INTERNATIONAL

Designation: ~~G7/G7M – 13~~ G7/G7M – 21

Standard Practice for ~~Atmospheric Environmental Exposure Testing of Nonmetallic~~ Natural Weathering of Materials[1]

This standard is issued under the fixed designation G7/G7M; 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 U.S. Department of Defense.

1. ~~Scope~~ Scope*

1.1 This practice covers procedures to be followed for direct exposure of ~~nonmetallic~~ materials to the environment. ~~When originators of a weathering test have the actual exposure conducted by a separate agency, the specific conditions for the exposure of test and control specimens must be clearly defined and mutually agreed upon between all parties.~~Typically, this testing is performed on exposure racks tilted at a commonly-used tilt angle from the horizontal (such as 5 or 45 degrees) and facing the equator. Other exposure orientations can be used.

1.2 ~~For exposures behind glass, refer to Practice~~This practice is not intended for the ~~G24.~~corrosion testing of bare metals, or for testing behind glass.

1.2.1 For corrosion testing, refer to Practice G50

1.2.2 For exposures behind glass, refer to Practice G24

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4 This practice is technically equivalent to the parts of ISO ~~877~~ 877-1 and -2 that describe direct exposures of specimens to the environment.

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

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] This practice is under the jurisdiction of ASTM Committee G03 on Weathering and Durability and is the direct responsibility of Subcommittee G03.02 on Natural and Environmental Exposure Tests.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3614 Guide for Laboratories Engaged in Sampling and Analysis of Atmospheres and Emissions
~~E41~~E772 Terminology ~~Relating to Conditioning~~of Solar Energy Conversion ~~(Withdrawn 2019)~~
E824 Test Method for Transfer of Calibration From Reference to Field Radiometers
~~E913 Method for Calibration of Reference Pyranometers With Axis Vertical by the Shading Method (Withdrawn 2005)[3]~~
~~E941 Test Method for Calibration of Reference Pyranometers With Axis Tilted by the Shading Method (Withdrawn 2005)[3]~~
G24 Practice for Conducting Exposures to Daylight Filtered Through Glass
G50 Practice for Conducting Atmospheric Corrosion Tests on Metals
G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials
G130 Test Method for Calibration of Narrow- and Broad-Band Ultraviolet Radiometers Using a Spectroradiometer
G167 Test Method for Calibration of a Pyranometer Using a Pyrheliometer

2.2 *ISO Standards:*[3]

ISO 877 Plastics—Methods of Exposure to Direct Weathering; to Weathering Using Glass-Filtered Daylight, and to Intensified Weathering by Daylight Using Fresnel Mirrors
ISO 9370 Plastics—Instrumental Determination of Radiant Exposure in Weathering Tests—General Guidance and Basic Test Method
ISO 9060:2018 Solar Energy – Specification and Classification of Instruments for Measuring Hemispherical Solar and Direct Solar Radiation

~~2.3 *ASTM Adjuncts:*~~
~~A Test Rack[5]~~

2.3 *Other Standards:*

WMO – No. 8, "Guide to Meteorological Instruments and Methods of Observation," seventh edition, World Meteorological Organization, Geneva, Switzerland, 2008

3. Terminology

3.1 *Definitions*—The definitions given in ~~Terminology~~Terminologies ~~E41~~G113 and ~~Terminology G113~~E772 are applicable to this practice.

4. Significance and Use

4.1 The relative durability of materials in natural exposures can be very different depending on the location of the exposure because of differences in ultraviolet (UV) radiation, relative humidity, time of wetness, temperature, wet-dry cycling, freeze-thaw cycling, pollutants, and other factors. Therefore, it cannot be assumed that results from one exposure in a single location will be useful for determining relative durability in a different location. Exposures in several locations with different climates which represent a broad range of anticipated service conditions are recommended.

4.2 Because of year-to-year climatological variations, results from a single exposure test cannot be used to predict the absolute rate at which a material degrades. Several ~~years of repeat exposures~~ exposures, repeated over several years are needed to get ~~an "average"~~a representative test result for a given location.

