

# **HALLATON**

## **ENVIRONMENTAL LININGS**

### **INSTALLATION MANUAL**

Guidelines for Installation of:  
HDPE and LLDPE Geomembrane Installation  
Specification

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Content from this document was taken from the installation guidelines provided by the International Association of Geosynthetic Installers (IAGI). Additional information can be found at [www.IAGI.org](http://www.IAGI.org).



# HALLATON

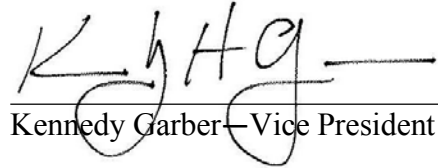
## ENVIRONMENTAL LININGS

### HALLATON INSTALLATION MANUAL CLARIFICATION:

This QC/Installation Manual is to be used as a guideline and has been supplied as an example of Hallaton's standard installation practice. Hallaton will comply with any and all installation requirements as listed in the project specifications on all geosynthetic materials. If there are any discrepancies between the project specifications and Hallaton's installation manual, the more stringent requirement will apply unless otherwise approved.

Hallaton does not have an installation manual available for Geocomposite, GCL, or Geotextile; however, Hallaton will install all materials per the project specifications and/or approved recommendations from the Manufacturer.

If there are any questions or concerns, please feel free to contact me. Thank you.



Kennedy Garber—Vice President of Construction

# 1: General

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## 1.1 References

### A. American Society for Testing and Materials (ASTM):

1. D4437 - 08, Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
2. D 5820, Test Method for Air Testing.
3. D5820-95, Pressurized Air Channel Test for Dual Seamed Geomembranes.

### B. Geosynthetic Research Institute (GRI):

1. GRI GM 9, Cold Weather Seaming of Geomembranes
2. GRI GM 14, Test Frequencies for Destructive Seam Testing Selecting, variable intervals for taking geomembrane destructive samples using the method of attributes.
3. GRI GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.
4. GRI GM 20, Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts.

## 1.2 Delivery, Storage and Handling

1. Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the manufacturer's name, product identification, material thickness, roll number, roll dimensions and roll weight.
2. Geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.
3. Rolls shall be stored away from high traffic areas. Rolls shall be continuously and uniformly supported on a smooth, level prepared surface.

## 1.3 Project Conditions

Geomembrane should not be installed in the presence of standing water, while precipitation is occurring, during excessive winds, or when material temperatures are outside the limits specified in Section 2.3.

## 1.4 Geomembrane Installation Warranty

The Geomembrane Installer shall guarantee workmanship for a time period, agreed upon by project participants, commencing with the date of final acceptance.



# 2: Execution

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## 2.1 Subgrade Preparation

1. The subgrade shall be prepared in accordance with the project specifications. The geomembrane subgrade shall be uniform and free of sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.
2. The Geomembrane Installer and Owner’s Representative shall inspect the surface to be covered with the geomembrane on each day’s operations prior to placement of geomembrane to verify suitability.
3. The Geomembrane Installer and Owner’s Representative shall provide daily written acceptance for the surface to be covered by the geomembrane in that day’s operations. The surface shall be maintained in a manner, during geomembrane installation, to ensure subgrade suitability.
4. All subgrade damaged by construction equipment and deemed unsuitable for geomembrane deployment shall be repaired prior to placement of the geomembrane. All repairs shall be approved by the Owner’s Representative and the Geomembrane Installer. This damage, repair, and the responsibilities of the contractor and Geomembrane Installer shall be defined in the preconstruction meeting.

## 2.2 Geomembrane Placement

1. No geomembrane shall be deployed until the applicable certifications and quality control certificates are submitted to and approved by the Owner’s Representative within the timeframe specified in the contract documents. If the material does not meet project specifications it shall be removed from the work area.
2. The geomembrane shall be installed to the limits shown on the project drawings and essentially as shown on approved panel layout drawings.
3. No geomembrane material shall be unrolled and deployed if the material temperatures are lower than 32 degrees Fahrenheit unless otherwise approved by the Owner’s Representative. The specified minimum temperature for material deployment may be adjusted by the Owner’s Representative. Temperature limitations should be defined in the preconstruction meeting. Typically, only the quantity of geomembrane that will be



anchored and seamed together in one day should be deployed.

