



Standard Practice for Outdoor Weathering of Plastics¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice is intended to cover procedures for the exposure of plastic materials to weather.

NOTE 1—See Practice G 24 for aging under glass.

1.2 This practice is limited to the method by which the material is to be exposed and the general procedure to be followed. It is intended for use with finished articles of commerce as well as with all sizes and shapes of test specimens.

1.3 Means of evaluation of the effects of weathering will depend on the intended use for the test material.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.*

NOTE 2—This standard and ISO 877.2-1991, Method A, are technically equivalent.

2. Referenced Documents

2.1 ASTM Standards:

D 883 Terminology Relating to Plastics²

D 1600 Terminology for Abbreviated Terms Relating to Plastics²

D 1898 Practice for Sampling of Plastics³

E 772 Terminology Relating to Solar Energy Conversion⁴

E 824 Test Method for Transfer of Calibration from Reference to Field Radiometers⁵

E 913 Method for Calibration of Reference Pyranometers with Axis Vertical by the Shading Method⁵

E 941 Test Method for Calibration of Reference Pyranometers with Axis Tilted by the Shading Method⁵

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials⁵

G 24 Practice for Conducting Exposures to Daylight Filtered Through Glass⁵

G 84 Practice for Measurement of Time-of Wetness on Surfaces Exposed to Wetting Conditions as in Atmospheric Corrosion Testing⁶

G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials⁵

G 141 Guide for Addressing Variability in Exposure Testing on Nonmetallic Materials⁵

G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests⁵

2.2 ISO Standard:

ISO 877.2-1991 Method A, Methods for Exposure to Direct Weathering, to Weathering Using Glass-Filtered Daylight, and to Intensified Weathering Using Fresnel Mirrors⁷

3. Terminology

3.1 *Definitions*—For definitions of technical terms pertaining to plastics used in this practice, see Terminologies D 883, D 1600, G 113, and E 772.

4. Significance and Use

4.1 Tests conducted in accordance with this practice are used to evaluate the stability of plastic materials when they are exposed outdoors. The relative durability of plastics in outdoor use can be very different depending on the location of the exposure because of differences in ultraviolet (UV) radiation, time of wetness, temperature, pollutants, and other factors. It cannot be assumed, therefore, that results from one exposure in a single location will be useful for determining relative durability in a different location. Exposures in several locations

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² *Annual Book of ASTM Standards*, Vol 08.01.

³ Discontinued 1998. See 1998 *Annual Book of ASTM Standards*, Vol 08.01.

⁴ *Annual Book of ASTM Standards*, Vol 12.02.

⁵ *Annual Book of ASTM Standards*, Vol 14.04.

⁶ *Annual Book of ASTM Standards*, Vol 03.02.

⁷ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

with different climates that represent a broad range of anticipated service conditions are recommended.

4.1.1 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 are needed to get an average test result for a given location.

4.2 The results of short-term exposure tests can provide an indication of relative outdoor performance, but they should not be used to predict the absolute long-term performance of a material. The results of tests conducted for less than 12 months will depend on the particular season of the year in which they begin.

5. Apparatus

5.1 The test site shall conform to the requirements of Practice G 7. Unless otherwise specified, position exposure racks so that they face the equator. The angle of the exposure rack relative to the horizontal can vary depending upon the end-use conditions that are being evaluated.

NOTE 3—Test sites at latitudes less than 23°27' from the equator in either hemisphere will have a period during the year when the declination of the sun will exceed the latitude of the site.

5.1.1 *At-Latitude Racks*—These racks shall be adjusted such that the exposed surfaces are at an angle from the horizontal corresponding exactly to the site latitude angle (Note 4).

NOTE 4—At-latitude exposure provides maximum annual total solar-radiant exposure at most non-subtropical sites. In most non-desert areas, however, maximum annual ultraviolet-radiant exposure is provided by exposure at an angle of the latitude angle minus 10°.

5.1.2 *45° Racks*—These racks shall be adjusted such that the exposed surfaces of specimens are at an angle of 45° to the horizontal.

5.1.3 *90° Racks*—These racks shall be adjusted such that the exposed surfaces of specimens are at an angle of 90° to the horizontal.

