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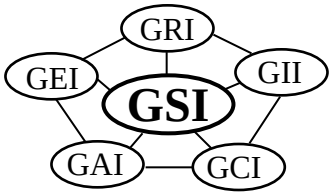

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Revision 5 - March 24, 2021
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GRI Guide GM10*

Standard Guide for

"The Stress Crack Resistance of HDPE Geomembrane Sheet"

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1. Scope

1.1 This guide covers polyethylene in the resin density range of 0.932 g/cc or greater, which results in a geomembrane with minimum density of 0.940 g/cc when mixed with carbon black and additives. This compounded material is commonly referred to in the geomembrane industry as high density polyethylene (HDPE) and this terminology will be used accordingly in this guide.

1.2 This guide uses data obtained from the Notched Constant Tensile Load (NCTL) test, per ASTM D5397 Test Method, to generate a behavioral curve. It then prescribes the procedure to be used to obtain the transition time (T_t) from this curve and furthermore sets a minimum value for "T_t". The guide is oriented toward test specimens taken from fabricated sheets of the geomembrane under consideration. The guide also recommends the frequency of such testing.

1.3 This guide also addresses data obtained from the Single Point-Notched Constant Tensile Load (SP-NCTL) test, per the Appendix of the ASTM D 5397 Test Method. It prescribes the number and orientation of test specimens and sets a value for minimum acceptable

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This guide will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

times without failure. The guide is oriented toward test specimens taken from fabricated geomembrane sheets. It also recommends the frequency of such testing.

1.4 For textured or structured geomembranes the test specimens must be taken within the smooth (nontextured) surfaces along the edges of the sheet.

1.5 In the context of quality systems and management, this guide is focused on manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product(s) represent the stated objective and properties set forth in this guide.

2. Referenced Documents

2.1 ASTM Standards

D6693 - Test Method for Tensile Properties of Plastics
D883 - Definitions of Terms Relating to Plastics
D1822 - Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials
D5397 - Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
D5397 Appendix - The Single Point Notch Constant Tension Load Test

3. Classification

3.1 This guide covers the stress crack resistance of HDPE geomembranes. According to ASTM D 883, stress crack is defined as "an external or internal crack in a plastic caused by tensile stresses less than its short-time mechanical strength."

3.2 This guide focuses on those geomembranes produced from virgin polyethylene in the density range of 0.932 g/cc or greater. When formulated with typical amounts of carbon black and additives, the resulting minimum density is 0.940 g/cc. This compounded material is commonly referred to as HDPE in the geomembrane industry.

3.3 While stress cracking in plastics is a fundamental resin property it should be recognized that it can be influenced by the thermal history of the sheet during the manufacturing process.

4. Sample Preparation

4.1 Test specimens to be used for the full NCTL test and the SP-NCTL test are taken directly from samples of the as-manufactured geomembrane sheet. They should be taken at uniform distances across the roll width with the exception of textured surfaces as discussed in section 1.4.

4.2 Test specimens can also be taken from a small scale laboratory extruder, however, the correlation of results to the as-manufactured sheet is unknown. If the results are used to estimate the quality of as-manufactured sheet, a correlation must be developed on a material and process specific basis.

Note 2: Since thermal history during processing is recognized as an important variable, test results obtained on sheet produced by small scale laboratory extruder could be different from test results obtained on sheets produced on full size commercial equipment.

5. Test Specimens and General Conditions

5.1 Geomembrane sheet thicknesses that are applicable for this guide are from 0.75 mm (30 mil) to 3.0 mm (120 mils).

Note 3: It should be noted that the failure time at any applied stress level is somewhat effected by the thickness of the geomembrane sheet. Generally, specimens of small thickness will result in a longer failure times than those of large thickness due to their density variation.

5.2 Dimensions of the individual dumbbell shaped test specimens shall be in accordance with ASTM D1822 for both the NCTL and SP-NCTL tests.

5.3 The thickness of the test specimens must be within 5% of the nominal thickness of the geomembrane sheet.

5.4 Per ASTM D5397 and its Appendix, the notch depths for both NCTL and SP-NCTL test specimens shall be such that a ligament of 80% of nominal sheet thickness remains after notching to sustain the applied loads.

