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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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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.

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 822, D 904, D 1499, D 3361, D 3815, E 765 and Test Methods C 732, C 734, C 741, D 529, 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 all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

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 Test Method for Accelerated Weathering Test Conditions and Procedures Bituminous Materials (Carbon-Arc Method)[3]

D 750 Test Method for Rubber Deterioration in Carbon-Arc 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 859 Test Methods for Silica in Water[6]

D 904 Practice for Exposure of Adhesive Specimens to Artificial Light[7]

D 1293 Test Methods for pH of Water[6]

D 1499 Practice for Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics[8]

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 Test Methods for Evaluating the Lightfastness and Weatherability of Printed Matter[9]

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[10]

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[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.

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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 G23 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 11.01.
[7] *Annual Book of ASTM Standards*, Vol 15.06.
[8] *Annual Book of ASTM Standards*, Vol 08.01.
[9] *Annual Book of ASTM Standards*, Vol 06.02.
[10] *Annual Book of ASTM Standards*, Vol 04.03.

D 3815 Practice for Accelerated Aging of Pressure-Sensitive Tapes by Carbon-Arc Exposure Apparatus[11]
D 4517 Test Methods for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy[12]
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E 765 Practice for Evaluation of Cover Materials for Flat Plate Solar Collectors[13,14]

2.2 *AATCC Standards:*[15]
Blue Wool Lightfastness
Test Method 16A Colorfastness to Light, Carbon-Arc Lamp, Continuous Light

2.3 *ISO Standard:*[16]
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 [17]

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),
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

[11] *Annual Book of ASTM Standards*, Vol 15.09.
[12] *Annual Book of ASTM Standards*, Vol 11.02.
[13] *Annual Book of ASTM Standards*, Vol 12.02.
[14] *Annual Book of ASTM Standards*, Vol 14.02.
[15] Available from the Secretary, American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.
[16] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.
[17] 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.

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

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 Fig. 2 and Fig. 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. 4-6.

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 ensure 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.

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 *Specimen Water Spray*:

