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Designation: G 23 – 90

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa 19103
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Standard Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[1]

This standard is issued under the fixed designation G 23; 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.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers the basic principles and operating procedures for light-exposure apparatus with and without water spray employing a carbon-arc light source.

1.2 This practice does not specify the exposure conditions best suited for the material to be tested. It is limited to the method of obtaining, measuring, and controlling the conditions and procedures of the exposure. Sample preparation, test conditions, and evaluation of results are covered in ASTM test methods or specifications for specific materials.

NOTE 1—Attention is called to the following test methods and practices for more information on use of this practice for specific materials:
Practices D 529, D 822, D 904, D 1499, D 3361, D 3815, E 765 and Test Methods C 732, C 734, C 741, D 750, D 3424 and D 3583.

1.3 This practice includes four procedures:

1.3.1 *Method 1*—Continuous exposure to light and intermittent exposure to water spray.

1.3.2 *Method 2*—Alternate exposure to light and darkness and intermittent exposure to water spray.

1.3.3 *Method 3*—Continuous exposure to light without water spray. Specific exposure conditions for testing fabric are found in AATCC Test Method 16A.

1.3.4 *Method 4*—Alternate exposure to light and darkness without water spray.

1.4 The values stated in SI units are to be regarded as the standard. The inch-pound unit equivalents of the SI units may be approximate.

1.5 *This standard does not purport to address the safety problems 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:*

C 732 Test Method for Aging Effects of Artificial Weathering on Latex Sealants[2]
C 734 Test Method for Low-Temperature Flexibility of Latex Sealants After Artificial Weathering[2]
C 741 Test Method for Accelerated Aging of Wood Sash Face Glazing Compound[2]
D 529 Practice for Accelerated Weathering Test of Bituminous Materials[3]
D 750 Test Method for Rubber Deterioration in Carbon-Arc or Weathering Apparatus[4]
D 822 Practice for Conducting Tests on Paint and Related Coatings and Materials Using Filtered Open-Flame Carbon-Arc Light- and Water-Exposure Apparatus[5]
D 904 Practice for Exposure of Adhesive Specimens to Artificial (Carbon-Arc Type) and Natural Light[6]
D 1499 Practice for Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics[7]
D 3361 Practice for Operating Light- and Water-Exposure Apparatus (Unfiltered Open-Flame Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products Using the Dew Cycle[5]
D 3424 Method for Evaluating the Lightfastness of Printed Matter[5]
D 3583 Methods of Testing Joint Sealant, Hot-Applied, Elastomeric Type for Portland Cement Concrete Pavements, or Joint Sealant, Hot-Applied Elastomeric, Jet-Fuel-Resistant Type, for Portland Cement Concrete Pavements[8]
D 3815 Practice for Accelerated Aging of Pressure Sensitive Tapes by Carbon-Arc Exposure Apparatus[9]
E 765 Practice for Evaluation of Cover Materials for Flat Plate Solar Collectors[10]

2.2 *AATCC Standards:*[11]
Blue Wool Lightfastness
Test method 16A Colorfastness to Light, Carbon-Arc Lamp, Continuous Light

[1] This practice is under the jurisdiction of ASTM Committee G-3 on Durability of Nonmetallic Materials and is the direct responsibility of Subcommittee G03.03 on Simulated and Controlled Environmental Tests.
Current edition approved Oct. 26, 1990. Published December 1990. Originally published as E 42 – 42 T. Last previous edition G 23 – 89. Replaces E 42 – 69 and combines G 23 – 69 (1975) and G 25 – 81.
Practice G 25, Standard Recommended Practice for Operating Enclosed Carbon Arc Type Apparatus for Light Exposure of Nonmetallic Materials, is to be discontinued since it now is covered in this edition of G 23 and its Methods 3 and 4.