5.5 The yield stress used for calculating the percent applied loads in Section 6.4 shall be obtained according to ASTM D6693.

Note 4: The applied stress to be imposed on the notched test specimens are percentages of the yield stress of the sheet per ASTM D6693 at 21°C ± 2°C. In contrast, the NCTL and SP-NCTL tests are tested at 50 ± 1°C.

5.6 Test specimens shall be immersed in a suitable bath containing a 10% Igepal (CO 630)/90% tap water solution, maintained at 50°C ± 1°C.

Note 5: In case of disputes between the parties involved, deionized water should be used instead of tap water.

Note 6: It is generally considered good practice to use deionized water so as to maintain the wetting agent solution for the maximum time possible.

Note 7: The solution should be changed every 1000 h or sooner.

5.7 The constant load test device shall be equipped with timers and other incidental items per ASTM D5397.

6. NCTL Tests per ASTM D5397

6.1 Data Required - Per ASTM D5397, data sets of percent yield stress (% σ_y) versus average failure time (F_t) shall be generated.

6.2 A minimum of thirty test specimens are die cut in one direction from the sample of the geomembrane sheet (3 replicates at 10 different loads). The longitudinal axis of the dumbbell shaped test specimens will generally be the cross machine direction of the geomembrane sheet.

6.3 The test specimens, in sets of three, are subjected to each applied stress. The applied stress levels should range from approximately 50% to 20% of the yield strength, in maximum increments of 5%.

6.4 Tests at the lowest stress level shall start first and incrementally increase through each stress interval to the highest stress level.

6.5 For this guide focused on manufacturing quality control (MQC) testing, the yield value used to calculate the applied loads shall be the manufacturer's mean value for the geomembrane resin/formulation under consideration.

Note 8: For manufacturing quality assurance (MQA) testing, the yield value will generally be from five tests per ASTM D6693 for the particular resin/formulation under consideration. Since this is a statistically small sample, the value will generally be different (higher or lower) than the manufacturer's mean value of yield stress. Communication between the parties involved is recommended to resolve possible differences.

6.6 The resulting test data shall be presented on a log-log plot of the percent yield stress versus average failure time of the three tests at each load, as shown in Figure 1. At least 3 points shall be located in the ductile region of the curve and at least 3 points shall be located in the brittle region of the curve. Adequate points shall be available to define the shape of the transition region of the curve.

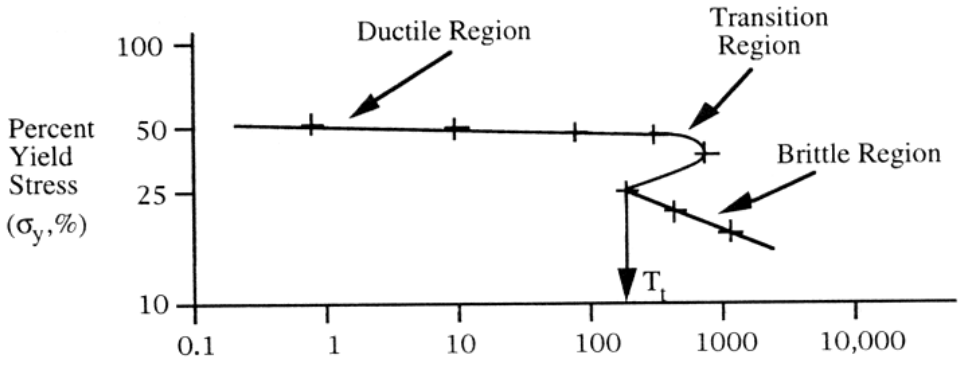

Figure 1 - Possible response of curves resulting from a complete NCTL test

6.7 The transition time (T_t) shall be identified as the time corresponding to the onset point of the brittle portion of the curve provided that such point has a lower failure time than any point in the transition region of the curve. If no such point has been determined, back extrapolation of the brittle curve shall be used to identify a smooth curve from the points located in the transition region.

