



SKAPS INDUSTRIES

**HDPE & LLDPE Geomembrane
Installation Guideline**



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1.01 Summary

This guideline provides an overview of installation procedures of HDPE and LLDPE geomembrane (both smooth and textured surfaced) consistent with industry accepted practices to ensure the installed geomembrane products will perform its intended purposes. All installation work shall be performed as per project specifications.

1.02 References

- A. Construction Quality Assurance (CQA) Plan
- B. Latest Version of American Society for Testing and Materials (ASTM) standards
 - 1) ASTM D4437, "Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes".
 - 2) ASTM D6392, "Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes".
 - 3) ASTM D5641, "Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber".
 - 4) ASTM D5820, "Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes".
 - 5) ASTM D6365, "Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test".
- C. Geosynthetic Research Institute (GRI):
 - 6) GRI GM 9, "Cold Weather Seaming of Geomembranes."
 - 7) GRI GM 10, "The Stress Crack Resistance of HDPE Geomembrane Sheet."
 - 8) GRI GM 12, "Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage."
 - 9) GRI GM 13, "Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes."
 - 10) GRI GM 14, "Test Frequencies for Destructive Seam Testing Selecting, variable intervals for taking geomembrane destructive samples using the method of attributes".
 - 11) GRI GM 17, "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes".
 - 12) GRI GM 19, "Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes".



1.03 Submittals

(A) Submit following to the engineer or owner for review and approval so the project construction schedule not affected.

- 1) Documentation of manufacturer's qualifications.
- 2) Manufacturer's Quality Control Program Manual.
- 3) Technical Datasheet with properties of each material.
- 4) Sample of each material.
- 5) List of at least twelve projects completed with SKAPS material.
- 6) Copy of Sample Warranty of each material as per project specification.

(B) Shop Drawings

- 7) Submit shop drawings showing proposed panel layout identifying seams and details, seams generally follow the direction of the slope.
- 8) Butt seams or roll-end seams shall not occur on a slope without owner's approval.
- 9) Placement/installation shall not commence without owner's approval.

(C) Additional Submittals (During Installation and at Completion)

- 10) Manufacturer's warranty of each material
- 11) Installation warranty
- 12) Daily acceptance of sub-grade surface
- 13) Low-temperature seaming procedures if applicable
- 14) Prequalification test seam samples
- 15) Field seam non-destructive test results
- 16) Field seam destructive test results
- 17) Daily field installation reports
- 18) Record drawings of installation

1.04 Quality Control

- 1) Manufacturer shall have least five years of experience in the manufacturing of the specified or similar products. Manufacturer shall have manufactured at least 500,000 m² (5,000,000 ft²) of the specified or similar products within last five years.
- 2) Installer shall be approved by the owner prior to commence installation.
- 3) Installer shall have least three years of experience in the installation of the specified or similar products. Installer shall have installed at least 500,000 m² (5,000,000 ft²) of the specified or similar products within last five years.
- 4) Installation shall be performed under the supervision of a field Installation Supervisor, who is responsible for geomembrane panel layout, seaming, patching, testing, repairs etc. The Field



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Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 10 projects with total of at least 500,000 m² (5,000,000 ft²) of the specified or similar products within last five years.

- 5) Seaming shall be performed under the supervision of a master seamer, who has seaming experience of a at least 300,000 m² (3,000,000 ft²) of the specified or similar products within last five years using the same type of apparatus to be used in the project.
- 6) Seaming, patching, testing and other welding shall be performed by qualified technician.

1.05 Delivery, Storage and Handling

- a) Each roll delivered to the project site shall be labelled with manufacturer's name, product identification, material thickness, roll number, roll type, roll dimensions and roll weight.
- b) Protect the Geomembrane from mud, dirt, dust, grease, puncture, cutting or any other damaging or deleterious conditions.
- c) Store all rolls on a smooth level surface. Do not use wooden pallets. Do not stake more than three rolls high. When necessary chocks the rolls.
- d) Any visible damage to rolls should be noted and reported to appropriate party.

