Designation: D1435 – 13

# Standard Practice for Outdoor Weathering of Plastics[1]

This standard is issued under the fixed designation D1435; 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 is intended to cover procedures for the exposure of plastic materials to weather.

NOTE 1—See Practice G24 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.

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 877.2-2009, Method A, are technically equivalent.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

E772 Terminology of Solar Energy Conversion

G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials

G24 Practice for Conducting Exposures to Daylight Filtered Through Glass

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

2.2 *ISO Standard:*

ISO 877.2-2009 Plastics—Methods of exposure to solar radiation—Part 2: Direct weathering and exposure behind glass[3]

## 3. Terminology

3.1 *Definitions*—For definitions of technical terms pertaining to plastics used in this practice, see Terminologies D883, D1600, G113, and E772.

## 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 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 twelve months will depend on the particular season of the year in which they begin.

[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.50 on Durability of Plastics.

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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.

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

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

## 5. Apparatus

5.1 The test site shall conform to the requirements of Practice G7. 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—Exposure at the latitude angle is typically used to compare exposures from different locations when solar radiation is the main factor, and temperature and moisture are not being considered.

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 *5° Racks*—These racks shall be adjusted such that the exposed surfaces of specimens are at an angle of 5° to the horizontal.

5.1.5 *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.

5.1.6 *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 G7 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 unless it is used in relation to an end-use system. 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 Some 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. The specimen holder shall not constitute a backing for that portion of the material to be evaluated unless it is used in relation to an end-use system.

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. This method of mounting is shown in Fig. 1.

5.3.5 *Plate Holders*—This type of holder is a universal panel consisting of a slotted-aluminum plate on which electrical white glaze spool or knob porcelain insulators 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 at least 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. 2.

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 G7.

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 G7.

## 6. Sampling

6.1 Sampling shall be in accordance with the pertinent considerations outlined in Guide G141.

## 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

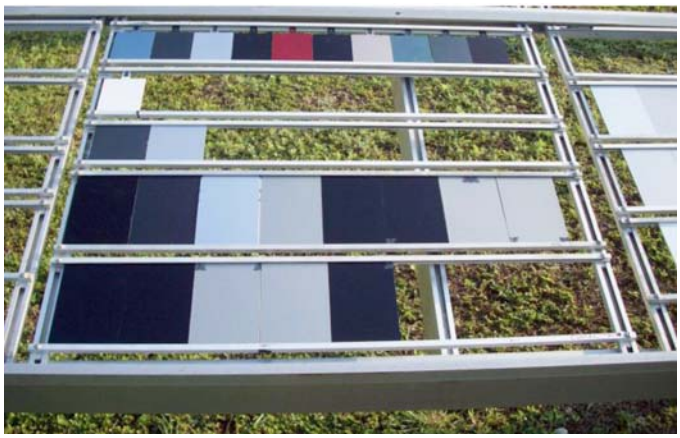

**FIG. 1 Suitably Mounted Specimens in a Frame**

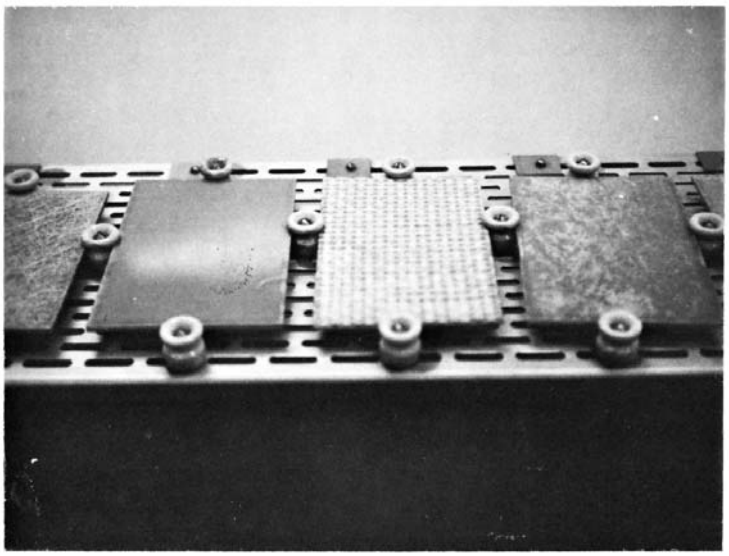

**FIG. 2 Suitably Mounted Specimens on a Plate Holder**

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 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 three replicates of each experimental material being evaluated is recommended in order to account 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 ± 5°C and 50 ± 20 % relative humidity. They shall be kept in a storage cabinet or 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, rock or bare earth 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 $MJ/m^2$.

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 $MJ/m^2$. 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 $MJ/m^2$) 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 G147 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.

**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 |

10.8 Unexposed file specimens shall be used for visual comparison to exposed specimens at the end of the exposure. If interim evaluations are made it is best practice to use the file specimen as the comparison. If there is a masked area on the specimen, this area may only be used for interim visual comparisons provided there are no obvious changes to the masked area. Any use of the masked area must be noted on the report.

NOTE 10—It is possible that changes could have occurred on the masked area that is not obvious.

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 $MJ/m^2$,

11.1.4 If required, total solar radiant exposure (295 to 3000 nm) for each exposure level, expressed in $MJ/m^2$,

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

NOTE 11—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.

11.1.6.2 Temperature average and temperature extremes,

11.1.6.3 Humidity average and humidity extremes,

11.1.6.4 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 D5780 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,

11.1.14 Any deviation from this practice, and

11.1.15 Observations 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

## SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue, D1435 - 05, that may impact the use of this standard. (June 1, 2013)

*(1)* Added 5.1.4 for specific reference to 5° as an acceptable angle of exposure.
*(2)* Changed Note 4 to reflect the addition of 5° and the comparison to horizontal exposure.
*(3)* Added reference to new Fig. 1 in 5.3.4 showing specimens mounted in a frame.
*(4)* Deleted Footnote 4 since as there are many sources of double-headed porcelain insulators
*(5)* Changed the recommended number of replicates from two to three in 7.3.
*(6)* In 7.4, added the option to use a dark storage cabinet to store the file specimens in .
*(7)* In Section 8, added to other types of ground cover for desert areas.
*(8)* In 10.8, added the possibility to use a masked area for visual comparison, but ensuring that final comparison is made with an unexposed control.
*(9)* In 11.1.3 and 11.1.4, deleted the requirement to report certain radiometer data.
*(10)* Deleted old 11.1.6.2, which was the requirement to report time of wetness
*(11)* In 11.1.14, moved the requirement to report any deviations from the practice to its own line.
*(12)* Added a new Figure 1 to show the suitable mounting on a frame.