[2] *Annual Book of ASTM Standards*, Vol 04.07.
[3] *Annual Book of ASTM Standards*, Vol 04.04.
[4] *Annual Book of ASTM Standards*, Vol 09.01.
[5] *Annual Book of ASTM Standards*, Vol 06.01.
[6] *Annual Book of ASTM Standards*, Vol 15.06.
[7] *Annual Book of ASTM Standards*, Vol 08.01.
[8] *Annual Book of ASTM Standards*, Vol 04.03.
[9] *Annual Book of ASTM Standards*, Vol 15.09.
[10] *Annual Book of ASTM Standards*, Vol 12.02.
[11] Available from the Secretary, American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

Laboratory _____
Material _____
G 23 Test Method No. _____
Reference Standard Used: _____
Other ASTM Test No. _____ Method No. _____
Exposure Apparatus: ASTM Type _____
Mfr. Model _____ Serial No. _____
Light Source: Enclosed _____ Open Flame _____
Filters: Type _____, Age _____ h.
Elapsed Exposure Time: _____ h
Exposure Conditions: Program _____ h
Light _____ min Dark _____ min

Black-Panel Temperature	____°C (°F)	
Dry Bulb Temperature	____°C (°F)	____°C (°F)
Relative Humidity	____%	____%
Specimen Water Spray	____min	____min
Rack Spray (when used)	____min	____min

Specimen Spray Water Type: _____
Specimen Spray Nozzle Type: Mfg. Designation _____
Specimen Relocation Procedure During Exposure: _____

Identify Properties to be Determined on Test Specimens and Identify Test Procedures or Methods Used for Property Measurement.
Operator/Date: _____
Supervisor/Date: _____

FIG. 1 Report Form

2.3 *ISO Standard:*[12]
ISO Gray Scale

3. Significance and Use

3.1 Several types of apparatus with different exposure conditions are available for use. No single operating procedure for light exposure apparatus with or without water can be specified as a direct simulation of natural exposure. This practice does not imply expressly or otherwise an accelerated weathering test.

3.2 Since natural environments vary with respect to geography, topography, and different exposure periods, it may be expected that the effects of natural exposure will vary accordingly. Furthermore, all materials are not affected equally by the same environment. Therefore, results obtained by use of this practice should not be represented as equivalent to those of any natural weathering test until the degree of quantitative correlation has been empirically established for the material in question.

3.3 Variations in results may be expected among instruments of different types and when operating conditions among similar type instruments vary within the accepted limits of this practice. Therefore, no reference should be made to results from use of this practice unless accompanied by the report form as specified in Fig. 1.

4. Apparatus[13]

4.1 The apparatus employed shall use one or two carbon-arc lamps as the source of radiation, and shall be one of the following types, or equivalent. The term "cycle" is defined as the total time for all exposure conditions (light, light plus water spray, dark periods) that are repeated.

NOTE 2—Several models of carbon-arc type exposure devices are no longer commercially available and should be considered obsolete. Exposures in these devices are not recommended and should only be made when mutually agreed upon by all interested parties.

4.1.1 *Type D*—Twin enclosed carbon-arc lamp apparatus, with a 762 mm (30 in.) diameter specimen drum rotating at 1 rpm, automatic control of temperature and cycle, and manually adjusted humidifier.

4.1.2 *Type DH*—Same as Type D, except with automatic control of the humidity.

4.1.3 *Type E*—Single open-flame sunshine carbon-arc lamp apparatus, with a 959 mm (37.75 in.) diameter specimen rack rotating at 1 rpm, automatic control of temperature and cycle, and manually adjusted humidifier.

4.1.4 *Type EH*—Same as Type E, except with automatic control of the humidity.

4.1.5 *Type H*—Single enclosed carbon-arc lamp apparatus, with a 508 mm (20 in.) diameter specimen rack, rotating at 1 rpm, automatic control of temperature and cycle, and manual regulation of the humidity.

4.1.6 *Type HH*—Same as Type H, except with automatic control of the humidity.

4.2 The apparatus should consist of a suitable frame within which is located a test chamber, and necessary compartments for housing control and regulating equipment.

4.3 Provision should be made for mounting or supporting the test specimens in a circular rack or drum that is rotated around the arc or arcs. This provides uniform distribution of the radiation on all specimens around the circumference of the rack. It does not, however, improve the distribution of the radiation along the vertical axis.

4.4 Adequate ventilation should be provided in the test chamber to prevent contamination of the specimens from combustion products of the arc.

4.5 The apparatus should include equipment necessary for measuring and controlling the following:

4.5.1 Arc current,

4.5.2 Arc voltage,

4.5.3 Black-panel temperature (Note 3),

[12] Available from American National Standards Institute, 1430 Broadway, New York, NY 10017.

[13] Available from the Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL. 606132 and from Suga Test Instruments Co., Ltd. 4-14, Shinjuku 5-chome, Shinjuku-ku, Tokyo, 160, Japan.