4.3 Solar ~~ultraviolet~~UV radiation varies considerably as a function of time of year. This can cause large differences in the apparent rate of degradation in many ~~polymers.~~materials. Comparing results for materials exposed for short periods (less than one year) is not recommended unless materials are exposed at the same time in the same location.

4.4 ~~Defining exposure periods in terms of~~ The duration of natural weathering tests is often based on time (24 months for example). The variability between different exposures can be reduced by using a duration based on total solar or ~~solar-ultraviolet radiant energy can reduce variability in results from separate exposures. Solar ultraviolet~~solar UV radiant exposure. Solar UV measurements are typically made using instruments which record broadband UV (for example, 295 to 385 ~~nm) or narrow band UV,~~ nm), as described in 7.2.4 ~~and 7.2.5~~. An inherent limitation in ~~solar-radiation measurements is that they do not reflect the~~

[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.

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

FIG. 1 Typical Exposure Rack

~~effects of temperature and moisture, which~~ timing a weathering test based solely on solar-radiation measurements is that temperature and moisture may also influence the rate or type of degradation.

4.5 The design of the exposure rack, the location of the specimen on the exposure rack, and the ~~type or color~~ type, color, and emissivity of adjacent specimens can affect specimen temperature and time of wetness. In order to minimize variability caused by these factors, ~~it is recommended that test specimens, control specimens, and any applicable~~ control and weathering reference material ~~be placed on a single test panel or on test panels placed adjacent to each other~~specimens should be placed adjacent to test specimens during exposure.

4.6 It is ~~strongly~~ recommended that at least one control ~~material~~specimen be part of any exposure evaluation. When used, the control ~~material~~specimen shall meet the requirements of Terminology G113, and be of similar composition and construction compared to test specimens. It is preferable to use two control ~~materials,~~specimens, one with relatively good durability and one with relatively poor durability. Unless otherwise specified, use at least two replicate specimens of each test and control ~~material~~specimen being exposed. Control ~~materials~~specimens included as part of a test shall be used for the purpose of comparing the performance of test ~~materials~~specimens relative to the controls.

5. Test Sites, Location of Test Fixtures, and Exposure Orientation

5.1 *Test Sites*—Exposures can be conducted in any type of climate. However, in order to get more rapid indications of outdoor durability, exposures are often conducted in locations that receive high levels of solar radiation, temperature, and moisture. Typically, these conditions are found in hot desert and subtropical or tropical climates. Known attributes of the use environment should be represented by the locations selected for outdoor durability evaluation. For example, if the use environment for the product being evaluated will include ~~freeze/thaw~~freeze-thaw cycling, specimen exposure in a northern ~~temperature~~temperate climate is recommended. In addition, exposures are often conducted in areas where specimens are subjected to salt air (seashore) or industrial pollutants.

5.1.1 Unless otherwise specified, ~~test fixtures or racks shall be located in cleared areas. Unless otherwise specified,~~ the area beneath and in the vicinity of the test fixtures shall have ground cover typical of the climatological area where the exposures are being conducted. In desert areas, the typical ground cover is often gravel to control dust, and in most temperate or subtropical areas, the typical ground cover is low-cut grass. The type of ground cover at the exposure site shall be indicated in the test report. If test fixtures are placed over ground covers not typical of the climatological area (for example, rooftops, concrete or asphalt), specimens may be subjected to different environmental conditions than if using typical ground cover or exposing at ground level. These differences may affect test results.

5.2 The lowest row of specimens on a test fixture or rack shall be positioned at least 0.45 m [18 in.] above the surface of the ground and shall not contact vegetation. This will also minimize the possibility that damage that might occur during ~~area~~grounds maintenance.

5.3 Test fixtures shall be placed in a location so that there is no shadow on any specimen when the sun's angle of elevation above the horizon is greater than 20°.

5.4 *Exposure Orientation*—Unless otherwise specified, exposure racks shall be oriented so that specimens face the equator. Specimens can be exposed at ~~a number of different orientations~~ any orientation or "exposure ~~angles"~~angle" in order to simulate end-use conditions of the material being evaluated. Typical exposure angles are as follows:

5.4.1 *Latitude Angle*—Exposure rack is positioned so that the exposed surface of specimens are at an angle from the horizontal that is equal to the ~~geographical~~ latitude of the exposure ~~site.~~site and facing the equator.

