



Standard Test Method for Rubber Deterioration—Discoloration from Ultraviolet (UV) and Heat Exposure of Light-Colored Surfaces¹

This standard is issued under the fixed designation D 1148; 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 test method was prepared jointly by the Society of Automotive Engineers and ASTM International.)

1. Scope

1.1 This test method covers techniques to evaluate the surface discoloration of white or light-colored vulcanized rubber that may occur when subjected to UV or UV/visible exposure from specified sources under controlled conditions of relative humidity, or moisture, and temperature.

1.2 This test method also describes how to qualitatively evaluate the degree of discoloration produced under such conditions.

1.3 The term “discoloration” applies to a color change of the rubber sample, as distinguished from staining (see **Note 1**), that refers to a color change of a metal finish in contact with or adjacent to the rubber specimen.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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—Tests for staining are covered by Test Methods **D 925**.

2. Referenced Documents

2.1 *ASTM Standards:*²

D 925 Test Methods for Rubber Property—Staining of Surfaces (Contact, Migration, and Diffusion)

D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

¹ This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.

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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.

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets

D 3183 Practice for Rubber—Preparation of Product Pieces for Test Purposes from Products

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G 154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

3. Summary of Test Method

3.1 Specimens to be tested for discoloration are exposed to UV or UV/visible radiation. The specimens shall include one or more control specimens of known discoloration characteristics.

3.2 After exposing the specimens to actinic radiation for specified periods of time, under controlled conditions of relative humidity, or moisture, and temperature, the degree of discoloration is rated against discoloration of the control specimens, which have been exposed simultaneously with the test specimens.

4. Significance and Use

4.1 The surface of white or light-colored vulcanized rubber articles, or vulcanized rubber covered with an organic finish, may discolor when exposed to conditions of humidity, or moisture, heat, and sunlight. This change in color of light-colored rubber surfaces is objectionable to the consumer.

4.2 Results obtained should be treated only as indicating the effect of irradiance from the specified source (either UVA-340 lamps or a xenon arc with a Daylight Filter) and not as equivalent to the result of any natural exposure, unless the degree of quantitative correlation has been empirically established for the material in question.

4.3 This test method may be used for producer-consumer acceptance, referee purposes, and research and development work.

5. Apparatus

5.1 *Fluorescent UV/Condensation Apparatus (Practice G 154)*—Use Fluorescent UV test apparatus that conforms to the requirements defined in Practices **G 151** and **G 154**.

5.1.1 Unless otherwise specified, the spectral power distribution (SPD) of the fluorescent lamp shall conform to the requirements of Table 1 in Practice **G 154** (UVA-340 Lamp). Refer to **Fig. 1**.

5.2 *Xenon Arc Light Apparatus (Practice G 155)*—Use xenon arc test apparatus that conforms to the requirements defined in Practices **G 151** and **G 155**.

5.2.1 Unless otherwise specified, the spectral power distribution (SPD) of the filtered xenon lamp shall conform to the requirements of Table 1 in Practice **G 155** (Xenon Arc with Daylight Filter). Refer to **Fig. 2**.

5.3 Color meter capable of measuring tristimulus colors for amber, blue, and green with or without automatic calculation for $L^* a^* b^*$ or $L^* a^* b^*$ values. If without automatic calculations, a computer program should be available for this calculation.

6. Test Specimen

6.1 The test specimen shall be prepared from a vulcanized production part or from a test slab prepared in accordance with Practices **D 3182** and **D 3183**. The specimen shall be rectangular in shape, 62 by 12 mm (2.4 by 0.5 in.). If a specimen of this size cannot be prepared from a production part, a modification of the size may be agreed upon between the purchaser and the seller.

6.2 An unexposed file specimen of the same compound as that stated in **6.1** shall be prepared and reserved for color comparisons without being subjected to exposure.

7. Procedure

7.1 The two procedures (Fluorescent UV/Condensation and Xenon Arc) contain different types of exposure sources and test conditions and may produce different test results. They cannot

be used interchangeably without supporting data that demonstrates equivalency of the procedures for the materials tested.

7.2 Refer to Table A3.1 in Practice **G 151** for the allowed operational fluctuations of the specified set points for irradiance, temperature, and relative humidity. If the actual operating conditions do not comply with the maximum allowable fluctuations in Table A3.1 after the equipment has stabilized, discontinue the test and correct the cause of the problem before continuing.

