



Designation: D 5272 – 92 (Reapproved 1999)

Standard Practice for Outdoor Exposure Testing of Photodegradable Plastics¹

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1. Scope

1.1 This practice defines test conditions applicable when Practices D 1435 and G 7 are employed for the outdoor exposure testing of photodegradable plastics.

1.2 *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 1—There is no ISO standard that is equivalent to this standard.

2. Referenced Documents

2.1 ASTM Standards:

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting²

D 883 Terminology Relating to Plastics²

D 1435 Practice for Outdoor Weathering of Plastics²

D 1898 Practice for Sampling of Plastics²

D 3593 Test Method for Molecular Weight Averages and Molecular Weight Distribution of Certain Polymers by Liquid Size-Exclusion Chromatography (Gel Permeation Chromatograph GPC) Using Universal Calibration³

D 3826 Practice for Determining Degradation End Point in Degradable Polyolefins Using a Tensile Test³

E 772 Terminology Relating to Solar Energy Conversion⁴

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials⁵

3. Terminology

3.1 The terminology given in Terminology E 772 and Terminology D 883 is applicable to this practice.

4. Significance and Use

4.1 When discarded as litter, articles made using photodegradable plastics are subject to attack by daylight (particularly solar-ultraviolet radiation), oxygen, heat, and water. The 5°

exposure angle used in this practice represents typical conditions for degradation experienced by litter.

4.2 This practice requires characterization of the duration of exposure in terms of solar-ultraviolet radiation. Solar-ultraviolet radiation varies considerably as a function of location and time of year. This can cause dramatic differences in the time required to produce a specified level of degradation in a polymer. Daro⁶ has shown that when the same lot of polyethylene containing an iron-salt prodegradant is exposed at various times of the year in a single location, the time required to produce an average of two chain scissions per molecule varied by over 130 %. Daro, and Zerlaut and Anderson⁷ have shown that this variability can be significantly reduced when total solar or solar-ultraviolet radiation, or both, is used to characterize the exposure increments.

4.3 In addition to variations in level of daylight and solar-ultraviolet radiation, there are significant differences in temperature, and moisture stresses between different locations, and between different years, or periods within a single year, at a single location. Because of this variability, results from this test cannot be used to predict the absolute rate at which photodegradable plastics degrade. Results from this test can be used to compare relative rates of degradation for materials exposed at the same time in the same location. Results from multiple exposures of a common lot of material (during different seasons over several years) at different sites can be used to compare the relative rates at which a particular photodegradable plastic will degrade in each location.

NOTE 2—An inherent limitation in solar-radiation measurements is that they do not reflect the effects of variations in temperature and moisture exposure, which often can be as important as solar radiation. The same solar-ultraviolet radiation increment will not necessarily give the same changes in properties of the test specimen in different exposure sites. Results from this practice must be regarded as giving only a general indication of the degree of degradability and should always be considered in terms of characteristics of the exposure site as well.

4.4 Where measurement of total solar-ultraviolet radiation is not possible, exposure duration can be determined by the

¹ This practice is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.96 on Environmentally Degradable Plastics.

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

³ *Annual Book of ASTM Standards*, Vol 08.02.

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

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

⁶ Daro, A., et al, "Degradation of Polymer Blends IV, Natural Weathering of Low Density and Linear Low Density Polyethylene," *European Polymer Journal*, Vol 26, No. 1, 1990, pp. 47-52.

⁷ Zerlaut, G. L., and Anderson, T. A., "Ultraviolet Radiation as a Timing Technique for Outdoor Weathering of Materials," Society of Automotive Engineers, SAE Technical Paper Number 850348, 1985.