5.4.2 *45°*—Exposure rack is positioned so that the exposed specimens are at an angle of 45° from the ~~horizontal.~~ horizontal facing the equator. This is the most commonly used exposure orientation.

5.4.3 *90°*—Exposure rack is positioned so that the exposed specimens are at an angle of 90° from the ~~horizontal.~~horizontal facing the equator.

5.4.4 *5°*—Exposure rack is positioned so that the exposed specimens are at an angle of 5° from the ~~horizontal.~~ horizontal facing

FIG. 2 Backed Exposure Rack

the equator. This angle is preferred over horizontal exposure to avoid standing water on ~~specimens being exposed.~~ exposed specimens. This exposure angle typically receives the highest levels of solar ~~radiation~~ radiant exposure during mid-summer and is used to ~~test~~expose materials that would normally be used in horizontal or nearly horizontal applications.

NOTE 1—Exposures conducted at less than the site latitude typically receive more ~~ultraviolet radiation~~ UV radiant exposure than exposures conducted at larger angles.

5.4.5 Any other angle that is mutually agreed on by all interested parties may be used. In some instances, exposures facing directly away from the equator or some other specific direction may be desired. The test report shall contain the ~~exact~~ angle and specimen orientation.

5.5 *Specimen Backing*—Three types of specimen backing can be used. Avoid comparisons between materials degradation unless all exposures were conducted with the same specimen backing.

5.5.1 *Unbacked Exposures*—Specimens are exposed so that the portion of the test specimen being evaluated is subjected to the effects of the weather on all sides. For materials that deform easily during exposure, a wire mesh can be used to provide support and prevent deformation or distortion.

5.5.2 *Backed Exposures*—Specimens are attached to a solid substrate so that only the front surface is exposed. Surface temperatures of specimens in backed exposures will be higher than for specimens subjected to unbacked exposures. In some cases, the substrate is painted black, which produces significant differences in surface temperature compared to exposures conducted on unpainted ~~substrate.~~substrates. This can cause large differences in degradation rates when compared to backed exposures conducted on unpainted substrates.

5.5.3 *Black Box Exposure*—Specimens are attached to the front face of a black painted aluminum box (see 6.2.3 and Fig. 3). The specimens form the top surface of the box. If there are not enough test specimens to completely cover the top surface, open areas shall be filled with black painted sheet metal panels so that the box is completely closed.

