



Designation: G151 – 19

# Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers 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 appro-*

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

1.5 *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:<sup>2</sup>

- D618 Practice for Conditioning Plastics for Testing
- D3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials (Withdrawn 2016)<sup>3</sup>
- D5870 Practice for Calculating Property Retention Index of Plastics
- E41 Terminology Relating to Conditioning (Withdrawn 2019)<sup>3</sup>
- E171 Practice for Conditioning and Testing Flexible Barrier Packaging
- 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 of Solar Energy Conversion
- E839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Cable
- G23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials (Withdrawn 2000)<sup>3</sup>
- G26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials (Discontinued 2001) (Withdrawn 2000)<sup>3</sup>

<sup>1</sup> 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.

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<sup>2</sup> 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.

<sup>3</sup> The last approved version of this historical standard is referenced on www.astm.org.

- G53** Practice for Operating Light-and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials (Withdrawn 2000)<sup>3</sup>
- 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
- 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 Ultraviolet (UV) Lamp Apparatus for 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*:<sup>4</sup>
- ISO 4892, Part 1** Plastics: Exposure to laboratory Light Sources—General Guidance
- ISO 9370** Plastics: Instrumental Determination of Radiant Exposure in Weathering Tests—General Guidance and Basic Test Method
- 2.3 *CIE Document*:<sup>5</sup>
- CIE Publication Number 85: 1989** Technical Report—Solar Spectral Irradiance
- 2.4 *Other Documents*:
- IES LM-58-13** Spectroradiometric Measurement Methods for Light Sources (2013 or Later)<sup>6</sup>
- NIST SP250-89** Spectral Irradiance Calibrations<sup>7</sup>
- 2.5 *ASTM Adjuncts*:<sup>8</sup>
- SMARTS2**, Simple Model for Atmospheric Transmission of Sunshine

### 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:

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

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

<sup>6</sup> Available from Illuminating Engineering Society of North America (IESNA), 120 Wall Street, New York, NY 10005, <https://www.ies.org/>.

<sup>7</sup> Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

<sup>8</sup> Available from ASTM International Headquarters. Order Adjunct No. **ADJG173CD**. Original adjunct produced in 2005.

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).<sup>9</sup>

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**.

<sup>9</sup> The boldface numbers in parentheses refer to the list of references at the end of this standard.

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:

4.2.1 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 (2, 3); 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 85-1989, 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 The apparatus should have a means to monitor and control the specimen irradiance.

NOTE 12—In apparatus that do not provide irradiance control, the specimen irradiance may vary over time as the source and some optical filters used to modify its spectral distribution age. This variance may contribute to differences between weathering tests conducted in different apparatus as well as those conducted in the same apparatus at separate times.

5.1.7.1 In apparatus equipped with irradiance control, an irradiance set point control system comprised of an integrated on-board irradiance sensor coupled with an electronic feedback loop shall operate to maintain the irradiance at the set point. This control system shall be calibrated to report the irradiance at the specimen plane whether the on-board irradiance sensor is located within the specimen plane or outside the specimen plane.

5.1.7.2 The irradiance set point control system shall be calibrated at regular intervals relative to an irradiance reference device (that is, a radiometer or other suitable transfer calibration standard) to assure acceptable accuracy and reliability. The irradiance set point control system shall be calibrated when replacing any component of the optical system (for example, at each lamp replacement or filter change) and each time the weathering method is changed. A full calibration of the irradiance set point control system shall be conducted at least once per year. More frequent calibrations and intermediate checks are recommended.

5.1.7.3 The irradiance reference device shall be calibrated in accordance with ISO 9370 resulting in traceability to a National Metrology Institute (NMI). This device shall be calibrated at regular intervals to assure acceptable measurement uncertainty, traceability, and reliability. Refer to the manufacturer's recommendation for guidance on calibration interval.

NOTE 13—For guidance on good laboratory practices for measurement and calibration of irradiance see IES LM-58-13 and NIST SP250-89.

5.1.7.4 Spectrally selective radiometers within the chain of traceability shall comply with one of the types specified in ISO 9370. A full calibration of the spectrally selective radiometer shall be conducted in accordance with Test Method G130 at least once per year. More frequent calibrations are recommended.

