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HDPE AND LLDPE GEOMEMBRANE INSTALLATION SPECIFICATION



The information provided in this manual uses current quality control and quality assurance standards within the geomembrane industry. It is the sole responsibility of the user to determine the suitability and use of the information and/or discusses material (s). Agru America, Inc. is not an installer of Geosynthetic Membranes. This manual is provided only as a guideline and is not meant as an authority. Agru America will not be held liable for the installation of Geosynthetic Membranes by others.

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1. GENERAL

1.1 Summary

This specification includes furnishing and installing HDPE and LLDPE geomembranes. The HDPE formulated sheet density includes 0.940 g/cc or greater. The LLDPE formulated sheet density includes 0.939 or less. Geomembranes with both smooth and textured surfaces are included.

1.2 References

1.2.1. American Society for Testing and Materials (ASTM):

- 1.2.1.1. ASTM Standard D4437, 1988 (1999), "Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes", ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D4437-99, www.astm.org.
- 1.2.1.2. ASTM Standard D 5199, 2001 (2006), "Standard Test Method for Measuring the Nominal Thickness of Geosynthetics", ASTM International, West Conshohocken, PA, 2001, DOI: 10.1520/D5199-01R06, www.astm.org.
- 1.2.1.3. ASTM Standard D 5641, 1994 (2006), "Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber", ASTM International, West Conshohocken, PA, 1994, DOI: 10.520/D5641-94R06, www.astm.org.
- 1.2.1.4. ASTM Standard D 5820, 1995 (2006), "Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes", ASTM International, West Conshohocken, PA, 1995, DOI: 10.1520/D5820-95R06, www.astm.org.
- 1.2.1.5. ASTM Standard D 5994, 1994 (2003), "Standard Test Method for Measuring Core Thickness of Textured Geomembrane", ASTM International, West Conshohocken, PA, 1994, DOI: 10.1520/D5994-98R03, www.astm.org.
- 1.2.1.6. ASTM Standard D 6365, 1999 (2006), "Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test", ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D6365-99R06, www.astm.org.
- 1.2.1.7. D5820-95, Pressurized Air Channel Test for Dual Seamed Geomembranes

1.2.2. Geosynthetic Research Institute (GRI):

- 1.2.2.1. GRI GM 9, 1995, “Cold Weather Seaming of Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org
- 1.2.2.2. GRI GM 10, 1997 (2006), “The Stress Crack Resistance of HDPE Geomembrane Sheet”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org
- 1.2.2.3. GRI GM 13, 1997 (2009), “Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org
- 1.2.2.4. GRI GM 14, 1998, “Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes” Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org
- 1.2.2.5. GRI GM 17, 2000 (2009), “Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org
- 1.2.2.6. GRI GM 19, 2002 (2010), “Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org



1.3 Submittals

1.3.1. Submit the following to the Project Engineer or Property Owner, for review and approval, within a reasonable time, to expedite shipment and/or installation of the Geomembrane:

1.3.1.1. Documentation of Manufacturer's Qualifications (as specified in subsection 1.04A);

1.3.1.2. Manufacturer's Quality Control Program Manual (or descriptive documentation);

1.3.1.3. Material Properties Sheet, (including at a minimum all properties specified in GRI GM 13 and test methods used);

1.3.1.4. Material Sample;

1.3.1.5. Documentation of Installer's qualifications, (as specified below);

1.3.1.5.1. Submit a list of at least ten facilities completed by installer. (For each installation, provide the name and type of facility, facility location, date of installation, name and telephone number of facility contact, type and thickness of geomembrane used and, surface area of the installed geomembrane.)

1.3.1.5.2. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and Technicians assigned to this project.

1.3.1.5.3. Installer's Quality Control Program

1.3.1.6. Material and Liner Installation Warranties;

1.3.1.6.1. Submit a copy of all material warranties.

1.3.1.6.2. Submit a copy of all liner installation warranties.

1.3.2. Shop Drawings

1.3.2.1. Submit copies of shop drawings for engineer's approval within a reasonable time. Shop drawings shall show the proposed panel layout identifying seams and details. Seams should generally follow the direction of the slope. Butt seams or roll-end seams should not occur on a slope unless approved by the Owner's Representative. However, if allowed, these seams should be staggered.

1.3.2.2. Placement of geomembrane should not occur until Owner's Representative has received and approved the shop drawings.

