INTERNATIONAL

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Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials[1]

This standard is issued under the fixed designation G154; 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 is limited to the basic principles for operating a fluorescent UV lamp and water apparatus; on its own, it does not deliver a specific result.

1.2 ~~This practice covers the basic principles and operating procedures for using fluorescent UV light, and water apparatus~~ It is intended to be used in conjunction with a practice or method that defines specific exposure conditions for an application along with a means to evaluate changes in material properties. This practice is 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 usage. 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 G151 describes ~~performance criteria for all exposure devices that use laboratory light sources. This practice replaces Practice~~general procedures to be used when exposing nonmetallic materials in accelerated test devices that use ~~G53, which describes very specific designs for devices used for fluorescent UV exposures. The apparatus described in Practice~~ laboratory light sources.~~G53 is covered by this practice.~~

NOTE 2—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.

1.3 Test specimens are exposed to fluorescent UV light under controlled environmental conditions. Different types of fluorescent UV ~~light~~lamp sources are described.

NOTE 3—In this standard, the terms *UV light* and *UV radiation* are used interchangeably.

1.4 Specimen preparation and evaluation of the results are covered in ASTM methods or specifications for specific materials. General guidance is given in Practice G151 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.~~

NOTE 4—General information about methods for determining the change in properties after exposure and reporting these results is described in ISO 4582 and Practice D5870.

1.5 The values stated in SI units are to be regarded as ~~the~~ standard. No other units of measurement are included in this standard.

1.6 *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.*

1.7 This standard is technically similar to ISO 4892-3 and ISO ~~DIS 11507.~~16474-3.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

~~D3980~~D5870 Practice for ~~Interlaboratory Testing of Paint and Related Materials~~Calculating Property Retention Index of Plastics ~~(Withdrawn 1998)~~

~~E691~~D6631 ~~Practice for~~ Guide for Committee D01 for Conducting an Interlaboratory Study ~~to Determine the~~ for the Purpose of Determining the Precision of a Test Method

[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.

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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.

***A Summary of Changes section appears at the end of this standard**

~~G53 Practice for Operating Light-and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials (Withdrawn 2000)[3]~~
G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials
G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
G177 Tables for Reference Solar Ultraviolet Spectral Distributions: Hemispherical on 37° Tilted Surface
~~2.2 *CIE Standard:*~~
~~CIE-Publ. No. 85: Recommendations for the Integrated Irradiance and the Spectral Distribution of Simulated Solar Radiation for Testing Purposes[4]~~
2.2 *ISO Standards:*[3]
ISO 4582 Plastics—Determination of the Changes of Colour and Variations in Properties After Exposure to Daylight Under Glass, Natural Weathering or Artificial Light
ISO 4892-1 Plastics—Methods of Exposure to Laboratory Light ~~Sources, Part~~ Sources—Part 1, Guidance
ISO 4892-3 Plastics—Methods of Exposure to Laboratory Light ~~Sources, Part~~ Sources—Part 3, Fluorescent UV lamps
ISO ~~DIS 11507~~16474-3 ~~Paint~~Paints and ~~Varnishes—Exposure~~Varnishes—Methods of ~~Coatings to Artificial Weathering in Apparatus—Exposure to Fluorescent Ultraviolet and Condensation Apparatus~~Exposure to Laboratory Light Sources—Part 3: Fluorescent UV Lamps

3. Terminology

3.1 *Definitions*—The definitions given in Terminology G113 are applicable to this practice.

~~3.2 *Definitions of Terms Specific to This Standard*—As used in this practice, the term *sunlight* is identical to the terms *daylight* and *solar irradiance, global* as they are defined in Terminology G113.~~

~~3.2.1 *Fluorescent Ultraviolet (UV) Apparatus*—An apparatus for performing exposure tests using fluorescent UV lamps as the light source.~~

3.2 *Definitions of Terms Specific to This Standard*—As used in this practice, the term *sunlight* is identical to the terms *daylight* and *solar irradiance, global* as they are defined in Terminology G113.

3.2.1 *Fluorescent Ultraviolet (UV) lamp Apparatus*—an apparatus specifically designed for performing artificial accelerated weathering and irradiation tests using fluorescent UV lamps as the light source and including a means to expose the test specimens to moisture and controlled temperature.