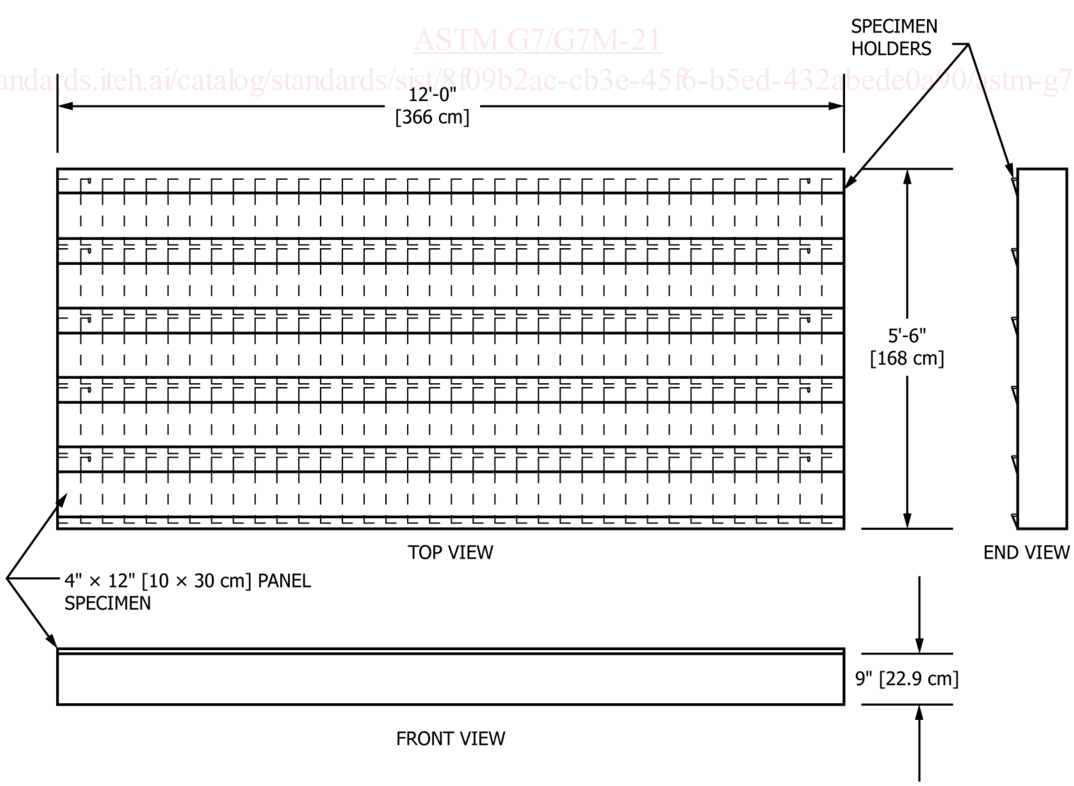

FIG. 3 Black Box

FIG. 4 Black Box in Use

6. Construction of Test Fixtures (Exposure Racks)

6.1 *Materials of Construction*—All materials used for test fixtures shall be noncorrodible without surface treatment. Aluminum Alloys 6061T6 or 6063T6 have been found suitable for use in most locations. Properly primed and coated steel is suitable for use in desert areas. Monel has been found suitable in highly corrosive areas. Untreated wood is acceptable in desert areas but may pose maintenance problems in other areas. (See Fig. 1.)

6.1.1 For backed exposures (see 6.2.2 and Fig. 2), use exterior-grade plywood to form a solid surface to which specimens are directly attached. Replace the plywood when there is any warping or distortion that changes the orientation of the specimens, or when there are visible signs of delamination or fiber separation. Medium-density overlay (MDO) or high-density overlay (HDO) plywood types are satisfactory substrates and require less frequent replacement than plywood with no overlay. The edges of the plywood should be sealed with a durable paint to prevent delamination. The type and thickness of plywood used shall be described in the test report. Other substrates can be used if agreed upon between interested parties.

6.2 *Test Fixture Design*—Test racks shall be constructed to hold specimens or specimen holders of any convenient width and length. Racks shall be constructed so that any contamination from specimens higher on the fixture cannot ~~directly run down onto~~ contaminate specimens in lower positions.

6.2.1 *Unbacked Exposures*—Test racks shall be constructed so that most of the test specimen is exposed to the effects of the weather on all sides. Specimens are attached to the test fixture at the top or bottom, or both, using clamping devices, properly spaced slots, or mechanical fasteners. The method of attachment shall not prevent expansion and contraction of specimens caused by temperature or moisture. Use fastening devices for attaching specimens to the test fixture that will not ~~corrode or degrade and~~ corrode, degrade, or contaminate the specimens. Aluminum, ~~properly~~ galvanized steel, or ~~stainless steel~~ stainless-steel fasteners are recommended.

6.2.2 *Backed Exposures*—Test racks shall be constructed so that specimens are attached to a plywood substrate. The thickness of the plywood and type of coating used, if any, shall be agreed upon by all interested parties and must be reported.

NOTE 2—Backed exposures as described in this standard are not insulated exposures. For some applications such as outdoor exposure tests for roofing products, a layer of insulation material is attached behind the solid substrate to which specimens are attached. Insulated exposures of this type produce higher specimen temperatures than those that would be seen on backed exposures conducted according to this practice.

6.2.3 *Black Box Exposures*—An aluminum box 0.23 m [9 in.] deep with the outside surface painted black. The top surface is open and fitted with mounting strips to hold specimens firmly in place. Two types of black boxes are in common usage. One measures approximately 1.7 m [5.5 ft] high and 3.7 m [12 ft] wide and the other measures 1.5 m [5 ft] high and 1.8 m [6 ft] wide. Fig. 3 shows the design and dimensions for an acceptable black box. Fig. 4 shows a typical black box in use. All exposure positions on a black box shall be filled with either test or control specimens or blank panels. Specimens for black box exposure which are not flat shall be attached to a flat panel before mounting in the exposure rack.

