

SECTION 33 47 13
GEOMEMBRANE LINER SYSTEM VS 1.00 9832 sec cont

PART 1 GENERAL

1.1 RELATED DOCUMENTS

1.2 SUMMARY

The Work includes furnishing and installing a prefabricated geomembrane liner for secondary containment of fuel storage as shown on the drawings and as specified in these Special Provisions and the geomembrane fabricator's and installer's approved shop drawings.

1.3 RELATED REQUIREMENTS

1.4 REFERENCES

- A. ASTM D751 – Standard Test Methods for Coated Fabrics
- B. ASTM D413 – Standard Test Methods for Rubber Property – Adhesion to Flexible Substrate
- C. ASTM D4833 – Standard Test Method for Index Puncture Resistance of Geomembranes
- D. ASTM D2136 – Standard Test Method for Coated Fabrics – Low Temperature Bend Test
- E. ASTM G153 – Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for exposure of Nonmetallic Materials
- F. ASTM D1204 – Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperatures
- G. ASTM D471 – Standard Test Method for Rubber Property – Effect of Liquids
- H. ASTM D3389 – Standard Test Method for Coated Fabrics Abrasion Resistance
- I. ASTM D696 – Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics between -30° C and 30° C with a Vitreous Silica Dilatometer
- J. ASTM D5641 – Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
- K. ASTM D4437 – Standard Practice for Nondestructive Testing (NDT) for Determining the Integrity of Seams used in Joining Flexible Polymeric Sheet Geomembranes
- L. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
- M. ASTM D430 - Standard Test Methods for Rubber Deterioration—Dynamic Fatigue
- N. ASTM F1677 - Standard Test Method for Using a Portable Inclineable Articulated Strut Slip Tester (PIAST), Brungrager Mark II

1.5 SUBMITTALS

- A. Geomembrane Manufacturer
 - 1. Geomembrane manufacturer shall submit a list of the name and location of at least 5 projects using XR geomembranes in exposed secondary containment applications, with at least 20 years of successful service. Include in the submittal the name and location of at least 10 projects using XR geomembranes which each exceed 500,000 square feet in size.
 - 2. Geomembrane manufacturer shall provide certification that each roll of membrane supplied for the project meets the requirements of Section 2.2.
 - 3. Geomembrane manufacturer shall provide a certification that factory fabricator is approved by manufacturer.
 - 4. Manufacturer's standard catalog information and specifications.

5. Manufacturer's warranty per section 1.8 A.
- B. Geomembrane Factory Fabricator
1. Geomembrane factory fabricator shall provide a list of not less than 5 projects and not less than 500,000 sq ft of successfully fabricated XR Geomembrane.
 2. Shop QC/Q Plan for handling, welding and testing.
 3. Shop drawings with a proposed panel layout to cover the liner area shown in the project plans.
 4. Welded seam samples
 5. Tensiometer calibration certificate showing current date and successful operation.
 6. Fabricator's warranty per section 1.8 B.
- C. Field Geomembrane Installer
1. Field geomembrane installer shall provide a list of not less than 5 projects and not less than 500,000 square feet of successfully installed XR Geomembranes.
 2. Field geomembrane installer shall provide a field QC/QA Plan and field test reports of all seaming activities.
 3. Geomembrane fabricator's certification that field geomembrane installer is approved by geomembrane manufacturer for welding, testing and handling of XR-5 Geomembranes.
 4. Subgrade Acceptance Certificate from field geomembrane Installer
 5. Tensiometer calibration certificate from field geomembrane installer.
 6. Welded seam samples from field geomembrane installer
 7. Field geomembrane installer's warranty per section 1.8 C.

1.6 QUALITY ASSURANCE

- A. Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship.
- B. Testing requirements
1. The geomembrane manufacturer shall conform to the approved submittals in Section 1.5 A, providing documentation to the Owner or their representative.
 2. The factory fabricator shall conform to the approved submittals in Section 1.5 B providing documentation to the Owner or their representative.
 3. The geomembrane installer shall conform to the approved submittals in Section 1.5 C, providing documentation to the Owner or their representative.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Factory fabricated panels
1. Factory fabricated panels shall be accordion-folded, or rolled, onto sturdy wooden pallets designed to be moved by a forklift or similar equipment, or the panels shall be rolled around a hollow core and moved by straps through the core.
 2. Each factory fabricated panel shall be prominently and indelibly marked with the panel size and placement designation.
 3. Factory fabricated panels shall be protected as necessary to prevent damage during shipment and storage.
 4. Factory fabricated panels which have been delivered to the project site shall be stored in a dry area and single stacked. All materials shall be covered.
- B. Welding equipment
1. Welding equipment shall be delivered to the site in sealed containers and stored per manufacturer's recommendations. Brand name, model and serial number shall be visible.
- C. Miscellaneous materials

1. All project materials shall be delivered, stored and handled in accordance with manufacturers' recommendations.

1.8 WARRANTY

- A. Furnish a written warranty from the geomembrane manufacturer that covers weathering and chemical resistance specific to the project for a period of 10 years. The warranty must include test data to support the assumption of compatibility.
- B. Furnish a written warranty from the factory fabricator that covers the integrity of factory seams for a period of 2 years.
- C. Furnish a written warranty from the field geomembrane installer that covers the integrity of all field seams, connections and layout of the geomembrane for a period of 1 year.

