



Designation: G 151 – 97

Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources¹

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1. Scope

1.1 This practice provides general procedures to be used when exposing nonmetallic materials in accelerated test devices that use laboratory light sources. Detailed information regarding procedures to be used for specific devices are found in standards describing the particular device being used. For example, detailed information covering exposures in devices that use carbon-arc, xenon-arc, and fluorescent UV light sources are found in Practices G 23, G 26, and G 53, respectively.

NOTE 1—New performance based standards describing exposures in carbon-arc, xenon-arc, and fluorescent UV exposures are being developed by Subcommittee G 03.03.

1.2 This practice also describes general performance requirements for devices used for exposing nonmetallic materials to laboratory light sources. This information is intended primarily for producers of laboratory accelerated exposure devices.

NOTE 2—Certification of conformance to the performance requirements for new exposure devices generally is the responsibility of the manufacturer.

1.3 This practice provides information on the use and interpretation of data from accelerated exposure tests. Specific information about methods for determining the property of a nonmetallic material before and after exposure are found in standards describing the method used to measure each property. Information regarding the reporting of results from exposure testing of plastic materials is described in Practice D 5870.

NOTE 3—The Committee G-3 is developing standard guides for application of statistics to exposure test results and for addressing variability in exposure testing of nonmetallic materials.

NOTE 4—This standard is technically equivalent to ISO DIS 4892, Part 1.

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 applica-*

bility of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
- D 3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer and Related materials³
- D 5870 Practice for Calculating Property Retention Index of Plastics³
- E 41 Terminology Relating to Conditioning⁴
- E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials⁵
- E 585 Specification for Base-Metal Thermocouple Materials⁶
- E 644 Test Methods for Testing Industrial Resistance Thermometers⁶
- E 772 Terminology Relating to Solar Energy Conversion⁷
- E 839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Material⁶
- G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials⁴
- G 23 Practice for Operating Light Exposure Apparatus (Carbon-Arc) Type With and Without Water for Exposure of Nonmetallic Materials⁴
- G 24 Practice for Conducting Exposures to Daylight Filtered Through Glass⁴
- G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc) Type With and Without Water for Exposure of Nonmetallic Materials⁴
- G 53 Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV Condensation Type) for Exposure of Nonmetallic Materials⁴
- G 113 Terminology Relating to Natural and Artificial Weathering Tests for Nonmetallic Materials⁴
- G 130 Method for Calibration of Narrow- and Broad-Band Ultraviolet Radiometers Using a Spectroradiometer⁴

² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 06.01.

⁴ Annual Book of ASTM Standards, Vol 14.02.

⁵ Annual Book of ASTM Standards, Vol 15.09.

⁶ Annual Book of ASTM Standards, Vol 14.03.

⁷ Annual Book of ASTM Standards, Vol 12.02.

¹ This practice is under the jurisdiction of ASTM Committee G-3 on Weathering and Durability and is the direct responsibility of Subcommittee G03.03 on Simulated and Controlled Exposure Tests.

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G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests⁴

2.2 ISO Standards:

ISO 4892, Part 1 Plastics: Exposure to laboratory Light Sources—General Guidance⁸

ISO 9370 Plastics: Instrumental Determination of Radiant Exposure in Weathering Tests—General Guidance and Basic Test Method⁸

2.3 CIE Documents:

CIE Publication Number 85: 1989, Technical Report—Solar Spectral Irradiance⁹

when identical bandpasses are used, do not take into consideration the effects of temperature, moisture, and differences in spectral power distribution between the laboratory light source and daylight.

NOTE 5—If use of an acceleration factor is desired in spite of the warnings given in this practice, such acceleration factors for a particular material are only valid if they are based on data from a sufficient number of separate exterior and laboratory accelerated exposures so that results used to relate times to failure in each exposure can be analyzed using statistical methods. An example of a statistical analysis using multiple laboratory and exterior exposures to calculate an acceleration factor is described by J.A. Simms (1).¹⁰

3. Terminology

3.1 *Definitions*— The definitions given in Terminologies E 41, E 772, and G 113 are applicable to this practice.

4. Significance and Use

4.1 Significance:

4.1.1 When conducting exposures in devices that use laboratory light sources, it is important to consider how well the accelerated test conditions will reproduce property changes and failure modes associated with end-use environments for the materials being tested. In addition, it is essential to consider the effects of variability in both the accelerated test and outdoor exposures when setting up exposure experiments and when interpreting the results from accelerated exposure tests.

