Designation: D3045 – 92 (Reapproved 2003)

Standard Practice for Heat Aging of Plastics Without Load[1]

This standard is issued under the fixed designation D3045; 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 Department of Defense.

1. Scope

1.1 This practice is intended to define the exposure conditions for testing the resistance of plastics to oxidation or other degradation when exposed solely to hot air for extended periods of time. Only the procedure for heat exposure is specified, not the test method or specimen. The effect of heat on any particular property may be determined by selection of the appropriate test method and specimen.

1.2 This practice should be used as a guide to compare thermal aging characteristics of materials as measured by the change in some property of interest. This practice recommends procedures for comparing the thermal aging characteristics of materials at a single temperature. Recommended procedures for determining the thermal aging characteristics of a material at a series of temperatures for the purpose of estimating time to a defined property change at some lower temperature are also described.

1.3 This practice does not predict thermal aging characteristics where interactions between stress, environment, temperature, and time control failure occurs.

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.*

NOTE 1—ISO-2578 is considered to be technically equivalent to this practice.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D573 Test Method for Rubber—Deterioration in an Air Oven
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1870 Practice for Elevated Temperature Aging Using a Tubular Oven[3]
D1898 Practice for Sampling of Plastics[3]
E145 Specification for Gravity-Convection and Forced-Ventilation Ovens
E456 Terminology Relating to Quality and Statistics

2.2 *ISO Standard:*

ISO 2578 (1974) Determination of Time-Temperature Limits After Exposure to Prolonged Action of Heat[4]

3. Terminology

3.1 The terminology given in Terminology D883 and Terminology E456 is applicable to this practice.

4. Significance and Use

4.1 The use of this practice presupposes that the failure criteria selected to evaluate materials (that is, the property or properties being measured as a function of exposure time) and the duration of the exposure can be shown to relate to the intended use of the materials.

4.2 Plastic materials exposed to heat may be subject to many types of physical and chemical changes. The severity of the exposures in both time and temperature determines the extent and type of change that takes place. A plastic material is not necessarily degraded by exposure to elevated temperatures, but may be unchanged or improved. However, extended periods of exposure of plastics to elevated temperatures will generally cause some degradation, with progressive change in physical properties.

4.3 Generally, short exposures at elevated temperatures may drive out volatiles such as moisture, solvents, or plasticizers, relieve molding stresses, advance the cure of thermosets, and may cause some change in color of the plastic or coloring agent, or both. Normally, additional shrinkage should be expected with loss of volatiles or advance in polymerization.

[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.

4.4 Some plastic materials may become brittle due to loss of plasticizers after exposure at elevated temperatures. Other types of plastics may become soft and sticky, either due to sorption of volatilized plasticizer or due to breakdown of the polymer.

4.5 The degree of change observed will depend on the property measured. Different properties, mechanical or electrical, may not change at the same rate. For instance, the arc resistance of thermosetting compounds improves up to the carbonization point of the material. Mechanical properties, such as flexural properties, are sensitive to heat degradation and may change at a more rapid rate. Ultimate properties such as strength or elongation are more sensitive to degradation than bulk properties such as modulus, in most cases.

4.6 Effects of exposure may be quite variable, especially when specimens are exposed for long intervals of time. Factors that affect the reproducibility of data are the degree of temperature control of the enclosure, humidity of the oven, air velocity over the specimen, and period of exposure. Errors in exposure are cumulative with time. Certain materials are susceptible to degradation due to the influence of humidity in long-term heat resistance tests. Materials susceptible to hydrolysis may undergo degradation when subjected to long-term heat resistance tests.

4.7 It is not to be inferred that comparative material ranking is undesirable or unworkable. On the contrary, this practice is designed to provide data which can be used for such comparative purposes. However, the data obtained from this practice, since it does not account for the influence of stress or environment that is involved in most real life applications, must be used cautiously by the designer, who must inevitably make material choices using additional data such as creep and creep rupture that are consistent with the requirements of his specific application.

4.8 It is possible for many temperature indexes to exist, in fact, one for each failure criterion. Therefore, for any application of the temperature index to be valid, the thermal aging program must duplicate the intended exposure conditions of the end product. If the material is stressed in the end product in a manner not evaluated in the aging program, the temperature index thus derived is not applicable to the use of the material in that product.

4.9 There can be very large errors when Arrhenius plots or equations based on data from experiments at a series of temperatures are used to estimate time to produce a defined property change at some lower temperature. This estimate of time to produce the property change or "failure" at the lower temperature is often called the "service life." Because of the errors associated with these calculations, this time should be considered as "maximum expected" rather than "typical."

5. Apparatus

5.1 Provisions for conditioning at specified standard conditions.

5.2 *Oven*—A controlled horizontal or vertical air flow oven, employing forced-draft circulation with substantial constant fresh air intake is recommended. When it is necessary to avoid contamination among specimens or materials, a tubular oven method such as Practice D1870 may be desirable. Oven apparatus shall be in accordance with Specifications E145, Type IIB for temperature up to 70°C. For higher temperature, Type IIA is required. Provision should be made for suspending specimens without touching each other or the side of the chamber. Recording instrumentation to monitor the temperature of exposure is recommended.

5.3 *Test Equipment* to determine the selected property or properties, in accordance with appropriate ASTM procedures.

6. Sampling

6.1 The number and type of test specimens required shall be in accordance with the ASTM test method for the specific property to be determined; this requirement should be met at each time and temperature selected.

6.2 Sampling should also be in accordance with the pertinent considerations outlined in Practice D1898.

7. Test Specimens

7.1 The number and type of test specimens required shall be in accordance with the ASTM test method for the specific property to be determined; this requirement should be met at each time and temperature selected. Unless otherwise specified or agreed upon by all interested parties, expose a minimum of three replicates of each material at each time and temperature selected.

7.2 The specimen thickness should be comparable to but no greater than the minimum thickness of the intended application.

7.3 The method of specimen fabrication should be the same as that of the intended application.

8. Conditioning

8.1 Conduct initial tests in the standard laboratory atmosphere as specified in Practice D618, and with specimens conditioned in accordance with the requirements of the ASTM test method for determining the specific property or properties required.

8.2 When required, conditioning of specimens following exposure at elevated temperature and prior to testing, unless otherwise specified, shall be in accordance with Practice D618.

8.3 If possible, avoid simultaneous aging of mixed groups of different compounds which might cause cross contamination.

9. Procedure

9.1 When tests at a single temperature are used, all materials must be exposed at the same time in the same device. Use a sufficient number of replicates of each material for each exposure time so that results of tests used to characterize the material property can be compared by analysis of variance or similar statistical data analysis procedure.

9.2 When testing at a series of temperatures in order to determine the relationship between a defined property change and temperature, use a minimum of four exposure temperatures. The following procedures are recommended for selecting exposure temperatures:

9.2.1 The lowest temperature should produce the desired level of property change or product failure in approximately nine to twelve months. The next higher temperature should