1.06 Defects and Repair

All seams and non-seam areas of the geomembrane shall be checked for defects, holes, blisters, contamination by foreign matter and dispersion irregularities of raw resin using following procedures:

- a) Any defect in the seam or sheet that has an actual hole larger than ¼ inch or tear shall be circled with appropriate marking to indicate a patch is required. If the tear is on a slope or in area of stress and has a sharp edge, it must be rounded prior to patch.
- b) Any defect in the seam or sheet has not an actual hole shall be circled with appropriate marking to indicate that a repair method may be only an extruded bead and that a patch is not required.
- c) Blisters and dispersion irregularities of raw resin shall be patched.
- d) Patches shall be performed by extrusion welding. No more than 10% of the thickness shall be removed by grinding no more than 10 minutes prior to weld.
- e) Welding shall begin where the grinding started and must overlap the previous seam by minimum two inches.
- f) Re-seaming over an existing seam without regrinding shall not be permitted.
- g) Patches shall be round or oval in shape using same geomembrane and extend minimum six inches beyond the edges of defects.
- h) Each repair must be tested by non-destructive test method. Any repair failed, must be repeated and retested until it passes.
- i) Document all seams that initially failed the test and include evidence that these seams were repaired again and pass the test.
- j) Owner or his presentative shall conduct a final walk-through to confirm all repairs have been completed and debris removed.



1.07 Cover Geomembrane

- a) The geomembrane shall be covered as soon as possible.
- b) Any cover material placed over geomembrane shall be placed with care to avoid damage to geomembrane.
- c) Any cover material deployed over geomembrane shall be free of sharp objects, foreign and organic material, or debris of any kind which could damage the geomembrane.
- d) The use of lightweight machinery with low ground pressure is allowed.
- e) Care shall be taken while backfilling anchor trenches to prevent any damage to the geomembrane. If damage occurs, it shall be repaired prior to backfilling.

1.08 Pre-Construction Meeting

A pre-construction meeting shall be held at the site prior to installation of the geomembrane should attend by owner, owner's representative (engineer and/or CQA firm), geomembrane installer and the earthwork contractor. A designated person will document the meeting and send a copy of minutes to each attendee.

Following topics shall include:

- a) Chain of authority and communication. Resolution of any project document ambiguity.
- b) Methods for documenting, reporting and distributing documents and reports.
- c) Procedures for packaging and storing archive samples.
- d) Review of time schedule for all installation and testing.
- e) Review of panel layout and numbering systems for panels and seams including details for marking on geomembrane.
- f) Procedures and responsibilities for preparation and submission of as-built panel and seam drawings.
- g) Temperature and weather limitations. Installation procedures for adverse weather conditions. Defining acceptable subgrade, geomembrane, or ambient moisture and temperature conditions for working during liner installation.
- h) Subgrade conditions, dewatering responsibilities and subgrade maintenance plan.
- i) Deployment techniques including allowable subgrade for the geomembrane.
- j) Plan for controlling expansion/contraction and wrinkling of the geomembrane.
- k) Covering of the geomembrane and cover soil placement.
- l) Measurement and payment schedules.
- m) Health and safety
- n) Responsibilities of each party.



Article II - Product

2.01 Source Quality Control

- a) 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 GRI GM 13 for HDPE geomembrane or GRI GM 17 for LLDPE geomembrane, or modified as required for project specific conditions.
- b) The manufacturer's quality control certifications including results of quality control testing of the products 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 shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager.
- c) The Manufacturer will provide Certification that the geomembrane and welding rod supplied for the project are made from the same material type and are compatible.

2.02 Geomembrane

- a) The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work, also suitable and durable for intended purposes. 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 shall be supplied as a continuous sheet with no factory seams in rolls. The geomembrane will meet the property requirements as shown in Table A (GRI GM 13) or Table B (GRI GM 17).
- b) Material conformance testing if required by the Owner's Representative will be conducted using in-plant sampling or as specified for the project.
- c) The field seams shall meet the property requirements as required by project specifications.