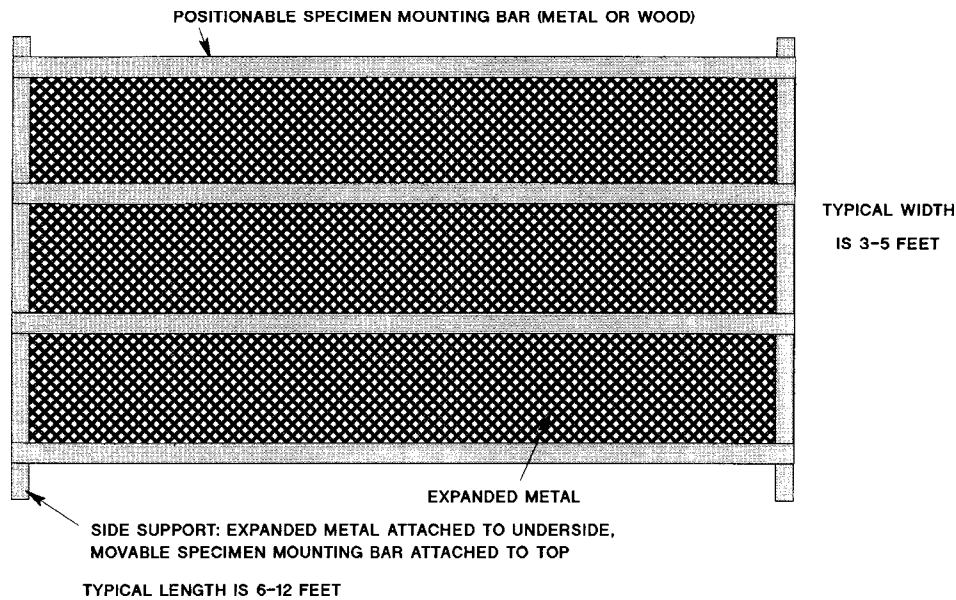


FIG. 1 Typical Rack Construction for Exterior Exposures of Photodegradable Plastics

number of days, weeks, or months exposed. When this practice is used, a reference material whose degradation properties have been well established must be exposed at the same time as the other materials being tested. The reference material used must be agreed upon by all interested parties. The time to produce a specified level of degradation for each material in this simultaneous exposure is then compared. It is also a good practice to use reference materials when exposure length is determined by total solar or solar UV radiant exposure.

NOTE 3—A reference material can be a single lot of material which has shown consistent results after a number of exposures. It is not necessary that the composition or properties of the reference material be characterized and certified by a recognized standards agency or group.

5. Apparatus

5.1 Use exposure racks constructed in accordance with the requirements of Practice G 7. Unless otherwise specified, position the exposure racks so that specimens face the equator and so that the exposed surfaces are 5° from the horizontal. If other exposure rack orientations are used, they must be reported.

5.2 Use one of the following rack constructions for exposing photodegradable plastic specimens:

5.2.1 *Exposure Rack A*—Positionable mounting bars used for attaching specimens shall be arrayed over a regular mesh expanded-metal (aluminum or stainless steel) sheet backing. Use 16–18 gage metal with approximately 0.5-in. openings. It is recommended that the surface area of the expanded metal be 60 to 70 % open. Use a noncorroding material for the mounting bars. 6061T6 aluminum or untreated wood are typical materials used for the mounting bars. Fig. 1 is a top view showing typical rack construction.

5.2.2 *Exposure Rack B*—Unpainted exterior-grade plywood forms the rack surface to which specimens are directly attached. Replace the plywood when there is any evidence of delamination or fiber separation which could produce sharp edges and damage exposed specimens. Medium-density over-

lay (MDO) or high-density overlay (HDO) plywood are satisfactory substrates and will require less frequent replacement than plywood with no overlay.

NOTE 4—There is less air circulation around the specimens when Rack B exposures are used. Degradation rates from exposures using Rack B will be somewhat faster than those using Rack A because specimen temperatures will be higher. Comparisons between materials should only be made with exposures conducted at the same time and using the same rack type.

5.3 Solar Radiometers:

5.3.1 *Ultraviolet Radiometer*—A total ultraviolet (UV) radiometer that measures ultraviolet radiation in the wavelength region from 295 to 385 nm should be used.⁸ Calibrate the radiometer in suitable radiometric units, preferably in watts per square metre per volt ($\text{Wm}^{-2} \text{V}^{-1}$), and shall be maintained in at least semiannual calibration against a standard source of special irradiance.⁹ Narrow band radiometers (for example, with 20 nm bandpass) can also be used if agreed upon by all interested parties. Narrow band radiometers must also be calibrated at least semiannually against a standard source of spectral irradiance. A certificate of calibration shall be provided with all total solar-ultraviolet or narrow band irradiance measurements. It is recommended that calibrations be traceable to a recognized national standards agency such as the National Institute for Science and Technology in the United States.

NOTE 5—The use of narrow band filter UV radiometers having selective spectral sensitivity may not be sensitive to all variations of solar-ultraviolet radiation. Monitoring at a narrow band (for example, 20 nm) may not relate to the total photodegradation of the plastic material, which is a result of a complex interaction of many factors, including sensitivity across a broad wavelength region.

⁸ Model TUVR Total Ultraviolet Radiometer manufactured by the Eppley Laboratory, 12 Sheffield Ave., Newport, RI 02804, has been found to be suitable for this purpose when maintained in frequent calibration.

⁹ Suitable calibrations may be obtained from some manufacturers, and from the Eppley Laboratory, 12 Sheffield Ave., Newport, RI 02804.