4. Summary of Practice

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

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

4.2 The exposure condition may be varied by selection of:
4.2.1 The fluorescent lamp,
4.2.2 The ~~lamp's~~lamp's irradiance level,
4.2.3 The type of moisture exposure,
4.2.4 The timing of the ~~light~~ light, dark, and moisture ~~exposure,~~periods, and
~~4.2.5 The temperature of light exposure, and~~
4.2.5 The temperature ~~of moisture exposure, and~~ during each exposure condition.
~~4.2.7 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~~consistent with the end use conditions, including the effects of the UV portion of sunlight, moisture, and heat. ~~These~~ Typically, these exposures ~~may include a means to introduce moisture to the test specimen.~~ would include moisture in the form of condensing humidity. 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,~~ (**Warning—**Refer to Practice G151 for full cautionary guidance applicable to all laboratory weathering devices.~~these exposures would include moisture in the form of condensing humidity.~~)

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

~~NOTE 2—**Caution:** Refer to Practice G151 for full cautionary guidance applicable to all laboratory weathering devices.~~

5.2 ~~Variation in results may be expected when operating conditions are varied within the accepted limits of this practice.~~This practice provides general procedures for operating fluorescent UV lamp weathering devices that allow for a wide range of exposure conditions. Therefore, no reference shall be made to results from the use of this practice unless accompanied by a report detailing the specific operating conditions in conformance with ~~the~~ Section 10.

5.2.1 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. Generally, two controls are recommended: one known to have poor durability and one known to have good durability. It is recommended that at least three replicates of each material evaluated be exposed in each test to allow for statistical evaluation of results.

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

5.2.3 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.

NOTE 5—See Guide D6631 for guidance.

6. Apparatus

6.1 *Laboratory Light Source*—The light source shall be one or more fluorescent UV lamps. A variety of fluorescent UV lamps can be used for this procedure. Differences in lamp intensity or spectrum may cause significant differences in test results. ~~A detailed description of the type(s) of lamp(s) used should be stated in detail in the test report. The particular testing application determines which lamp should be used. See Appendix X1 for lamp application guidelines.~~

~~NOTE 3—Do not mix different types of lamps. Mixing different types of lamps in a fluorescent UV light apparatus may produce major inconsistencies in the light falling on the samples, unless the apparatus has been specifically designed to ensure a uniform spectral distribution.~~

6.1.1 Do not mix different types of lamps. Mixing different types of lamps in a fluorescent UV apparatus may produce major inconsistencies in the light falling on the samples, unless the apparatus has been specifically designed to ensure a uniform spectral distribution.

6.1.1.1 A detailed description of the type(s) of lamp(s) used shall be stated in the test report. The particular testing application determines which lamp is used. See Appendix X1 for lamp application guidelines.

~~NOTE 4—Many fluorescent lamps age significantly with extended use. Follow the apparatus manufacturer's instructions on the procedure necessary to maintain desired irradiance (**1,2**).~~

6.1.2 ~~Actual irradiance~~ The apparatus should include an irradiance control system to monitor and control the irradiance. In apparatuses without irradiance control, the actual irradiance levels at the test specimen surface may vary due to the type ~~or~~ of lamps, manufacturer of the ~~lamp used, or both, the~~ lamps, age of the lamps, ~~the~~ accumulation of dirt or other residue on the lamps, distance to the lamp array, ~~and the~~ air temperature within the chamber and ~~the~~ ambient laboratory temperature. ~~Consequently, the use of a radiometer to monitor and control the radiant energy is recommended.~~

NOTE 6—In general, in apparatuses without irradiance control, lamp output will decrease with increasing chamber or laboratory temperature, or both.

6.1.3 ~~Several factors can affect the spectral power distribution of fluorescent UV lamps:~~Fluorescent lamps age with extended use. Follow the apparatus manufacturer's instructions on the procedure necessary to maintain desired irradiance **(1, 2)**.[4]

~~6.1.2.1 Aging of the glass used in some types of lamps can result in changes in transmission. Aging of glass can result in a significant reduction in the short wavelength UV emission of some lamp types,~~

~~6.1.2.2 Accumulation of dirt or other residue on lamps can affect irradiance,~~

~~6.1.2.3 Thickness of glass used for lamp tube can have large effects on the amount of short wavelength UV radiation transmitted, and~~

~~6.1.2.4 Uniformity and durability of phosphor coating.~~

6.1.4 ~~*Spectral Irradiance:*~~ *Standard Fluorescent UV Lamps—*

~~NOTE 5—Fluorescent UVA lamps are available with a choice of spectral power distributions that vary significantly. The more common may be identified as UVA-340 and UVA-351. These numbers represent the characteristic nominal wavelength (in nm) of peak emission for each of these lamp types. The actual peak emissions are at 343 and 350 nm, respectively.~~Fluorescent UV lamps are available with a choice of spectral power distributions that vary significantly. The more common are identified as UVA-340, UVA-351, and UVB-313. These numbers represent the characteristic nominal wavelength (in nm) of peak emission for each of these lamp types. The actual peak emissions are at 343 nm, 350 nm, and 313 nm, respectively.

