



**SPECIAL PROVISIONS
FOR
GEOMEMBRANE OVER EXPANDED POLYSTYRENE BLOCK GEOFOAM**

**Warren County
IM-NHS-035-2(427)57--03-91**

**Effective Date
November 15, 2022**

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

150930.01 DESCRIPTION.

This work shall consist of furnishing and placing a high density polyethylene (HDPE) geomembrane over expanded polystyrene (EPS) block geofoam fill for the purpose of preventing petroleum-based products from infiltrating and damaging the blocks. The work shall include design of the method of developing the strength of the geomembrane across joints, seams or overlaps between adjacent sheets of geomembrane, and implementing that method in placement of the geomembrane.

150930.02 MATERIALS.

A. General.

The geomembrane shall be flexible and puncture-free. The geomembrane shall be flexible at ambient temperatures above 45°F without additional heating of the geomembrane. Geomembrane shall be made of textured HDPE, nominal thickness 30 mil. Geomembrane used shall meet, at a minimum, the standards in Table 150930.02-1. Where geomembrane is required, it shall be textured on both sides. The method and degree of texturing shall be approved by the Engineer. The texturing shall be consistent among rolls and consistent with the samples approved by the Engineer. The chemical resistance of the geomembrane and seams shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources. Geomembrane shall be shipped rolled. No reclaimed material (that is, material that has seen previous service) shall be allowed in the geomembrane sheet. The geomembrane shall be free of pinholes and reasonably free from surface blemishes, scratches and other defects as judged by the Engineer.

B. Physical Properties.

Table 150930.02-1: HDPE Geomembrane – 30 mil Textured

Properties	Test Method	Required Test Values ⁽¹⁾	Manufacturer QC Test Frequency	Conformance QA Test Frequency
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	ASTM D5994	nom. (-5%) -10% -15%	per roll	1 per 20,000 sf
Asperity Height mils (min. ave.)	ASTM D7466	16 mil	every 2 nd roll ⁽²⁾	1 per 20,000 sf

Formulated Density (min. ave.)	ASTM D1505 or ASTM D792	0.940 g/cc	1 per 20,000 sf	1 per 20,000 sf
Tensile Properties (min. ave.) ⁽³⁾ <ul style="list-style-type: none"> yield strength break strength yield elongation break elongation 	ASTM D6693 Type IV	63 lb/in. 45 lb/in. 12% 100%	1 per 20,000 sf	1 per 20,000 sf
Tear Resistance (min. ave.)	ASTM D1004	21 lbs	1 per 20,000 sf	N/A
Puncture Resistance (min. ave.)	ASTM D4833	45 lbs	1 per 20,000 sf	1 per 20,000 sf
Stress Crack Resistance ⁽⁴⁾	ASTM D5397 (App.)	500 hr.	note ⁽¹²⁾	N/A
Carbon Black Content (range)	ASTM D4218 ⁽⁵⁾	2.0-3.0 %	1 per 20,000 sf	1 per 20,000 sf
Carbon Black Dispersion	ASTM D5596	note ⁽⁶⁾	1 per 20,000 sf	1 per 20,000 sf
Oxidative Induction Time (OIT) (min. ave.) ⁽⁷⁾ <ul style="list-style-type: none"> Standard OIT --- or --- High Pressure OIT 	ASTM D3895 ASTM D5885	100 min. 400 min.	note ⁽¹²⁾	N/A
Oven Aging at 85°C ^{(7),(8)} <ul style="list-style-type: none"> Standard OIT (min. ave.) - % retained after 90 days --- or --- High Pressure OIT (min. ave.) - % retained after 90 days 	ASTM D5721 ASTM D3895 ASTM D5885	55% 80%	note ⁽¹²⁾	N/A
UV Resistance ⁽⁹⁾ <ul style="list-style-type: none"> Standard OIT (min. ave.) --- or --- High Pressure OIT (min. ave.) - % retained after 1600 hrs⁽¹¹⁾ 	ASTM D7238 ASTM D3895 ASTM D5885	N.R. ⁽¹⁰⁾ 50%	note ⁽¹²⁾	N/A
<p>(1) Based on Geosynthetic Research Institute's GRI Specification GM13, Revision 14, dated January 6, 2016.</p> <p>(2) Alternate the measurement side for double sided textured sheet.</p> <p>(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction.</p> <ul style="list-style-type: none"> Yield elongation is calculated using a gage length of 1.3 inches. Break elongation is calculated using a gage length of 2.0 inches. <p>(4) The P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.</p> <p>(5) Other methods such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.</p> <p>(6) Carbon black dispersion (only near spherical agglomerates) for ten different views:</p> <ul style="list-style-type: none"> Nine in Categories 1 or 2, and One in Category 3. <p>(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.</p> <p>(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.</p> <p>(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.</p> <p>(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.</p> <p>(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.</p> <p>(12) Manufacturer may provide certification letter.</p>				