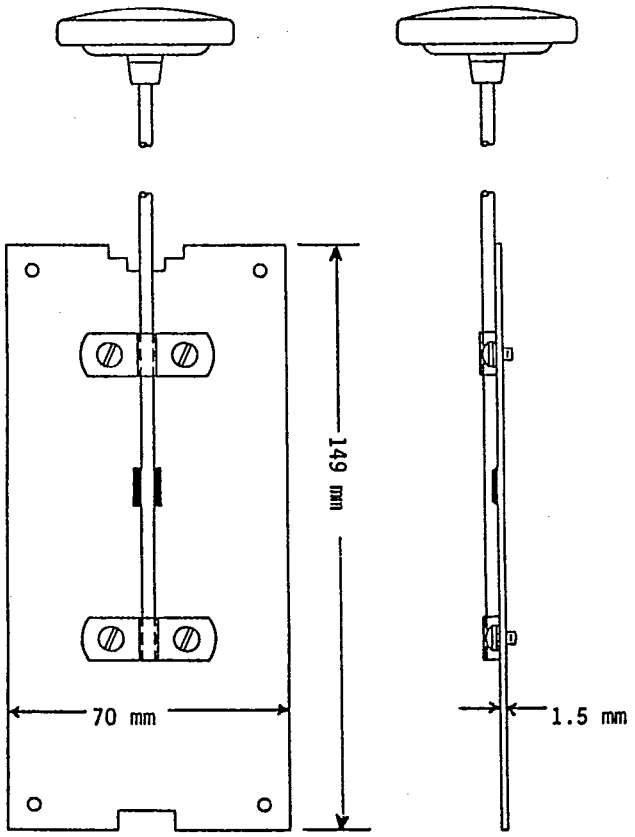


FIG. 2 Black Panel Thermometer Unit Using Dial Type Thermometer

4.5.4 Water-spray pressure,
4.5.5 Operating schedule or cycle,
4.5.6 Exposure time, and
4.5.7 Relative humidity (Types DH, EH, and HH only).

4.6 Types DH, EH, and HH apparatus are equipped with thermostatically actuated vaporizing units for adding moisture to the air as it passes through the conditioning chamber prior to its entry into the test chamber. Type H and some Types D, and E have manually regulated, electrically operated vaporizing units. Relative humidity of the air in the test chamber is calculated from the readings of the wet- and dry-bulb thermometers, either indicating or reporting, whose sensing portion is located in the air stream at its point of exit from the test chamber.

4.7 The black-panel thermometer unit should consist of a stainless steel panel 1 by 70 by 150 mm (.060 by 2.75 by 5.875 in.) to which is mechanically fastened a temperature sensing device. This device shall be capable of measuring temperature to a repeatability of 4 ± 1°C (see Figs. 2 and 3). The face of the panel with the temperature sensing device attached should be finished with two coats of baked-on black enamel selected for its resistance to light and water.

4.8 Detailed requirements and operating conditions of the apparatus are given in Table 1 and Figs. 4 to 6.

5. General Procedure

5.1 Prepare specimens of a suitable size and shape for mounting in the drum or rack of the apparatus in accordance with the detailed requirements specified for the material to be tested.

5.2 Mount the test specimens, except those whose shape or other physical characteristics make it impractical, vertically both above and below the horizontal center line of the source of radiation. To assure that specimens receive the greatest uniformity of radiant exposure, reposition them vertically in a sequence which will provide each specimen equivalent exposure periods in each location. When the exposure interval does not exceed 24 h, each specimen should be located equidistant from the horizontal axis of the arc. For exposure intervals not exceeding 100 h, daily rotation of the specimens is recommended. Other methods of achieving uniform total irradiation may be employed if mutually agreed upon by concerned parties.

5.3 For enclosed arcs only, where physical characteristics do not permit suspension of specimens in a vertical position, expose them horizontally on a rack 165 mm (6.5 in.) below the horizontal center of the source or sources of radiation. Mount the specimens on a circular horizontal rack equipped with turntables, so that each specimen is rotated on its own axis as all of the specimens are rotated around the source or sources of radiation.

5.4 Temperature measurement and control should be based on the black-panel thermometer unit. Support the panel with the thermometer attached in the specimen drum or rack in the same manner as the test specimens so that it will be subjected to the same influences.