~~[7] Gueymard, C., "Parameterized Transmittance Model for Direct Beam and Circumsolar Spectral Irradiance," *Solar Energy*, Vol 71, No. 5, 2001, pp. 325-346.~~

~~[8] Gueymard, C. A., Myers, D., and Emery, K., "Proposed Reference Irradiance Spectra for Solar Energy Systems Testing," *Solar Energy*, Vol 73, No 6, 2002, pp. 443-467.~~

[4] ~~Myers, D. R., Emery, K., and Gueymard, C., "Revising and Validating Spectral Irradiance Reference Standards for Photovoltaic Performance Evaluation," Transactions of the American Society of Mechanical Engineers, *Journal of Solar Energy Engineering*, Vol 126, pp 567–574, Feb. 2004.~~ The boldface numbers in parentheses refer to a list of references at the end of this standard.

6.1.4.1 *Spectral ~~Irradiance~~ Power Distribution of UVA-340 Lamps for Daylight UV*—The spectral power distribution of UVA-340 fluorescent lamps shall comply with the requirements specified in Table 1.

NOTE 7—The main application for UVA-340 lamps is for simulation of the short and middle UV wavelength region of daylight.

6.1.4.2 *Spectral ~~Irradiance~~ Power Distribution of UVA-351 Lamps for Daylight UV Behind Window Glass*—The spectral power distribution of UVA-351 lamp for Daylight UV behind Window Glass shall comply with the requirements specified in Table 2.

NOTE 8—The main application for UVA-351 lamps is for simulation of the short and middle UV wavelength region of daylight ~~which~~that has been filtered through window glass (**3**).

6.1.4.3 *Spectral ~~Irradiance~~ Power Distribution of UVB-313 Lamps*—The spectral power distribution of UVB-313 fluorescent lamps shall comply with the requirements specified in Table 3.

NOTE 9—Fluorescent UVB lamps have the spectral distribution of radiation peaking near the 313-nm mercury ~~line.~~ line, and as such, are not recommended for sunlight simulation. They emit significant amounts of radiation below ~~300~~295 nm, the nominal cut on wavelength of global solar radiation, that may result in aging processes not occurring outdoors. ~~Use of this lamp is not recommended for sunlight simulation.~~ See Table 3.

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 ~~radiant~~light source, may provide for means of controlling temperature and relative humidity. When required,

TABLE 1 Relative Ultraviolet Spectral Power Distribution Specification for Fluorescent UVA-340 Lamps for Daylight UV[A,B]

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Benchmark Solar Radiation Percent[D,E,F]	Maximum Percent[C]
~~λ < 290~~			~~0.01~~
~~290 ≤ λ ≤ 320~~	~~5.9~~	~~5.8~~	~~9.3~~
~~320 < λ ≤ 360~~	~~60.9~~	~~40.0~~	~~65.5~~
~~360 < λ ≤ 400~~	~~26.5~~	~~54.2~~	~~32.8~~

TABLE 1 Relative Ultraviolet Spectral Power Distribution Specification for Fluorescent UVA-340 Lamps for Daylight UV[A,B]

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Benchmark Solar Radiation Percent[D,E]	Maximum Percent[C]
λ < 290			0.01
290 ≤ λ ≤ 320	5.9	5.8	9.3
320 < λ ≤ 360	60.9	40.0	65.5
360 < λ ≤ 400	26.5	54.2	32.8

[A] Data in Table 1 are the irradiance in the given bandpass expressed as a percentage of the total irradiance from 290 to 400 nm. The manufacturer is responsible for determining conformance to Table 1. Annex A1 states how to determine relative spectral irradiance.

[B] The data in Table 1 are based on the rectangular integration of 65 spectral power distributions for fluorescent UV devices operating with UVA 340 lamps of various lots and ages. The spectral power distribution data is for lamps within the aging recommendations of the device manufacturer. The minimum and maximum data are at least the three sigma limits from the mean for all measurements.

