Designation: G151 – 10

Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources[1]

This standard is issued under the fixed designation G151; 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 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 open flame carbon arc, enclosed carbon arc, xenon arc and fluorescent UV light source are found in Practices G152, G153, G154, and G155 respectively.

NOTE 1—Carbon-arc, xenon arc, and fluorescent UV exposures were also described in Practices G23, G26, and G53 which referred to very specific equipment designs. Practices G152, G153, and G154, and G155 are performance based standards that replace Practices G23, G26, and G53.

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.

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 D5870.

NOTE 2—Guide G141 provides information for addressing variability in exposure testing of nonmetallic materials. Guide G169 provides information for application of statistics to exposure test results

NOTE 3—This standard is technically equivalent to ISO 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 applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D3924 Specification for Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials

D5870 Practice for Calculating Property Retention Index of Plastics

E41 Terminology Relating To Conditioning

E171 Specification for Atmospheres for Conditioning and Testing Flexible Barrier Materials

E644 Test Methods for Testing Industrial Resistance Thermometers

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E772 Terminology Relating to Solar Energy Conversion

E839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Material

G23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) Wigh and Without Water for Exposure of Nonmetallic Materials[3]

G26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[3]

G53 Practice of Operating Light-and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials[3]

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

G130 Test Method for Calibration of Narrow- and Broad-Band Ultraviolet Radiometers Using a Spectroradiometer

G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

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

Current edition approved April 1, 2010. Published May 2010. Originally approved in 1997. Last previous edition approved in 2009 as G151 – 09. DOI: 10.1520/G0151-10.

[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] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests
G152 Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
G153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
G154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials
G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
G156 Practice for Selecting and Characterizing Weathering Reference Materials
G169 Guide for Application of Basic Statistical Methods to Weathering Tests
G177 Tables for Reference Solar Ultraviolet Spectral Distributions: Hemispherical on 37° Tilted Surface

2.2 *ISO Standards:*
ISO 4892, Part 1 Plastics: Exposure to laboratory Light Sources—General Guidance[4]
ISO 9370 Plastics: Instrumental Determination of Radiant Exposure in Weathering Tests—General Guidance and Basic Test Method[4]

2.3 *CIE Document:*
CIE Publication Number 85: 1989 Technical Report—Solar Spectral Irradiance[5]

2.4 *ASTM Adjuncts:*
SMARTS2, Simple Model for Atmospheric Transmission of Sunshine[6]

3. Terminology

3.1 *Definitions*—The definitions given in Terminologies E41, E772, and G113 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 solar radiation, even when identical bandpasses are used, do not take into consideration the effects on a material of irradiance, temperature, moisture, and differences in spectral power distribution between the laboratory light source and solar radiation.

NOTE 4—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**).[7]

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 solar radiation.

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 that do not have any temperature cycling or that produce temperature cycling, or thermal shock, or both, that is not representative of use conditions.

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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from the Commission Internationale de L'Eclairage, CIE, Central Bureau, Kegelgasse 27, A-1030 Vienna, Austria or the U.S. National Committee for CIE, National Institute for Science and Technology, Gaithersburg, MD.

[6] Available from ASTM International Headquarters. Order Adjunct No. ADJG173CD. Original adjunct produced in 2005.

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

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 best made when they 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 change a characteristic property to some specified level.

4.2.1.1 Reproducibility of test results between laboratories has been shown to be good when the stability of materials is evaluated in terms of performance ranking compared to other materials or to a control;[8,9] therefore, exposure of a similar material of known performance (a control) at the same time as the test materials is strongly recommended.

4.2.2 In some applications, weathering reference materials are used to establish consistency of the operating conditions in an exposure test.

4.2.3 Reference materials, for example, blue wool test fabric, also may be used for the purpose of timing exposures. 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 that 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 5—Definitions for control and reference material that are appropriate to weathering tests are found in Terminology G113.

NOTE 6—Practice G156 describes procedures for selecting and characterizing weathering reference materials used to establish consistency of operating conditions in a laboratory accelerated test.

NOTE 7—Results from accelerated exposure tests should only 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 point of maximum irradiance is at least 90 % of the maximum measured irradiance.

5.1.4 If irradiance at any position in the area used for specimen exposure is between 70 and 90 % of the maximum irradiance, specimens shall be periodically repositioned to reduce variability in radiant exposure. The repositioning schedule shall be agreed upon by all interested parties. Appendix X2 describes some possible specimen placement and repositioning plans and frequencies.

NOTE 10—While not required in devices meeting the irradiance uniformity requirements of 5.1.3, periodic specimen repositioning is a good practice to reduce the variability in exposure stresses experienced during the test interval.

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 ASTM G177 describes a standard solar ultraviolet spectrum that can be used as a basis for comparing laboratory accelerated light sources with sunlight. The atmospheric conditions used in this standard solar spectrum were selected to maximize the fraction of short wavelength solar ultraviolet radiation.

NOTE 11—Previous versions of this standard used a solar spectrum defined in CIE Publication 85-1999, Table 4 as the benchmark for comparing light sources used in laboratory accelerated exposure tests to solar radiation. Appendix X3 provides a comparison of the atmospheric conditions and solar spectra of ASTM G177 and Table 4 of CIE 85.

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 solar radiation. With proper selection of filters for these light sources, much of the short wavelength light can be eliminated. However, with many filters a small, but significant, amount of this short wavelength (less than 300 nm) radiation 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 solar radiation. The xenon arc, when appropriately filtered, produces radiation with a spectral power distribution that is a good simulation of average solar radiation 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

[8] Fischer, R., "Results of Round Robin Studies of Light- and Water-Exposure Standard Practice," *Symposium on Accelerated and Outdoor Durability Testing of Organic Materials, ASTM STP 1202*, ASTM, 1993.

[9] Ketola, W., and Fischer, R. "Characterization and Use of Reference Materials in Accelerated Durability Tests," VAMAS Technical Report No. 30, available from NIST, Gaithersburg, MD.