5.1.4 *Horizontal Racks*—These racks shall be positioned such that the exposed surfaces of the specimens are horizontal (Note 5).

NOTE 5—To provide moisture runoff for most horizontal-type testing of plastics, 5° south exposure is usually preferred. However, plastic roofing membranes, artificial turf, and other plastics that may be exposed at horizontal in their end-use condition should be exposed at 0° horizontal.

5.1.5 *Other-Angle Racks*—These racks shall be adjusted such that the exposed surfaces of specimens are at a tilt angle mutually agreed upon between the interested parties.

5.2 *Materials and Manner of Construction*—Test racks and hardware shall conform to the requirements of Practice G 7 and shall provide for attachment of specimens or holders of any convenient width and length. The structural members of the test racks shall not constitute a backing to the specimens under test. Fasteners used to attach specimens to the test rack shall provide for secure attachment but allow specimens to expand or contract with thermal changes, moisture absorption or desorption, or plasticizer loss.

5.3 *Specimen Holders:*

5.3.1 Most specimens under test will not be of an exact size for mounting directly on the frame. Specimen holders should be used to support the many sizes of specimens involved in this testing. In no case shall the specimen holder constitute a backing for that portion of the material to be evaluated.

5.3.2 The specimen holders shall be constructed of an inert material. (Aluminum extruded shapes have been found to be suitable.)

5.3.3 The design of the specimen holders shall be such that each specimen or sheet in a holder cannot shift its position, yet is not constrained (that is, it is free to expand or contract with thermal changes, swell because of moisture absorption, or shrink because of plasticizer loss).

5.3.4 *Frame Holders*—These holders are in the shape of a frame that may be subdivided as necessary to provide proper spacing of the specimens. The exposure aperture of each frame shall be of sufficient size to expose the entire test area of each specimen when sufficient specimens are contained.

5.3.5 *Plate Holders*—This type of holder is a universal panel consisting of a slotted-aluminum plate on which electrical white glaze porcelain insulators⁸ are mounted at proper positions to affix various-sized specimens. The specimens are mounted in the grooves of the insulators at a fixed distance of 11 mm from the slotted back plate. The insulators provide inert mounting while the slotted plate permits free circulation of air behind the specimen. This method of mounting is shown in Fig. 1.

5.4 *Instruments for Measuring Climatological Data:*

5.4.1 *Instruments Used to Measure Ambient Temperature and Relative Humidity*—Instruments and procedures used for measurement of ambient temperature and relative humidity shall be in accordance with Practice G 7.

5.4.2 *Instruments Used to Measure Solar Radiation*—Instruments and calibration procedures used for measurement of total solar radiation, total solar ultraviolet radiation, or narrow band solar ultraviolet radiation shall be in accordance with Practice G 7.

6. Sampling

6.1 Sampling shall be in accordance with the pertinent considerations outlined in Practice D 1898.

7. Test Specimens

7.1 Exposure test specimens may be of any size or shape that can be mounted in a holder or applied directly to the racks. They may be specimens suited to the means of evaluating the effects of weathering on a specific physical property, or they may be larger specimens from which smaller specimens for evaluation may be cut. Exposure test specimens should be large enough that mounting edges may be removed where evaluation test results would otherwise be affected.

7.2 As far as practical, exposure test specimens shall simulate service conditions of an end-use application. All materials of an unknown end use application will normally be run in an

⁸ A satisfactory insulator for this purpose is Catalog No. 615160, Special No. 6 Knob, dry-process, porcelain insulator, available from Porcelain Products, Carey, OH.