Article III - Execution

3.01 Sub-Grade Preparation

- a) Subgrade for geomembrane shall be prepared and maintained as per project specification.
- b) Subgrade for geomembrane shall be uniform, firm, free of sharp or angular objects, sudden change in grade that may damage the geomembrane.
- c) Subgrade for geomembrane shall be free from excessive moisture or standing water.
- d) If area of subgrade for geomembrane cannot be compacted satisfactorily shall be replaced with properly compacted fill.
- e) The Geomembrane Installer and Owner or his representative shall inspect the surface daily and accept the suitability before laying down geomembrane.
- f) The Geomembrane Installer must repair all subgrade damaged by construction equipment and deemed unsuitable for geomembrane deployment. All repair must be approved by owner or his representative prior to geomembrane deployment.
- g) Do not install geomembrane while precipitation, in the presence of standing water, during excessive wind, or when material temperatures are outside the specified limits.

3.02 Geomembrane Placement

- a) The geomembrane installation shall follow approved Panel Placement Drawings with limits shown on the project drawings. Any changes must be approved prior to deployment of geomembrane.
- b) To deploy geomembrane roll, use a spreader bar assembly with a loader bucket or other methods approved by the owner or his representative.
- c) No geomembrane shall be unrolled and/or deployed when temperatures are below 0 degrees C (32 degrees F) and above 40 degrees C (104 degrees F), unless approved by the owner or his representative.
- d) No geomembrane shall be unrolled and/or deployed in the presence of excessive fog, rain, dew etc., during any precipitation, and high wind, unless approved by the owner or his representative.
- e) Only deploy the geomembrane quantity anchored and seamed together in one day.
- f) Smoking and wearing shoes damaging geomembrane shall not be allowed.
- g) Do not allow any vehicular traffic directly on geomembrane other than an approved low ground pressure vehicle.
- h) Drive any vehicle on geomembrane as straight as possible. No sharp turns, sudden stops or quick starts are allowed.
- i) Place sand bags as temporary ballast on geomembrane to prevent wind uplift.

3.03 Seaming Procedures

- a) Installation during cold weather shall follow guidelines as per GRI GM9.



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- b) Field seaming shall not be performed when geomembrane temperatures are below 0 degrees C (32 degrees F) and above 75 degrees C (170 degrees F) unless approved by the owner or his representative with appropriate precaution and safety of liner technicians.
- c) Field seaming shall be performed using automatic fusion welding equipment and techniques. Extrusion welding may be used where fusion welding is not possible such as at pipe penetration, patches, repairs and short (less than a roll width) runs of seams.
- d) Prior to seaming, make sure the area of welding is free of moisture, dirt and any foreign matters that can affect the integrity of the weld.
- e) Field seaming shall run from Anchor Trench to the end of the deployed geomembrane.
- f) Verify minimum overlap of four inches for fusion welding and six inches for extrusion welding are provided for geomembrane panels.
- g) Do not use cleaning solvent unless approved by the manufacturer.

3.04 Pipe and Structure Penetration Sealing System

- a) Provide penetration sealing system as shown in the Project Drawings.
- b) Penetrations shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Project Drawings. The pre-fabricated or field fabricated assembly shall be field welded to the geomembrane as shown on the Project Drawings so as to prevent leakage. Alternatively, where field non-destructive testing cannot be performed, attachments will be field spark tested by standard holiday leak detectors in accordance with ASTM 6365
- c) Spark testing should be done in areas where both air pressure testing and vacuum testing are not possible.
- d) A spark indicates a hole in the seam. The faulty area shall be located, repaired and retested by the Geomembrane Installer.
- e) Care should be taken if flammable gases are present in the area to be tested.

3.05 Field Quality Control

The Owner's Representative shall be notified prior to all pre-qualification and production welding and testing, or as agreed upon in the pre-construction meeting.

(A) Prequalification Test Seams

- 1) Installer will verify adequacy of seaming parameters; speed, temperature and pressure of welding equipment and prepare Test Seam.
- 2) Each welding technician shall create Test Seam at the beginning of each seaming period. Test Seam shall be performed 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



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lengthwise. At a minimum, tests seams should be made by each technician 1 time every 4–6 hours; additional tests may be required with changes in environmental conditions.