4.1.2 No laboratory exposure test can be specified as a total simulation of actual use conditions in outdoor environments. Results obtained from these laboratory accelerated exposures can be considered as representative of actual use exposures only when the degree of rank correlation has been established for the specific materials being tested and when the type of degradation is the same. The relative durability of materials in actual use conditions can be very different in different locations because of differences in UV radiation, time of wetness, relative humidity, temperature, pollutants, and other factors. Therefore, even if results from a specific exposure test conducted according to this practice are found to be useful for comparing the relative durability of materials exposed in a particular exterior environment, it cannot be assumed that they will be useful for determining relative durability of the same materials for a different environment.

4.1.3 Even though it is very tempting, calculation of an *acceleration factor* relating x h or megajoules of radiant exposure in a laboratory accelerated test to y months or years of exterior exposure is not recommended. These acceleration factors are not valid for several reasons.

4.1.3.1 Acceleration factors are material dependent and can be significantly different for each material and for different formulations of the same material.

4.1.3.2 Variability in the rate of degradation in both actual use and laboratory accelerated exposure test can have a significant effect on the calculated acceleration factor.

4.1.3.3 Acceleration factors calculated based on the ratio of irradiance between a laboratory light source and daylight, even

4.1.4 There are a number of factors that may decrease the degree of correlation between accelerated tests using laboratory light sources and exterior exposures. More specific information on how each factor may alter stability ranking of materials is given in Appendix X1.

4.1.4.1 Differences in the spectral distribution between the laboratory light source and sunlight.

4.1.4.2 Light intensities higher than those experienced in actual use conditions.

4.1.4.3 Test conditions where specimens are exposed continuously to light when actual use conditions provide alternate periods of light and dark.

4.1.4.4 Specimen temperatures higher than those in actual conditions.

4.1.4.5 Exposure conditions that produce unrealistic temperature differences between light and dark colored specimens.

4.1.4.6 Exposure conditions, which produce very frequent cycling between high and low specimen temperatures, or which produce unrealistic thermal shock.

4.1.4.7 Unrealistically high or low levels of moisture.

4.1.4.8 Absence of biological agents or pollutants.

4.2 Use of accelerated tests with laboratory light sources.

4.2.1 Results from accelerated exposure tests conducted according to this standard are best used to compare the relative performance of materials. A common application is conducting a test to establish that the level of quality of different batches does not vary from a control material with known performance. Comparisons between materials are made best when the materials are tested at the same time in the same exposure device. Results can be expressed by comparing the exposure time or radiant exposure necessary to reduce the level of a characteristic property to some specified level.

4.2.1.1 It is strongly recommended that at least one control material be exposed with each test for the purpose of comparing the performance of the test materials to that of the control. Ideally, the control material should be of similar composition and construction and be chosen so that its failure modes are the same as that of the material being tested. It is preferable to use two controls, one with relatively good durability and one with relatively poor durability.

4.2.1.2 Sufficient replicates of each control material and each test material being evaluated are necessary in order to allow statistical evaluation of results. Unless otherwise specified, use a minimum of three replicates for all test and control

⁸ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

⁹ CIE

¹⁰ The boldface numbers in parentheses refer to the list of references at the end of this standard.

materials. When material properties are measured using destructive tests, a separate set of specimens is needed for each exposure period.

4.2.2 In some applications, reference materials are used to establish consistency of the operating conditions in an exposure test. Reference materials, for example, blue wool test fabric, also may be used for the purpose of timing exposures.

4.2.2.1 In some cases, a reference material is exposed at the same time as a test material and the exposure is conducted until there is a defined change in property of the reference material. The test material then is evaluated. In some cases the results for the test material are compared to those for the reference material. These are inappropriate uses of reference materials when they are not sensitive to exposure stresses, which produce failure in the test material, or when the reference material is very sensitive to an exposure stress that has very little effect on the test material.

NOTE 6—Definitions for control and reference material that are appropriate to weathering tests are found in Terminology G 113.

NOTE 7—Subcommittee G03.01 is developing a standard practice for selecting and characterizing weathering reference materials used to establish consistency of operating conditions in a laboratory accelerated test.

4.3 Results from accelerated exposure tests only should be used to establish a pass/fail approval of materials after a specific time of exposure to a prescribed set of conditions when the variability in the exposure and property measurement procedure has been quantified so that statistically significant pass/fail judgments can be made.

