7.1 The test specimens shall be in accordance with the appropriate test method used for the properties being measured.

7.2 All test specimens shall be prepared in accordance with the pertinent material standards and other relevant ASTM standards.

7.3 Annealing of thermoplastic materials and post-curing of thermosetting materials has a significant effect on many properties. To minimize errors caused by these effects, annealing and post-curing shall be conducted accurately in accordance with pertinent material standards or, if not available, in accordance with the material manufacturer's recommendations. The conditions used for any annealing or post curing of specimens shall be reported.

7.4 The number of specimens tested shall be in accordance with the test method for the particular properties being measured. Large numbers of test specimens should be used in cases of extreme variability, in which the standard deviation of test results is more than 20 % of the mean value. If the test method used does not require a specific number of test specimens, a minimum of five replicate specimens of each material shall be used.

8. Procedure

8.1 *Exposure of Test Specimens*

8.1.1 When determining the PRI for materials exposed to natural weathering, conduct exposures in accordance with Practice D1435.

8.1.2 When the PRI for exposure to concentrated natural sunlight is to be determined, conduct exposures in accordance with Practice D4364.

8.1.3 When the PRI for exposure to laboratory light sources is to be determined, conduct exposures in accordance with one of the following ASTM standards:

(1) Practice F1499 for exposures to filtered open-flame carbon-arc light sources;

(2) Practice D2565 for exposures to xenon-arc light sources;

(3) Practice D4329 for exposure to fluorescent ultraviolet (UV) light sources; and

(4) Practice D6360, D4329 for exposures to enclosed carbon-arc light sources;

(5) Procedures for exposure to these and other types of light sources are also described in ASTM or ISO standards applicable to specific types of materials; these can also be used when mutually agreed upon by all interested parties.

~~8.1.4When the PRI for exposure to heat onermined, conduct exposures in accordance with Practice~~

8.1.4 When the PRI for exposure to heat is to be determined, conduct exposures in accordance with Practice D3045. Exposures used to determine the PRI will typically be conducted at one or two temperatures. The procedures covered in Practice D3045, which describe the calculation of a time to fail, would not be used for tests to determine the PRI.

8.1.5 When the PRI for chemical exposure is to be determined, conduct exposures in accordance with Test Method D543.

8.2 *Material Properties Measured with Nondestructive Tests*—When material properties are measured using non-destructive methods (for example, gloss, haze, and transparency), determine the PRI as follows:

8.2.1 Determine the initial level of the measured property, $P_{i,o}$, for each replicate specimen of the materials being tested.

8.2.2 Expose all replicate test specimens to the environment desired, conducting exposures in accordance with the applicable ASTM standards.