1.3.3. Additional Submittals (To be provided during and after installation is complete.)

1.3.3.1 Manufacturer's warranty (refer to subsection 1.07).

1.3.3.2. Geomembrane installation warranty (refer to subsection 1.08).

1.3.3.3. Daily written acceptance of sub-grade surface (refer to subsection 3.01.C).

1.3.3.4. Low-temperature seaming procedures if applicable (refer to subsection 3.03.A).

1.3.3.5. Prequalification test seam samples (refer to subsection 3.05.A.6).

1.3.3.6. Field seam non-destructive test results (refer to subsection 3.05.B.1).

1.3.3.7. Field seam destructive test results (refer to subsection 3.05.C.6).

1.3.3.8. Daily field installation reports (refer to subsection 3.05.G).

1.3.3.9. Installation record drawing (refer to subsection 3.05).

1.4 Quality Control

1.4.1. Manufacturer's Qualifications: The manufacturer shall have at least five (5) years experience in the manufacturing of the specified or similar geomembrane product and shall have manufactured at least 1,000,000 M² (10,000,000 FT²) of the specified type of geomembrane or a similar product during the last five years.

1.4.2. Installer's Qualifications

1.4.2.1. The Geomembrane Installer shall be an approved installer by the Manufacturer.

1.4.2.2. The Geomembrane Installer shall have at least three (3) years experience installing the specified or similar geomembrane and shall provide a list outlining at least ten (10) projects totaling 500,000 M² (5,000,000 FT²) of the specified type of geomembrane or similar completed within the past three (3) years.

1.4.2.3. A Field Installation Supervisor performs and assumes responsibility throughout the geomembrane installation including geomembrane panel

layout, seaming, patching, testing, repairs, and all other outlined responsibilities. The Field Installation Supervisor shall have experience in or supervision in the installation and seaming of at least ten (10) projects totally 500,000 M² (5,000,000 FT²) of geomembrane or the type specified or similar product.

1.4.2.4. Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) with seaming experience of a minimum of 300,000M² (3,000,000FT²) of the geomembrane type specified or similar product, using the same type of seaming apparatus to be used in the current project. During the seaming, the Field Installation Supervisor and/or Master Seamer are present.

1.4.2.5. Qualified technicians employed by the Geomembrane installer complete all seaming, patching, testing, and other welding operations.

1.5 Delivery, Storage and Handling

1.5.1. Manufacturer labels must be on all rolls delivered to the project.

1.5.2. A firmly affixed label attached to the selvage edge, shall clearly state the manufacturer's name, product identification, material thickness, roll number, roll type, roll dimensions and roll weight.

1.5.3. The Manufacturer protects the Geomembrane from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

1.5.4. Continuously and uniformly supported, rolls are stored away from high traffic areas on a smooth, level surface. Chocks keep the rolls secure when necessary.

1.6 Project Conditions

Do not install Geomembrane in the presence of standing water, while precipitation is occurring, during excessive winds, or when material temperatures are outside the limits specified in Section 3.3.2.1 and 3.3.3.

1.7 Material Warranty

Material manufacturer shall guarantee material against defects and premature aging from environmental conditions on a pro rata basis for a specified period of time acceptable to owner and manufacturer.

1.8 Geomembrane Installation Warranty

The Geomembrane Installer shall guarantee the geomembrane installation against defects in the installation and workmanship for a time period satisfactory to all parties commencing with the date of final acceptance.

1.9 Geomembrane Pre-Construction Meeting

1.9.1. A Pre-Construction Meeting held at the site prior to installation of the geomembrane will include the Geomembrane Installer, Owner, Owner's representative (Engineer and/or CQA Firm), and the Earthwork Contractor.

1.9.2. Topics for this meeting shall include:

1.9.2.1. Health and Safety

1.9.2.2. Lines of authority and communication, resolution of any project document ambiguity.

1.9.2.3. Methods for documenting, reporting and distributing documents and reports

1.9.2.4. Procedures for packaging and storing archive samples.

1.9.2.5. Review of time schedule for all installation and testing.

1.9.2.6. Review of panel layout and numbering systems for panels and seams including details for marking on geomembrane

- 1.9.2.7. Procedures and responsibilities for preparation and submission of as-built panel and seam drawings
 - 1.9.2.8. Temperature and weather limitations, installation procedures for adverse weather conditions, defining acceptable sub grade, geomembrane, or ambient moisture and temperature conditions for working during liner installation
 - 1.9.2.9. Sub grade conditions, dewatering responsibilities and sub grade maintenance plan
 - 1.9.2.10. Deployment techniques including allowable sub grade for the geomembrane
 - 1.9.2.11. Plan for controlling expansion/contraction and wrinkling of the geomembrane
 - 1.9.2.12. Covering of the geomembrane and cover soil placement
 - 1.9.2.13. Measurement and payment schedules
 - 1.9.2.14. Responsibilities of each party
- 1.9.3. A designated person will document the meeting and send a copy of the minutes to each person in attendance.