PART 2 PRODUCTS

2.1 GENERAL

- A. The geomembrane material shall be manufactured specifically for the purpose of containing spilled fuel in a secondary containment area.
- B. The geomembrane material shall consist of factory fabricated sheets that minimize field seaming requirements. The total length of factory seams shall exceed the total length of field seams by a factor of at least 7:1 unless approved by the Engineer.
- C. The geomembrane material shall have a treated base fabric that eliminates the need for edge protection. Encapsulated edges will not be acceptable in lieu of treated base fabric.
- D. Included with geomembrane will be all items necessary for completion of project including anchor bars, embedment strips, walkmats, preformed pipe boots, clamps, etc.
- E. The manufacturer of the geomembrane shall have a minimum of 30 years of proven experience manufacturing the product used in this project.

2.2 GEOMEMBRANE

- A. 9832 XR-5 Geomembrane manufactured by Seaman Corporation complying with all properties in Table 1.

Table 1: Geomembrane Properties

Property	Test Method	Requirement- Imperial Units	Requirement- Metric Units
Base Fabric	Type	Polyester	Polyester
Membrane Construction	Type	Coated Fabric	Coated Fabric
Edge Protection	Type	Base Fabric Tie Coat	Base Fabric Tie Coat
Base Fabric Weight	ASTM D751	7.5 oz/yd ² nom.	254 g/m ² nom.
Finished Membrane Weight	ASTM D751	32 +2 oz/yd ² nom.	1085 +70 g/m ² nom.
Thickness	ASTM D 751	36 mils min.	0.91 mm min.
Trapezoid Tear	ASTM D751	50/50 lbf min.	233/233 N min.
Yield Tensile Strength	ASTM D751, Grab Method, Proc A	650/650 lbf min.	2892/2892 N min.
Elongation at Yield	ASTM D751	20% min.	20% min.

Table 1: Geomembrane Properties (continued)

Property	Test Method	Requirement- Imperial Units	Requirement- Metric Units
Adhesion - Ply	ASTM D751, Type A	15 lbf/in min. or Film Tearing Bond	130 N/5 cm min. or Film Tearing Bond
Hydrostatic Resistance	ASTM D751, Method A	800 psi min.	5.51 MPa min.
Puncture Resistance	ASTM D4833	275 lbf min.	1200 N min.
Bursting Strength	ASTM D751 Ball Tip	950 lbf min.	4220 N min.
Low Temperature Bend	ASTM D2136, 4 hrs, 1/8 in (3.1 mm) mandrel	Pass @ -30° F	Pass @ -35° C
Weathering Resistance	ASTM G153, Carbon Arc	8000 hrs with no appreciable changes, or stiffening/cracking of coating	8000 hrs with no appreciable changes, or stiffening/cracking of coating
Dimensional Stability	ASTM D1204, 212° F (100° C), 1 hr, each direction	0.5% max. change	0.5% max. change
Coefficient of Thermal Expansion Contraction	ASTM D696	8 x 10 ⁻⁶ in/in/°F max. change	1.4 x 10 ⁻⁵ cm/cm/°C max. change
Abrasion Resistance	ASTM D3389, H-18 wheel, 100 g	2000 cycles with no exposed base fabric	2000 cycles with no exposed base fabric
Water Absorption	ASTM D741, 7 days, 212° F (100° C)	0.34 oz/ft ² max.	0.14 kg/m ² max.
Hydrocarbon Resistance	Retention of Yield Tensile Strength, 75 months full exposure with exposed base fabric, Crude Oil and Jet A	>95% retention	>95% retention
Vapor Transmission	ASTM D814 unleaded gasoline, no alcohol	0.388 oz/24 hrs/ft ² nom.	117 g/m ² /day nom.
Dead Load	ASTM D751, Room Temperature, 1 in (2.54 cm) thermal weld, 4 hours	Pass @240 lbf min.	Pass @ 1068 N min.
Dead Load	ASTM D751, 160°F (70° C), 1 in (2.54 cm) thermal weld, 4 hours	Pass @120 lbf min.	Pass @ 534 N min.
Bonded Seam Strength	ASTM D751, Grab Method, Proc A	650 lbf min.	2892 N min.
Adhesion – Thermal Seam	ASTM D751	40 lbf/2 in weld min.	175 N/ 5 cm weld min.