5.1.7.5 The irradiance set point control system and the irradiance reference device shall be calibrated in terms of irradiance,  $E_e$ , for a defined wavelength or defined wavelength interval. Common examples of irradiance control points and spectral ranges used in commercial weathering apparatus include 340 nm, 420 nm, 300-400 nm, and 300-800 nm. Other control points and spectral ranges may be used as agreed upon by all interested parties.

## 5.2 Temperature:

5.2.1 The surface temperature of exposed materials depends on the ambient temperature, the amount of radiation absorbed, the emissivity of the specimen, the thermal conduction within the specimen, and the heat transmission between specimen and air or specimen holder. Since it is not practical to monitor the

surface temperature of individual test specimens, a specified black-panel sensor is used to measure and control temperature within the test chamber. It is strongly recommended that the black panel temperature sensor be mounted within the specimen exposure area so that it receives the same radiation and cooling conditions as a flat test panel surface. The black panel also may be located at a fixed distance position different from the test specimens and calibrated for temperature in the specimen exposure area. This is not recommended, however, because black panels mounted at a fixed position away from the specimens may not indicate temperatures representative of the test specimens, even if they are calibrated to record temperature at positions within the specimen exposure area, due to differences in light intensity and movement of air.

5.2.1.1 The type of mounting used for uninsulated black or white panels (that is, whether the back of the panel is directly exposed to air or if the panel is placed against a solid metal backing) will have an effect on the conditions in the chamber. Describe the mounting used for the uninsulated black or white panel in the test report.

NOTE 14—Previous versions of this standard specified an uninsulated black panel with an open back subjected to the air within the exposure chamber. Tests using a different backing configuration may produce different results. Therefore, if a user wishes to compare to historical exposure results, it is recommended that the user duplicate the previous backing configuration of the uninsulated black panel.

5.2.2 Exposure devices shall use either an uninsulated black panel (commonly referred to as a black panel thermometer) or an insulated black panel (commonly referred to as a black standard thermometer) as black panel sensor. Requirements for each type are found in Annex A2.

5.2.3 The temperature indicated by the uninsulated black-panel or insulated thermometer depends on the irradiance of the laboratory light source and the temperature and speed of air moving in the test chamber. Uninsulated black-panel temperatures generally correspond to those for dark coatings on metal panels. Insulated black panel thermometer temperatures generally correspond to those for the exposed surface of dark samples with poor thermal conductivity. At conditions used in typical exposure tests, the temperature indicated by an insulated black panel thermometer will be 3–12 °C higher than an uninsulated black panel thermometer. The response time for temperature changes is slightly slower for insulated black panel thermometers compared to uninsulated black panel thermometers.

5.2.3.1 At low irradiance, the difference between the temperature indicated by an uninsulated black panel or insulated black panel and the real specimen may be small. When light sources that emit very little infrared radiation are used, there generally will be very small difference in temperatures indicated by the two types of black panels or between light and dark colored specimens.

NOTE 15—There can be differences in temperature indicated by a single type of black panel thermometer, depending on the specific design of the device supplied by different manufacturers. Work is being conducted within Subcommittee 6 ISO TC/61 to characterize the differences between the different types of temperature sensing devices and between temperature sensing devices of the same type.

5.2.4 In order to evaluate the range of surface temperatures of the exposed specimens, the use of an uninsulated or insulated white panel thermometer is recommended, in addition to the uninsulated black panel or insulated black panel thermometer. In some cases, temperature of either the uninsulated or insulated white panel thermometer may be used to specify exposure conditions. The uninsulated or insulated white panel shall be constructed in the same way as the corresponding uninsulated or insulated black panel thermometer, except for use of a white coating with a good resistance to aging. The reflectance of the white coating between 450 and 800 nm shall be at least 60 % and at least 30 % between 800 and 1500 nm.

5.2.5 When requested, suppliers of insulated or uninsulated black or white panels shall provide certification that the black or white coating meets the reflectance requirements given in this practice.

5.2.6 Exposure devices that control temperature of a black or white temperature sensor shall be able to maintain fluctuations at the control point as specified in **Annex A3**.

5.2.7 Manufacturers of exposure devices shall assure that the temperature of a black or white panel temperature sensor placed anywhere within the specimen exposure area shall be within  $\pm 3$  °C of the set point temperature for set points up to 70 °C and within  $\pm 4$  °C for set point temperatures above 70 °C.