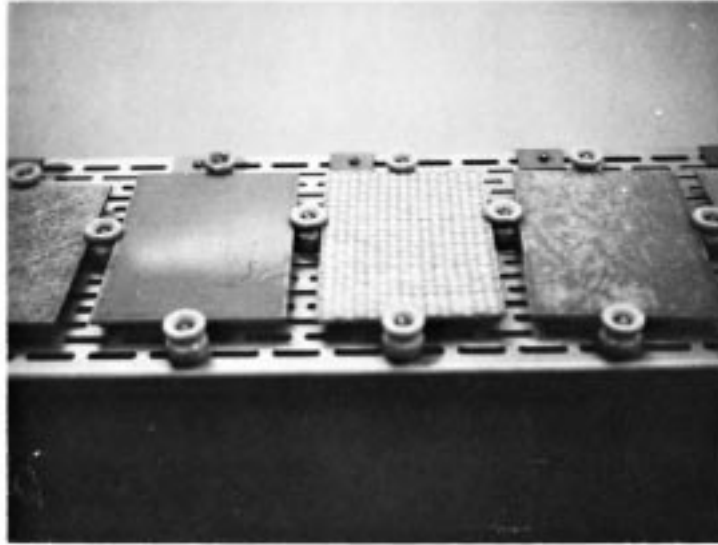


FIG. 1 Suitably Mounted Samples

unbacked condition. When conditions of use are known, the specimen exposed will consist of the plastic material being evaluated plus suitable backing materials to conform to projected practice. The effect of backing is highly significant and contributes to the degradation as a function of reflectance, heat absorption, moisture retention, etc. It shall always be used in relation to an end-use system rather than as a standard mounting method.

7.3 The use of at least two replicates of each experimental material being evaluated is recommended in order to allow for variability.

7.4 The total number of specimens will be determined by the removal schedule and number of replicates plus file specimens. These file specimens shall be retained at conditions of $23.0 \pm 5^\circ\text{C}$ and $50 \pm 20\%$ relative humidity. They shall be covered with inert wrapping to exclude light exposure during the exposure period.

8. Test Sites

8.1 Weathering racks shall be located in cleared areas, preferably at a suitable number of climatologically different sites representing the variable conditions under which the plastic product will be used. Climatological variations within these areas may include those represented by desert, seashore (salt air), industrial locations, tropical, and subtropical regions, plus areas exhibiting a wide range in solar radiant energy. The area beneath and in the vicinity of the weathering racks should be typical of the ground cover in that climatological area. In desert areas in which sand is the prevailing ground cover, coarse gravel is recommended to prevent abrasion and significant dust accretion due to wind-blown sand (Note 6). The ground cover should be low-cut grass in most temperate, tropical, and subtropical areas.

NOTE 6—Sand as a ground cover may be desirable where the abrasive

effects of exposure to wind-blown sand is a part of the desired exposure.

9. Exposure Stages

9.1 Use one of the following methods to specify the exposure stages at which changes in properties of test specimens are determined:

NOTE 7—The same exposure stage (by whichever method is used) will not necessarily give the same changes in properties of the test specimen at different exposure sites. The exposure stages must be regarded as providing only a general indication of the degree of exposure, and the results should always be considered in terms of characteristics of the exposure site as well.

9.2 *Exposure Time*—Specify the duration of the exposure in terms of months (1, 3, 6, 12, 15, etc.) or years (1, 1.5, 2, 3, 4, 5, etc.), unless otherwise instructed.

NOTE 8—The results for exposure stages of less than one year will depend on the season of the year in which the exposure was made. For instance, summer exposures are generally more severe than winter exposures. Seasonal effects are averaged in exposures of several years.

9.2.1 If required, report the total solar radiant exposure and total solar UV radiant exposure that has been measured by radiometers positioned at the same tilt and azimuth angle as the test specimens.

9.3 *Solar-Radiation Measurements*—Since solar radiation is one of the most important factors in the deterioration of plastics during weathering exposure, exposure stages may be defined in terms of the amount of radiation received by the specimens. An inherent limitation in solar-radiation measurements is that they do not reflect the effects of variations in temperature and moisture exposure, which can often be as important as solar radiation.

9.3.1 *Total Solar Irradiance*—Measure the total solar irradiance using solar-radiation measuring instrumentation as described in 5.4.2. Total solar radiant exposure shall be expressed in MJ/m².

9.3.2 *Total Ultraviolet Irradiance*—Measure the total solar-ultraviolet irradiance using ultraviolet-measuring instrumentation as described in 5.4.2. Total solar-ultraviolet radiant exposure shall be expressed in MJ/m². This is the recommended method for determining exposure stages when polymer degradation is being evaluated. Table 1 shows typical UV radiant exposures for 12 months in subtropical and desert climates.

NOTE 9—The average UV radiant exposures shown for subtropical and desert climates are based on several years of measurement in these test environments. The actual yearly values may vary widely from Table 1.