2. PRODUCTS

2.1. Source Quality Control

2.1.1. Manufacturing Quality Control

- 2.1.1.1. The test methods and frequencies used by the manufacturer for quality control/quality assurance of the above geomembrane prior to delivery, shall be in accordance with the latest revision of the GRI GM 13 for HDPE geomembrane or GRI GM 17 for LLDPE geomembrane, or modified as required for project specific conditions.
- 2.1.1.2. The manufacturer's geomembrane quality control certifications, including results of quality control testing of the products, as specified in subsection 2.01.A.3, must be supplied to the Owner's Representative to verify that the materials supplied for the project are in compliance with all product and or project specifications. The certification, signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager, includes lot and roll numbers and corresponding shipping information.
- 2.1.1.3. The Manufacturer provides production/manufacturing Certification that the geomembrane and welding rod supplied for the project are from the same material type and are compatible.

2.2. Geomembrane

- 2.2.1. The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work. The product will satisfactorily complete testing demonstrating its suitability and durability for the purposes intended. The geomembrane rolls shall be seamless, high density polyethylene (HDPE - Formulated Sheet Density $\geq 0.94\text{g/cc}$) or linear low density polyethylene (LLDPE - Formulated Sheet Density $\leq 0.939\text{ g/cc}$) containing no plasticizers, fillers or extenders and shall be free of holes, blisters or contaminants, and leak free verified by 100% in line spark or equivalent testing. The geomembrane supplied is a continuous sheet with no factory seams in rolls.

The geomembrane will meet the property requirements as shown in (GRI GM 13 for HDPE) or (GRI GM 17 for LLDPE). To download current GRI GM specifications go to the Geosynthetic Research Institute:
<http://www.geosynthetic-institute.org/specifications.htm>

2.2.2. Material conformance testing by the Owner's Representative, if required, will be conducted using in-plant sampling or as specified for the project.

2.2.3. The geomembrane seams shall meet the property requirements as shown in **Section 5** or as required by project specifications



3. EXECUTION

3.1 Sub-grade Preparation

3.1.1. The sub grade shall be prepared in accordance with the project specifications. The geomembrane sub grade shall be uniform and free of sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.

3.1.2. The Geomembrane Installer and Owner's Representative shall inspect the surface before covering with the geomembrane on each day's operations to verify suitability.

3.1.3. The Geomembrane Installer and Owner's Representative shall provide daily a written acceptance of the surface before covering with the geomembrane. During installation, the Installer and Owner's Representative must ensure daily surface maintenance ensuring sub-grade suitability.

3.1.4. Prior to placement of the geomembrane, the Installer and Owner's Representative must repair all sub grade damaged by construction equipment and deemed unsuitable for geomembrane deployment. The Installer and Owner's Representative provides approval for all repairs. All damage and repair protocol including contractor and Installer responsibilities, are outlined in the preconstruction meeting.

3.2 Geomembrane Placement

3.2.1. The Owner's Representative approves all applicable certifications and quality control certificates listed in subsection 1.03 within the timeframe specified in the Contract Documents. If the material does not meet project specifications, the Contractor removes it from the work area.

