Designation: G 152 – 00a$^{\epsilon 1}$

Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials[1]

This standard is issued under the fixed designation G 152; 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.

ϵ^1 NOTE—Table X1.2 was added editorially in May 2001.

1. Scope

1.1 This practice covers the basic principles and operating procedures for using open flame carbon-arc light and water apparatus intended to reproduce the weathering effects that occur when materials are exposed to sunlight (either direct or through window glass) and moisture as rain or dew in actual use. This practice is limited to the procedures for obtaining, measuring, and controlling conditions of exposure. A number of exposure procedures are listed in an appendix; however, this practice does not specify the exposure conditions best suited for the material to be tested.

NOTE 1—Practice G 151 describes performance criteria for all exposure devices that use laboratory light sources. This practice replaces Practice G 23, which describes very specific designs for devices used for carbon-arc exposures. The apparatus described in Practice G 23 is covered by this practice.

1.2 Test specimens are exposed to filtered open flame carbon arc light under controlled environmental conditions. Different filters are described.

1.3 Specimen preparation and evaluation of the results are covered in methods or specifications for specific materials. General guidance is given in Practice G 151 and ISO 4892-1. More specific information about methods for determining the change in properties after exposure and reporting these results is described in ISO 4582.

1.4 The values stated 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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.5.1 Should any ozone be generated from the operation of the light source, it shall be carried away from the test specimens and operating personnel by an exhaust system.

1.6 This practice is technically similar to ISO 4892-4.

2. Referenced Documents

2.1 *ASTM Standards:*

D 3980 Practice for Interlaboratory Testing of Paint and Related Materials[2]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[3]

G 23 Practice for Operating Light—Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[4]

G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[3]

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources[3]

2.2 *CIE Standard:*

CIE-*Publ.* No. 85: Recommendations for the Integrated Irradiance and the Spectral Distribution of Simulated Solar Radiation for Testing Purposes[5]

2.3 *ISO Standards:*

ISO 4582, Plastics—Determination of the Changes of Colour and Variations in Properties After Exposure to Daylight Under Glass, Natural Weathering or Artificial Light[6]

ISO 4892-1, Plastics—Methods of Exposure to Laboratory Light Sources, Part 1, General Guidance[6]

ISO 4892-4, Plastics—Methods of Exposure to Laboratory Light Sources, Part 4, Open-Flame Carbon Arc Lamp[6]

[1] This practice is under the jurisdiction of ASTM Committee G3 on Weathering and Durability and is the direct responsibility of Subcommittee G03.03 on Simulated and Controlled Exposure Tests.

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[2] Discontinued 1998; see *1998 Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 14.04.

[5] Available from Secretary, U.S. National Committee, CIE, National Institute of Standards and Technology, Gaithersburg, MD 20899.

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

3. Terminology

3.1 *Definitions*—The definitions given in Terminology G 113 are applicable to this practice.

3.1.1 As used in this practice, the term *sunlight* is identical to the terms *daylight* and *solar irradiance, global* as they are defined in Terminology G 113.

4. Summary of Practice

4.1 Specimens are exposed to repetitive cycles of light and moisture under controlled environmental conditions.

4.1.1 Moisture usually is produced by spraying the test specimen with demineralized/deionized water or by condensation of water vapor onto the specimen.

4.2 The exposure condition may be varied by selection of:

4.2.1 Light source filter,

4.2.2 The type of moisture exposure,

4.2.3 The timing of the light and moisture exposure,

4.2.4 The temperature of light exposure, and

4.2.5 The timing of a light/dark cycle.

4.3 Comparison of results obtained from specimens exposed in same model of apparatus should not be made unless reproducibility has been established among devices for the material to be tested.

4.4 Comparison of results obtained from specimens exposed in different models of apparatus should not be made unless correlation has been established among devices for the material to be tested.

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 sunlight, moisture, and heat. These exposures may include a means to introduce moisture to the test specimen. Exposures are not intended to simulate the deterioration caused by localized weather phenomena, such as atmospheric pollution, biological attack, and saltwater exposure. Alternatively, the exposure may simulate the effects of sunlight through window glass. Typically, these exposures would include moisture in the form of humidity.

5.2 *Cautions*—Refer to Practice G 151 for full cautionary guidance applicable to all laboratory weathering devices. Variation in results may be expected when operating conditions are varied within the accepted limits of this practice. No reference, therefore, shall be made to results from the use of this practice unless accompanied by a report detailing the specific operating conditions in conformance with Section 10. It is recommended that a similar material of known performance, a control, be exposed simultaneously with the test specimen to provide a standard for comparative purposes. It is recommended that at least three replicates of each material evaluated be exposed in each test to allow for statistical evaluation of results.