7.3 Specimens should be confined to an exposure area in which the irradiance is at least 90 % of the irradiance at the center of the exposure area. Unless it is known that irradiance uniformity meets this requirement, use one of the procedures described in Practice **G 151**, Section 5.1.4, to ensure equal radiant exposure on all specimens, or to compensate for differences within the exposure chamber. If the specimens do not completely fill the racks, fill the empty spaces with blank metal panels to maintain the test conditions within the chamber. The apparatus shall be operated continuously. However, if the test needs to be interrupted to perform routine maintenance or inspection, it should be during a dry period.

7.4 *Procedure for Exposure in Fluorescent UV/Condensation Apparatus (Practice G 154)*—Unless otherwise specified, operate the fluorescent UV test apparatus with UVA-340 lamps in accordance with Practice **G 154**.

7.4.1 Use the following exposure cycle: Set the irradiance level to 0.77 W / (m² · nm) at 340 nm. Expose specimens to a continuous cycle of 8 h light at 60°C uninsulated black panel temperature followed by 4 h of condensation at 50°C uninsulated black panel temperature.

7.5 *Procedure for Exposure in Xenon Arc Apparatus (Practice G 155)*—Unless otherwise specified, use the following operating conditions:

7.5.1 The xenon arc test apparatus shall be used with a Daylight Filter and conform to the spectral power distribution specifications in Practice **G 155**.

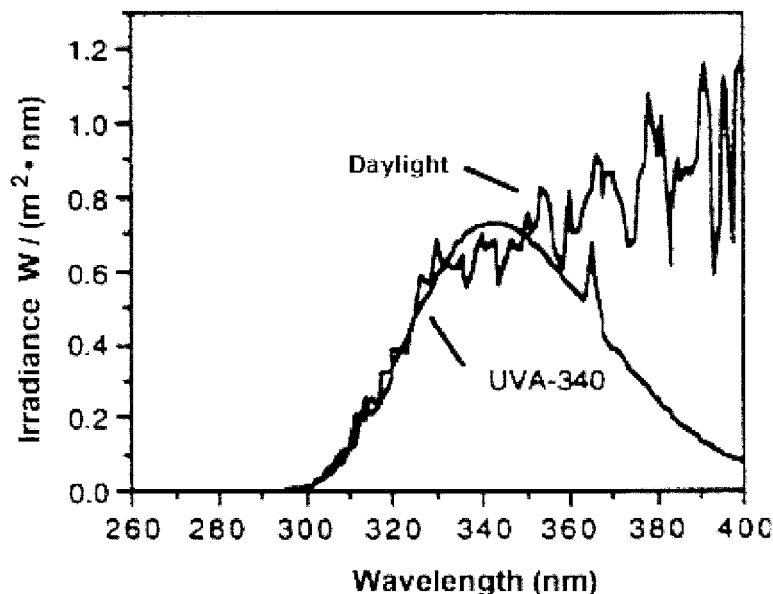


FIG. 1 Spectral Power Distributions of UVA-340 Lamp Versus Daylight

SPD of Daylight Filtered Xenon Arc vs. Daylight

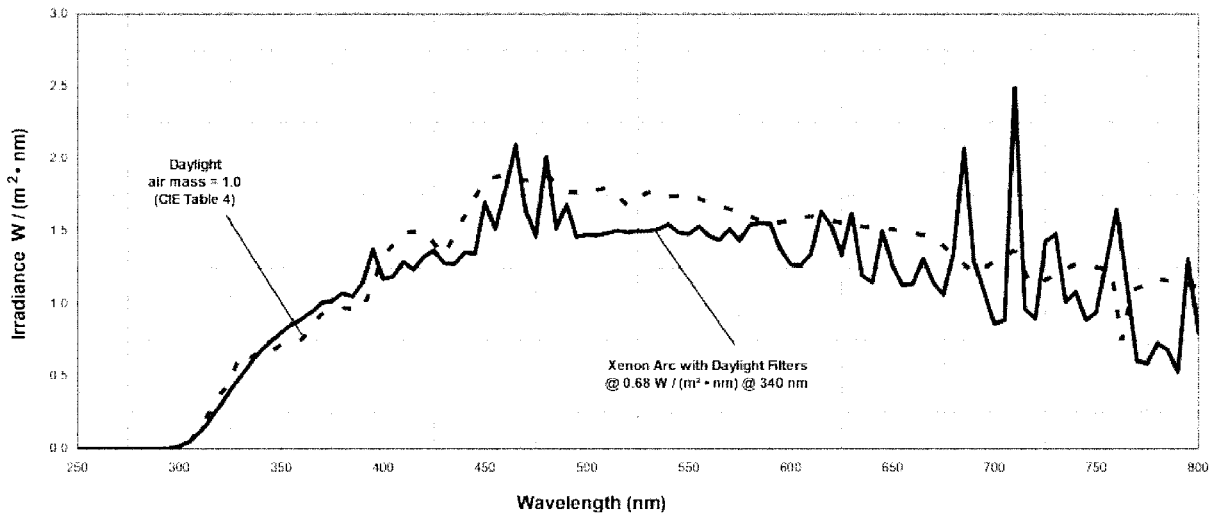


FIG. 2 Spectral Power Distributions of Xenon Arc with Daylight Filter Versus Daylight

7.5.2 Set the irradiance level at 0.55 W / (m² • nm) at 340 nm. Consult the manufacturer of the apparatus for equivalent broad band irradiance levels at 300 to 400 nm and 300 to 800 nm.