2.3 EMBEDMENT STRIP

- A. XR Embedment Strips manufactured by Seaman Corporation complying with all properties in Table 2.

Table 2: Embedment Strip Properties

Property	Test Method	Requirement- Imperial Units	Requirement- Metric Units
Compound	Type	XR-5	XR-5
Membrane Construction	Type	Non Reinforced	Non Reinforced
Section Length	Measure	10 ft nom.	3.05 m nom.
Section Width	Measure	3.75 in nom.	95.2 mm nom.
Anchor Finger Length	Measure	1 in nom.	25.4 mm nom.
Tensile Strength	ASTM D638	1500 psi min.	10.3 MPa min.

2.4 WALKMAT

- A. XR Walkmat manufactured by Seaman Corporation complying with all properties in Table 3.

Table 3: Walkmat Properties

Property	Test Method	Requirement- Imperial Units	Requirement- Metric Units
Base Membrane	Type	XR-5	XR-5
Membrane Construction	Type	Composite on Coated Fabric	Composite on Coated Fabric
Edge Protection	Type	Base Fabric Tie Coat	Base Fabric Tie Coat
Relief Edge-both sides	Measure	3.5 in nom.	8.9 cm nom.
Thickness	ASTM D751	95 mil nom.	2.4 mm nom.
Dimensional Stability	ASTM D1204, 212 ^o F (100 ^o C), 1 hr, each direction	1.5% change nom.	1.5% change nom.
Demattia Flexibility	ASTM D430-07, 300 cpm	10,000 cycles with no chunking nom.	10,000 cycles with no chunking nom.
Puncture Resistance	ASTM D4833	240 lbf nom.	1068 N nom.
Coefficient of Friction- wet	ASTM F1677	1.5 nom.	1.5 nom.
Yield Tensile Strength	ASTM D751, Grab Method, Proc A	400 lbf nom.	1780 N min.

2.5 CONNECTION MATERIALS

- A. Embedment strips will be supplied by the geomembrane manufacturer which are constructed of the same polymer as the geomembrane. Strips will be 10' x 4" and will be fully weldable to the geomembrane. Embedment strips will be used for geomembrane termination at new concrete surfaces.
- B. Where noted on the plans, stainless steel batten bars will be provided made of ¼" x 2" Type 304 stainless steel. Anchor bolts will also be stainless steel, 3/8" diameter and sufficient length to

secure the batten bars to the concrete. Bolt spacing will be 12" on center or as indicated on the plans.

2.6 MISCELLANEOUS MATERIALS

- A. Provide adhesive compounds and tapes as recommended by geomembrane manufacturer for bonding to walls and penetrations. All materials must be resistant to the contents of the storage tanks and be compatible with the geomembrane.
- B. Where noted on the plans, slip resistance membranes (walkmats) shall be provided by the geomembrane manufacturer which are based on the supplied geomembrane and thermally tack-weldable to the main geomembrane.
- C. Welding rod manufactured from XR-5 geomembrane will be supplied for use in sealing some termination points, as approved by the Engineer.
- D. Provide preformed boots and sleeves constructed from the same material as the geomembrane where available from the geomembrane manufacturer.
- E. Joint sealants shall be resistant to the contents of the storage tanks, and compatible with the geomembrane.
- F. Band clamps for sealing pipe and other penetrations shall be made of stainless steel.
- G. Windsacks and permanent sandbags shall be constructed from the same material as the geomembrane.
- H. Solvents should only be used as approved by the Engineer.

2.7 WELDING EQUIPMENT

- A. Supply thermal welding equipment recommended by the equipment supplier for welding XR-5 geomembranes and capable of producing factory and field seams capable of meeting the requirements of Section 2.2 A, Table 1, Dead Load, Bonded Seam Strength and Adhesion-Thermal Welds.
- B. Provide tensiometers capable of measuring the seam strength requirements of Section 2.2 A, Table 1, Bonded Seam Strength and Adhesion-Thermal Seam.
- C. Tensiometers will be calibrated, and documentation shall be provided per Sections 1.5 B. 5, and 1.5 C. 5.

PART 3 EXECUTION

3.1 FACTORY FABRICATION

- A. The individual XR-5 liner widths shall be factory fabricated into large sheets custom designed for this project to minimize field seaming. Seams perpendicular to the slopes in a sunlight exposed application shall be acceptable. Panel layout shall be done in a manner that minimizes field seams and takes advantage of prefabrication so that sealing penetrations in the containment area is most efficient and secure. The length of factory vs. field seam shall meet the requirements of Section 2.1 B.
- B. A two-inch nominal seam done by automatic thermal high-pressure welding is required. The surface of the welded areas must be dry and clean. Pressure must be applied to the full width of the seam on the top and bottom surface while the welded area is still in a melt-type condition. The bottom welding surface must be flat to ensure that the entire seam is welded properly. If the floor of the fabrication facility is used as a bearing surface during the welding, the temperature of that surface must be within 5 degrees F of the air temperature of the facility.