4. No vehicular traffic shall travel on the geomembrane other than an approved low ground pressure vehicle or equivalent.
5. Sandbags or equivalent ballast shall be used as necessary to temporarily hold the geomembrane material in position under the foreseeable and reasonably expected wind conditions. Sand bag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geomembrane.
6. Geomembrane placement shall not be done if moisture prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations should be defined in the preconstruction meeting.
7. Damaged panels or portions of the damaged panels which have been rejected shall be marked and their removal from the work area recorded.
8. The geomembrane shall not be allowed to "bridge over" voids or low areas in the subgrade. The geomembrane shall rest in intimate contact with the subgrade.
9. Wrinkles caused by panel placement or thermal expansion shall be minimized.
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, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations and if approved by the Owner's Representative.
11. Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to affect a good weld and allow for proper testing. In no case shall this overlap be less than 3 inches.

## 2.3 Seaming Procedures

1. Cold weather installations should follow guidelines as outlined in GRI GM9.
2. No geomembrane material shall be seamed when liner temperatures are less than 32 degrees Fahrenheit unless the following conditions are complied with:
  - A. Seaming of the geomembrane at material temperatures below 32 degrees Fahrenheit is allowed if the Geomembrane Installer can demonstrate to the Owner's Representative, using pre-qualification test seams, that field seams



comply with the project specifications, the safety of the crew is ensured, and geomembrane material can be fabricated (i.e. pipeboots, penetrations, repairs, etc.) at subfreezing temperatures.

- B. The Geomembrane Installer shall submit to the Owner's Representative for approval, detailed procedures for seaming at low temperatures, possibly including the following:
  - i. Preheating of the geomembrane.
  - ii. The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.
  - iii. Number of test welds to determine appropriate seaming parameters.
- 3. No geomembrane material shall be seamed when the sheet temperature is above 170 degrees Fahrenheit as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Owner's Representative. This approval will be based on 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.
- 4. Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams.
- 5. Fishmouths or excessive wrinkles at the seam overlaps shall be minimized and when necessary cut along the ridge of the wrinkles back into the panel so as to affect a flat overlap. The cut shall be terminated with a keyhole cut (1/2 inch diameter hole) to minimize crack/tear propagation. The overlay shall subsequently be seamed. The key hole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 6 inches beyond the cut in all directions.





## 2.4 Pipe and Structure Penetration Sealing System

1. Penetration sealing system shall be provided as shown in the Project Drawings.
2. 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 to prevent leakage.

## 2.5 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. Test seams shall be prepared and tested by the Geomembrane Installer to verify that seaming parameters (speed, temperature and pressure of welding equipment) are adequate.
2. Test seams shall be made by each welding technician and tested in accordance with ASTM D 4437 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 10 feet long for fusion welding and 3 feet long for extrusion welding with the seam centered lengthwise. At a minimum, test seams shall be made by each technician 1 time every 4-6 hours; additional tests may be required with changes in environmental conditions.
3. Two 1-inch 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 for shear strength. Each specimen should fail in the parent material and not in the weld, "Film Tear Bond" (F.T.B. failure). Seam separation equal to or greater than 25% of the track width shall be considered a failing test.
4. The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Subsection 2.5.C.4 of this section. Four specimens shall pass and the fifth



specimen must meet or exceed 80% of the required seam strength for the test seam to be a passing seam.

5. If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam can be produced.
6. A sample from each test seam shall be labeled. The label shall indicate the 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 by the Geomembrane Installer over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester and outcome of all non-destructive testing shall be recorded 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. Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods. The Geomembrane Installer shall demonstrate to the Owner's Representative all test methods to verify the test procedures are valid.
5. Extrusion seams shall be vacuum box tested by the Geomembrane Installer in accordance with ASTM D 4437 using the following equipment and procedures:
  - A. Equipment for testing extrusion seams shall be comprised of but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base, port hole or valve assembly



and a vacuum gauge; a vacuum pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and connections; a plastic bucket; wide paint brush or mop; and a soapy solution.

- B. The vacuum pump shall be charged and the tank pressure adjusted to approximately 5 psi.
  - C. The Geomembrane Installer shall create a leak-tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 12 in by 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 5 psi for approximately five (5) seconds. The geomembrane should be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after five (5) seconds, the area shall be considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.
  - D. All areas where soap bubbles appear shall be marked, repaired and then retested.
  - E. At locations where seams cannot be nondestructively tested, such as pipe penetrations, alternate nondestructive spark testing (as outlined in section 2.4.2) or equivalent should be substituted.
  - F. 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.
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 and procedures:
- A. 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 30 psi, mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.



