Designation: D 4355 – 07

Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus[1]

This standard is issued under the fixed designation D 4355; 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 test method covers the determination of the deterioration in tensile strength of geotextiles by exposure to xenon arc radiation, moisture, and heat.

1.2 The light and water exposure apparatus employs a xenon-arc light source.

1.3 *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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 123 Terminology Relating to Textiles
D 1898 Practice for Sampling of Plastics
D 4439 Terminology for Geotextiles
D 5035 Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials
G 141 Guide for Addressing Variability in Exposure Testing on Nonmetallic Materials
G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources
G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *geotextile*—any permeable textile material used with foundation, soil, rock, earth, or any other geotechnical engineering related material that is an integral part of a man-made product, structure, or system.

3.2 *Definitions:*

3.2.1 For definitions of other textile terms used in this test method, refer to Terminology D 123, for geotextile terms refer to Terminology D 4439.

3.2.2 The definitions given in Terminology G 113 are applicable to this standard.

4. Summary of Test Method

4.1 Five specimens of a geotextile for the machine direction and for the cross machine direction are exposed in a xenon arc device for each of the following times: 0 (control specimens), for 150, 300, and 500 h. The exposure consists of 120-min cycles as follows: 90 min of light only at 65 ± 3°C uninsulated black panel temperature and 50 ± 5% relative humidity, followed by 30 min of light plus water spray.

4.2 After each exposure period, the specimens are subjected to a cut or ravel strip tensile test. The average breaking strength in each direction is compared with the average breaking strength in each direction of the control specimens. The percent strength retained is plotted versus exposure period to produce a degradation curve for the specimens from each direction.

5. Significance and Use

5.1 This method is intended to induce property changes associated with end use conditions, including the effects of solar radiation, moisture and heat. The exposure used is not intended to simulate the deterioration caused by localized weather phenomena such as atmospheric pollution, biological attack, and salt water exposure.

5.2 The relation between time to failure in an exposure conducted in accordance with this test method, and service life in a specific outdoor environment requires determination of an acceleration factor as defined in Terminology G 113. The acceleration factor is material-dependent and is only valid if it is based on data from a sufficient number of separate exterior

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.02 on Endurance Properties.

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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.

and laboratory-accelerated exposures so that the results used to relate times to failure in each exposure can be analyzed using statistical methods.

NOTE 1—An example of a statistical analysis using multiple laboratory and exterior exposures to calculate an acceleration factor is described by J. A. Simms.[3] See Practice G 151 for more information and additional cautions about the use of acceleration factors.

5.2.1 The deterioration curve obtained from the results of this test method enables the user to determine the tendency of a geotextile to deteriorate when exposed to xenon arc radiation, water and heat.

5.3 Variation in results may be expected when operating conditions are varied within the accepted limits of this test method. Its intended use is as a qualitative assessment of the presence of ultraviolet inhibitors, and comparison of that influence between products. However, no inference to the time of stability should be implied by the test results to the relation between time duration and outdoor exposure.

NOTE 2—Information on sources of variability and on strategies for addressing variability in the design, execution and data analysis of laboratory accelerated exposure tests is found in Guide G 141.

5.3.1 If it becomes necessary for the purchaser and seller to use this test method for acceptance testing, the statistical bias, if any, between the purchaser's and seller's laboratories should be determined. Such comparison is to based on specimens randomly drawn from the sample of geotextile being evaluated.

5.3.2 In such cases, as a minimum, the two parties should take a group of test specimens which are as homogeneous as possible, and which are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing started. If a bias is found, either its cause must be found and corrected, or the purchaser and the supplier must agree to interpret future test results in the light of the known bias.

6. Apparatus

6.1 *Xenon-Arc Apparatus*, with daylight filters conforming to Practices G 151 and G 155.

NOTE 3—Previous versions of this standard referenced in Practice G 26 which describes specific equipment designs of xenon arc devices. Practice G 26 has been replaced by Practice G 151, which gives performance criteria for all devices that use laboratory light sources, plus Practice G 155, which gives requirements for exposure of nonmetallic materials in xenon arc devices.

6.1.1 The apparatus must be capable of exposing the specimens to cycles of light only, followed by light and moisture as water spray.

6.2 *Strength Testing Apparatus*, conforming to that described for a 2-in. cut or ravel strip test, as described in Test Methods D 5035.

7. Sampling

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of rolls of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of fabric to be the primary sampling units. If the specification requires sampling during manufacture, select the rolls for the lot sample at uniformly spaced time intervals throughout the production period.

NOTE 4—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of fabric, and between specimens from a swatch from a roll of fabric, so as to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—Take for the laboratory sample a sample extending the full width of the fabric of sufficient length along the selvage from each sample roll such that the requirements of 8.1 are met. The sample shall exclude material from the outer wrap of the roll or the inner wrap around the core unless the sample is taken at the production site, at which point inner and outer wrap material may be used.