7.5.3 The default exposure cycle shall be 102 min light only followed by 18 min light plus either water spray on the front surface or immersion in water (refer to Note 2). The water spray temperature is typically 21 ± 5°C, but may be lower if ambient water temperature is low and a holding tank is not used to store purified water. The immersion water is kept at a constant temperature, which shall be less than 40°C.

NOTE 2—Water spray and immersion in water frequently produce different results. In the immersion technique, the test specimens are placed in a chamber that is periodically flooded with either recirculated or running water, which completely covers the specimens. The maximum temperature attained by a black colored specimen is determined with the black standard thermometer (BST) held under water on the same plane and distance from the surface as the test specimens. The immersion system is made from corrosion resistant materials that do not contaminate the water.

7.5.4 Set the uninsulated Black Panel Temperature (BPT) at 63°C during the dry period of exposure to light. Consult the manufacturer of the apparatus for the equivalent insulated black panel temperature (Black Standard Temperature (BST)).

7.5.5 Relative humidity shall be set at 60 % during the dry period of exposure to light in xenon arc apparatus that provides for control of relative humidity.

7.5.6 The chamber air temperature shall be set at 44°C in apparatus that provides for adjustment of the chamber air temperature.

7.6 One or more control specimens using rubber material of known discoloration characteristics shall be included.

7.7 Any change in color of a test specimen in relation to the original sample shall be considered as discoloration.

7.7.1 The degree of discoloration can be judged visually to be greater or less than the control specimen and can be given

a numerical rating based on an arbitrary scale of degree of discoloration which may be agreed upon between the purchaser and the seller.

7.7.2 The change in color can be measured instrumentally using commercial color meters (refer to Note 3) for specimens prepared according to Section 6. Calculate the difference between an unexposed specimen and the exposed specimen, as follows:

$$\Delta E = E_U - E_E \quad (1)$$

$$\Delta E^* = E_U^* - E_E^* \quad (2)$$

where:

- ΔE = difference between unexposed and exposed specimen
- E_U = unexposed specimen
- E_E = exposed specimen

NOTE 3—Some color meters calculate ΔE and others calculate ΔE^* , while some may calculate both. Either expression is suitable for use in this test method, but one must not mix them together. A complete equation can be found in Practice D 2244.

8. Report

8.1 The report shall include the following information:

- 8.1.1 Type of radiation used, either UVA-340 or filtered xenon arc lamp;
- 8.1.2 Exposure time in hours;
- 8.1.3 Date of test;
- 8.1.4 Identification of test and control specimens;
- 8.1.5 Size and shape of specimen(s) if not in accordance with the standard shape and size;
- 8.1.6 An estimate of the degree of discoloration according to a visual estimation, described in 7.7.1, or an instrumental evaluation according to 7.7.2.

9. Precision and Bias

9.1 A precision and bias study has not yet been prepared.

9.2 *Bias*—Bias cannot be determined because no acceptable standard weathering reference materials are available.

10. Keywords

10.1 fluorescent UV; heat discoloration; rubber products; ultraviolet; ultraviolet light discoloration; UVA-340; xenon arc

APPENDIX

(Nonmandatory Information)

X1. COLOR METER

X1.1 Set up the color meter according to the directions supplied by the manufacturer for optimum performance. This will include any necessary calibrations.

X1.1.1 If the color meter requires a standard plaque, observe any precautions for plaque storage, cleanliness, and re-calibration.

X1.1.2 Obtain amber, blue, and green tristimulus reflectance readings for each specimen to be measured, including the unexposed file specimen (which was not exposed to ultraviolet light).

X1.1.2.1 Color meters present data differently; however, $L a b$ and $L^* a^* b^*$ data can be obtained from any color meter either as part of the instrumental calculations or, if not, computer programs can be used to generate the necessary data.

X1.2 To assess the discoloration of a sample as compared to the unexposed file specimen, subtract the E_E or E_E^* value of the exposed specimen from the E_U or E_U^* value of the unexposed specimen. This is the difference (ΔE) or (ΔE^*) on which the discoloration evaluation is based. See 7.7.2.

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