6.8 The minimum value for the transition time for an acceptable HDPE geomembrane sheet using the above procedure shall be 250 hours.

Note 9: The original value of 100 hours[1] transition time value was deduced from a data base which included fourteen commercial virgin geomembranes and seven field exhumed geomembranes. The majority of the evaluated geomembranes had a thickness of 2.0 mm (0.080 in.). In light of recent upgrade of SCR to 500 hours this value is now increased to 250 hours.

6.9 For sheets with transition times well in excess of 250 hours the determination of the complete brittle portion of the curve can be extremely long. For example, if the test is ongoing and a linear ductile line is still in evidence after 1000 hours, a conclusion can be reached that the geomembrane sheet under consideration will possess a transition time greater than 250 hours. In some cases, the test can be concluded and a report written as to the satisfaction of this guide.

6.10 A full NCTL test shall be conducted on each resin/formulation used by the geomembrane manufacturer.

7. SP-NCTL Tests per ASTM D 5397-Appendix

7.1 SP-NCTL tests per the Appendix of ASTM D 5397 shall be performed on samples of geomembrane sheet for each two resin lots. For the purposes of this guide, a lot is defined as a railcar of pellets which is typically in the range of 70,000 Kg to 90,000 Kg (150,000

[1]Hsuan, Y.G., Koerner, R.M., and Lord, A.E., (1993) "Stress-Cracking Resistance of High-Density Polyethylene Geomembranes" Journal of Geotechnical Engineering, ASCE, Vol. 119, No. 11, pp. 1840-1857.

to 200,000 lb.). Thus, the frequency of testing is every two (2) railroad cars of the above capacity (or equivalent).

Note 10: If multiple gauges of sheet are made from a given resin lot only the sheet with highest gauge thickness needs to be tested to comply with this guide.

7.2 Samples can also be taken from a small scale laboratory extruder, however, the correlation of results to the as-manufactured sheet must be developed on a material and process specific basis.

7.3 Test specimens are to be taken in the cross machine direction of the geomembrane sheet under consideration.

7.4 The constant load applied to the test specimen(s) shall be 30% of the yield stress per ASTM D6693. The yield stress value used in the test shall be the manufacturer's mean value for the geomembrane resin/formulation under consideration.

7.5 The criteria to be used for pass/fail decisions shall be set forth in Table 1.

Table 1 – Various SP-NCTL Test Criteria for Pass/Fail Decisions

Test Cycle	Yield Stress (based on ASTM D 6693)	Number of Test Specimens	Passing Criteria	If Noncompliance Occurs
A	the manufacturer's mean value via MQC testing	5	4 out of 5 with F_t > 500 hr (noncomplying specimen with F_t > 250 hr)	retest using cycle B
B	the manufacturer's mean value via MQC testing	5	4 out of 5 with F_t > 500 hr (noncomplying specimen with F_t > 250 hr)	reject railcar or perform full retest using cycle C
C	the manufacturer's mean value via MQC testing	30	Onset of brittle portion of curve T_t > 250 hr	reject railcar

8. Certification

8.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the geomembrane was manufactured and tested in accordance with this guide together with a report of the test results shall be furnished.

9. Retest and Rejection

9.1 If the results of any test do not conform to the requirements of this guide, retesting to determine conformity may be performed as agreed upon between the parties involved.

Revision Schedule
for
The Stress Crack Resistance of HDPE Geomembrane Sheet

Original: January 30, 1997

Revision 1 – March 12, 1997: Adjusted details in Table 1.

Revision 2 – June 18, 2003:
Increased 200 to 300 hours per GM13 revision
Increased noncomplying specifier from 100 to 150 hours
Changed ASTM D638 to ASTM D6693

Revision 3 – February 20, 2006: Decreased frequency of testing from 1 resin lot to 2 resin lots. See Section 7.1.

Revision 4 – July 23, 2015: Increased SCR value from 300 to 500 hours per GM13. Increased noncomplying specifier from 150 to 250 hours. Added Note 7. The standard's identification was changed from a specification to a guide which better reflects the content of the document.

Revision 5 – March 24, 2021: Corrected numerical error in Section 6.9 from 100 to 250 hours.