5.2.8 The test report shall indicate whether an insulated or uninsulated black or white panel was used. If either type of black or white panel thermometer is not positioned in the specimen exposure area, the exact position used shall be described in the test report.

5.2.9 If chamber air temperature is measured, the temperature sensing element shall be shielded from the light source and water spray. Exposure devices, which control temperature of chamber air shall be able to maintain temperature of chamber air within  $\pm 3$  °C of the set point temperature.

5.2.10 Calibrate thermocouples according to instructions provided by the device manufacturer. If no instructions are provided by the device manufacture, sheathed thermocouples shall be calibrated according to Test Methods **E839**, and resistance thermometers used as the sensing element for black or white panel thermometers shall be calibrated according to Test Methods **E644**. Unless otherwise specified, devices used to measure temperature shall be calibrated at least annually. Wherever possible, calibrations should be traceable to a nationally recognized standards agency.

### 5.3 Humidity and Wetting:

5.3.1 The presence of moisture may have a significant effect on exposure tests. Any apparatus operated according to this standard, which attempts to simulate the effects of moisture, shall have means for providing moisture to specimens using one or more of the following methods: humidification of chamber air, formation of condensation, water spray, or immersion. The type and rate of material degradation can be affected significantly by the method used to provide moisture stress.

5.3.2 The purity of the water used for specimen wetting is very important. Without proper treatment to remove cations,

anions, organics, and particularly silica, exposed specimens will develop spots or stains that do not occur in exterior exposures. Unless otherwise specified, water used for specimen wetting shall have a maximum of 1 ppm solids and a maximum of 0.2 ppm silica. If the water used for specimen wetting is above 1 ppm solids, the solids and silica levels must be reported. Recirculation of water used for specimen wetting is not recommended and if done the recirculated water shall meet the specified purity requirements.

NOTE 16—Distillation, or a combination of deionization and reverse osmosis can effectively produce water with the desired purity.

5.3.3 If specimens are found to have deposits or stains after exposure, the water purity must be checked to determine if it meets the purity requirements described in **5.3.2**. On some occasions, exposed specimens can be contaminated by deposits from bacteria that can grow in the purified water used for specimen wetting. If bacterial contamination is detected, the entire system used for specimen wetting shall be flushed with a chlorinating solution, such as sodium hypochlorite and thoroughly rinsed prior to resuming exposures.

5.3.4 Although it does not always correlate with silica content, it is recommended that the conductivity of the water used for specimen wetting be monitored continuously and that exposures be stopped whenever the conductivity is above 5  $\mu\text{S}/\text{cm}$ .

5.3.5 All components of the specimen wetting unit shall be fabricated from stainless steel, plastic, or other material that does not contaminate the water. If plastic materials are used, they shall not leach low molecular weight UV absorbing components into the water.

5.3.6 In devices where humidity within the test chamber is controlled, sensors used to determine humidity shall be placed within the test chamber air flow and shielded from direct radiation and water spray. When humidity is controlled, the measured relative humidity shall be within  $\pm 5$  % of the set point humidity.

5.3.6.1 Calibrate the sensors used to determine humidity according to the device manufacturer's instructions.

5.3.7 Any device intended to introduce wetting of specimens, for example, by spray or immersion, shall have means to program intervals with and without wetting.

NOTE 17—There is currently no generally accepted method for characterizing the uniformity or consistency of specimen wetting.

5.4 *Other Apparatus Requirements*—Although various apparatus designs are used in practice, each apparatus shall include the following:

5.4.1 Any device intended to provide light and dark cycles shall have means to program intervals with or without light. The time of each light and dark cycle shall be controlled to within  $\pm 10$  % of the shortest cycle time used. It is preferable to use cycle timers that are accurate and reproducible as possible. Optionally, means to provide a record of the length of light and dark cycles may be provided.

5.4.2 To fulfill the requirements of particular test procedures, the apparatus also may need to provide means to register or record the following operational parameters.

5.4.2.1 Line voltage;

- 5.4.2.2 Lamp voltage and where appropriate, lamp wattage;
  - 5.4.2.3 Lamp current;
  - 5.4.2.4 Temperature of uninsulated or insulated black or white panel thermometer;
  - 5.4.2.5 Test chamber air temperature;
  - 5.4.2.6 Test chamber relative humidity;
  - 5.4.2.7 Water spray cycles;
  - 5.4.2.8 Irradiance or radiant exposure, or both, over a specified spectral region; and
  - 5.4.2.9 Duration of exposure (radiation time and total, if different).
- 5.4.3 Follow the recommendations of the device manufacturer regarding calibration of devices used to record each operational parameter.