- 3) Two 25 mm (1 in) wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and also for shear strength. Each specimen should fail in the parent material and not in the weld, "Film Tear Bond"(F.T.D. failure). When the seam separation is equal to or greater than 25% of the track width, it is a failed test.
- 4) The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Tables of this Section. Four specimens out of five must meet the acceptable seam strength values to pass.
- 5) If a test seam fails, immediately an additional test seam shall be conducted. If the additional test seam fails, the seaming apparatus shall be rejected for further seaming. Deficiencies must be corrected and a successful test seam shall be produced before using the apparatus for additional seaming.
- 6) A sample from each test seam shall be labeled with date, geomembrane temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The sample shall then be given to the Owner's Representative for archiving.

(B) Field Seam Non-destructive Testing

- 1) All field seams shall be non-destructively tested over the full seam length before the seams are covered. Each seam shall be recorded with unique number or designation with the location, date, test unit, name of tester and outcome of all non-destructive testing and submitted to the Owner's Representative.
- 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. All defects found should be repaired, retested and remarked to indicate acceptable completion of the repair.
- 3) Non-destructive testing shall be performed using vacuum box, air pressure or spark testing equipment.
- 4) Experienced technicians familiar with the specified test methods shall perform all non-destructive tests. The Geomembrane Installer shall demonstrate that all test methods to verify the test procedures are valid to the Owner's Representative.
- 5) Extrusion seams shall be vacuum box tested by the in accordance with ASTM D 6392 and ASTM D 5641 with the following suggested equipment and procedures:
 - a) Vacuum box assembly consisting of a rigid housing
 - b) Transparent viewing window
 - c) Soft rubber gasket attached to the base
 - d) Port hole or valve assembly and a vacuum gauge
 - e) Vacuum pump assembly equipped with a pressure controller and pipe connections
 - f) Rubber pressure/vacuum hose with fittings and connections



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- g) Plastic bucket
- h) Wide paint brush or mop
- i) Soapy solution
- 6) The vacuum pump shall be charged and the tank pressure adjusted to approximately 35 kPa (5 psig).
- 7) 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. Then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa (5 psig) for approximately 5 seconds and continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after 5 seconds, the area shall be considered leak free. Depressurized the box and move over the next adjoining area with an appropriate overlap and repeat the process.
- 8) All areas where soap bubbles appear shall be marked, repaired and then retested.
- 9) At locations where seams cannot be nondestructively tested, such as pipe penetrations, alternate nondestructive spark testing or equivalent should be substituted.
- 10) 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.

(C) Double Fusion Seams

Double Fusion seams with an enclosed channel shall be air pressure tested in accordance with ASTM D 5820 and ASTM D 6392 and the following suggested equipment and procedures:

- 1) 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.
- 2) Manometer equipped with a sharp hollow needle or other approved pressure feed device.
- 3) Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld.
- 4) The air pump shall be adjusted to a pressure of 210 kPa (30 psig), and the valve closed.
- 5) Allow 2 minutes for the injected air to come to equilibrium in the channel, and sustain pressure for 5 minutes.
- 6) If pressure loss does not exceed 28 kPa (4 psig) after this five minute period the seam shall be considered leak tight.
- 7) Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam.
- 8) The needle or other approved pressure feed device shall be removed and the feed hole sealed.
- 9) If loss of pressure exceeds 28 kPa (4 psig) during the testing period or pressure does not stabilize, the faulty area shall be located, repaired and retested.
- 10) Record all results of the pressure testing on the liner at the seam tested and on a pressure testing record.