[C] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minimum and maximum for the data used. For any individual spectral power distribution, the calculated percentage for the bandpasses in Table 1 will sum to 100 %. For any individual fluorescent UVA-340 lamp, the calculated percentage in each bandpass must fall within the minimum and maximum limits of Table 1. Test results can be expected to differ between exposures using devices with fluorescent UVA-340 lamps in which the spectral power distributions differ by as much as that allowed by the tolerances. Contact the manufacturer of the fluorescent UV devices for specific spectral power distribution data for the fluorescent UVA-340 lamp used.

[D] The benchmark solar radiation data is defined in ASTM G177 and is for atmospheric conditions and altitude chosen to maximize the fraction of short wavelength solar UV. While this data is provided for comparison purposes only, it is desirable for the laboratory accelerated light source to provide a spectrum that is a close match to the benchmark solar spectrum.

~~[E] Previous versions of this standard used solar radiation data from Table 4 of CIE Publication Number 85. See Appendix X3 for more information comparing the solar radiation data used in this standard with that for CIE 85 Table 4.~~

[E] ~~For~~ For the benchmark daylight spectrum, the UV irradiance (290 to 400 nm) is ~~9.8 %~~9.8% and the visible irradiance (400 to 800 nm) is ~~90.2 %~~90.2% expressed as a percentage of the total irradiance from 290 to 800 nm. Because the primary emission of fluorescent UV lamps is concentrated in the ~~300~~290 to 400 nm bandpass, there are limited ~~data available for~~ visible light emissions ~~of~~from fluorescent UV lamps.

TABLE 2 Relative Spectral Power Distribution Specification for Fluorescent UVA-351 Lamps for Daylight UV Behind Window Glass[A,B]

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Window Glass Filtered Daylight Percent[D,E,F]	Maximum Percent[C]
λ < 300		0.0	0.2
300 ≤ λ ≤ 320	1.1	≤ 0.5	3.3
320 < λ ≤ 360	60.5	34.2	66.8
360 < λ ≤ 400	30.0	65.3	38.0

TABLE 2 Relative Spectral Power Distribution Specification for Fluorescent UVA-351 Lamps for Daylight UV Behind Window Glass[A,B]

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Window Glass Filtered Daylight Percent[D,E]	Maximum Percent[C]
λ < 300		0.0	0.2
300 ≤ λ ≤ 320	1.1	≤ 0.5	3.3
320 < λ ≤ 360	60.5	34.2	66.8
360 < λ ≤ 400	30.0	65.3	38.0

[A] Data in Table 2 are the irradiance in the given bandpass expressed as a percentage of the total irradiance from 300 to 400 nm. The manufacturer is responsible for determining conformance to Table 1. Annex A1 states how to determine relative spectral irradiance.

[B] The data in Table 2 are based on the rectangular integration of 21 spectral power distributions for fluorescent UV devices operating with UVA 351 lamps of various lots and ages. The spectral power distribution data is for lamps within the aging recommendations of the device manufacturer. The minimum and maximum data are at least the three sigma limits from the mean for all measurements.

[C] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minimum and maximum for the data used. For any individual spectral power distribution, the calculated percentage for the bandpasses in Table 2 will sum to 100 %. For any individual fluorescent UV device operating with UVA 351 lamps, the calculated percentage in each bandpass must fall within the minimum and maximum limits of Table 2. Test results can be expected to differ between exposures using fluorescent UV devices in which the spectral power distributions differ by as much as that allowed by the tolerances. Contact the manufacturer of the fluorescent UV devices for specific spectral power distribution data for the lamps used.

[D] The window glass filtered solar radiation data is for a solar spectrum with atmospheric conditions and altitude chosen to maximize the fraction of short wavelength solar UV (defined in ASTM G177) that has been filtered by window glass. The glass transmission is the average for a series of single strength window glasses tested as part of a research study for ASTM Subcommittee G3.02.G3.02 (3). While this data is provided for comparison purposes only, it is desirable for the laboratory accelerated light source to provide a spectrum that is a close match to this benchmark window glass filtered solar spectrum.

[E] Previous versions of this standard used window glass filtered solar radiation data based on Table 4 of CIE Publication Number 85. See Appendix X3 for more information comparing the solar radiation data used in the standard with that for CIE 85 Table 4.

[E] For For the benchmark window glass filtered solar spectrum, the UV irradiance (300 to 400 nm) is 8.2 % and the visible irradiance (400 to 800 nm) is 91.8 % expressed as a percentage of the total irradiance from 300 to 800 nm. Because the primary emission of fluorescent UV lamps is concentrated in the 300290 to 400 nm bandpass, there are limited data available for visible light emissions offrom fluorescent UV lamps.

provision shall be made for the spraying of water on the test specimen for the formation of condensate on the exposed face of the specimen or for the immersion of the test specimen in water.

