



Standard Practice for Operating Xenon Arc-Type Light-Exposure Apparatus With and Without Water for Exposure of Plastics¹

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1. Scope

1.1 This practice covers procedures applicable when Practice G 26 is employed for exposure of plastics. Reference is made to sample preparation and evaluation of test results.

1.2 *This standard does not purport to address all of the safety problems, 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:

D 859 Test Methods for Silica in Water²

D 1293 Test Methods for pH of Water²

D 4517 Test Method for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy³

G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials⁴

3. Significance and Use

3.1 Xenon arcs have been shown to have a spectral energy distribution, when properly filtered, which closely simulates the spectral distribution of sunlight at the surface of the earth.^{5,6,7} In comparison to sunlight exposure, this test is not necessarily an accelerated test.

3.2 Since the emitted energy from the xenon lamps decays with time and since the other parameters of temperature and water do not represent a specific known climatic condition, the results of laboratory exposure are not necessarily intended to correlate with data obtained by outdoor weathering. There may be no positive correlation of exposure

results between the xenon arc and other laboratory weathering devices.

4. Test Specimens

4.1 The size and shape of specimens to be exposed will be determined by the specifications of the particular test method used to evaluate the effects of the exposure on the specimens; the test method shall be determined by the parties concerned. Where practical, it is recommended that specimens be sized to fit specimen holders and sample racks supplied with the exposure apparatus. Unless supplied with a specific backing as an integral part of the test, specimens shall be mounted so that only the minimum specimen area required for support by the holder shall be covered.

4.2 The face of a specimen shall not be masked for the purpose of showing on one panel the effects of various exposure times. Misleading results may be obtained by this method, since the masked portion of the specimen is still exposed to temperature and humidity cycles that in many cases will affect results.

4.3 Since the thickness of a specimen may affect markedly the results of the test, the actual thickness shall be recorded at the start and at the conclusion of the exposure period.

4.4 Specimens having dimensions that are less than one half the height of the specimen rack must be located equidistant from the center horizontal plane of the arc to assure uniform radiation. Incident energy over the sample rack may vary as much as 20 % due to the geometry of the field of view. Therefore samples should be periodically rotated. Specimens to be exposed for several hundred hours may be relocated periodically to compensate for the variation in irradiance in the vertical plane. The rotation of specimen position in the rack may be in four steps, employed in the same sequence, from upper to lower specimen row and inverted in both specimen rows. The effect of this variation in irradiance on the specimen may depend upon the material as well as upon the lamp-to-specimen distance.

NOTE 1—An inclined specimen rack is available that reduces the variability of irradiance. Specimens are positioned tangential to an arc the radius of which is the distance from the center of the arc to the specimen face.

4.5 Specimens to be compared should be mounted with the exposed surface in the same vertical plane at equal distances from the lamp.

4.6 Replicate specimens may be used as unexposed controls when nondestructive measurements cannot be made on the specimens to be exposed.

NOTE 2—Since the stability of the control specimen is also time dependent, the operator is cautioned that over prolonged exposure periods, or where small differences in the order of acceptable limits are

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² Annual Book of ASTM Standards, Vol 11.01.

³ Annual Book of ASTM Standards, Vol 11.02.

⁴ Annual Book of ASTM Standards, Vols 08.03 and 14.02.

⁵ Searle, N. Z., Giesecke, P., Kinmonth, R., and Hirt, R., "Ultraviolet Spectral Distributions and Aging Characteristics of Xenon Arcs and Filters," *Applied Optics*, Vol. 3, No. 8, August 1964, pp. 923-27.

⁶ Boettner, E. A., and Miedler, L. J., "Simulating the Solar Spectrum with a Filtered High Pressure Xenon Lamp," *Applied Optics*, Vol. 2, No. 1, January 1963, pp. 105-108.

⁷ Hirt, R. C., Schmitt, R. G., Searle, N. Z., and Sullivan, A. P., "Ultraviolet Spectral Energy Distributions of Natural Sunlight and Accelerated Test Light Sources," *Journal of the Optical Society of America*, Vol. 50, No. 7, 1960, pp. 706-13.

anticipated, comparison of exposed specimens with the stored control may not be valid. Instrumental measurements are recommended whenever possible.

5. Apparatus

5.1 The exposure apparatus employed shall utilize a xenon-arc lamp as the source of radiation and should be Type B, BH or E as specified in Practice G 26.

5.1.1 *Type B⁸*—An exposure apparatus in which the source of radiant energy shall be a water-cooled xenon arc vertically located at the central axis of a 960-mm (37.75-in.) diameter specimen rack. Means shall be provided for automatic control of temperature and cycles. Means may be provided for adjustment of humidity. The specimen rack shall rotate at 1 ± 0.1 rpm.