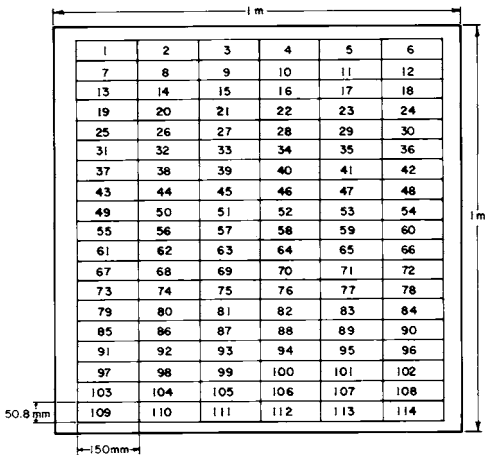
8. Specimen Preparation

8.1 Take two, one-metre square portions from the laboratory sample. Each shall be no closer to the selvage than 1/10 the sample width. One is to be used for machine direction specimens, the other for cross machine direction specimens.

NOTE 5—Since the thickness of a specimen may markedly affect test results, thickness of the replicate specimens shall be within ± 10% of the nominal dimensions. This is especially important when mechanical properties are being investigated.

8.2 Use template illustrated in Fig. 1 to identify potential specimens from which the actual specimens are drawn. To select these actual specimens randomly draw 20 specimens from both the machine and cross directions measuring 50 by 150 mm (2 by 6 in.) from the one-metre square portions of each laboratory sample as directed in Practice D 1898.

NOTE 6—In the event that roller grips are used to hold the specimens in the tensile testing machine, specimens must be longer than the 150 mm



1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36
37	38	39	40	41	42
43	44	45	46	47	48
49	50	51	52	53	54
55	56	57	58	59	60
61	62	63	64	65	66
67	68	69	70	71	72
73	74	75	76	77	78
79	80	81	82	83	84
85	86	87	88	89	90
91	92	93	94	95	96
97	98	99	100	101	102
103	104	105	106	107	108
109	110	111	112	113	114

FIG. 1 Specimen Selection Template

[3] Simms, J.A., *The Journal of Coatings Technology*, Vol 50, 1987, pp. 45-53.

length specified. They shall be of sufficient length to ensure proper gripping. The portions of the specimens may be rolled to accommodate placement in the weatherometer. See Fig. 2 and Fig. 3 for placement of specimens in the weatherometer. Please note that the rolled portions of the specimens shall be protected from exposure to the UV light while in the weatherometer.

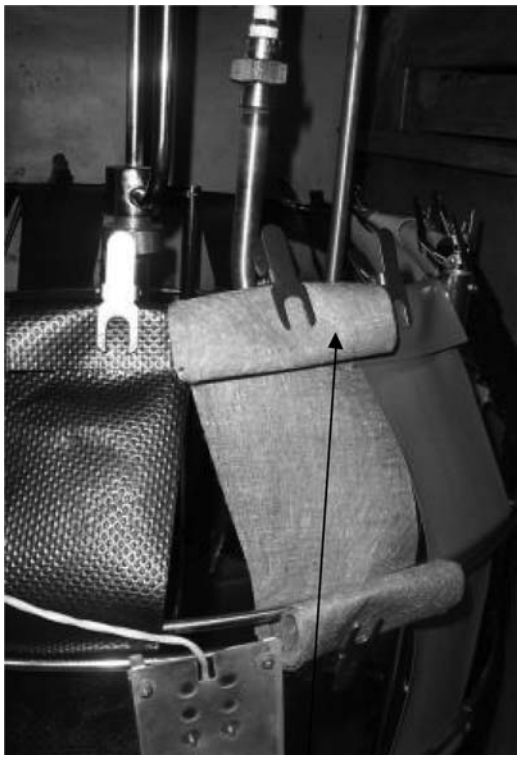
9. Procedure

9.1 Operate the xenon-arc test apparatus as directed in Practices G 151 and G 155. Expose test specimens to the following cycle: 90 min of light only at 65 ± 2.5°C (149 ± 5°F) uninsulated black panel temperature, and 50 ± 5 % relative humidity, followed by 30 min of light and water spray.

NOTE 7—Immersion in water during exposure to light is one of the methods specified in Practices G 151 and G 155 for providing moisture to specimens. It can be substituted for water spray if equivalency is demonstrated, or the geotextile will be immersed in water in its final installation.

9.1.1 Unless otherwise specified, maintain the minimum level of irradiance at the control point to produce 0.35 ± W(/m^2/ nm) at 340 nm. If the exposure device is not equipped with irradiance control, follow the device manufacturer's recommendations to produce this irradiance. for the equivalent 300-400 nm or 300-800 nm broad band irradiances and tolerances, consult the manufacturer for the specification.