(D) Destructive Field Seam Testing

- 1) One destructive test sample per 150 linear m (500 linear ft) seam length or another predetermined length in accordance with GRI GM 14 shall be taken from a location specified by the Owner's Representative. Sample locations shall not be informed in advance. Samples shall be cut as directed by the Owner's Representative prior to the completion of installation and as seaming progresses.
- 2) All field samples shall be marked with their sample number and seam number. The sample number, date, time, location, and seam number shall be recorded. Repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If a patch cannot be permanently installed over the test location the same day of sample collection, a temporary patch shall be tack welded or hot air welded over the opening until a permanent patch can be affixed.
- 3) The destructive sample size shall be 300 mm (12 in) wide by 1 m (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.
- 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. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, 4 of 5 test specimens must pass the stated criteria in project document. If 4 of 5 specimens pass, the sample qualifies for testing by the testing laboratory if required.
- 5) If independent seam testing is required by the specifications it shall be conducted in accordance with ASTM 5820 or ASTM D6392 or GRI GM 6.
- 6) Prepare and submit all reports of the results of examinations and testing to the owner's representative.
- 7) For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Engineer; typically 3 m (10 ft) on either side of the failed sample and laboratory seam tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 M in length (150 FT) shall be destructively tested.
- 8) Keep all samples out of critical areas such as in the bottom of ponds and other locations such as slopes and sumps.



(E) Identification of Defects

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

(F) Evaluation of Defects

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 which fails non-destructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

- 1) If a destructive sample fails the field or laboratory test, repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.
- 2) Defective seams, tears or holes shall be repaired by reseaming or applying an extrusion welded cap strip.
- 3) Re-seaming may consist of either:
 - a) Removing the defective weld area and rewelding the parent material using the original welding equipment; or
 - b) Re-seam the defective weld area by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.
 - c) Cap stripping entire faulty seam.
- 4) Blisters, larger holes, and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm (6 in) beyond all edges of the defects.
- 5) Locate, measure and record all repairs.

(G) Verification of Repairs on Seams

Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be re-seamed and re-tested until a passing test result. The number, date, location, technician and test outcome of each patch shall be recorded.

(H) Daily Field Installation Reports

At the beginning of each day's work, provide daily reports for all work accomplished on the previous work day to the Owner's Representative. Reports shall include the following:

- 1) Total amount and location of geomembrane placed
- 2) Total length and location of seams completed, name of technicians doing seaming and welding unit numbers



- 3) Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing
- 4) Results of pre-qualification test seams
- 5) Results of non-destructive testing
- 6) Results of vacuum testing of repairs
- 7) Destructive test results shall be reported prior to covering of liner

3.06 Geomembrane Acceptance

The Owner or his representative will accept the geomembrane when:

- a) The entire installation is finished or an agreed upon subsection of the installation is finished.
- b) All Installer's QC documentation is completed and submitted to the owner.
- c) Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

3.07 Anchor Trench

Construct as specified on the project documents.

3.08 Disposal of Scrap Materials

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. No scrap material shall be allowed to remain on the geomembrane surface.

Article IV – Measurement and Payment

As per project specifications.



Article V – Tables

Table 1A - Seam Strength and related Properties of Thermally Bonded Smooth and Textured Linear 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 |

Table 1B - Seam Strength and related Properties of Thermally Bonded Smooth and Textured Linear Low Density Polyethylene (LLDPE) Geomembrane (English Units)

| Geomembrane Nominal Thickness | 20 mils | 30 mils | 40 mils | 50 mils | 60 mils | 80 mils | 100 mils | 120 mils |
|--|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|
| Hot Wedge Seams ⁽¹⁾ | | | | | | | | |
| shear strength ⁽²⁾ , lb/in. | 30 | 45 | 60 | 75 | 90 | 120 | 150 | 180 |
| shear elongation at break ⁽³⁾ , % | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| peel strength ⁽²⁾ , lb/in. | 25 | 38 | 50 | 63 | 75 | 100 | 125 | 150 |
| peel separation, % | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Extrusion Fillet Seams ⁽¹⁾ | | | | | | | | |
| shear strength ⁽²⁾ , lb/in. | 30 | 45 | 60 | 75 | 90 | 120 | 150 | 180 |
| shear elongation at break ⁽³⁾ , % | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| peel strength ⁽²⁾ , lb/in. | 25 | 34 | 44 | 57 | 66 | 88 | 114 | 136 |
| peel separation, % | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |

Notes for Tables 1(a) and 1(b):

1. Also for hot air and ultrasonic seaming methods
2. 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
3. Elongation measurements should be omitted for field testing