



# **PVC GEOMEMBRANE INSTALLATION SPECIFICATION**

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**PVC Geomembrane Institute – Technology Program  
University of Illinois at Urbana-Champaign  
2215 Newmark Civil Engineering Lab  
205N. Mathews Ave.  
Urbana, IL 61801  
217-333-3929 / 217-244-2839 fax  
e-mail: [pgi-tp@uiuc.edu](mailto:pgi-tp@uiuc.edu)  
<http://www.pvcgeomembrane.com>**

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## **1.01 Summary**

- A. Section includes fabrication and installing PVC geomembranes in accordance with PGI requirements.

## **1.02 References**

## **1.04 Submittals**

- A. Submit under provisions of section 01300, Submittals.
- B. Submit the following to the Engineer or Owner, for review and approval, within a reasonable time so as to expedite shipment, fabrication and installation of the Geomembrane.
  - 1. Documentation of the manufacturers qualifications as specified in subsection 1.04 A of this section.
  - 2. Manufacturers quality control program manual.
  - 3. A sample property sheet, including at a minimum all properties specified, including test method used.
  - 4. Sample of material.
  - 5. Documentation of fabricator and installers experience, as specified in subsection 1.04 B and 1.04 C.
    - a. Submit a list of ten completed facilities. For each installation provide: name and type of facility; its location; the date of installation; name and telephone number of contact at the facility; type and thickness of geomembrane and surface area of installed geomembrane.
    - b. Submit resumes or qualifications of fabrication manager.
    - c. Fabrication quality control program.
    - d. Installation quality control program.
    - e. Example of Material Warranty and Fabricated Seam Warranty.
    - f. Copy of Manufacturers and Fabricator's quality control program.
- C. Shop drawings
  - 1. Submit copies of shop drawings within a reasonable time so as not to delay the start of material fabrication and installation.
  - 2. Shop drawing shall show the proposed panel layout identifying seams and details. Wherever possible, field seams should be oriented along the direction of the slope.
  - 3. Placement of geomembrane shall not be allowed until approval has been received from the engineer or owner.
- D. Additional submittals (in progress and at completion)

1. Manufacturers warranty (refer to subsection 1.07).
2. Fabricated seam warranty – 1 Year.
3. Installation warranty – 1 Year.
4. Daily written acceptance of subgrade
5. Low temperature deployment and seaming process
6. Daily field weld test results
7. Field seam destructive test results
8. Daily field installation reports
9. As-built drawings

#### **1.04 Qualifications**

- A. Manufacturers qualifications: The manufacturer of the PVC geomembrane of the type specified shall have at least five years experience in the manufacture of PVC geomembranes. In addition, the geomembrane manufacturer shall have manufactured at least a million square feet of the specified type of geomembrane in the last five years.
- B. Fabricators qualifications: The Fabricator of the proposed PVC geomembrane shall be a member of the PGI and shall have a minimum five million square feet of fabrication experience over the last 3 years.
- C. Installer qualifications: The Geomembrane Installer shall have at least three years experience in the installation of the specified geomembrane and shall have installed a minimum of five million square feet of the specified geomembrane on a minimum of ten projects. The installer shall be certified by the fabricator to install fabricated products.
  1. Installation shall be performed under the direction of a Field Installation Supervisor who shall be responsible throughout the geomembrane installation. Responsibilities include: geomembrane panel deployment, seaming, patching, testing, repairs and all other daily activities of the Geomembrane Installer.
  2. Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) who has seamed a minimum of three million square feet of the type specified, using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor or Master Seamer shall be present whenever field seaming is being performed.
  3. All seaming, patching, other welding operations, and testing shall be performed by a qualified technicians employed by the Geomembrane Installer.

### **1.05 Packaging**

- A. Each fabricated panel delivered to the site shall be wrapped with protective material and labeled by the fabricator. The label or marking shall have manufacturer's name, material thickness, panel identification number corresponding to panel placement layout, panel dimensions, and be labeled on fabricated material as well as protective cover.
- B. Panels shall be stored on a clean, level, dry area away from high traffic.

### **1.06 On – Site Conditions**

- A. No standing water, mud, snow and excessive moisture will be allowed. The Geomembrane will not be deployed in the presence of standing water, mud, snow or frozen subgrade conditions. Geomembrane should not be installed while precipitation is occurring or during excessive winds, or when temperatures are outside the limits specified in section 3.03.

### **1.07 Material Warranty**

As required by specification.