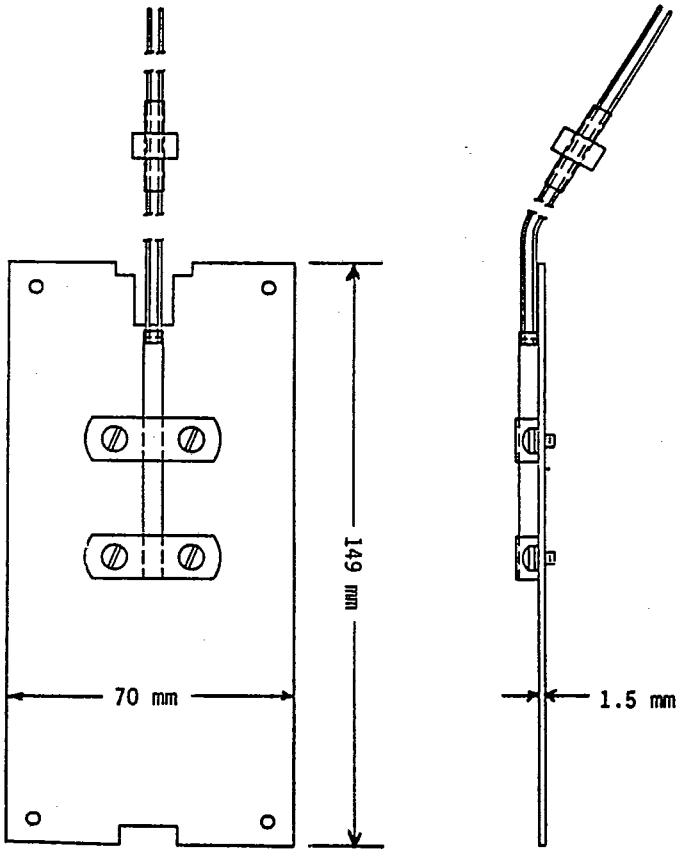


FIG. 3 Black Panel Thermometer Unit Using RTD Thermocouple Sensor

TABLE 1 Detail Requirements and Operating Conditions of Light- and Water-Exposure Apparatus

	Type[A]		
	D, DH	E, EH	H, HH
Line voltage, V:			
208 to 250	X	X	X
Arc voltage, V:			
120 to 145	X		X
48 to 52		X	
Arc current, A:			
15 to 17, ac	X		X
58 to 62, ac		X	
12 to 14, dc	X		X
58 to 62, dc		X	
Carbon electrodes, upper:			
neutral cored or solid[B]	X		X
copper-coated sunshine		X	
Carbon electrodes, lower:			
neutral cored or solid[B]	X		X
copper-coated sunshine[C]			
Flat panels of optical, heat-resistant glass with light transmission properties similar to Fig 7. #7740 Pyrex brand Filter panes[E] (3.0 mm) typically will transmit 1 % at 278 nm, 5 % at 285 nm and 50 % at 306 nm. #7058 Corex brand Filterpanes[F] (2.5 mm) typically transmits 1 % at 252 nm, 5 % at 262 nm and 50 % at 287 nm.		X	
Globe of optical, heat-resistant glass with nominal 1 % cut-off at 275 nm, with an increase in transmission to 91 % at 370 nm.[D]	X		X
Diameter of specimen rack or drum, mm (in.):			X
508 (20)			
762 (30)	X		
960 (37.7)		X	
Speed of rotation of specimen drum or rack:			
1 rpm	X	X	X
Automatic arc feed:			
Solenoid-operated	X		X
Motor-operated		X	
Spray (see figure indicated for arrangement, location, and capacity)	Fig. 4	Fig. 5	Fig. 6

[A] "X" in column indicates application to that type of apparatus.
[B] No. 70 Solid Carbon Electrodes and No. 20 Cored Carbon Electrodes or equivalent available from Atlas Electric Devices Co. or from Suga Test Instruments Co., Ltd.
[C] No. 22 Copper-Coated Sunshine Carbon Electrodes and No. 15.5 Copper-Coated Sunshine Carbon Electrodes or equivalent available from Atlas Electric Devices Co. or from Suga Test Instruments Co., Ltd.
[D] No. 9200-PX Globe or equivalent.
[E] 7740 Pyrex is a tradename for a soda borosilicate glass.
[F] 7058 Corex is a tradename for a potash lithia borosilicate glass.