- 3.2.2. The geomembrane installation must follow the limits shown on the project drawings and essentially as shown on approved Panel Placement Drawings. Submit any changes made to Panel Placement Drawings before deployment of liner materials. The Installer must receive approval for the changes prior to deployment of liner materials.
- 3.2.3. When temperatures are lower than 0 degrees C (32 degrees F), unless approved by the Owner's Representative, no geomembrane material can be unrolled and/or deployed. The Owner's Representative may adjust the minimum temperature for material deployment. The Installer and Owner's Representative defines temperature limitations during the preconstruction meeting. Only deploy the quantity of geomembrane anchored and seamed together in one day.
- 3.2.4. No vehicular traffic shall travel on the geomembrane other than an approved low ground pressure vehicle or equivalent. The Owner's Representative shall It is suggested that a test pad simulating the methods to be used and showing no damage to the liner will result, be performed prior to implementation of the proposed method.
- 3.2.5. Use sand bags or equivalent ballast as necessary temporarily holding the geomembrane material in position under the foreseeable and reasonably - expected wind conditions. Sand bag material shall be sufficiently close- knit to prevent fines from working through the bags and discharging on the geomembrane.
- 3.2.6. Installer and Owner's representative should not place geomembrane if moisture prevents proper sub grade preparation, panel placement, or panel seaming. Defined in the preconstruction meeting, the moisture limitations provide direction for the Installer and Owner's representative.

- 3.2.7. Damaged and rejected panels (or portions) shall be marked, removed from the work area, and the removal recorded/documentated.
- 3.2.8. The geomembrane should not "bridge over" voids or low areas in the sub grade. The geomembrane shall rest in intimate contact with the sub grade.
- 3.2.9. Wrinkles caused by panel placement or thermal expansion should be minimized in accordance with section 1.09 paragraph B11.
- 3.2.10. Considerations on Site Geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, minimization of the total length of field seams is required. Seams shall not be located at low points in the sub-grade unless geometry requires seaming at such locations and if approved by the Owner's Representative.
- 3.2.11. All panels must overlap prior to the seaming process. This overlap affects a weld and allows for proper testing. In no case shall this overlap be less than 75mm (3 in.).
- 3.2.12. Sharp stones or other hard objects that could potentially damage the membrane should not be within 1" (25mm) of the surface to be lined.
- 3.2.13. Sub-grade should be firm, unyielding and able to support deployment equipment without damage or rutting to the sub-grade.

3.3 Seaming Procedures

- 3.3.1. Cold weather installations should follow guidelines as outlined in GRI GM9.
- 3.3.2. The seaming process shall not occur when liner temperatures are less than 0 degrees C (32 degrees F) unless the Installer and/or Owner's Representative complies with the following conditions.

- 3.3.2.1. The seaming of the geomembrane at material temperatures below 0 degrees C (32 degrees F) only transpires when the Geomembrane Installer can demonstrate the following to the Owner's Representative using pre-qualification test seams.
- 3.3.2.1.1. Field seams comply with the project specifications.
 - 3.3.2.1.2. The safety of the crew ensured.
 - 3.3.2.1.3. Geomembrane material can be fabricated (i.e. pipe boots, penetrations, repairs. etc.) at sub-freezing temperatures.
- 3.3.2.2. The Geomembrane Installer shall submit to the Owner's Representative for approval, detailed procedures for seaming at low temperatures, possibly including the following:
- 3.3.2.2.1. Preheating of the geomembrane,
 - 3.3.2.2.2. Using a tent or other device preventing heat loss during seaming and rapid heat loss subsequent to seaming,
 - 3.3.2.2.3. Completion of a Number of test welds to determine appropriate seaming parameters.
- 3.3.3. If the geomembrane sheet temperature is above 75 degrees C (170 degrees F) as measured by an infrared thermometer or surface thermocouple, seaming transpires only with the approval by the Owner's Representative. This approval depends upon the recommendations by the manufacturer and on a field demonstration by the Geomembrane Installer using prequalification test seams to demonstrate that seams comply with the specification.
- 3.3.4. Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Use of extrusion welding takes place where fusion welding is not possible such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams.
- 3.3.5. In the case of fish mouths or excessive wrinkles at the seam overlap section, cut along the ridge of the wrinkles on the back into the panel if necessary. Terminate

the cut with a keyhole cut (nominal 10 mm (1/2 in) diameter hole) minimizing the crack/tear propagation. Then, seam the overlay. Patch the key hole cut with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm (6 in.) beyond the cut in all directions.

3.3.6. When extrusion welding 60 mil (1.5mm) or greater HDPE, it is advisable to bevel the top portion of the seam in a lengthwise direction to maximize intimate contact of material and improve continuity of weld.

3.3.7. Prior to seaming, confirm the area for welding is free of moisture, dirt and any foreign matter that can affect the integrity of the weld on an ongoing basis.

3.3.8. Take precaution and safety of the liner technicians, in extreme heat or cold, which can affect the health of the individuals.

