Designation: D5323 – 92 (Reapproved 2011)

Standard Practice for Determination of 2 % Secant Modulus for Polyethylene Geomembranes[1]

This standard is issued under the fixed designation D5323; 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.

1. Scope

1.1 This practice presents a technique for calculating the 2 % secant modulus for polyethylene geomembranes between 0.5 and 5 mm (20 and 200 mil) using Test Method D638.

1.2 This practice will facilitate modulus comparisons of similar materials by standardizing the method for deriving the points on the stress-strain curve from which the calculations are performed.

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

1.4 *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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D638 Test Method for Tensile Properties of Plastics

3. Terminology

3.1 *Definitions:*

3.1.1 *modulus of elasticity,* MPa (FL^{-2}), *n*—the ratio of stress (nominal) to corresponding strain below the proportional limit of a material, expressed in force per unit area, such as megapascals (pounds-force per square inch).

3.1.1.1 *Discussion*—The stress-strain relations of many plastics do not conform to Hooke's law throughout the elastic range, but rather deviate therefrom even at strains well below the elastic limit. For such materials, the slope of the tangent to the stress-strain curve at a low strain is usually taken as the modulus of elasticity (or elastic modulus). Since the existence of a true proportional limit in polyethylene is questionable, and with the impracticality of measuring it reliably, the use of secant modulus for comparative evaluations is preferred.

3.1.2 *secant modulus, n*—the ratio of stress (nominal) to corresponding strain at any specified point on the stress-strain curve.

3.1.2.1 *Discussion*—The measurement units for secant modulus may change, depending on the standard used. For the purposes of this practice, the measurement units shall be force per unit area (FL^{-2}), such as megapascals (pounds-force per square inch).

4. Significance and Use

4.1 Where to draw the tangent to determine the modulus of elasticity is often unclear when performing tensile tests with polyethylene geomembranes. This problem results in a wide variation in test results and therefore makes this property unreliable for comparisons.

4.2 A secant modulus based on 2 % strain can be useful when making comparisons between materials, in quality control, and in comparing the same sample after being subjected to a nonstandard environment.

4.3 Secant modulus is an approximation of modulus of elasticity and generally results in a lower value than that for the modulus of elasticity.

4.4 Although the technique for measuring 2 % secant modulus is described here, other percent secant moduli can be measured by this practice.

5. Procedure

5.1 Follow the test procedure described in Test Method D638.

5.1.1 A cross-head speed of 50 mm/min (2 ipm) is recommended for determining secant modulus, regardless of the type of geomembrane being evaluated. Faster cross-head speeds reduce resolution of the points on the curve.

5.1.2 High resolution of load and cross-head movement is important for obtaining accurate and reproducible values. Where possible, use settings on the testing equipment that will magnify this region.

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[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

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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.

5.2 Determine the load at 2 % strain.

5.2.1 Industry standard practice uses Test Method D638 Type IV specimens and permits the test to be conducted without an extensometer. Hence, strain up to the yield point will be based on a gage length of 33 mm (1.3 in.). This represents the reduced area of the specimen. A gage length of 33 mm (1.3 in.) requires a cross-head movement of 0.66 mm (0.026 in.) for 2 % strain.

5.2.2 Do not compare test results obtained with the use of extensometers to those obtained without the use of extensometers.

5.3 Calculate the 2 % secant modulus as follows:

$$2\ \%\ \text{secant modulus} = \frac{\text{stress}}{\text{strain}} \quad (1)$$

where:

stress = force/area (at 2 % strain),
area = initial cross-section area, and
strain = 0.02 (for 2 % secant modulus).

6. Report

6.1 In addition to the reporting requirements given in section 12 of Test Method D638, report the average 2 % secant modulus value and standard deviation based on the results from individual specimens tested from the sample.

7. Keywords

7.1 geomembranes; secant modulus; polyethylene

APPENDIXES

(Nonmandatory Information)

X1. NORMAL STRESS-STRAIN (FORCE-ELONGATION) CURVE

X1.1 Fig. X1.1 represents the initial portion of the elastic region on what would be considered the normal (true) stress-strain curve for polyethylene. The 2 % secant modulus is the slope of the line AC. Point B represents 2 % strain and is equal to a distance that is 0.02 times the original gage length.

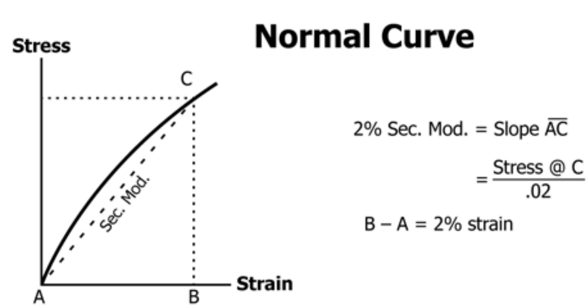

FIG. X1.1 Normal Curve

X2. TOE COMPENSATION

X2.1 In some stress-strain curves (Fig. X2.1), a toe region, AD, exists that does not represent a property of the material. It is an artifact caused by alignment, a take-up of slack, or seating of the specimen. In order to obtain the correct value of such a parameter as modulus, this artifact must be compensated for to yield the corrected zero point on the strain axis.

X2.2 To correct for this artifact so that the true zero strain point can be found, construct a tangent to the maximum slope at the inflection point (D). This is extended to intersect the strain axis at Point A'. Using Point A' as zero strain, determine the new 2 % Strain Point B'. Locate Point C' on the curve that corresponds to B'. Using these corrected points, calculate the 2 % secant modulus by obtaining the slope of Line A'C'.

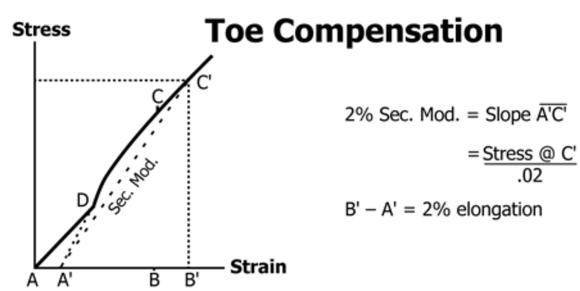

FIG. X2.1 Toe Compensation

X3. PRE-STRESS CURVE

X3.1 Opposite of toe compensation is the indication of a load at 0 % strain (Fig. X3.1). This may be caused by the start of the chart not being synchronized precisely with the start of the cross-head, or by stressing the specimen when mounting it in the grips. If this problem exists, secant modulus cannot be calculated. To correct these problems, it is recommended that the chart be started prior to starting the cross-head, or the specimen be remounted, as the case may be.

X3.2 If the chart is started before the cross-head, 0 % strain is the point at which the load deviates distinctly from the base line. Note that the procedure for toe compensation may have to be used to determine 0 % strain if the chart looks similar to Fig. X2.1.

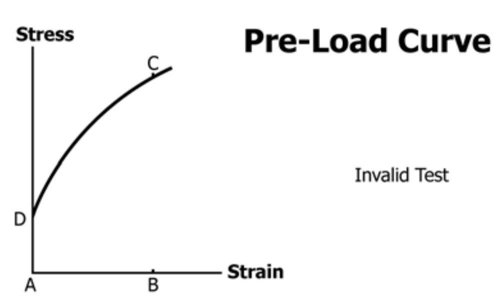

FIG. X3.1 Pre-Load Curve