5.4.1 Program the instrument to operate in a continuous light-on mode. Fill specimen rack with blanks and the black-panel thermometer. Operate in this mode while establishing the black-panel temperature according to the manufacturer's instructions. Allow the machine to come to operating temperature and equilibrate (allow 4 h of continuous running time and between 25 to 35 min after a spray cycle). Unless other temperatures and tolerances are specified in the applicable ASTM test method or detailed material specifications, the black-panel temperature shall be 63 ± 2.5°C (145 ± 5°F) (Note 3).

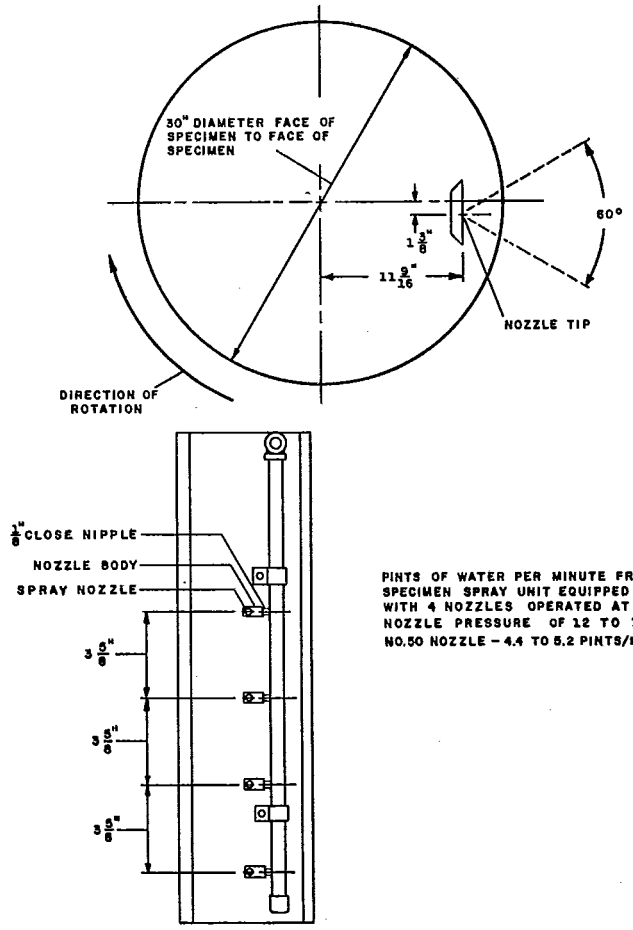
5.4.2 Compare the black-panel temperature with the specification. If the black-panel temperature is within 2.5 °C or 5°F of specification, no adjustment is necessary. If the observed temperature difference is greater than 2.5°C or 5°F, adjust the temperature controller and recheck the black-panel temperature during the next cycle. It is recommended that this procedure be performed after every 200 h of machine operation.

NOTE 3—Where desired, other black-panel temperatures may be employed provided they are specifically noted in the report of test results. Instructions for adjusting the intensity of the arc and the fading rate are supplied with the apparatus or are available upon request from the manufacturer. Consideration should always be given to installing the instrument in a room where the temperature and humidity conditions are controlled. The magnitude of the effects due to variation in the air supply can only be partially determined when the intake air is not controlled.

5.5 The water from the specimen spray should strike the test specimens in the form of a fine spray equally distributed over the test specimens. Unless otherwise specified in the applicable ASTM test method or detailed material specification, the water pressure, number, and type of nozzles should be in accordance with the detailed requirements for the various types of apparatus as indicated in Figs. 4 to 6. The pH of the water shall be 6.0 to 8.0, contain less than 1 ppm solids and leave no objectional deposits or stain on the specimens. The presence of very low levels of silicates in spray water has been shown to leave deposits on some specimens. It is recommended that the temperature of the water should be 16 ± 5 °C (60 ± 9°F). Recirculation is not recommended and must not be done unless the recirculated water is treated to meet the above requirements.

5.5.1 Set the cycle control unit cam until the machine is in a spray cycle. Observe the spray manifold. All spray heads should spray a stream of mist or water which reaches the panel surface. If any of the spray heads are not satisfactory, remove the spray manifold and clean each spray head. Install the manifold and recheck the spray operation.

