Designation: D7238 – 20

Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus[1]

This standard is issued under the fixed designation D7238; 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 standard covers the specific procedures and test conditions that are applicable for exposure of unreinforced polyolefin geomembranes to fluorescent UV radiation and condensation.

NOTE 1—Polyolefin geomembranes include high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), flexible polypropylene (fPP), etc.

1.2 Test specimens are exposed to fluorescent UVA-340 lamps under controlled environmental conditions. UVA-340 lamps are standard for this method.

NOTE 2—Other types of fluorescent UV lamps, such as UVB-313, can also be used based upon discussion between involved parties. However, if the test is run with another type of fluorescent UV lamp, such as UVB-313, this should be considered as a deviation from the standard and clearly stated in the test report. UVB-313 and UVA-340 fluorescent lamps generate different amounts of radiant power in different wavelength ranges; thus, the photochemical effects caused by these different lamps may vary.

1.3 This method covers the conditions under which the exposure is to be performed and the test methods for evaluating the effects of fluorescent UV, heat, and moisture in the form of condensation on geomembranes. General guidance is given in Practices G151 and G154.

1.4 The values listed in SI units are to be regarded as the standard.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

D5885/D5885M Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

D6693/D6693M Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

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

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

G156 Practice for Selecting and Characterizing Weathering Reference Materials

3. Terminology

3.1 *Definitions:* (According to Terminology G113.)

3.1.1 *control, n*—a material which is of similar composition and construction to the test material used for comparison, exposed at the same time.

3.1.2 *irradiance, n*—the radiant power per unit area incident on a receiver, typically reported in units of $W/(m^2 \cdot nm)$ at specified wavelength of measurement or in W/m^2 in a specified spectral range.

3.1.3 *reference material, n*—a material with known performance.

3.1.4 *ultraviolet regions, n*—the UV region of the spectrum is divided into three regions: UVA, radiation in wavelengths

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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.

between 315 nm and 400 nm; UVB, radiation in wavelengths between 280 nm and 315 nm; and UVC, radiation in wavelengths shorter than 280 nm (Ref. CIE Publication No. 20 (1972)).

4. Summary of Test Method

4.1 Geomembrane coupons are exposed to repetitive cycles consisting of ultraviolet radiation at a specified temperature followed by moisture in the form of condensation at a specified temperature in the absence of ultraviolet radiation.

4.2 The UV source is provided by fluorescent UVA-340 lamps, with lamp emissions peaking at 343 nm.

4.3 Water vapor shall be generated by heating water and filling the chamber with hot vapor, which then is made to condense on the front of the test coupons. The reverse side of the coupons is exposed to the cooling influence of ambient room air.

4.4 While this standard prescribes a particular set of exposure conditions, such conditions may be varied by agreement between the parties involved in the agreement or contract. Such variation may include the irradiance, the selection of the fluorescent UV lamps, the duration of the UV and condensation exposure periods, the temperature of UV exposure, and the temperature of the condensation exposure.

4.5 The periodically removed coupons are cut into test specimens, appropriately tested, and the results compared to unexposed samples for determination of a percent retained for each property evaluated.

5. Significance and Use

5.1 The use of this apparatus is intended to induce property changes associated with the end-use conditions, including the effects of the UV portion of sunlight, moisture, and heat. Exposures are not intended to simulate the deterioration caused by localized weather phenomena, such as atmospheric pollution, biological attack, and saltwater exposure.

NOTE 3—Refer to Practice G151 for cautionary guidance applicable to laboratory weathering devices.

5.2 Variation in results may be expected when operating conditions are varied within the accepted limits of this method.

5.3 Test data for one thickness of a geomembrane cannot be used as data for other thickness geomembranes made with the same formula (polymer, pigment, and stabilizers) since the degradation is thickness related.

NOTE 4—It is recommended that a similar material of known performance (a control) be exposed simultaneously with the test material to provide a standard for comparative purposes. When control material is used in the test program, it is recommended only one coupon be used for each UV exposure period to allow for OIT testing.