### **1.08 Fabricated Seam Warranty**

- A. The Fabricator shall warrant fabricated seams for a period of one (1) year after installation against defects in workmanship.

### **1.09 Geomembrane Installation Warranty**

- A. The Geomembrane Installer shall guarantee against defect in the installation and workmanship for a period of one (1) year commencing with the date of final acceptance.

### **1.10 Geomembrane Pre-construction Meeting**

- A. A geomembrane Pre-Construction meeting shall be held at the site prior to the installation of the PVC geomembrane. At a minimum this meeting should be attended by the Geomembrane Installer, Owner, Owner's Representative (Engineer or CQA Firm), and the Earthwork Contractor.
- B. Topics should include the following:
  - 1. Responsibilities of each party.
  - 2. Lines of authority and communication. Resolution of any project document ambiguity.
  - 3. Methods for documenting, reporting, and distributing documents and

- reports.
4. Procedures for packaging and storing archive samples.
  5. Review of the time schedule for all installation and testing. Schedule of workdays and or starting times if third party testing verification is required
  6. Review of panel layout, access, numbering systems for panels and seams including details for marking on the PVC geomembrane.
  7. Procedures and responsibilities for preparation and submission of as-built drawings.
  8. Temperature and weather limitations. Installation procedures for adverse weather conditions. Defining acceptable subgrade or ambient moisture and temperature conditions for working during liner installation.
  9. Subgrade conditions, dewatering responsibilities and subgrade maintenance plan.
  10. Deployment techniques including allowable subgrade for geomembrane.
  11. Covering of the Geomembrane and cover soil placement.
  12. Plan for minimizing wrinkles in geomembrane.
  13. Measurement and payment schedules.
  14. Health and safety.

## **2.01 Source Quality Control**

### Geomembrane

- A. The geomembrane shall consist of new, virgin materials and be manufactured specifically for this work and will have satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane shall be manufactured and fabricated by a member of the PGI and to the PGI 1103 specifications.

## **3.01 Subgrade Preparation**

- A. The subgrade shall be prepared in accordance with the project specifications. Surfaces to be lined will be smooth and free of all rocks and stones greater than 1/2" diameter, sticks, sharp objects, or debris of any kind. The surface should provide a smooth, flat, firm, unyielding foundation for the membrane with no sudden, sharp or abrupt changes or break in grade.

The maximum slope for PVC geomembrane should not exceed 3 horizontal to 1 vertical.

If the liner is to be installed at an elevation below the current or possible future ground water elevation, the OWNER will be responsible for providing an adequate underdrain system to prevent ground water pressure beneath the liner. Excessive ground water can force the liner upwards through the cover soil and any liquid contained in the impoundment.

- B. The geomembrane installer and the owner's representative shall inspect the surface to be covered with geomembrane on each day's operation prior to placing the geomembrane to verify suitability.
- C. The Geomembrane installer and Owner's Representative shall provide daily written acceptance for the surface to be covered in that day's operation. The surface shall be maintained in a manner to insure subgrade suitability.
- D. 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. The responsibility for repairs and maintenance of the subgrade shall be defined in the preconstruction meeting.

### **3.02 Geomembrane Placement**

- A. PVC geomembrane shall not be deployed until all applicable certifications and quality control certificates listed in subsection 1.03 of this section are submitted and approved by the owner's representative. Should the PVC geomembrane be deployed prior to approval of the Owner's Representative it will be at the sole risk of the geomembrane installer and/or contractor. If the material does not meet the specification it shall be removed from the site at no cost to the owner.
- B. The PVC geomembrane shall be installed to the project limits as detailed on the panel layout drawings.
- C. Temperature limitations shall be determined in the preconstruction meeting and approved by the Owner's Representative unless otherwise approved by the owner. Temperature limitations shall be determined in the preconstruction meeting and approved by the Owners Representative.
- D. No vehicles, other than those approved by the installer, are allowed on the geomembrane. Small rubber tired equipment with a ground pressure not exceeding 5 psi, and a total weight not exceeding 750 lbs will normally be allowed i.e., air compressors, generators, etc. that would be required during installation and testing.
- E. Sandbags or equivalent ballast shall be used as necessary to temporarily hold the PVC geomembrane material in position.
- F. Geomembrane placement shall not be done if moisture present prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations shall be defined in the preconstruction meeting.