5.6 The flat glass filter panes used in Types E or EH devices cannot be used for more than 2000 h. Monitor age and position of the filter panes so that the oldest can be



Metric Equivalents

mm	3.3	34.9	92.1	101.6	293.2	762	83 to 124 kPa	2.5 to 2.9 dm^3
in.	⅛	1⅜	3⅝	4	11⁹⁄₁₆	30	12 to 18 psi	4.4 to 5.2 pt

FIG. 4 Specimen Spray Arrangement for Types D and DH Apparatus

removed every 250 h. Filter globes used in type D or DH devices cannot be used for more than 2000 h. Replace the oldest of the filter globes every 1000 h. Replace the filter globe in Type H or HH devices after 2000 h of use or when pronounced discoloration or milkiness develops. Clean filters each day by wiping with a clean, dry non-abrasive cloth or towel. Filters can also be cleaned by washing with water, or a solution of detergent and water.

5.7 Unless otherwise specified in the applicable ASTM test method or detailed material specifications, operate Types E and EH apparatus with the filters in place and with the carbon electrodes specified in Table 1. If operated without filters or with other types of carbon electrodes, state this in the report of test results.

METHOD 1—CONTINUOUS EXPOSURE TO LIGHT AND INTERMITTENT EXPOSURE TO WATER SPRAY

6. Apparatus

6.1 The apparatus may be any of the recommended type equipped with water spray nozzles.

6.2 Program the instrument for continuous light and intermittent water spray according to the manufacturer's instructions. Since there are numerous light and water spray cycles which can be used, the cycle program selected must be by mutual agreement among the interested parties. Historical convention has established a cycle of 102 min of light followed by 18 min of light and water spray. This cycle permits the attainment of the maximum black-panel temperature during the light only portion of the exposure.

6.2.1 When testing the effects of photodegradation only, the water spray may be omitted (refer to Method 3).

6.3 In Types DH, EH and HH apparatus, dry and wet bulb temperature controls, humidifier and immersion heater controls should be adjusted as specified.

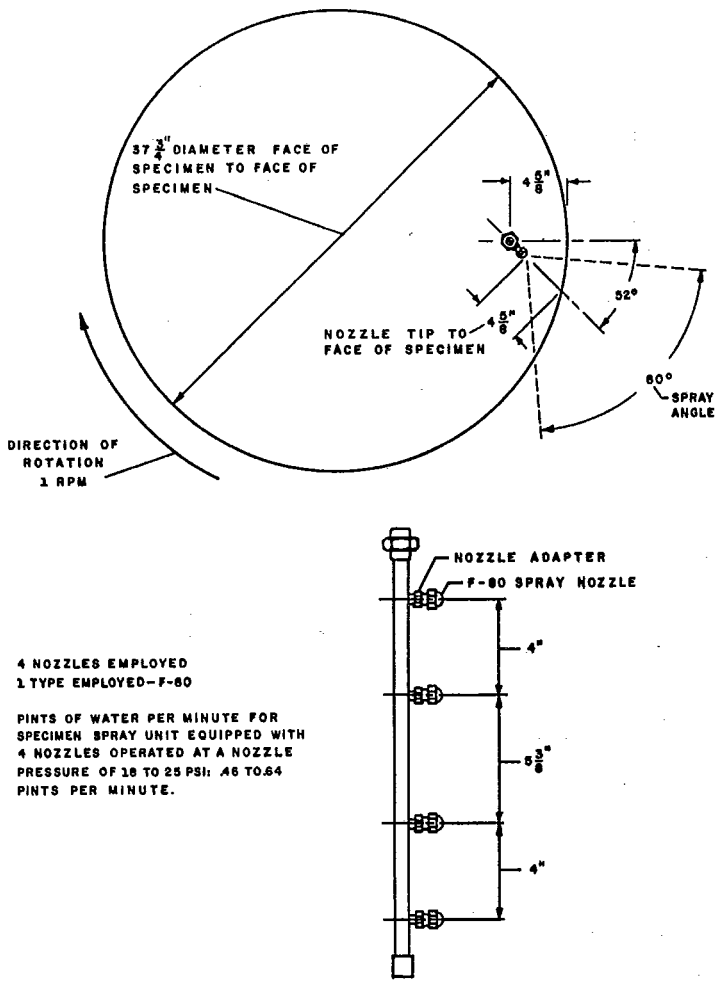
6.4 In Type H and in Types D and E with humidifier, humidity may be adjusted but not controlled.