- B. The testing activities shall be performed by the Geomembrane Installer. 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. The air pump shall be adjusted to a pressure of 30 psi, and the valve closed. Two (2) minutes shall be allowed for the injected air to come to equilibrium in the channel and pressure shall be sustained for five (5) minutes. If pressure loss does not exceed 4 psi after this five (5) minute period the seam shall be considered leak tight. Pressure shall be released from the opposite end, and pressure drop shall be verified on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.
- C. If loss of pressure exceeds 4 psi during the testing period or pressure does not stabilize, the faulty area shall be located, repaired and retested by the Geomembrane Installer.
- D. Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

### **C. Destructive Field Seam Testing**

1. One destructive test sample per 500 linear feet seam length or another predetermined length in accordance with GRI GM14 or GRI GM20 shall be taken by the Geomembrane Installer from a location specified by the Owner's Representative. The Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative 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. 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 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 12 inches wide by 42 inches 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 1-inch wide replicate specimens from the 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 with less than 25% separation. The fifth specimen must meet or exceed 80% of the required seam strength.
5. If independent seam testing is required by the specifications it shall be conducted in accordance with ASTM 5820 or ASTM D4437.
6. Reports of the results of examinations and testing shall be prepared and submitted 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 10 feet 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 150 feet in length shall be destructively tested.

#### **D. Identification of Defects**

Panels and seams shall be inspected by the Installer and Owner's Representative during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials and signs of contamination by foreign matter.



## **E. Evaluation of Defects**

Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described in Section 2.5.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, the Geomembrane Installer shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.  
Defective seams, tears or holes shall be repaired by reseaming or applying an extrusion welded cap strip.
2. Reseaming may consist of either:
  - A. Removing the defective weld area and rewelding the parent material using the original welding equipment.
  - B. Reseaming by extrusion welding along the overlap at the outside seam edge that is left by the fusion welding process.
3. 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 6 inches beyond all edges of the defects.
4. All repairs shall be measured, located and recorded.

## **F. 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 reseamed and retested until a passing test results. The number, date, location, technician and test outcome of each patch shall be recorded.



## **G. 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 work day. 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; and
6. Results of vacuum testing of repairs.

Destructive test results shall be reported prior to covering of liner or within 48 hours.

## **2.6 Liner Acceptance**

Geomembrane liner will be accepted by the Owner's Representative when:

1. The entire installation is finished or an agreed upon subsection of the installation is finished;
2. All Installer's QC documentation is completed and submitted to the owner;
3. Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

## **2.7 Anchor Trench**

Shall be constructed as specified on the project drawings.



## 2.8 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.

## 3: Measurement and Payment

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As per project specifications.



# Attachment A.

Table 1(a) - 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
<b>Hot Wedge Seams <sup>(1)</sup></b>								
shear strength <sup>(2)</sup> , lb/in.	30	45	60	75	90	120	150	180
shear elongation at break <sup>(3)</sup> , %	50	50	50	50	50	50	50	50
peel strength <sup>(2)</sup> , lb/in.	25	38	50	63	75	100	125	150
peel separation, %	25	25	25	25	25	25	25	25
<b>Extrusion Fillet Seams <sup>(1)</sup></b>								
shear strength <sup>(2)</sup> , lb/in.	30	45	60	75	90	120	150	180
shear elongation at break <sup>(3)</sup> , %	50	50	50	50	50	50	50	50
peel strength <sup>(2)</sup> , lb/in.	22	34	44	57	66	88	114	136
peel separation, %	25	25	25	25	25	25	25	25

Table 2(a) - 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
<b>Hot Wedge Seams<sup>(1)</sup></b>							
Shear strength <sup>(2)</sup> , lb/in.	57	80	100	120	160	200	240
Shear elongation at break <sup>(3)</sup> , %	50	50	50	50	50	50	50
Peel strength <sup>(2)</sup> , lb/in.	45	60	76	91	121	151	181
Peel separation, %	25	25	25	25	25	25	25
<b>Extrusion Fillet Seams</b>							
Shear strength <sup>(2)</sup> , lb/in.	57	80	100	120	160	200	240
Shear elongation at break <sup>(3)</sup> , %	50	50	50	50	50	50	50
Peel strength <sup>(2)</sup> , lb/in.	39	52	65	78	104	130	156
Peel separation, %	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 5<sup>th</sup> specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