6. Apparatus

6.1 *Laboratory Light Source*—Open flame carbon arc light sources typically use three or four pairs of carbon rods, which contain a mixture of rare-earth metal salts and have a metal coating such as copper on the surface. An electric current is passed between the carbon rods which burn and give off ultraviolet, visible, and infrared radiation. The carbon rod pairs are burned in sequence, with one pair burning at any one time. Use carbon rods recommended by the device manufacturer.

6.1.1 *Filter Types*—Radiation emitted by the open flame carbon arc contains significant levels of very short wavelength UV (less than 260 nm) and must be filtered. Two types of glass filters are commonly used. Other filters may be used by mutual agreement by the interested parties as long as the filter type is reported in conformance with the report section in Practice G 151.

6.1.2 None of these fibers changes the spectral power distribution of the open flame carbon arc to make it match daylight in the long wavelength UV or the visible light regions of the spectrum.

6.1.3 The following factors can affect the spectral power distribution of open flame carbon arc light sources:

6.1.3.1 Differences in the composition and thickness of filters can have large effects on the amount of short wavelength UV radiation transmitted.

6.1.3.2 Aging of filters can result in changes in filter transmission. The aging properties of filters can be influenced by the composition. Aging of filters can result in a significant reduction in the short wavelength UV emission of a burner.

6.1.3.3 Accumulation of dirt or other residue on filters can affect filter transmission.

6.1.3.4 Differences in the composition of the metallic salts used in he carbon rods can affect the spectral power distribution.

6.1.4 *Spectral Irradiance*:

6.1.4.1 *Spectral Irradiance of Open Flame Carbon Arc with Daylight Filters*—Daylight filters are used to reduce the short wavelength UV irradiance of the open flame carbon arc in an attempt to provide simulation of the short wavelength UV region of daylight. Although these filters are specified in many tests because of historical precedent, they transmit significant radiant energy below 300 nm (the typical cut-on wavelength for terrestrial sunlight) and may result in aging processes not occurring outdoors.[7] The data in Table 1 is representative of the spectral irradiance received by a test specimen mounted in the specimen plane of an open flame carbon arc equipped with daylight filters.

6.1.4.2 *Spectral Irradiance of Open Flame Carbon Arc With Window Glass Filters*—Window glass filters use a heat resistant glass to filter the open flame carbon arc in a simulation of sunlight filtered through single strength window glass.[8] The data in Table 2 is representative of the spectral irradiance received by a test specimen mounted in the specimen plane of an open flame carbon arc equipped with window glass filters.

NOTE 2—The most commonly used type of daylight filters are made from Potash-Lithia glass and are commonly known as Corex D filters.

[7] Fischer, R., Ketola, W., Murray, W., "Inherent Variability in Accelerated Weathering Devices," *Progress in Organic Coatings,* Vol 19 (1991), pp. 165–179.

[8] Ketola, W., Robbins, J. S., "UV Transmission of Single Strength Window Glass," *Symposium on Accelerated and Outdoor Durability Testing of Organic Materials, ASTM STP 1202,* ASTM, 1993.

TABLE 1 Relative Spectral Power Distribution Specification for Open Flame Carbon Arc With Daylight Filters

Ultraviolet Wavelength region
Irradiance as a Percentage of Total Irradiance from 300 to 400 nm

Bandpass (nm)	Open Flame Carbon Arc with Daylight Filters[A,B]	Sunlight[C]
250–279	0–4.0 %	0 %
280–290	0–1.8 %	0 %
291–300	0.1–1.3 %	0 %
301–320	2.4–5.4 %	5.6 %
321–340	6.8–10.4 %	18.5 %
341–360	9.4–14.8 %	21.7 %
361–380	21.6–27.6 %	26.6 %
381–400	44.6–56.6 %	27.6 %

Ultraviolet and Visible Wavelength region
Irradiance as a Percentage of Total Irradiance from 300 to 800 nm[D]

Bandpass (nm)	Open Flame Carbon Arc with Daylight Filters[A,B]	Sunlight[E]
300–400	22.7–34.1 %	11 %
401–700	51.1–67.3 %	72 %

[A]*Carbon Arc Data*—Open flame carbons arcs emit significant short wavelength UV radiation between 250 and 280 nm. The intensity of this short wavelength UV radiation varies with age and initial transmission of the filters used[7] and the composition of the carbon rods. Composition of the carbon rods may vary between production lots and between manufacturers.

[B]*Carbon Arc Data*—The ranges given are based on spectral power distribution measurements made for open flame carbon arcs devices operating with carbon rods from different sources and with filters from different lots and varying ages. The ranges are based on the three sigma limits from the averages of these SPD measurements.

[C]*Sunlight Data*—The sunlight data is for global irradiance on a horizontal surface with an air mass of 1.2, column ozone 0.294 atm cm, 30 % relative humidity, altitude 2100 m (atmospheric pressure of 787.8 mb), and an aerosol represented by an optical thickness of 0.081 at 300 nm and 0.62 at 400 nm.

[D]Data from 701 to 800 nm is not shown.