6. Apparatus

6.1 *Fluorescent UV/Condensation Apparatus,* complying with Practices G151 and G154.

6.2 Unless otherwise specified, the spectral power distribution of the fluorescent UV lamp shall conform to the requirements in Practice G154 for a UVA-340 lamp.

6.3 The apparatus must include a feedback loop controller and be capable of controlling the irradiance level within the guidelines set in Practice G154, Table X2.3, Operational Fluctuations On Exposure Conditions.

6.4 *Exposure Chamber Location:*

6.4.1 The apparatus shall be located in an area maintained at temperature range between 18 and 27 °C (64 and 81 °F) measured at a maximum distance of 150 mm (5.9 in.) from the plane door of the apparatus.

6.4.2 It is recommended that the apparatus be located at least 0.3 m (12 in.) from walls or other test devices. Nearby heat sources, such as ovens or heated test devices, shall be avoided or shielded because such sources can influence the results.

6.4.3 The room where the apparatus is located shall be adequately ventilated to remove the heat and moisture produced and to maintain the temperatures specified in 6.4.1.

6.5 *Instrument Calibration:*

6.5.1 To ensure standardization and accuracy, the instruments associated with the exposure apparatus (that is, timers, thermometers, UV sensors, radiometers) require recurrent calibration to ensure repeatability of test results. The calibration frequency recommended by the equipment manufacturer should be used.

NOTE 5—It is recommended that a weathering reference material should be evaluated at least once per year to assess the operation of the device. Practice G156 describes procedures for selecting and characterizing weathering reference materials used to establish consistency of operating conditions in a laboratory accelerated test.

7. Test Coupons

7.1 The number of coupons should be sufficient to produce five Test Method D6693/D6693M specimens from the exposure areas for each exposure period, while discarding a width of at least 12.5 mm across the entire perimeter of the exposed coupon to avoid side effects.

7.2 Prepare the test coupons so that the longer dimension of the test coupon is the machine direction of the test material.

7.3 Since the thickness of a coupon may markedly affect the results, thickness of the test and control coupon shall be within ±10 % of the nominal dimensions.

7.4 Retain adequate unexposed material for the determination of unexposed properties (tested one time to form the baseline for comparison of the exposed material properties).

8. Procedure

8.1 Attach the coupons, backed by an aluminum panel, to the coupon holders in the equipment in such a manner that the specimens are not subjected to any applied stress.

NOTE 6—Some UV fluorescent devices have a central stiffening bar on the holder. To ensure that the entire coupon is exposed to ultraviolet radiation, this bar should be removed prior to the start of the exposure cycle.

8.2 Place the coupon holders in the exposure device with the desired surfaces facing the lamps. If the coupons do not completely occupy the racks, fill the empty spaces with blank panels to maintain proper test conditions within the chamber.

8.3 The extreme right- and left-hand coupon holders shall be equipped with blank aluminum panels and shall not be used for coupon exposure.

8.4 Program the exposure device to achieve the following exposure conditions:

8.4.1 Twenty (20) h of UV with an uninsulated black panel temperature set point of 75 °C (167 °F) alternating with 4 h condensation at 60 °C (140 °F), uninsulated black panel temperature set point. See Practice G154, Table X2.3, for the maximum allowable operational fluctuation of the temperature setting.

8.4.2 Unless otherwise specified, apparatus with irradiance control shall be set at the control point at an irradiance level of 0.78 W/(m^2·nm) at 340 nm. See Practice G154, Table X2.3, for the maximum allowable operational fluctuation of the irradiance setting.

8.4.3 If the operational fluctuation is greater than the maximum allowable from either the temperature and irradiance setting at the control sensor during equilibrium operation, the test must be discontinued until the problem is solved.

NOTE 7—Refer to Practice G154, Table X2.1, Note 1 for historical set point information.

8.5 Reposition coupons horizontally once a week by (*1*) moving the two extreme right-hand coupon holders to the far left of the exposure area, and (*2*) sliding the remaining coupon holders to the right.