9.3.2.1 Total solar radiant exposure (in MJ/m²) must also be measured and reported for each exposure stage defined by UV radiant exposure.

9.3.3 *Specified Narrow-Band Ultraviolet Irradiance*—The UV irradiance in specified narrow-wavelength intervals (or bands) that conform closely to the wavelengths to which the material is most sensitive may also be used to follow the exposure stages.

10. Procedure

10.1 Mark the test and control specimens to be exposed with an identifying number, letter, or symbol so that they may be identified readily after exposure. Specimen marking shall be in accordance with Practice G 147 and shall be such that there is no interference with either the exposure or the subsequent testing. (Preferably, mark both specimen and specimen holder on the side not exposed to weather, as advanced weathering can obscure even deeply scribed marks.)

10.2 Record the initial appearance and physical-property data appropriate to the evaluation method used.

10.3 Mount the test specimens in the holder or directly to the exposure rack. It is convenient to group specimens to be removed from exposure at the same time in one holder.

10.4 Record a diagram of the test specimen holder layout, and record the date of installation and length of exposure planned.

10.5 Ensure that the radiometers are mounted at a tilt and azimuth angle that is identical to that of the test specimens.

10.6 Mount the specimens on racks for the prescribed time, solar radiant energy, or total UV radiant energy.

10.7 Establish a fixed procedure of cleaning, visual examination, conditioning, and testing of the specimens. This procedure will vary with materials, but it must be uniform in a series of tests on one material to provide comparative results.

10.8 Unexposed file specimens shall be used for visual comparison to exposed specimens at various exposure levels.

10.9 Exposures and inspections may be planned to permit reporting the following:

10.9.1 Change after a specified exposure,

10.9.2 Exposure to a specified change in properties, and

10.9.3 A record of a series of measurements versus exposure.

11. Report

11.1 Report the following information:

11.1.1 Angle of exposure (horizontal, 45° or 90°), and direction of exposure,

11.1.2 Duration of exposure of each specimen at each site, and dates of exposure,

11.1.3 If required, total UV radiant exposure (295 to 385 nm) for each exposure level, expressed in MJ/m², the manufacturer and model of the UV radiometer used, data of last calibration, and calibrating laboratory,

11.1.4 If required, total solar radiant exposure (295 to 3000 nm) for each exposure level, expressed in MJ/m², the manufacturer and model of the pyranometer used, date of last calibration, and calibrating laboratory,

11.1.5 If required, solar UV radiant exposure measured in narrow bandpass including the bandpass in which the radiant exposure was measured.

11.1.6 Description of the climate at each site and summary of the pertinent climatological data at each site for the exposure period involved, as follows:

11.1.6.1 Rainfall, and

11.1.6.2 If required, time of wetness (see Practice G 84),

NOTE 10—These data are intended as an indication of the climate at the test site, and the values reported are not to be used as absolute limits for any particular specimen on exposure.

11.1.6.3 Temperature average and temperature extremes,

11.1.6.4 Humidity average and humidity extremes,

11.1.6.5 Geographical location of the National Weather Service relative to the test site if climatological data is not measured at the test site,

11.1.7 General appearance properties of the exposed specimens and control materials, if used,

11.1.8 Results of property tests and description or reference to tests used to evaluate the property measured. Calculate retention of characteristic property according to Practice D 5780 when it is reported.

11.1.9 Suitably complete identification of the specimen,

11.1.10 Laboratory name,

11.1.11 Site latitude,

11.1.12 Test method and sequence of the test events,

11.1.13 Specimen mounting, and

11.1.14 Observations, deviations, and waivers pertinent to the testing.

12. Precision and Bias

12.1 No statements of precision and bias are applicable to this practice. These are dependent on the ASTM test methods for the specific properties being measured.

13. Keywords

13.1 exposure; natural weathering; outdoor weathering; plastics

TABLE 1 Typical UV Radiant Exposures for 12 Months in Subtropical and Desert Climates

Exposure Time (Months)	Average UV Radiant Exposure (MJ/m ² , 295 to 385 nm)	
	Subtropical Climate (at 5°)	Desert Climate (at latitude)
12	308	333

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