3.3.9. Seaming should run through the Anchor Trench to terminate at the end of the sheet goods.

3.4 Pipe and Structure Penetration Sealing System

3.4.1. Provide penetration-sealing system as shown in the Project Drawings.

3.4.2. Construct all penetrations from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Project Drawings. In the case of Structured Liners such as SuperGripNet™, DrainLiner™ or similar materials offered by Agru America, Inc, use the smooth or textured liner of the same density for such fabrications. Weld the pre-fabricated or field fabricated assembly to the geomembrane as shown on the Project Drawings to prevent leakage. Once complete, test the assembly as outlined in section 3.05.B. If the Installer cannot perform the field non-destructive testing, attachments will be field spark tested by standard holiday leak detectors in accordance with ASTM

6365. Spark testing should be done in areas where both air pressure testing and vacuum testing is not possible.

3.4.2.1. Equipment for Spark testing shall be comprised of but not limited to; a hand held holiday spark tester, and conductive wand that generates a high voltage.

3.4.2.2. The testing steps performed by the Geomembrane Installer include:

3.4.2.2.1. Place an electrically conductive tape or wire beneath the seam prior to welding.

3.4.2.2.2. Complete a calibration test on a trial seam containing a non-welded segment ensuring the identification of such a defect (non-welded segment) under the planned machine settings and procedures.

3.4.2.2.3. Upon completion of the weld, enable the spark tester and hold approximately 25mm (1 in) above the weld moving slowly over the entire length of the weld in accordance with ASTM 6365. If no spark occurs, the weld is leak free.

3.4.2.3. A spark indicates a hole in the seam. The Geomembrane Installer locates, repairs, and retests the faulty area.

3.4.2.4. When flammable gasses are present, use special care and precautions in the area to be tested.

3.5. Field Quality Control

The Owner's Representative must receive information prior to all pre qualification and production welding and testing, or as agreed upon in the pre construction meeting.

3.5.1. Prequalification Test Seams

3.5.1.1. The Geomembrane Installer tests seams and prepares seams verify seaming parameters (speed, temperature and pressure of welding equipment) are adequate.

- 3.5.1.2. Each welding technician creates seams and tests each in accordance with ASTM D 4437 at the beginning of each seaming period. Welding technicians test the seaming under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.3 meters (10 feet) long for fusion welding and 1 meter (3 feet) long for extrusion welding with the seam centered lengthwise. At a minimum, each welding technician creates one test seam after seaming 4–6 hours; additional tests may be required with changes in environmental conditions.
- 3.5.1.3. Two 25 mm (1 in) wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. The specimens tested by the Geomembrane Installer require using a field tension meter testing both tracks for peel strength and shear strength. Each specimen should fail in the parent material and not in the weld, "Film Tear Bond"(F.T.B. failure). When the seam separation is equal to or greater than 25% of the track width, it is a failed test.
- 3.5.1.4. Listed in the Tables in Section 5 provide the minimum acceptable seam strength values obtained for all specimens tested. Four specimens out of five must meet the acceptable seam strength values for consideration as passing.
- 3.5.1.5. If a test seam fails, the welding technician must immediately conduct an additional test seam. If the additional test seam fails, the welding technician rejects the seaming apparatus. The technician must correct the apparatus deficiencies and produce a successful test seam before using the apparatus for any other/additional production seaming.
- 3.5.1.6. The technician labels a sample from each test seam. The label indicates the date, geomembrane temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The technician then gives the sample to the Owner's Representative for archiving.

3.5.2. Field Seam Non-destructive Testing

3.5.2.1. The technician non-destructively tests over the full seam length before the Geomembrane Installer covers it. Numbered or otherwise designated, each seam's label includes the location, date, test unit, name of tester and outcome of all non-destructive testing. Once recorded, the technician submits the information to the Owner's Representative.

3.5.2.2. Testing should be done as the seaming work progresses, not at the completion of all field seaming, unless agreed to in advance by the Owner's Representative. All defects found during testing shall be numbered and marked immediately after detection. The technician must repair, retest, and remark all defects indicating the acceptable completion of the repair.

3.5.3. Non-destructive testing shall be performed using vacuum box, air pressure or spark testing equipment.

3.5.4. Experienced technicians familiar with the specified test methods perform all non-destructive tests. The Geomembrane Installer demonstrates all test methods verifying the validity of said test procedures for the Owner's Representative.