## 6. Test Specimens

### 6.1 Form and Preparation:

6.1.1 The dimensions of the test specimens normally are those specified in the appropriate test method for the property or properties to be measured after exposure. When the behavior of a specific type of article is to be determined, the article itself should be exposed whenever possible.

6.1.2 For some tests, specimens to be exposed may be cut from a larger sheet or part that is formed by extrusion, injection molding, or other process. The exact shape and dimensions of the specimens to be exposed will be determined by the specific test procedure used for measurement of the property of interest. The procedures used to machine or cut individual test specimens from a larger sheet or part may affect the results of the property measurement and the apparent durability. Therefore, the method used for specimen preparation shall be agreed upon by the interested parties and should be related closely to the method normally used to process the material in typical application.

6.1.3 Unless otherwise specified or required, do not cut individual test specimens for property measurement from larger specimens that have been exposed. The effects any cutting or machining operation may have on the properties of individual test specimens usually are much larger when the test specimens are cut from a large piece after exposure. This is especially true for materials that embrittle on exposure.

6.1.3.1 When test specimens are cut from an exposed sheet or larger part, they should be taken from an area that is at least 20 mm from the fixture holding the material or from the exposed specimen edges. In no circumstances shall any material from the exposed face be removed during the test specimen preparation.

6.1.4 When comparing materials in an exposure test, use test specimens that are similar in dimensions and exposed area.

### 6.2 Number of Test Specimens:

6.2.1 The number of test specimens for each test condition or exposure period shall be that specified in the appropriate test method for the property or properties to be measured after exposure.

6.2.2 Unless otherwise specified or required, use at least three replicate specimens where properties are measured using nondestructive tests and six replicate specimens where properties are measured using destructive tests.

6.2.3 When material properties are measured using destructive tests, a separate set of specimens is needed for each exposure period. When destructive tests are used, the total number of test specimens required will be determined by the number of exposure periods used and whether unexposed file specimens are tested at the same time as exposed specimens.

6.2.4 Control materials with known durability should be included with each exposure test. It is recommended that control materials known to have relatively poor and good durability be used. Control materials are used for the purpose of comparing the performance of the test materials to the controls. Before laboratory to laboratory comparisons are made it is necessary to establish agreed upon control materials. The number of specimens of the control material should be the same as that used for test materials.

### 6.3 Storage and Conditioning:

6.3.1 Conditioning and handling of test, control, reference, and file specimens shall be according to Practice G147.

6.3.2 If test specimens are cut or machined from larger pieces, they should be conditioned after machining according to Practice D618, Specification D3924, or Practice E171. In some circumstances, it may be necessary to precondition the sheets prior to cutting or machining to facilitate specimen preparation. The properties of some materials are very sensitive to moisture content and the duration of conditioning may need to be longer than those specified in these standards, particularly where specimens have been exposed to climatic extremes.

## 7. General Procedure

7.1 Mark each specimen that will be exposed with a unique identifying number in accordance with Practice G147.

7.1.1 Do not touch the surface of exposed specimens or optical components with bare skin because oils that are deposited may act as UV absorbers or contain contaminants which accelerate degradation.

7.2 Specific conditions and procedures for the exposure test depend on the type of device used and the material being tested. For open flame carbon-arc, enclosed carbon-arc, fluorescent UV, and xenon-arc exposures, these can be found in Practices G152, G153, G154, and G155 and in other standards, which reference these practices.

7.2.1 For each exposure test, specific set points for important parameters such as irradiance, temperature, and humidity are used. Typically, these parameters are measured and controlled at a single position within the chamber. During normal operation, there is an allowable departure of the measured value from the set point. Annex A3 provides detailed information about the maximum allowable departure of the measured value from the set point.

7.2.2 A single point measurement does not mean conditions throughout the cabinet are the same. It does not mean two tests run in similar cabinets will produce the same results. Cabinets that control temperature by the black panel will not produce the same test as cabinets that control by air temperature.

7.3 Select material properties that exhibit a significant change during the exposure period in order to provide weathering performance discrimination among a series of materials.