150930.03 CONSTRUCTION.

A. Submittals.

1. The Contractor shall submit the following documents and samples to the Engineer a minimum of 14 days prior to delivery of the geomembrane to the site:
 - a. Identification of the proposed material source or sources, including manufacturers' literature.
 - b. Manufacturer's Material Certifications for each roll of geomembrane sheet. As a minimum, the Contractor shall perform the tests given in Table 150930.02-1 on the geomembrane sheet prior to shipping geomembrane sheet to the site.

- c. Description of how the geomembrane will be made continuous across the entire EPS fill. The description shall include how the strength of the geomembrane shall be maintained across joints, seams, or splices between adjacent sheets of geomembrane.
 - d. Quality control program of the geomembrane installer and material supplier.
2. Notify the Engineer in writing a minimum of 7 days prior to starting placement of the geomembrane. The notice shall state the material to be used, the equipment to be used, the date and time placement operations will start, and the name of the person in the field who will be in charge of the geomembrane placement.
 3. Submit proposed geomembrane panel layouts to the Engineer at least 7 days prior to mobilization of crews.

B. Sampling and Testing.

Geomembrane Seam Testing: All geomembrane seams shall be tested and evaluated prior to acceptance. Testing of the seams shall be conducted by the geomembrane installer under observation of the Engineer. All testing shall be in compliance with the Quality Assurance Plan.

1. Trial Test Seams: The geomembrane installer shall maintain and use equipment and personnel at the site to perform testing of test seams. Test seams shall be made each day prior to commencing field seaming. These seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Such test seams shall be made at the beginning of each seaming period; at changes of equipment, equipment settings, weather, or sheet temperature; at the Engineer's discretion; and at least once every four to six hours during continuous operation of each welding machine. Also, each seamer shall make at least one test seam each day. Requirements for test seams are as follows:
 - a. The test seam sample shall be at least 3 feet long by 1 foot wide with the seam centered lengthwise. Six adjoining specimens 1 inch wide each shall be die cut from the test seam sample. These specimens shall be tested in the field with a tensometer for both shear (three specimens) and peel (three specimens) for single-track fusion welds or extrusion welds. For dual-track fusion welds, the Contractor shall test each track as if it was a single-track weld. Test seams shall be tested by the Contractor under observation of the Engineer. The specimens should not fail in the weld. The geomembrane installer shall supply qualified quality control personnel and testing equipment. No strain measurements need to be obtained in the field. A passing fusion or extrusion welded test seam shall be achieved when the criteria described in these Special Provisions are satisfied with the exclusion of any strain requirements. If a test seam fails, the entire operation shall be repeated. If the additional test seam fails, the seaming apparatus or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved. Test seam failure is defined as failure of any one of the specimens tested in shear or peel. For double-weld seams, both weld tracks shall meet the test seam criteria.
 - b. The Engineer shall observe all test seam procedures. The remainder of the successful test seam sample shall be assigned a number and marked accordingly by the Engineer, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. The sample itself should be retained in the Contractor's archives. In addition, at least one tested specimen from each test as selected by the Engineer shall be retained by the Engineer.
2. Non-Destructive Testing: Production seams shall be tested by the Contractor continuously using non-destructive techniques according to ASTM D4437. The geomembrane installer shall perform all pressure and vacuum testing under the observation of the Engineer. Requirements for non-destructive testing are as follows:
 - a. Single Weld Seams - the geomembrane installer shall maintain and use equipment and personnel at the site to perform continuous vacuum box testing on all single weld production seams. The system shall be capable of applying a vacuum of at least 3 psi. The vacuum shall be held for a minimum of 10 seconds for each section of seam.

- b. **Double Weld Seams** - The geomembrane installer shall maintain and use equipment and personnel to perform air pressure testing of all double weld seams. The system shall be capable of applying a pressure of at least 30 psi for not less than 5 minutes. Pressure loss tests shall be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," Geosynthetic Research Institute Test Method GM6. As outlined by the test method, following a 2 minute pressurized stabilization period pressure losses over a measurement period of 5 minutes shall not exceed 5.0 psi for 30 mil thick membrane.