3.5.5. The Geomembrane Installer tests all extrusion seams using a vacuum box in accordance with ASTM D 4437 and ASTM D 5641 and the following equipment and procedures:

3.5.5.1. Equipment for testing extrusion seams is not limited to but should include:

3.5.5.1.1. A vacuum box assembly consisting of a rigid housing,

3.5.5.1.2. A transparent viewing window,

3.5.5.1.3. A soft rubber gasket attached to the base,

3.5.5.1.4. Port hole or valve assembly and a vacuum gauge,

3.5.5.1.5. A vacuum pump assembly equipped with a pressure controller and pipe connections,

3.5.5.1.6. A rubber pressure/vacuum hose with fittings and connections,

3.5.5.1.7. A plastic bucket,

3.5.5.1.8. A wide paintbrush or mop, and

3.5.5.1.9. A soapy solution.

3.5.5.2. The Geomembrane Installer must charge the vacuum pump and adjust the tank pressure to approximately 35 kPa (5 psig).

3.5.5.3. The Geomembrane Installer shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3m (12 in) by 1.2m (48 in) (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa (5 psig) for approximately 3-4 seconds. The Installer must continuously examine the geomembrane through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after 3-4 seconds, consider the area leak free. Once the area is leak free, depressurize the box and move it over the next adjoining area with an appropriate overlap and the process repeated.

3.5.5.4. All areas where soap bubbles appear shall be marked, repaired and then retested.

3.5.5.5. At seam locations where the Installer is unable to non-destructively test, such as pipe penetrations, the Installer must substitute alternate non-destructive spark testing (as outlined in section 3.04.B) or equivalent.

3.5.5.6. All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

3.5.6. Double Fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D 5820 and ASTM D 4437 and the following equipment guidelines and procedures.

3.5.6.1. Equipment for testing double fusion seams shall be comprised of but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa (30 psig), mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.

3.5.6.2. The Geomembrane Installer completes all testing activities. Both ends of the seam to be tested are sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of 210 kPa (30 psig), and the valve closed. Allow 2 minutes for the injected air to come to equilibrium in the channel, and sustain pressure for 5 minutes.

If pressure loss does not exceed 28 kPa (4 psig) after the five-minute period, the Installer considers the seam leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feedhole sealed.

3.5.6.3. If loss of pressure exceeds 28 kPa (4 psig) during the testing period or pressure does not stabilize, the Geomembrane Installer locates, repairs and retests the faulty area.

3.5.6.4. Record all results of the pressure testing on the liner at the seam tested and on a pressure testing record.

3.5.6.5. If release of pressure from opposite end of tested seam does NOT deflate seam, the Installer takes measures to determine the cause and remedies to air test 100% of the seam under scrutiny.

3.5.7. Destructive Field Seam Testing

3.5.7.1. The Installer analyzes one destructive test sample per 150 linear m (500 linear ft) seam length or the Geomembrane Installer shall take another predetermined length in accordance with GRI GM 14 from a location specified by the Owner's Representative. The Geomembrane

Installer receives the sample locations without advance notice of the locations. The Geomembrane Installer cuts samples as directed by the Owner's Representative before the complete installation and as seaming progresses.

3.5.7.2. All field samples shall be marked with their sample number and seam number including the sample number, date, time, location, and seam number recorded. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If the installation of a permanent patch over the test location the same day of sample collection is not possible, place a temporary patch either tack welded or hot air welded over the opening until affixing a permanent patch.

3.5.7.3. Testing requires the destructive samples size at least 300 mm (12 in) wide, 1m (36 in) long, with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Owner's Representative as an archive sample; one section given to the Owner's Representative for laboratory testing as specified in paragraph 5 below; and one section retained by the Geomembrane Installer for field testing as specified in paragraph 4 below.

3.5.7.4. For field-testing, the Geomembrane Installer shall cut 10 identical 25 mm (1 in) wide replicate specimens from his sample. The Geomembrane Installer shall test five specimens for seam shear strength and five for peel strength. The Geomembrane Installer performs peel tests on both the inside and outside weld tracks. To be acceptable, four (4) of five (5) test specimens must pass the stated criteria in section 2.02 with less than 25% separation. If four (4) of five (5) specimens pass, the sample qualifies for testing by the testing laboratory if required.