- G. Damaged panels or portions of damaged panels which have been rejected shall be marked and their removal from the work area recorded.
- H. The geomembrane shall not be allowed to "bridgeover" voids or low areas in the subgrade. In these areas the PVC geomembrane shall be installed with sufficient slack as to allow material to remain in intimate contact with the subgrade.
- I. In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd geometric locations, the total length of the field seam shall be minimized. If at all possible, seams shall not be located at low points in the subgrade unless geometry requires seaming to be done at these locations.
- J. Overlapping:
  - Chemical Seam – 6-8" with a 2" wide seam.
  - Thermal Seams:
    - Single Track – 4 to 6" lap and a minimum 1.5" wide seam.
    - Dual Track – 4 to 6" lap and minimum 0.5" wide seams

### **3.03 Seaming Procedures**

- A. Cold weather seaming procedures may include the following.
  - 1. Storage of fabricated product in a heated space prior to deployment.
  - 2. Applying preheat immediately in front of area to be welded.
  - 3. QA/QC testing should include additional test weld to determine if field seams can be made to meet the PGI 1103.
  - 4. The Owners representative shall approve the cold weather procedures and be available to verify that seam quality parameters can be met.
- B. High temperature seaming procedures may include the following:
  - 1. Suspension of work if temperatures create a dangerous work atmosphere for the installation crew and inspectors.
  - 2. Preparation of additional qualification strips to determine if welding can be completed and verified to meet PGI 1103 seam strengths.
- C. Fishmouths shall be kept to a minimum and when necessary be cut out and repaired so as to effect a flat overlap. All repairs shall extend a minimum of 6" past any cut in all directions.



### **3.04 Seaming Specifications**

#### **1. Chemical Seaming**

- A. Prior to starting any field welds each seam crew shall prepare a test seam to verify quality and temperature requirements can be met.
- B. Panels to be welded shall be overlapped a minimum of 6".
- C. Care should be taken to clean all areas with a rag prior to applying chemicals.
- D. A sufficient amount of chemical shall be placed on both sheets of the PVC geomembrane with either a squeeze bottle or paintbrush and form a continuous 2" weld path.
- E. After application of chemical, the seam area should be rolled with a seam roller releasing any air bubbles and forming a continuous seam path. The seaming crew shall take care to always tie-in to the chemical seam area as they continue along down the seam.
- F. Upon completion of each seam, the seam shall be inspected and any loose areas re-rolled or add chemical as required to complete the seam.

#### **2. Thermal Welding Specifications**

- A. Each Master Seamer shall complete a trial weld of 5' and each sample shall be tested as listed in the testing tables of this document.
- B. Panel to be seamed together shall be overlapped 4" to 6".
- C. Panels shall be wiped clean removing dirt and dust prior to seaming.
- D. Panel should be positioned and all wrinkles pulled out of the seam area prior to seaming.
- E. Master Seamer shall walk with welder at all times and continually check overlap, temperature and weld quality.
- F. Destructive seam samples shall be pulled at intervals as directed by the Owners Representative or at a minimum of one per 500 lineal feet of thermal welded seam when Air Lance Testing is done or when Air Channel Testing is done no destructive samples will be taken.

G. If dual track welding is specified, both sides of the weld shall be tested.

H. Samples shall be tested as listed in testing tables of this document.

### **3.05 Pipes and Structure Penetration Sealing System**

- A. Provide penetration sealing system as shown on the Project Drawings.
- B. Penetrations shall be sealed using the same PVC geomembrane material, flat stock, prefabricated boots, and accessories as shown on the project drawings. The prefabricated or field fabricated assembly shall be field welded to the main PVC geomembrane as shown on the project drawing so as to prevent leakage.
- C. These areas can be welded with any of the methods listed in section 3.04.
- D. All areas shall be Air Lance tested and verified to be leak free.

### **3.06 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 the seaming parameters are adequate.
2. Test seams shall be made in accordance with ASTM D 4437 by each welding technician at the beginning of each seaming period. Test seaming shall be conducted under the same conditions and with the same equipment and operator as production seaming. The test seams shall be approximately 5' long for all types of field welds.
3. Samples shall be tested in accordance with testing tables in this document. It should be noted that conditioning of samples and appropriate temperature and humidity requirements must be met to allow for proper testing of the PVC geomembrane.
4. If there is no area on site to provide for these requirements seam strength can be verified for production and trial welds sent to an independent lab to verify quality.
5. For peel and shear testing see testing section of this document. Field shear results should meet the requirements of PGI-1103.