[E]*Sunlight Data*—The sunlight data is from Table 4 of CIE Publication No. 85, global solar irradiance on a horizontal surface with an air mass of 1.0, column ozone of 0.34 atm cm, 1.42 cm precipitable water vapor, and an aerosol represented by an optical thickness of 0.1 at 500 nm.

TABLE 2 Typical Relative Spectral Power Distribution for Open Flame Carbon Arc With Window Glass Filters (Representative Data)

Ultraviolet Wavelength Region
Irradiance as a Percentage of Total Irradiance from 300 to 400 nm

Bandpass (nm)	Open Flame Carbon Arc with Window Glass Filters[A]	Estimated Window Glass Filtered Sunlight[B]
250–270	0 %	0 %
271–290	0 %	0 %
291–300	0 %	0 %
301–320	2.1 %	0.1–1.5 %
321–340	8.1 %	9.4–14.8 %
341–360	13.2 %	23.2–23.5 %
361–380	27.3 %	29.6–32.5 %
381–400	49.3 %	30.9–34.5 %

Ultraviolet and Visible Wavelength Region Irradiance as a Percentage of Total Irradiance from 300 to 800 nm[C]
Irradiance as a Percentage of Total Irradiance from 300 to 800 nm[C]

Bandpass (nm)	Open Flame Carbon Arc with Window Glass Filters[E]	Estimated Window Glass Filtered Sunlight[D]
300–400	22.7–34.1 %	9.0–11.1 %
401–700	51.1–67.3 %	71.3–73.1 %

*Data from 701 to 800 nm is not shown

[A]*Carbon Arc Data*—This data are for a typical spectral power distribution for an open flame carbons arc with window glass filters. Not enough spectral data is available for meaningful analysis to develop a specification. Subcommittee G03.03 is working to collect sufficient data in order to develop a specification.

[B]*Sunlight Data*—The sunlight data is for global irradiance on a horizontal surface with an air mass of 1.2, column ozone 0.294 atm cm, 30 % relative humidity, altitude 2100 m (atmospheric pressure of 787.8 mb), and an aerosol represented by an optical thickness of 0.081 at 300 nm and 0.62 at 400 nm. The range is determined by multiplying solar irradiance by the upper and lower limits for transmission of single strength window glass samples used for studies conducted by Subcommittee G03.02.[7]

[C]*Sunlight Data*—The sunlight data is from Table 4 of CIE Publication No. 85, global solar irradiance on a horizontal surface with an air mass of 1.0, column ozone of 0.34 atm cm, 1.42 cm precipitable water vapor, and an aerosol represented by an optical thickness of 0.1 at 500 nm.

6.2 *Test Chamber*—The design of the test chamber may vary, but it should be constructed from corrosion resistant material, and in addition to the radiation source, may provide for means of controlling temperature and relative humidity. When required, provision shall be made for the spraying of water on the test specimen or for the formation of condensate on the exposed face of the specimen.

6.2.1 The radiant source(s) shall be located with respect to the specimens such that the irradiance at the specimen face complies with the requirements in Practice G 151.

6.3 *Instrument Calibration*—To ensure standardization and accuracy, the instruments associated with the exposure apparatus, for example, timers, thermometers, wet bulb sensors, dry bulb sensors, humidity sensors, UV sensors, radiometers, require periodic calibration to ensure repeatability of test results. Whenever possible, calibration should be traceable to national or international standards. Calibration schedule and procedure should be in accordance with manufacturer's instructions.

6.4 *Thermometer*—Either insulated or uninsulated black or white panel thermometers may be used. Thermometers shall conform to the descriptions found in Practice G 151. The type of thermometer used, the method of mounting on specimen holder, and the exposure temperature shall be stated in the test report.

6.4.1 The thermometer shall be mounted on the specimen rack so that its surface is in the same relative position and subjected to the same influences as the test specimens.

6.4.2 Some specifications may require chamber air temperature control. Positioning and calibration of chamber air temperature sensors shall be in accordance with the descriptions found in Practice G 151.

NOTE 3—Typically, these devices control by black panel temperature only.

6.5 *Moisture*—The test specimens may be exposed to moisture in the form of water spray, condensation, or high humidity.

6.5.1 *Water Spray*—The test chamber may be equipped with a means to introduce intermittent water spray onto the front or the back of the test specimens, under specified conditions. The spray shall be applied so that the specimens are uniformly wetted. The spray system shall be made from corrosion resistant materials that do not contaminate the water used.

6.5.1.1 *Spray Water Quality*—Spray water must have a conductivity below 5 µS/cm, contain less than 1-ppm solids, and leave no observable stains or deposits on the specimens. Very low levels of silica in spray water can cause significant deposits on the surface of test specimens. Care should be taken to keep silica levels below 0.1 ppm. In addition to distillation, a combination of deionization and reverse osmosis can effectively produce water of the required quality. The pH of the