- 3. **Destructive Testing:** Destructive testing shall be performed at a frequency of at least one test per every 500 linear feet of production seam. The destructive seam testing locations will be selected by the Engineer. Sufficient samples shall be obtained by the geomembrane installer to provide one sample to the archive, one sample to the Engineer for laboratory testing, and one sample to be retained by the geomembrane installer for field or laboratory testing. Testing requirements are as follows: Each sample shall be large enough to test five specimens in peel and five specimens in shear. The average values of each set of five specimens must meet the specification, and four of the five specimen tests must meet the specifications for the seam to be considered a passing seam. If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80% of the values required for the seam for the sample to pass. All specimens must fail in film tear bond (FTB) and meet the strain or separation requirements of Table 150930.02-1. Samples which do not pass the shear and peel tests shall be re-sampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then additional samples shall continue to be obtained until the questionable seam area is defined. Requirements for each destructive test are as follows:
 - a. The geomembrane installer shall test samples in the field or in a laboratory. All tests shall be performed using a calibrated, motor-driven, strain-controlled tensometer approved by the Engineer.
 - b. Peel shall be measured for one sample (that is, five specimens). Peel tests shall be evaluated for the criteria described in Table 150930.02-1 and Table 150930.03-1.
 - c. Shear shall be measured for one sample (that is, five specimens). Strain measurements are required for the shear specimens. Laboratory tests shall be evaluated for the criteria described in Table 150930.02-1 and Table 150930.03-1.
 - d. The Engineer shall observe all production seam field test procedures. The Engineer shall perform laboratory testing for both peel and shear and evaluate test results in accordance with Table 150930.02-1 and Table 150930.03-1.
 - e. The Engineer shall be responsible for the archive specimen. The Engineer shall assign a number to the archive sample and mark the sample with the number. The Engineer shall also log the date, seam number, approximate location in the seam, and field test pass-or-fail description, if applicable.
 - f. For double-weld seams, all destructive testing shall be performed for each weld to ensure a continuous good weld.

- 4. **Damaged areas,** areas that fail quality control testing, and areas where samples are taken for destructive testing shall be repaired by the geomembrane installer. No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods. Repaired areas shall be tested for seam integrity. Damaged materials are the property of the Contractor and shall be removed from the site at the geomembrane installer's expense. The Contractor shall retain all ownership and responsibility for the geomembrane until acceptance by the Engineer.

Table 150930.03-1: Field Testing Requirements – 30 mil HDPE Geomembrane

Properties	Test Method	Sample Size	Minimum Field Test Frequency	Acceptance Criteria
Shear Test	ASTM D-6392 (excl. Section 6.3, "Conditioning")	42 in. long seam, 12 in. wide	Average 1 every 1000 lineal feet for each type of welding	No more than 1 out of 5 non-FTB or not meeting yield strength. Minimum yield strength for the seam is 60 lb/in.

Peel Test	ASTM D-6392 (excl. Section 6.3, "Conditioning")	42 in. long seam, 12 in. wide	Average 1 every 1000 lineal feet for each type of welding	No more than 1 out of 5 non-FTB or not meeting yield strength. Minimum yield strength for the seam is 45 lb/in for fusion wedge seams and 39 lb/in for extrusion fillet seams.
Air-Pressure	GRI GM-6	N/A	All dual track seams	Pressure drop no more than 5 psi with initial pressure 30 psi for 5 minutes, following an initial relaxation period.
Vacuum	ASTM D5641	N/A	All extrusion seams	Examine weld for approximately 10 seconds through window for vacuum of minimum 4 psi.

C. Procedures.

The actual construction procedures shall be determined by the Contractor. The following are minimum requirements, and should be referenced by the Contractor when preparing submittals.

D. Delivery, Storage, and Handling.

1. Transportation of the geomembrane is the responsibility of the Contractor. The Contractor shall be liable for all damages to the materials incurred prior to and during transportation to the site.
2. Handling, storage, and care of the geomembrane prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damages incurred prior to final acceptance of the geomembrane by the Engineer.
3. The Contractor shall be responsible for storage of the geomembrane material at the site.
4. The geomembrane shall be protected from sunlight, moisture, excessive heat or cold, puncture, or other damaging or deleterious conditions. The Geomembrane shall be protected from mud, dirt, and dust. Any additional storage procedures required by the manufacturer shall be the Contractor's responsibility.