METHOD 2—ALTERNATIVE EXPOSURE TO LIGHT AND DARKNESS AND INTERMITTENT EXPOSURE TO WATER SPRAY

7. Apparatus

7.1 The apparatus shall be Type DH, EH and HH apparatus with automatic humidity control and water spray nozzles.

7.2 Operation during the light on period should be as described in Section 5.



Metric Equivalents

mm	101.6	117.5	136.5	266.7	959	124 to 172 KPa	0.26 to 0.36 dm^3
in.	4	4⅝	5⅜	10½	37¾	18 to 25 psi	0.46 to 0.64 pt

FIG. 5 Specimen Spray Arrangement for Types E and EH Single Open-Flame Sunshine Carbon-Arc Lamp Apparatus

7.2.1 Separate controls for temperatures and humidification may be adjusted during the dark period for automatic control as the cycle alternates from light to dark. In Type EH apparatus, a spray rack to cool the specimens by wetting the unexposed back surface can result in development of condensation on the exposed specimen surface during the dark interval.

7.3 All Types DH, EH, H, HH and some Type D, and E may be programmed to operate with alternating light and dark intervals without control of relative humidity.

METHOD 3—CONTINUOUS EXPOSURE TO LIGHT WITHOUT WATER SPRAY

8. Apparatus

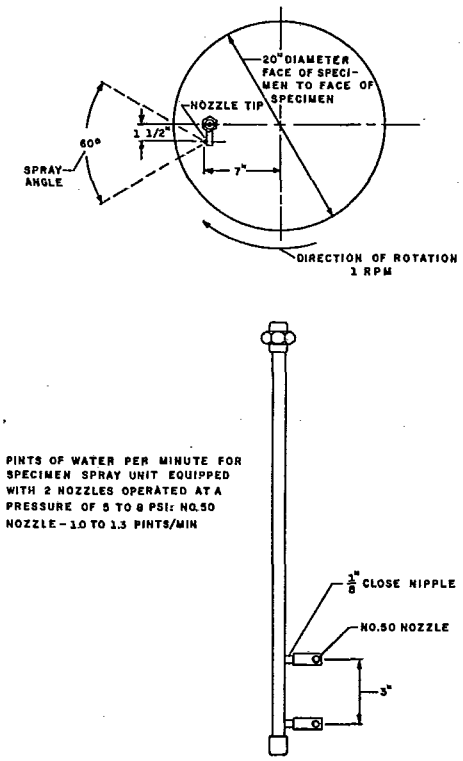
8.1 The apparatus shall be Type D or DH, E or EH, H or HH light-exposure devices programmed for continuous light only, according to the manufacturer's instructions.

8.2 Adjust the controls on the apparatus so that the black panel temperature is 63 ± 2.5°C (145 ± 5°F) (Note 3), and for a relative humidity of 30 ± 5 % in devices with automatic humidity control.

8.3 Expose the materials to be tested as determined by mutual agreement among the concerned parties or, when not otherwise specified, in accordance with one of the following:

8.3.1 *Versus One AATCC Blue Wool Lightfastness Standard*—Expose the test specimen and any mutually agreed upon AATCC Blue Wool Lightfastness Standard partially masked until the difference between its masked and unmasked portion exhibits a color change equal to Step 4 of the ISO Gray Scale. Report the results by any mutually agreed-upon method of measuring change in the test specimen.

8.3.2 *Versus Set of AATCC Blue Wool Lightfastness Standards*—Expose the test specimen and a set of AATCC Blue Wool Lightfastness Standards partially masked until a maximum permissible amount of change, as determined by specified or mutually agreed-upon method of measurement, occurs in the test specimen. Assign it a classification number equal to that of the numbered standard that most nearly exhibits a change in color equal to Step 4 on the ISO Gray Scale. Where one standard shows a color change greater than Step 4 and the next higher number standard shows less than a Step 4 color change, an intermediate or half-grade rating may be used.



Metric Equivalents

3.2 mm	⅛ in.
38.1 mm	1½ in.
76.2 mm	3 in.
88.9 mm	3½ in.
508 mm	20 in.
34 to 55 kPa	5 to 8 psi
0.56 to 0.73 dm^3	1.0 to 1.3 pt

FIG. 6 Specimen Spray Arrangement for Types H and HH Single Enclosed Carbon-Arc Lamp Apparatus

8.3.3 *Versus Other Standard Sample*—Expose the test specimen and any mutually agreed-upon standard sample until either shows an agreed-upon amount of change when measured by any mutually agreed-upon method. Report the results on the basis of a comparison of the specimen with the standard sample.