5.1.2 *Type BH⁸*—Similar to Type B, except with automatic humidity control.

5.1.3 *Type E⁹*—An exposure apparatus in which the source of radiant energy shall be three air-cooled xenon arc lamps operating simultaneously at 4500 watts each. The lamps shall be located around a central core which shall be positioned at the center of a 610-mm (24.1-in.) diameter specimen rack. Means shall be provided for automatic control of temperature, humidity, and cycles. The specimen rack should rotate.

NOTE 3—For Type B and BH apparatus, a three-tiered specimen rack is available that reduces the variability of irradiance. Specimens are positioned tangential to an arc the radius of which is the distance from the center of the arc to the specimen face. For Type E apparatus, specimen racks are available that reduce the variability of irradiance by preventing mounting of samples at the top and bottom of the rack.

5.1.4 Other types of apparatus specified in Practice G 26 are acceptable if agreed upon between the supplier and the purchaser.

5.2 The xenon arcs employed shall be of the long-arc water-cooled type operated through suitable reactance transformers and electrical equipment from a suitable 50 or 60-Hz power supply. They shall employ cylindrical optical filters to simulate a designated spectral energy distribution.

5.2.1 For Type B and BH apparatus, the xenon-arc lamp shall consist of a quartz xenon burner tube with borosilicate glass inner and outer optical filters.¹⁰

5.2.2 For Type E apparatus, the xenon-arc lamp system shall consist of three xenon burners surrounded by an inner and an outer quartz cylinder. Three special UV¹¹ partial filters shall be positioned outside the outer quartz cylinder.

5.3 For Types B and BH apparatus, distilled or deionized water should be circulated past the burner at a flow rate sufficient to remove excess heat. Passing water through a cartridge demineralizer installed in the recirculation line just ahead of the lamp minimizes contamination of the quartz envelope of the burner.

5.4 For Type E apparatus, distilled or deionized water should be circulated between the two quartz cylinders for removal of excess infrared radiation. A heat-exchange unit

should be used to cool the recirculated water.

5.5 Since xenon-arc lamps, like all gas discharge lamps, will have a progressive drop in radiation output with continued use and since optical fibers will change in their transmission characteristics, provision shall be made in the apparatus (automatically or manually) for minimizing changes in the intensity of the radiation at the face of the sample. The greatest change in both the xenon burner and optical filters occurs in the first 20 h of use. For this reason, burners, and optical filters pre-aged by the instrument manufacturer are recommended for critical testing when a more rapidly changing rate of intensity is undesirable.

5.6 For Types B and BH apparatus, intensity changes are minimized by progressively increasing the wattage of the lamp. For Type E apparatus, intensity changes are minimized by replacing the three xenon burners in rotation such that one burner is replaced every 500 h.

5.7 Many polymers are selectively absorbing. The energy that a molecule absorbs depends upon the wavelength of the incident radiation. It is desirable to monitor the level of irradiance of the photochemically effective wavelengths if intercomparisons are to be made among samples not exposed simultaneously. Samples may be exposed then to known amounts of irradiation using the time integral of irradiance.

5.7.1 Where suitable radiometers are available, exposure may be specified as a time period at a mutually agreed upon level of irradiance at the sample distance, or as a mutually agreed upon level of irradiation instead of a time interval.

5.7.1.1 Based upon measurements made at latitude angle of cloudless daylight during the vernal equinox suggested minimum values of irradiance for achieving accelerated exposures are as follows:

0.2 W/m² at 320 nm
0.35 W/m² at 340 nm
0.5 W/m² at 380 nm
0.75 W/m² at 420 nm

5.8 Testing temperatures shall be measured and regulated on the basis of a black-panel thermometer mounted on the sample rack and facing the light source. Lamp-to-panel distance shall be the same as that between lamp and specimen.

5.8.1 Unless otherwise specified, testing shall be conducted at a black-panel temperature of $63 \pm 3^\circ\text{C}$ regulated to an equilibrium condition during the dry portion of a light-on cycle.

5.9 *Water Purity*—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.

5.9.1 Water used for specimen spray shall leave no objectional deposits or stains on the exposed specimens. The water contains a maximum of 1 ppm solids and a maximum of 0.2 ppm silica. Silica levels can be determined using the procedures defined in Test Methods D 859 or D 4517. Prepackaged analysis kits are commercially available that are capable of detecting silica levels of less than 200 parts per billion (ppb). Distillation or a combination of deionization and reverse osmosis treatment can effectively produce water

⁸ Available from Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613.

⁹ Available from DSET Laboratories, Inc. Special Environmental Test Division, Box 1850 Black Canyon Stage I, Phoenix, AZ 85027

¹⁰ Corning 7740 Pyrex® (borosilicate).

¹¹ Schott Suprax® pre-aged