3.5.7.5. If the specifications require an independent seam testing, conduct the testing in accordance with ASTM 5820 or ASTM D4437.

3.5.7.6. Prepare and submit all reports of the results of examinations and testing to the Owner's Representative.

3.5.7.7. For field seams, if a laboratory test fails, it is an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. The Geomembrane Installer should take additional destructive test portions at locations indicated by the Engineer; (typically 3 m (10 ft) on either side of the failed sample) and perform additional laboratory seam tests. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams. When seams fail the destructive test, the Installer re-seams or repairs seams with a cap-strip. Cap-strip seams shall be non-destructively vacuum box tested until achieving adequacy of the seams. The Geomembrane Installer must destructively test all Cap strip seams exceeding 50 M in length (150 FT).

3.5.7.8. The Installer keeps all samples out of critical areas such as in the bottom of ponds and other locations such as slopes and sumps.

3.5.8. Identification of Defects

3.5.8.1. The Installer and Owner's Representative inspects panels and seams during and after panel deployment to identify all defects, including holes, blisters, un-dispersed raw materials and signs of contamination by foreign matter.

3.5.9. Evaluation of Defects: The Installer must complete a non-destructive test for each suspect location on the liner (both in seam and non-seam areas) using one of the methods described in Section 3.05.B. Each location failing non-destructive testing is marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

3.5.9.1. If a destructive sample fails the field or laboratory test, the Geomembrane Installer shall repair the seam between the two

nearest passed locations on both sides of the failed destructive sample location.

3.5.9.2. All repairs of defective seams, tears or holes use either re-seaming or applying an extrusion welded cap strip process.

3.5.9.3. Re-seaming may consist of either:

3.5.9.3.1. Removing the defective weld area and re-welding the parent material using the original welding equipment; or

3.5.9.3.2. Re-seam the defective weld area by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.

3.5.9.3.3. Cap stripping entire faulty seam.

3.5.9.4. The Installer repairs blisters, larger holes, and contamination by foreign matter using required patches and/or extrusion weld beads.

Each patch shall extend a minimum of 150 mm (6 in) beyond all edges of the defects.

3.5.9.5. Locate, measure and record all repairs.

3.5.10. Verification of Repairs on Seams: Each repair requires a non-destructive test using either vacuum box or spark testing methods. An indication of a successful repair includes areas passing the non-destructive test. Areas failing the tests require re-seaming and retesting until results show a passing test. Requirements for areas failing the tests include re-seaming and retesting until passing test results. The Installer records the number, date, location, technician and test outcome of each patch.

3.5.11. Daily Field Installation Reports: At the beginning of each day's work, the Installer shall provide the Engineer with daily reports for all work accomplished on the previous workday. Reports shall include the following:

3.5.11.1. Total amount and location of geomembrane placed

3.5.11.2. Total length and location of seams completed, name of technicians doing seaming and welding unit numbers

3.5.11.3. Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing

3.5.11.4. Results of pre-qualification test seams

3.5.11.5. Results of non-destructive testing

3.5.11.6. Results of vacuum testing of repairs

3.5.12. Prior to covering the liner, report all Destructive test results.

3.5.13. Perform and complete all quality assurance no more than 72 hours after geomembrane deployment.

3.6 Liner Acceptance

3.6.1. The Owner's Representative accepts the Geomembrane liner when:

3.6.1.1.1. The entire installation is completed or an agreed upon subsection of the installation is finished.

3.6.1.1.2. The Installer submits all completed QC documentation to the owner.

3.6.1.1.3. Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

3.6.1.1.4. All submittals are accepted.

3.07 Anchor Trench

Construct as specified on the project drawings.

3.8 Disposal of Scrap Materials

3.8.1. On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap material in a location approved by the Owner, remove equipment used in connection with the work herein, and shall leave the premises in a neat acceptable manner. Finally, remove all scrap material from the surface of the geomembrane.

4. MEASUREMENT AND PAYMENT

The project specifications document/outline the required measurements and payment of services. All parties sign all documents prior to project start up.

5. GEOTEXTILES, GEONETS and GEOCOMPOSITES

5.1 Geotextiles

The general arrangement of Geotextiles includes aligning seams parallel to the prevailing slope and seams finished by either heat seaming with an approved hand held or self-motivated thermal device or by sewing with a stitching approved by the engineer. Whichever stitching method is used, the thread should be compatible with the fabric and have similar chemical resistance to the liner used.