METHOD 4—ALTERNATE EXPOSURE TO LIGHT AND DARKNESS WITHOUT WATER SPRAY

9. Apparatus

9.1 The apparatus shall be Type H or HH programmed to a predetermined cycle of light and darkness by turning off the carbon arc.

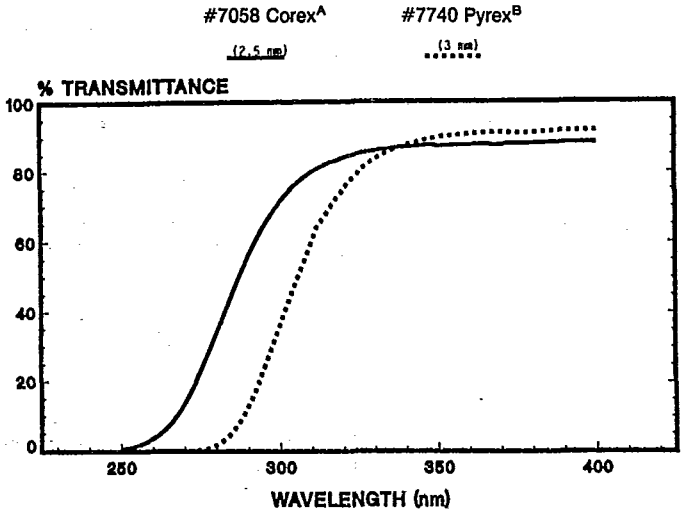


FIG. 7 Representative UV Transmission Curves for 2.5 mm and 3 mm Filter Glasses[A]

[A] # 7058 Corex is a tradename for a potash lithia borosilicate glass.
[B] #7740 Pyrex is a tradename for a soda borosilicate glass.

9.2 The procedure for Method 4 is the same as specified for Method 3 except that the following light-dark interval shall replace the continuous light condition of Method 3.

9.2.1 Unless otherwise specified by the detailed requirements for the type of material being tested, adjust the controls of the apparatus so that it produces a cycle of 1 h of darkness followed by 3.8 h of light. Repeat this cycle for the duration of the test. During the light-on period the black-panel temperature, at equilibrium, shall be 63 ± 2.5°C (145 ± 5°F). During the period while the light is off, the black-panel temperature will progressively drop until it is in equilibrium with the air in the test chamber. The relative humidity of the air at the face of the test specimens will progressively rise during the light-off period until equilibrium is reached.

10. Report

10.1 The report shall include the following:
10.1.1 Type and model of exposure device,
10.1.2 Type of light source,
10.1.3 Type, thickness, and age of filters,
10.1.4 Elapsed exposure time,
10.1.5 Light and dark-water-humidity cycle employed,
10.1.6 Operating black-panel temperature,
10.1.7 Operating relative humidity,
10.1.8 Type of spray water,
10.1.9 Type of spray nozzle, and
10.1.10 Specimen relocation procedure.

APPENDIX

(Nonmandatory Information)

X1. OBSOLETE APPARATUS

X1.1 The following types of apparatus are no longer commercially available and should be considered obsolete. Although existing units may be operated in accordance with Methods 1 and 3 of this practice, results may not be comparable with those obtained in superseding models.

X1.1.1 *Type A*—Single enclosed carbon-arc lamp apparatus*

with a 762 mm (30 in.) diameter specimen drum rotating at 1 rpm, automatic control of temperature and cycle, and no automatic control of the humidity.

X1.1.2 *Type AH*—Same as Type A, except with automatic control of humidity.

X1.1.3 *Type B*—Single enclosed carbon-arc lamp apparatus, 3 RPH, 762 mm (30 in.) diameter specimen drum, automatic temperature control, no automatic humidity control. Last manufactured in 1955.

X1.1.4 *Type C*—Same as Type B but without automatic temperature control. Last manufactured in 1960.

X1.1.5 *Type F*—Single open flame carbon arc lamp apparatus, 0.5 rph, 960 mm (37.75 in.) diameter specimen rack with vertical specimen mounting. No automatic control of temperature or humidity. Last manufactured in 1950.

X1.1.6 *Type G*—Same as Type F but with inclined specimen rack.

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