6.2.1 The radiantlight source(s) shall be located with respect to the specimens such that the uniformity of irradiance at the specimen face complies with the requirements in Practice G151.

6.2.2 Lamp replacement, lamp rotation, and specimen repositioning may be required to obtain uniform exposure of all specimens to UV radiation and temperature. Follow manufacturer's recommendation for lamp replacement and rotation.

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, and radiometers) require periodic calibration to ensure repeatability of test results. Whenever possible, calibration should be traceable to national or

TABLE 3 Relative Spectral Power Distribution Specification for Fluorescent UVB 313 lamps[A,B]

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Benchmark Solar Radiation Percent[D,E,F]	Maximum Percent[C]
λ < 290	1.3		5.4
290 ≤ λ ≤ 320	47.8	5.8	65.9
320 < λ ≤ 360	26.9	40.0	43.9
360 < λ ≤ 400	1.7	54.2	7.2

TABLE 3 Relative Spectral Power Distribution Specification for Fluorescent UVB 313 lamps[A,B]

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Benchmark Solar Radiation Percent[D,E]	Maximum Percent[C]
λ < 290	1.3		5.4
290 ≤ λ ≤ 320	47.8	5.8	65.9
320 < λ ≤ 360	26.9	40.0	43.9
360 < λ ≤ 400	1.7	54.2	7.2

[A] Data in Table 3 are the irradiance in the given bandpass expressed as a percentage of the total irradiance from 250 to 400 nm. The manufacturer is responsible for determining conformance to Table 3. Annex A1 states how to determine relative spectral irradiance.

[B] The data in Table 3 are based on the rectangular integration of 44 spectral power distributions for fluorescent UV devices operating with UVB 313 lamps of various lots and ages. The spectral power distribution data is for lamps within the aging recommendations of the device manufacturer. The minimum and maximum data are at least the three sigma limits from the mean for all measurements.

[C] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minimum and maximum for the data used. For any individual spectral power distribution, the calculated percentage for the bandpasses in Table 3 will sum to 100 %. For any individual UVB 313 lamp, the calculated percentage in each bandpass must fall within the minimum and maximum limits of Table 3. Test results can be expected to differ between exposures conducted in fluorescent UV devices using UVB 313 lamps in which the spectral power distributions differ by as much as that allowed by the tolerances. Contact the manufacturer of the fluorescent UV device for specific spectral power distribution data for the device operated with the UVB 313 lamp used.

[D] The benchmark solar radiation data is defined in ASTM G177 and is for atmospheric conditions and altitude chosen to maximize the fraction of short wavelengthsolar wavelength solar UV. This data is provided for comparison purposes only.

[E] Previous versions of this standard used solar radiation data from Table 4 of CIE Publication Number 85. See Appendix X3 for more information comparing the solar radiation data used in this standard with that for CIE 85 Table 4.

[E] For For the benchmark solar spectrum, the UV irradiance (290 to 400 nm) is 9.8 %9.8% and the visible irradiance (400 to 800 nm) is 90.2 % expressed as a percentage of the total irradiance from 290 to 800 nm. Because the primary emission of fluorescent UV lamps is concentrated in the 300290 to 400 nm bandpass, there are limited data available for visible light emissions offrom fluorescent UV lamps.

international standards. Calibration schedule and procedure shouldshall be in accordance with manufacturer's instructions. Calibration should be traceable to a national metrological institute (NMI).

6.4 *Radiometer*—The use of a radiometer to monitor and control the amount of radiant energy received at the sample is recommended. If a radiometer is used, it shall comply with the requirements in Practice G151.

6.5 *Thermometer*—Either insulated or un-insulated black or white panel thermometers may be used. The un-insulated thermometers may be made of either steel or aluminum. Thermometers shall conform to the descriptions found in Practice G151.

NOTE 10—Typically, these devices control by un-insulated black panel thermometer only.

6.5.1 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.

6.5.2 Some specificationsThe apparatus may requireprovide chamber air temperature control. Positioning and calibration of chamber air temperature sensors shall be in accordance with the descriptions found in Practice G151.

NOTE 9—Typically, these devices control by black panel temperature only.

6.6 *Moisture*—The test specimens may be exposed to moisture A means for exposing the specimen to moisture shall be provided. The moisture may be in the form of water spray, condensation, or high humidity.