5.2 Geonet

Geonet may be butt joined or lapped if specified. At five-foot (5'/1.5m) intervals along the edge, the Installer applies Nylon/plastic cable ties to the net edge.

Complete end splices as follows:

1. On slopes, the ends will overlap two feet (2'/0.6m) with uphill panels on top and two (2) rows of cable ties applied at 6" spacing or per engineers specification.
2. In flat areas, the ends will overlap a minimum to six inches (6"/15 cm) and one (1) row of three (3) cable ties applied.

5.3 Geocomposites

Geocomposites can overlap with the net portion tied and the Geotextile portion thermally bonded or seamed as required by the project specifications.

5.4 Repairs

Repair any holes, tears, or burns through the Geotextile from thermal seaming by patching with the same Geotextile. The patch will be a minimum of twelve inches (12"/30cm) larger (in all directions) than the area repaired and will be spot bonded thermally. Repair all geonet holes and/or tears using a patch of the same geonet. Patches are a minimum of twelve inches (12"/30cm) larger in all directions than the area repaired. Tie the patch in place using a minimum of four (4) nylon cable ties.

6.0 - TABLES

"This section shall include the current GRI GM13 (HDPE) or GRI GM17 (LLDPE) manufacturer's specification or a revision of GRI GM13 (HDPE) or GRI GM 17 (LLDPE) specific to the unique project requirements and/or standards, as determined by the owner or owners' agent." TO BE INSERTED BY COMPANY PREPARING SUBMITTALS TO GUARANTEE MOST CURRENT GRI SPECIFICATION.

SEAM STRENGTHS - HDPE and LLDPE GRI GM 19

Table 1: Seam Strength and related Properties of Thermally Bonded Smooth and Textured **High Density Polyethylene (HDPE)** Geomembrane **(English Units)**

Geomembrane Nominal Thickness	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams ⁽¹⁾							
shear strength ⁽²⁾ , lb/in.	57	80	100	120	160	200	240
shear elongation at break ⁽³⁾ , %	50	50	50	50	50	50	50
peel strength ⁽²⁾ , lb/in.	45	60	76	91	121	151	181
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams ⁽¹⁾							
shear strength ⁽²⁾ , lb/in.	57	80	100	120	160	200	240
shear elongation at break ⁽³⁾ , %	50	50	50	50	50	50	50
peel strength ⁽²⁾ , lb/in.	39	52	65	78	104	130	156
peel separation, %	25	25	25	25	25	25	25

Notes for Table 1 – (Used also for hot air and ultrasonic seaming methods.)

1. Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be low as 80% of the listed values
2. Elongation measurements should be omitted for field testing

Table 2: Seam Strength and related Properties of Thermally Bonded Smooth and Textured **Linear Low Density Polyethylene (LLDPE)** Geomembrane (**English Units**)

Geomembrane Nominal Thickness	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams ⁽¹⁾							
shear strength ⁽²⁾ , lb/in.	45	60	75	90	120	150	180
shear elongation at break ⁽³⁾ , %	50	50	50	50	50	50	50
peel strength ⁽²⁾ , lb/in.	38	50	63	75	100	125	150
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams ⁽¹⁾							
shear strength ⁽²⁾ , lb/in.	45	60	75	90	120	150	180
shear elongation at break ⁽³⁾ %	50	50	50	50	50	50	50
peel strength ⁽²⁾ , lb/in.	34	44	57	66	88	114	136
peel separation, %	25	25	25	25	25	25	25

Notes for Table 2 - Also for hot air and ultrasonic seaming methods

1. Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be low as 80% of the listed values
2. Elongation measurements should be omitted for field testing

Non-Destructive Air Channel Test

Table 3: Initial Pressure Schedule

Material	Field Testing	
	Minimum PSI	Maximum PSI
30 mil	15	30
40 mil	20	30
60 mil	24	30
80 mil	24	30
100 mil	24	32

Table 4: Maximum Allowable Pressure Drop

Material Field Test (after five minutes)

- 30 mil 4 PSI
- 40 mil 4 PSI
- 60 mil 4 PSI
- 80 mil 4 PSI
- 100 mil 4 PSI

Note: At all times before heat sealing the end of the seam, the operator should insure that the void or air channel is free of obstruction.

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