5. Requirements for Laboratory Exposure Devices

5.1 Light Source:

5.1.1 The exposure device shall provide for placement of specimens and any designated sensing devices in positions which provide uniform irradiance by the light source.

NOTE 8—In some devices, several individual light sources are used simultaneously. In these devices, the term *light source* refers to the combination of individual light sources being used.

5.1.2 Manufacturers of exposure devices shall assure that the irradiance at any location in the area used for specimen exposures is at least 70 % of the maximum irradiance measured in this area. Procedures for measuring irradiance uniformity are found in Annex A1.

NOTE 9—During use, the irradiance uniformity in exposure devices can be affected by several factors, such as deposits, which can develop on the optical system and chamber walls. Irradiance uniformity also can be affected by the type and number of specimens being exposed. The irradiance uniformity as assured by the manufacturer is valid for new equipment and well defined measuring conditions.

5.1.3 Periodic repositioning of the specimens during exposure is not necessary if the irradiance at positions farthest from the center of the specimen area is at least 90 % of that measured at the center of the exposure area.

5.1.4 If irradiance at positions farthest from the center of the exposure area is between 70 and 90 % of that measured at the center, one of the following three techniques shall be used to use for specimen placement.

5.1.4.1 Periodically reposition specimens during the exposure period to ensure that each receives an equal amount of

radiant exposure. The repositioning schedule shall be agreed upon by all interested parties.

5.1.4.2 Place specimens only in the exposure area where irradiance is at least 90 % of the maximum irradiance.

5.1.4.3 Randomly position replicate specimens within the exposure area that meets the irradiance uniformity requirements defined in 5.1.4

5.1.5 Replace lamps and filters according to the schedule recommended by the device manufacturer. Follow the apparatus manufacturer's instructions for lamp and filter replacement and for pre-aging of lamps or filters, or both.

5.1.6 CIE Publication No. 85–1989 provides data on solar spectral irradiance for typical atmospheric conditions, which can be used as a basis for comparing laboratory light sources with daylight. For example, global solar irradiance in the 300 to 2450 nm band is given as 1090 W/m² for relative air mass 1, with 1.42 cm precipitable water, and 0.34 cm of ozone (measured at a pressure of 1 atmosphere and temperature of 0°C). Table 1 shows a broad band condensed spectral irradiance for global solar radiation at this atmospheric condition in the UV, visible and infrared portions of the spectrum. This represents the maximum global solar irradiance that would be experienced by materials exposed on a horizontal surface at the equator near noon on a clear day at the spring or autumn equinox.

5.1.6.1 Direct radiation from xenon burners, open flame carbon arcs, and some fluorescent lamps contains considerable amounts of short wavelength ultraviolet radiation not present in daylight. With proper selection of filters for these light sources, much of the short wavelength light can be eliminated. Even when filters are used, however, a small, but significant, amount of this short wavelength (less than 300 nm) radiation often is present in the spectral distribution of the filtered light source. Fluorescent UV lamps can be selected to have a spectral output corresponding to a particular ultraviolet region of sunlight. The xenon arc, when appropriately filtered, produces radiation with a spectral power distribution that is a good simulation of average sunlight throughout the UV and visible region.

5.1.7 A radiometer, which complies with the requirements outlined in ISO 9370 may be used to measure irradiance, E, or the spectral irradiance, E_λ, and the radiant exposure, H, or the spectral radiant exposure, H_λ, on the specimen surface.

5.1.7.1 If used, the radiometer shall be mounted so that it receives the same irradiance as the specimen surface. If it is not positioned within the specimen plane, it shall be calibrated for irradiance at the specimen distance.

5.1.7.2 The radiometer shall be calibrated in the emission

TABLE 1 Spectral Global Irradiance (condensed from Table 4 of CIE Publication No. 85–1989)

Wavelength (nm)	Irradiance (Wm ⁻²)	Percent Total (300-2450 nm)	Percent of UV and Visible (300-800 nm)
300-320	4.1	0.4	0.6
320-360	28.5	2.6	4.2
360-400	42.0	3.9	6.2
300-400	74.6	6.8	11.0
400-800	604.2	55.4	89.0
300-800	678.8	62.2	100.0
800-2450	411.6	37.8	...
300-2450	1090.4	100.0	...