7. Instrumentation

7.1 Unless otherwise specified, instruments for determining climatological data during the exposure period shall be operated within 1000 m of the test racks. Data obtained shall be reported if requested as part of the results of a test.

7.2 Instruments for recording the following are recommended:

7.2.1 *Ambient Temperature (Daily Maximum and Minimum)*—Instruments used for recording ambient temperature shall be a thermocouple ~~(Type~~(Types T or ~~J),~~ J are recommended), a thermistor, or a resistance temperature device (RTD). Any instrument used shall have a current calibration traceable to ~~the~~a National Metrology Institute ~~for Standards and Technology (NIST) and~~ (NMI) and must be calibrated no less often than every twelve months. Instruments shall be mounted inside a white ventilated enclosure.

7.2.2 *Relative Humidity (Daily Maximum and Minimum)*—Instruments used for recording relative humidity must have a current calibration traceable to ~~NIST.~~ a National Metrology Institute (NMI). Instruments shall be mounted inside a white ventilated enclosure.

7.2.3 *Total Solar Radiation*—For measurement of total solar radiation, use a pyranometer meeting either ISO 9060:2018 Class A or B requirements or WMO (World Meteorological Organization) High Quality or Good Quality specification. Calibrate the pyranometer at the ~~tilt-angle at which it will be used in suitable radiometric units.~~ orientation and tilt angle planned for deployment. Modern pyranometer manufacturers recommend calibration intervals of two years but no more frequent than once annually. Calibrate the pyranometer against an instrument traceable to the WRR (World Radiometric ~~Reference) at least annually.~~ Reference). Perform this comparison either by comparison to a suitable reference pyranometer in accordance with Test Method E824 or by the direct shading disk calibration in accordance with Test Method ~~E941~~G167 ~~(for axis vertical and tilted respectively).~~ . If at tilt calibrations are not available, correct for tilt angle effects in accordance with the instructions provided by the radiometer manufacturer. If requested, a certificate of calibration shall be provided with all total solar irradiance measurements.

NOTE 3—Most radiometers are calibrated and sold as systems, complete with read out means which show appropriate units. In such cases radiometers are calibrated in Wm^{-2}. ~~For radiometers~~ Radiometers without direct ~~ready-out, calibration units~~ read-out are typically calibrated in Wm^{-2}~~V~~μV^{-1}.

NOTE 4—ISO 9370 also provides procedures for calibrating radiometers used for measuring total solar or solar ultraviolet radiation.

7.2.4 *Total Solar Ultraviolet Radiation*—For measurement of total solar ~~ultraviolet~~UV radiation, use a radiometer that measures ~~ultraviolet~~UV radiation in the wavelength region from ~~at least~~ 295 to 385 nm. The total solar ~~ultraviolet~~UV radiometer shall ~~be calibrated~~ have a current calibration against a standard source of spectral irradiance traceable to ~~NIST, or other national standards laboratory,~~ a National Metrology Institute (NMI). The instrument used to measure total solar UV radiation shall be calibrated at least annually. Test Method G130 describes calibration of narrow and broad-band ~~ultraviolet~~UV radiometers using a spectroradiometer. Furthermore, transfer of calibration from reference to field radiometer can be performed in accordance with Test Method E824. The calibration shall be in suitable radiometric units, preferably in watts per square ~~metre~~meter per volt ($Wm^{-2}V^{-1}$). If requested, a certificate of calibration shall be provided with all total solar ~~ultraviolet~~UV irradiance measurements.

NOTE 5—Traditionally, UV radiometers measuring 295 to 385 nm have been used. Use of radiometers with different integrated wavelength ~~response~~responses (for example, those that respond to 400 nm) can result in recorded UV radiant exposures that ~~are up to 10 to 15 % higher.~~will be different.

7.2.5 *Narrow-Band Solar ~~Ultraviolet~~UV Radiation*—~~Narrowband~~ Though not common, narrowband radiometers can be used to measure specific wavelength bands of solar ~~ultraviolet~~UV radiation in the UVB or UVA regions. Unless otherwise specified, the narrow-band radiometers shall ~~be calibrated~~ have a current calibration against a standard source of spectral irradiance at least