5.5.1 In Types D, E, and H apparatus, use the type and number of spray nozzles recommended by the manufacturer.

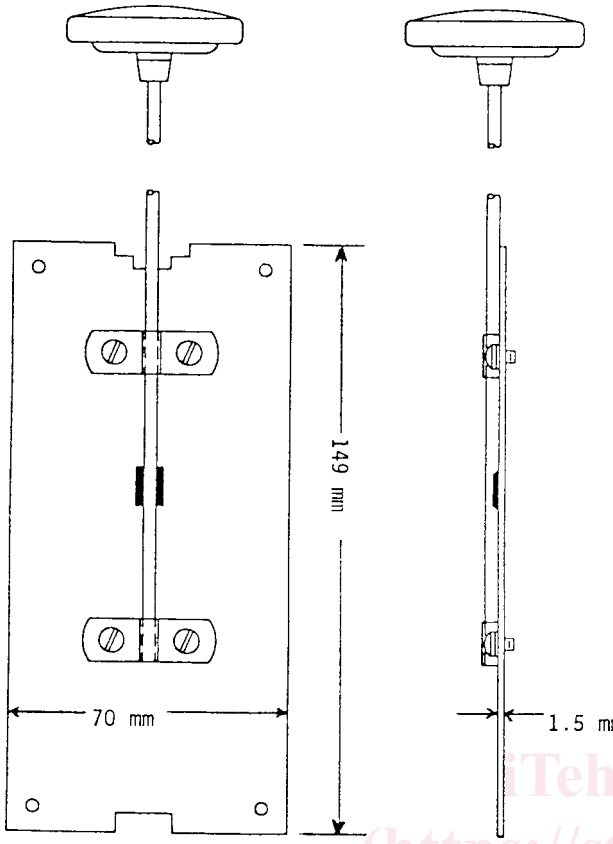

FIG. 2 Black Panel Thermometer Unit Using Dial Type Thermometer

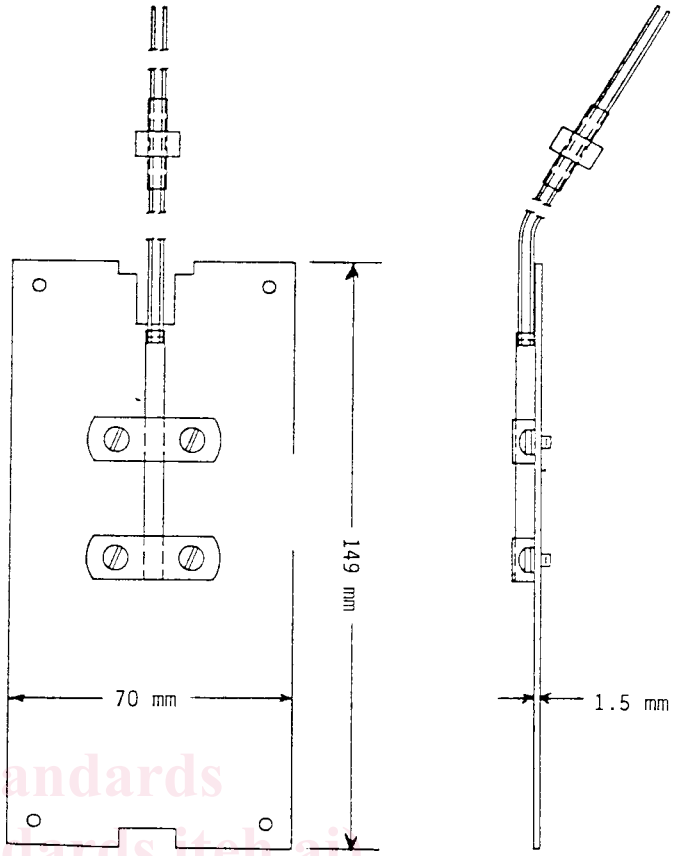

FIG. 3 Black Panel Thermometer Unit Using RTD Thermocouple Sensor

Unless otherwise required, operate Type D spray nozzles at 84 to 124 kPa (12–18 psi), Type E nozzles at 124 to 172 kPa (18 to 25 psi), and Type H nozzles at 35 to 55 kPa (5 to 8 psi) measured at the nozzle. Unless otherwise required, use the spray nozzle configuration shown in Figs. 4-6. Pass the specimens through the spray once in each minute or revolution of the rack during the spray cycle.

5.5.2 The spray water must strike the test specimens in the form of a fine spray equally distributed over the specimens. Check by setting the device to operate in a spray cycle. Observe the spray manifold. All spray heads should produce a fine spray or mist which reaches specimens mounted on the specimen drum. 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.

5.5.3 Water used for specimen spray shall have a pH of 6.0 to 8.0. Measure pH according to Test Methods D 1293. Typically, the temperature of the water used for specimen spray is near the ambient temperature of the laboratory in which the devices are operated (25± 5°C). If water used for specimen spray is chilled, specimens can be exposed to large, rapid temperature changes that may not be typical of exterior exposures.

5.5.4 *Water Purity*:

5.5.4.1 The purity of water used for specimen spray is very important. Without proper treatment to remove cations, anions, organics and particularly silica, exposed panels will develop spots or stains that do not occur in exterior exposures.

5.5.4.2 Water used for specimen spray shall leave no objectional deposits or stains on the exposed specimens. It is strongly recommended that the water contain a maximum of 1 ppm solids and a maximum of 0.2 ppm silica. Silica levels should be determined using the procedures defined in Test Methods D 859 or Test Method D 4517. Prepackaged analysis kits are commercially available that are capable of detecting silica levels of less than 200 parts per billion (ppb). A combination of deionization and reverse osmosis treatment can effectively produce water with the desired purity. If the spray water used is above 1 ppm solids, the solids and silica levels must be reported. Recirculation of water used for specimen spray is not recommended and must not be done unless the recirculated water meets the above requirements.

5.5.4.3 If specimens are found to have deposits or stains after exposure in the apparatus, the water purity must be checked to determine if it meets the requirements above. On some occasions, exposed specimens can be contaminated by deposits from bacteria that can grow in the purified water used for specimen spray. If bacterial contamination is detected, the entire system used for specimen water spray must be flushed with a chlorinating solution such as sodium hypochlorite and thoroughly rinsed prior to resuming exposures. Although it doesn't always correlate with silica content, it is recommended that resistivity of water used for specimen spray be continuously monitored and that exposures be discontinued whenever the resistivity falls below one megohm.

5.5.4.4 When the water purity requirements above are met