E. Execution.

1. Geomembrane Placement.

- a. Product protection: No support equipment shall be allowed on the geomembrane unless the equipment and protective measures are approved by the Engineer. Light-weight portable generators must be placed on protective rub sheets, and stands or supports shall be adequately padded to prevent potential damage to the rub sheet or geomembrane. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in any activity which damages the geomembrane.
- b. Surfaces to receive liner installation should be relatively smooth and even, and free of ruts, voids, protrusions, and deleterious material. Any damage to the surface caused by the Contractor's vehicles shall be repaired at the Contractor's expense.
- c. Deployment of the geomembrane shall be as follows:
 - 1) Unroll only those sections which are to be seamed together or anchored in one day. Panels should be positioned with the overlap recommended by the manufacturer, but not less than 3 inches, after the necessary alignment and cutting. On side slopes and next to structures, penetrations, and inclusions, the edge of the upslope sheet shall be positioned above the edge of the downslope sheet in a shingle-like fashion. Contractor shall drape the geomembrane a minimum of 5 feet beyond the edge of the EPS fill to allow proper draping along the sides.
 - 2) After panels are initially in place, wrinkles shall be minimized and the panels shall be secured by ropes, sand bags, or equivalent means. No securing methods shall be implemented which either penetrates the geomembrane or the EPS fill. Any damage to the geomembrane due to wind, rain, hail, or other weather shall be the sole responsibility of the Contractor.
- d. No horizontal seams should be within 5 feet of the toe or crest of a slope.
- e. The geomembrane shall be deployed in such a manner that the completed liner shall not exhibit any "trampoline" at the time protective cover or other materials are being placed over the geomembrane.

2. Geomembrane Seaming.

- a. Field seaming shall be made by fusion welding techniques wherever possible. Extrusion welding will be accepted where insufficient space exists to allow fusion welding. The Engineer may reject any proposed seaming method believed to be unacceptable.
- b. All foreign matter (dirt, water oil, etc.) shall be removed from the edges to be bonded. For extrusion-type welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Engineer to remove surface oxidation and prepare the surfaces for bonding. All abrasive buffing shall be performed using No. 80 grit or finer sandpaper. The grinding shall be performed so that grind marks are generally perpendicular to the edge of sheet. No solvents shall be used to clean the geomembrane.
- c. As much as practical, field seaming shall start from the top of the slope down. Tack welds (if used) shall use heat only; no double sided tape, glue or other method shall be permitted.
- d. The seams should be oriented as shown on the approved panel layout drawing, generally parallel to the line of maximum slope. In corners and odd shaped geometric locations, the number of field seams should be minimized.
- e. No seaming should be attempted above 104°F ambient air temperature. Below 41°F ambient air temperature, preheating of the geomembrane shall be required, unless it is demonstrated that this is not necessary (i.e., acceptable trial test (start-up) seams which duplicate, as closely as possible, actual field conditions). Preheating may be achieved by natural and/or artificial means (shelters and heating devices). Ambient temperature is measured six inches above the geomembrane surface. The geomembrane installer shall supply instrumentation for measurement of ambient temperature.
- f. A moveable protective layer of plastic may be required, as recommended by the Engineer, to be placed directly below each overlap of geomembrane that is to be seamed. This is to minimize moisture build-up between the sheets to be welded. The protective layer must be removed after seaming is complete unless approved by the Engineer.
- g. Seaming shall extend to the outside edge of panels to be placed in anchor trenches.
- h. No excessive grinding of the geomembrane prior to welding shall be permitted. Overground or improperly ground areas shall be replaced at the geomembrane installer's expense.
- i. Seams at panel corners of three or four sheets shall be completed in a fully leak-proof manner. Open ends of all air channels must be welded closed. A patch having a minimum dimension of 24 inches, extrusion welded to the parent sheet may be used.

3. Geomembrane Attachment to Structures.

The geomembrane shall be attached and sealed around reinforced concrete stormwater intake structures as detailed in the plans.

150930.04 METHOD OF MEASUREMENT.

The Engineer will measure the quantity of Geomembrane in square yards. The outside surface area of the expanded polystyrene foam shall be the area measured for payment. Material overlap at joints, extra material draping over the edge of fill, and material used for testing shall not be measured separately for payment.

150930.05 BASIS OF PAYMENT.

For the quantity of Geomembrane placed, the Contractor shall be paid for the unit price per square yard. This payment shall be full compensation to furnish and install the geomembrane including testing as noted in this special provision.