- C. Factory welds must meet the requirements of Section 2.2 A, Table 1, Dead Load, Bonded Seam Strength and Adhesion – Thermal Seam.

3.2 INSTALLATION

- A. Field geomembrane Installer shall be responsible for proper handling and storage of fabricated geomembrane panels prior to and during installation.
- B. Geomembrane installation shall not begin until a proper base has been prepared to accept the geomembrane. Base material shall be free from angular rocks, roots, grass and vegetation. Foreign materials and protrusions shall be removed, and all cracks and voids shall be filled, and the surface made level, or uniformly sloping as indicated on the drawings. The prepared surface shall be free from loose earth, rocks, rubble and other foreign matter. Generally, no rock or other object larger than USCS sand (SP) should remain on the subgrade in order to provide an adequate safety factor against puncture. The subgrade shall be uniformly compacted to ensure against settlement. The surface on which the geomembrane is to be placed shall be maintained in a firm, clean, dry and smooth condition during installation.
- C. Seal geomembrane on all perimeters. Minimize required field seams. Seal geomembrane at all protrusions. Follow plans and manufacturer's recommendations.
- D. Install prefabricated embedment strips in concrete for anchorage to new concrete. Attach geomembrane to embedment strip using thermal seaming per manufacturer's recommendations. Maximum gap between ends of embedment strip shall be ¼" and shall be sealed using extruded geomembrane compound to be supplied by the geomembrane manufacturer.
- E. Anchor the geomembrane at existing concrete and other termination areas. Install mechanical battens per this specification and the project plans.
- F. Install preformed boots to seal penetrations through the geomembrane unless approved otherwise by the Engineer. All boot materials shall be constructed of the same product or polymer as the geomembrane.
- G. Field seaming shall be performed as outlined in Section 3.1 B. Prior to welding, wipe surfaces of pieces clean and free of dirt, dust, moisture or other foreign materials. Solvent cleaning methods should only be used as recommended by the geomembrane manufacturer.
- H. All field seams must meet the requirements of Section 2.2 A, Table 1, Dead Load, Bonded Seam Strength and Adhesion – Thermal Seam.
- I. No field seams shall be made when the ambient air temperature is below 30 deg F, unless approved by the Engineer.
- J. Seams perpendicular to slopes in sunlight exposed applications shall be acceptable.
- K. No field seams shall be made during any precipitation.
- L. All joints, upon completion of work, shall be tightly bonded. Any lining surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade, shall as directed by the Owner or their representative, be replaced or covered, and sealed with an additional layer of lining of proper size, in accordance with the patch procedure.
- M. Patching procedure: Any repairs to the lining shall be patched with the geomembrane material. Patch material shall have rounded corners and shall extend a minimum of four inches in each direction from the damaged area. Seam repairs or seams which are questionable should be cap stripped with a one inch wide (minimum) strip of the geomembrane material. The requirements of Sections 3.2 H apply to this cap stripping.

3.3 FIELD QUALITY CONTROL

- A. Field Geomembrane Installer shall furnish information sufficient for the Engineer to be assured of the experience and qualifications of personnel responsible for the assembly, installation and field seaming.
- B. All field seams shall be tested using the Air Lance Method (ASTM D4437 Section 4.2). A compressed air source shall deliver 55 psi minimum to a 3/16 inch nozzle. The nozzle will be directed to the lip of the field seam in a near perpendicular direction to the length of the field seam. The nozzle will be held 4 inches maximum from the seam and travel at a rate not to exceed 40 feet per minute. Any loose flaps of 1/8" or greater shall be repaired and retested. Any welding technique which purposefully leaves an unbonded flap outside the weld area must be approved by the Engineer.
- C. All mechanical connections shall be Air Lance tested per Section 3.3 B.
- D. As an alternative to the requirements of section 3.3 B, all field seams may be inspected utilizing the Vacuum Box Technique (ASTM D564) using a 3 to 5 psi vacuum pressure. All leaks shall be repaired and retested.
- E. A test field seam of a minimum length of 5 feet will be prepared and tested using an Air Lance or a Vacuum Box and destructively tested according to ASTM D751 for Weld Adhesion and Yield Tensile Strength. All seam tests must pass the stated criteria in sections 2.2 A, Table 1, 3.3 B, and 3.3 D before proceeding. This test will be performed at the beginning of any workday.
- F. Destructive testing will be as approved in the QC Plan required in Section 1.5 C by the Engineer.
- G. Upon completion of installation, field geomembrane installer shall clean the entire facility leaving no portion of the geomembrane inaccessible for visual inspection.

END OF SECTION 33 47 13