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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Practice for Determining Permanent Effect of Heat on Plastics¹

This standard is issued under the fixed designation D 794; 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 is intended to define the conditions for testing the resistance of plastic sheet, plastic laminated materials, and molded plastics to changes in properties due to exposure at elevated temperatures. Only the procedure for heat exposure is specified, and not the test method or specimen. The effect of heat on any property may be determined by selection of an appropriate test method and specimen.

1.2 *This standard does not purport to address all of the safety problems, 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 comparable ISO standard.

2. Referenced Documents

2.1 ASTM Standards:

D 495 Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation²

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing³

D 756 Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions³

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials³

D 883 Terminology Relating to Plastics³

D 1870 Practice for Elevated Temperature Aging Using a Tubular Oven⁴

E 145 Specification for Gravity-Convection and Forced-Ventilation Ovens⁵

3. Terminology

3.1 **Definitions:** Definitions of terms applying to this practice appear in Terminology D 883.

4. Significance and Use

4.1 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.

4.2 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.

4.3 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 plasticiser or due to breakdown of the polymer.

4.4 The degree of change observed will depend on the property measured. Mechanical or electrical properties may not change at the same rate. For instance, the arc resistance, see Test Method D 495, of thermosetting compounds improves up to the carbonization point of the material. Mechanical properties, such as flexural properties, see Test Methods D 790, are sensitive to heat degradation and should be included in the test program.

4.5 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, the type of molding, cure, humidity of the oven room, air velocity over the specimen, and period of exposure. Errors in exposure are cumulative with time. Unless the effect of the molding procedure is a variable under investigation, transfer or injection molding is recommended as the trapped air and volatiles have a better chance to escape. Incompletely cured thermosets tend to blister or crack when exposed to high temperatures. 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.

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² Annual Book of ASTM Standards, Vols 08.01 and 10.02.

³ Annual Book of ASTM Standards, Vol 08.01.

⁴ Annual Book of ASTM Standards, Vols 08.02 and 09.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.

4.6 Certain plastic materials require postcure at or slightly below the expected use temperature. Manufacturer's recommendations in this regard should be considered in preparing specimens under this method.

5. Apparatus

5.1 *Oven*—A controlled horizontal or vertical air flow employing forced-draft circulation with substantial fresh air intake is recommended. When it is necessary to avoid contamination among specimens or materials, a tubular oven method, such as Practice D 1870, may be desirable. Oven apparatus shall be in accordance with Specification E 145, with the requirements for uniformity extended to include the range of test temperatures.

NOTE 2—Consideration should also be given to alleviating explosive hazards as well as disposal of any toxic gases that may be evolved.

5.2 *Specimen Rack*—A specimen rack of suitable design to allow ready air circulation around the specimens.

5.3 *Testing Apparatus*—Equipment for determining specific properties before and after exposure to heat shall conform to the requirements prescribed in the appropriate ASTM test method.

6. Sampling

6.1 Sampling shall be in accordance with the ASTM test methods for the specific properties to be determined.

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.

8. Conditioning

8.1 Conduct initial tests in the Standard Laboratory Atmosphere as specified in Practice D 618, and condition in accordance with the requirements of the ASTM test method for determining the specific property or properties required.

8.2 Preconditioning of specimens prior to exposure at elevated temperatures should be such that the influence of any residual moisture, absorbed gas, or other contaminants are considered.

8.3 When required, conditioning of specimens following exposure at elevated temperatures and prior to testing, unless otherwise specified, shall be in accordance with Practice D 618.

9. Procedure

9.1 Suspend the test specimens in the circulating-air oven.

9.2 *Continuous Heat Tests*—Determine the temperature - time limit by the maximum temperature which the plastic withstands for a given time. This limit depends upon the type of plastic and the temperature - time requirements. Exposure periods may range from minutes to weeks. Start the exposure schedules at a temperature, in degrees Celsius divisible by 25, close to the maximum recommended use temperature. Should failure occur at the temperature first chosen, decrease the exposure temperature in steps of 25°C to that point at which failure does not occur. Conversely, if failure does not occur at the first test temperature, increase the temperature in steps of 25°C until failure occurs as defined in Section 10.

9.3 *Cycling Heat Tests*—Cycling tests may be run under conditions agreed upon between the purchaser and the seller.

NOTE 3—In view of continued interest in cycling heat tests, further investigation is being carried out in order to arrive at generally useful exposure procedures. Specific examples of cycling procedures are given in Practice D 756.

10. Interpretation of Results

10.1 Failure due to heat is defined as a change in appearance, weight, dimension, or other properties that alter the plastic material to a degree that it is no longer acceptable for the service in question. Failure may result from blistering, cracking, loss of plasticizer or other volatile material that may cause embrittlement, shrinkage, or change in desirable mechanical or electrical properties.

11. Report

11.1 Report the following information:

11.1.1 Material and type of plastic subject to exposure,

11.1.2 Preconditioning and postconditioning procedure followed, if any,

11.1.3 Maximum temperature, time and environmental atmosphere to which the plastic was exposed without failure,

11.1.4 Test method and results obtained before and after exposure to heat for each property at the temperature - time conditions of interest,

11.1.5 Observations of any visible changes in the test specimen, and

11.1.6 Type of oven used.

12. Precision and Bias

12.1 No statements of precision and bias are applicable to this practice; these are dependent upon the ASTM test methods for the specific properties to be determined.

13. Keywords

13.1 effect of heat; exposure; permanent effect; plastics

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