NOTE 8—Practice G 155 does not specify a particular irradiance level. Various options are listed in Table X3.1 of the appendix in Practice G 155.



NOTE 1—When placing specimens to be tested using roller grips in weatherometer the rolled area in the clamp needs to be protected from exposure to UV to avoid degredation of this area (see arrow).

FIG. 3 Roller Grip Specimen in Weatherometer

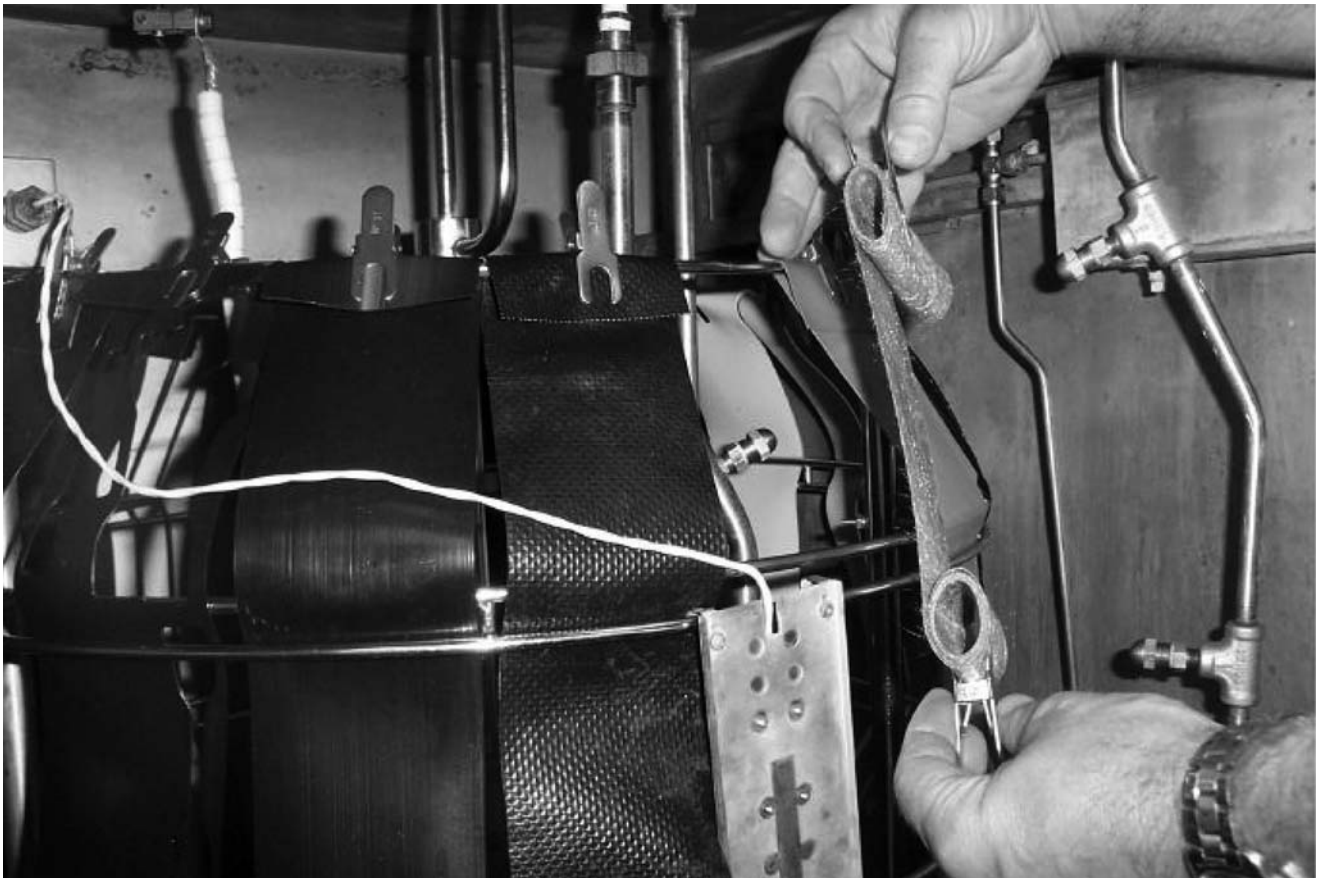


FIG. 2 Roller Grip Specimen Ready for Placement in Weatherometer

However, as the historical records of testing of geotextiles are based on the irradiance of 0.35 W/m^2/nm at 340 nm, this shall be the standard for Test Method D 4355.

