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An American National Standard

Standard Test Method for Accelerated Light Aging of Printing and Writing Paper by Xenon-Arc Exposure Apparatus[1]

This standard is issued under the fixed designation D6789; 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 test method describes a laboratory procedure for the exposure of printing and writing paper to xenon-arc light at elevated levels of light flux to permit accelerated aging of that type of paper.

1.2 This test method specifies the sample preparation and conditions of exposure required to obtain information on the relative stability of paper with regard to change in optical properties brought about by exposure of such paper to light.

1.3 This test method provides qualitative results regarding paper stability and does not define the life expectancy for a given paper to reach a specified set of optical properties.

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:*[2]

D685 Practice for Conditioning Paper and Paper Products for Testing

D985 Test Method for Brightness of Pulp, Paper, and Paperboard (Directional Reflectance at 457 nm)

D1968 Terminology Relating to Paper and Paper Products

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

2.2 *ASTM Adjuncts:*

ASTM Paper Aging Research Program[3]

2.3 *TAPPI Test Methods:*[4]

T 254 Cupriethylenediamine Disperse Viscosity of Pulp (Falling Ball Method)

T 524 Color of Paper and Paperboard (45°/0° Geometry)

T 1206 Precision Statement for Test Methods

3. Terminology

3.1 *Definitions*—Definitions shall be in accordance with Terminology D1968 or Terminology G113. For terms used in this specification which are not provided by Terminology D1968 or Terminology G113, see the *Dictionary of Paper*.[4]

4. Summary of Test Method

4.1 In this test method, light from a xenon-arc lamp that makes use of filters to simulate natural daylight that has passed through window glass is shone on a paper surface with light flux that is substantially greater than in normal indoor conditions of paper exposure. The light flux is applied in a controlled manner and for a specified period of time. The light flux causes photochemical reactions in the paper that change its reflectance (brightness) and color. By comparing initial and final levels of these parameters against difference criteria, a measure of optical stability is obtained.

5. Significance and Use

5.1 This test method will find use by parties concerned about the relative optical stability of various printing and writing papers.

5.2 The test will provide manufacturers, paper users and other interested parties with quantified rankings of paper

[1] This test method is under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Standard Documents Relating to Paper and Paper Products.

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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] Available from ASTM International Headquarters. Order Adjunct No.ADJD06PAPERAGING. Formerly Research Report D06–1004.

[4] Available from Technical Association of the Pulp and Paper Industry (TAPPI), 15 Technology Parkway South, Norcross, GA 30092, http://www.tappi.org.

stability that identify papers that are stable, moderately stable and unstable when exposed to light over periods of time.

5.3 The stability rankings may be used for definition of the relative stability of papers to light exposure, but will not define specific periods of life expectancy of a given paper.

6. Apparatus

6.1 Provide a test chamber that utilizes a sealed "long-arc" xenon lamp to illuminate the test samples. The lamp spectrum shall be in accordance with Practice G155, as per Table 2 of that document.

6.2 Use a glass filtration system in front of the lamp to simulate natural daylight that has passed through window glass. This is to cut off almost all of the very short wavelength light (nominally that which is below 320 nm) as occurs when daylight passes through window glass. Provide the glass filtration system as defined in Practice G155.

6.3 Provide a cooling system with the instrument such that temperature at the paper surface is maintained at ≥20°C and ≤30°C for all paper types. Air may be used as a cooling medium, but is not mandated so long as relative humidity of about 0.007 kg water/kg of dry air is maintained in the atmosphere above the paper surface and that a supply of oxygen, approximately equivalent to that which is found in standard air, is present at the paper surface. Apart from the oxygen, the remainder of the gas present shall be inert.

6.4 Utilize a test chamber that is designed such that it can be operated so as to ensure that it is free of ozone gas.

7. Calibration

7.1 Control the intensity [irradiance (*E*)] of the xenon arc lamp to 765 ± 75 W/m^2 as measured in the 290 to 800 nm wavelength range.

7.2 Recalibrate the instrument with sufficient frequency to ensure continual preservation of both the light spectrum and the light intensity. For recalibration frequency recommendations, refer to the manufacturer's instructions for the particular instrument in use.

7.3 Arrange the configuration of the test chamber so as to ensure uniformity of light intensity (irradiance) across the paper sample area and in a way that provides ≤10 % deviation from target intensity.

7.4 Check the temperature at the paper surface with sufficient frequency to ensure that it is at ≥20°C and ≤30°C throughout the test. Make these measurements with a properly calibrated optical pyrometer.

8. Conditioning

8.1 Condition all test specimens in the dark prior to and at completion of the light aging exposure in accordance with Practice D685.

9. Procedure

9.1 At all times throughout this test procedure, handle paper samples only with clean cotton gloves. This means that clean cotton gloves are required for handling of the paper both before and following the aging procedure.

9.2 Divide the sample equally into two parts. Use one part for exposure in the chamber. Cut a test specimen from this part to the size specified for testing by the test chamber manufacturer. Use the other for optical property tests of the unexposed paper. This is necessary to allow for proper light exposure in the chamber and at the same time to provide enough paper in each part to be cut to the small specimen size required for performance of subsequent standard optical property tests.

9.3 Measure the initial optical properties on both sides of the unexposed paper specimens after conditioning and just prior to insertion in the test chamber. The optical properties to be measured include reflectance (brightness) as found in Test Method D985 and color according to TAPPI Standard T 524. If test results are different on one side versus the other, report results for each side separately.

9.4 Conduct the test in a temperature and humidity controlled room that is maintained at 23°C and 50 % relative humidity according to Practice D685.

9.5 Cut test specimens to a size that is the maximum that will fit in the available space provided in the selected test chamber, taking care to ensure that the specimen will be uniformly irradiated over its entire surface.

9.6 Mount the specimens on the appropriate surface of the test chamber with clamps provided with the device. Take care to mount specimens of both sides of the paper for exposure.

9.7 Expose three replicate specimens of each paper to be tested to light from a xenon arc lamp controlled to 765 ± 75 W/m^2 as measured in the 290 to 800 nm wavelength range.

9.8 Expose the specimens for 48 ± 0.5 h. Do not remove the specimens from the chamber during the period of exposure. Remove the specimens from the test chamber at the end of the exposure at the same time of day at which the test was initiated.

9.9 Immediately upon removal from the test chamber, condition the exposed paper specimens in the dark for 24 h according to Practice D685.

9.10 Immediately upon removal from the conditioning process, measure the optical properties of the exposed specimens once again, taking care to again measure both sides of the paper sheets. Report any differences that exist between the two sides.

9.11 Measure directional reflectance, *R* (brightness), according to Test Method D985. Measure yellowness, *b**, according to TAPPI T 524.

10. Calculation and Interpretation of Results

10.1 Calculate the percentage change in reflectance at 457 nm (brightness) according to the following formula:

$$\% \text{ Change} = \frac{R_i - R_f}{R_i} \times 100 \quad (1)$$

where:
R_i = initial reflectance, and
R_f = final reflectance.

10.2 Calculate the absolute change in yellowness according to the following formula:

$$\text{Change in yellowness, } b^* = \left| b^*_f - b^*_i \right| \quad (2)$$

where:
b^*_f = final yellowness, and
b^*_i = initial yellowness.