8.6 The exposure duration shall be 400, 800, 1200, 1600, and 2000 h of UV or longer until sufficient change is obtained to establish trends in behavior. The total exposure times (UV time plus condensation time) corresponding to these UV exposures are 480, 960, 1440, 1920, and 2400 h, respectively.

8.7 Remove the appropriate number of coupons (see 7.1) at each exposure time for material evaluation.

9. Evaluation of Changes in Material Properties

9.1 *Test Methods to Be Utilized in the Evaluation Process:*

9.1.1 Test methods to be utilized in the evaluation process for both unexposed (file) and exposed coupons include high-pressure oxidative induction time (HP-OIT) (Test Method D5885/D5885M), tensile strength (Test Method D6693/D6693M), and melt index (Test Method D1238).

9.2 *Measurements on Unexposed Coupons:*

9.2.1 Determine the HP-OIT of the unexposed geomembrane material as the baseline value. Test three replicates and use the average of three values in the calculations.

9.2.2 Determine the breaking strength and percent break elongation of five replicate specimens in the machine direction, as directed in Test Method D6693/D6693M. Use the average values in the calculations.

9.2.3 Determine the melt index (Test Method D1238) using 190/2.16 on three replicate specimens. Use the average melt index value in the calculations.

9.3 *Measurements on Exposed Coupons:*

9.3.1 Take three specimens from the centrally located areas of the removed coupons to determine the HP-OIT values. Calculate the average value. The test method shall be same as the one used in 9.2.1. At least 12.5 mm must be discarded across the perimeter of the specimen to avoid side effects. This width may have to be increased for multi-component or reinforced geomembranes. Coupon(s) exposed in the oven should be selected so that the specimens tested after aging are as close as possible and aligned in machine direction with the specimens tested before aging.

NOTE 8—The sampling requirement proposed in 9.3.1 aims at minimizing the influence of the normal variation of the properties of a product across its length and width, to better focus on the property change caused by air-oven aging of the polymer. Should this requirement be impossible to meet (for example, because of the size of the laboratory sample), the results of the test should be interpreted considering the potential deviation associated to the location of the test specimens across the width.

NOTE 9—OIT and HP-OIT tests exhibit a normal repeatability (within lab) which may be large enough to be in the same range than the actual property changes for some products and formulations. Good laboratory practices must be followed to minimize deviations, and the results interpreted accordingly. This includes testing OIT or HP-OIT before and after aging on the same apparatus, immediately one after the other (that is, within the same calibration cycle, with the same environmental conditions and using the same operator, etc.), or, when it is impossible to do so, using a reference material with similar properties to monitor potential deviation caused by factors other than aging of the material.

9.3.2 Cut centrally located Test Method D6693/D6693M test specimens from the removed coupons, and test them accordingly. Determine breaking strength and percent break elongation at break of the five tensile specimens. Calculate the average values of each property.

9.3.3 Determine the melt index values of the three removed coupons according to Test Method D1238 and calculate an average value. The test condition shall be same as that used in 9.2.3.

NOTE 10—Tensile properties (Test Method D6693/D6693M) and melt index (Test Method D1238) may not show substantial changes within 1600 h of UV exposure.

9.4 Calculate the percent retained values of HP-OIT, breaking strength, percent break elongation, and melt index at each exposure time.

10. Report

10.1 Report the following information:

10.1.1 Type of lamp.

10.1.2 Report irradiance in W/(m^2·nm), or radiant exposure in J/(m^2·nm), and the wavelength in which measurements were made.

10.1.3 Coupon repositioning procedure, if different from the procedure described in 8.5.

10.1.4 A listing of the results for the exposed tested coupons for each exposure time and the results for the unexposed material.

10.1.5 A listing of the percent retained values for each exposure time.

10.1.6 Graphs of the percent retained values against exposure times and appropriate curve fitting so as to establish trends in the behavior.

10.1.7 A statement indicating whether the fluorescent UV apparatus has been calibrated in accordance with the manufacture's recommendations.