9.2 Randomly assign five specimens for each direction from each laboratory sample to each of the following exposure times: 0 (unexposed), 150, 300, and 500 clock hours. Place fifteen specimens from each direction from each laboratory sample in the apparatus, such that the side most likely to solar radiation will be exposed to radiation in the apparatus.

9.3 Rotate the positions of the specimens in accordance with Practice G 155.

9.4 At the end of each exposure time, remove the appropriate five specimens for each direction for cut or ravel strip tensile testing.

NOTE 9—Specimens should not be removed from the exposure apparatus for more than 24 h and then returned for additional test since this does not produce the same results on some materials as tests fun without this type of interruption. Report the elapsed time for any specimens for which exposure was interrupted for more than 24 h.

9.5 Determine the breaking strength in kilonewtons per metre (pounds-force per inch) of five unexposed (control) specimens and five exposed specimens from each exposure time interval, for each direction, from each laboratory sample as directed in Method D 5035 using a 2-in. width strip, except, a CRE or a CRT type testing machine shall be operated at 305 ± 10 mm (12 ± ½ in.) unless specified otherwise. The distance between clamps shall be 75 ± 1 mm (3 ± 0.05 in.). There may be no overall correlation between the results obtained with the CRE machine and the CRT machine. Consequently, these two breaking load testers cannot be used interchangeably. In case of controversy, the CRE method shall prevail.

10. Calculation

10.1 Calculate the average breaking strength for all exposed and unexposed (control) specimens for each direction.

10.2 Calculate the percent loss of strength from the unexposed specimens for the average results of each exposure time for each direction.

10.3 For the groups of five specimens from the unexposed specimens and the specimens exposed at various times, calculate the standard deviation and coefficient of variation for the strip tensile strength.

11. Report

11.1 The test report shall include the following information:

11.1.1 That the tests were made as directed in Test Method D 4355,

11.1.2 A full description of the specimens and their origin,

11.1.3 Any full details of sampling not included in Section 7,

11.1.4 Any details of specimen preparation not included in Section 8,

11.1.5 Type and model of exposure device and light source,

11.1.6 Type and age of filters at the beginning of the exposure and whether the filters where changed during exposure,

11.1.7 If required, irradiance in W/m^2 nm, or radiant exposure in J/m^2 , at the sample plane and the wavelength region in which the measurements were made,

11.1.7.1 Do not report irradiance or radiant exposure unless direct measurements were made during exposure,

11.1.8 Type of black or white panel thermometer, or both if used, and exact position of the thermometer if not located on the specimen plane,

11.1.9 Description of specimen repositioning, if used,

11.1.10 Exposure periods and the elapsed time for any specimens for which the exposure was interrupted for more than 24 h,

11.1.11 The total exposure times, along with the total irradiance at respective clock hour intervals, and the number of cycles as defined in 9.1.1,

11.1.12 A listing of the test results for the unexposed (control) and for each exposure time, for the machine and cross machine direction, consisting of individual breaking strength test results, and their average, and their standard deviation and coefficient of variation,

11.1.13 A listing of the percent of the average unexposed (control) strength retained for each exposure time for each direction, and

11.1.14 A plot of average breaking strength versus exposure time for each direction.

12. Precision and Bias

12.1 *Precision*:

12.1.1 *Interlaboratory Test Program*—An interlaboratory study of the Test Method D 4355 was performed in 2003. The design of the experiment, similar to that of Practice E 691, and a within-between analyzer of the data, are available from ASTM. In this study, there were five laboratories participated in the round robin study. Four different geotextiles were utilized; a 4 oz/yd^2. Heat bonded non-woven (Material 1), a 7.8 oz/yd^2. Spun bonded non-woven (Material 2), a 12 oz/yd^2. Needle-punched non-woven (Material 3), and a slit film woven (Material 4). The numbers used in the precision statement are based on the percentage of strength retained after exposure.

12.1.2 *95 % Repeatability Limit*—The 95 % confidence Repeatability Limits for the four materials are listed in the following table.

Material	Repeatability Limit (r)	Standard Deviation of Repeatability Limit (S_r)
1	45.9 %	16.4 %
2	7.9 %	2.8 %
3	23.1 %	8.3 %
4	8.1 %	2.9 %

12.1.3 *95 % Reproducibility Limit (Between Laboratory)*—The 95 % confidence Reproducibility Limits for the four materials are listed in the following table.

Material	Reproducibility Limit (R)	Standard Deviation of Reproducibility Limit (S_R)
1	78.7 %	28.1 %
2	18.0 %	6.4 %
3	54.1 %	19.3 %
4	10.4 %	3.7 %

12.2 *Bias*—The procedure in this test method has no bias because the value of that property can only be defined in terms of a test method.

13. Keywords

13.1 accelerated weathering; degradation; deterioration; geotextiles; solar radiation; xenon arc