6. If a test seam fails, an additional test seam shall be immediately completed. If the additional test seam fails, the seaming apparatus shall be rejected and not used until the deficiencies are corrected and a successful full test seam can be produced.
7. Each test seam shall be labeled with date, geomembrane temperature, number of seaming unit, panel identification, seam number or test location, and technician performing the test seam and pass or fail description.

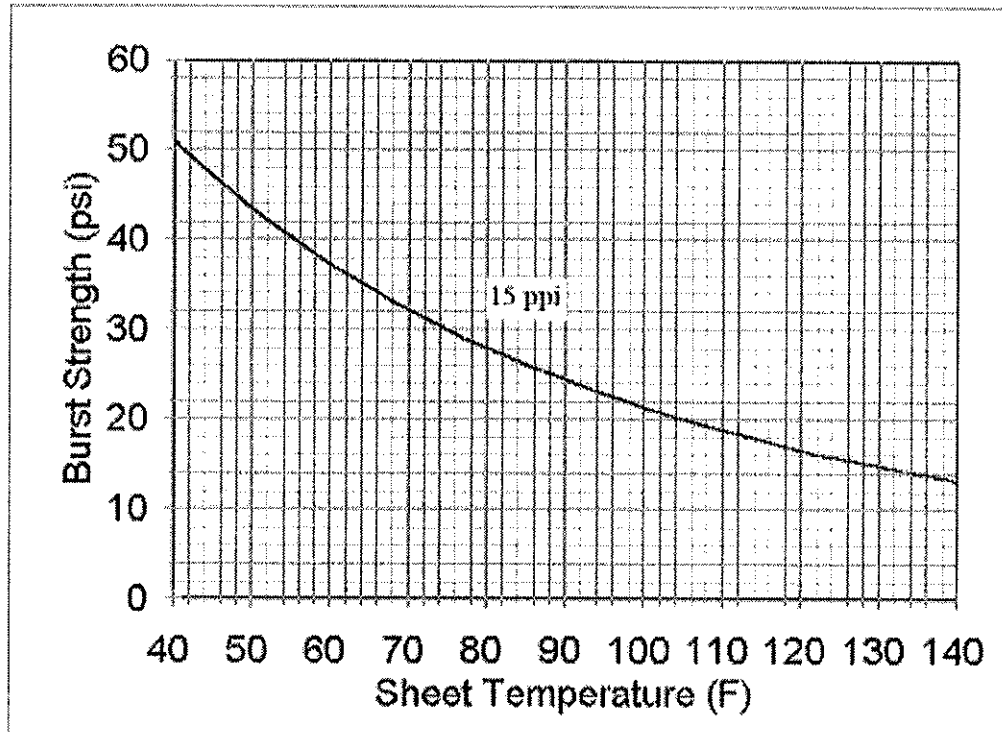
## **B. Non-Destructive Field Seam Testing**

1. All field seams shall be non-destructively tested by the Geomembrane Installer over the full length of the seams before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of QC person, and outcome of all non-destructive shall be recorded and submitted to the Owner's Representative.
2. Testing should be done as the seaming progresses, not at the completion of all field seaming, unless agreed in advance by the Owner's Representative. All defects found should be repaired, re-tested and remarked to indicate acceptable completion of repair.
3. Non-destructive testing shall be performed using either the air lance test method or by air pressure test method.
4. Air Lance Testing
  - a. Chemical and Solid Thermal welds shall be tested utilizing the Air Lance Test Method ASTM D 4464. The Geomembrane Installer shall provide shall provide an air compressor, air hose and air lance wand with a pressure gauge capable of measuring the air flow at the tip. The testing shall be performed by experienced technicians familiar with this testing procedure.
  - b. This non-destructive test involves placing the air lance wand ¼" to ½", but not more than 2", from the edge of the completed seam and closely monitoring the backside of the sheet for any air penetration through the seam. If air penetrates the seam area, the technician will either see this visibly or hear it audibly.
  - c. All seams tested by the air lance method shall be marked with the date tested, name of the technician, length of the seam and test results. As with all QC work this should be documented on all QC paperwork and

preferably witnessed by the Owners Representative or his designated employee.

5. Air Channel Testing

- a. Dual Track Thermal seams with an enclosed air channel shall be pressure tested by the Geomembrane Installer in accordance with the following equipment and procedures.
- b. 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 420 kPa (60 PSI), mounted on a cushion to protect the geomembrane; and a manometer equipped with an approved pressure feed device.
- c. The testing activities shall be performed by the geomembrane installer. Both ends of the seam to be tested shall be sealed and an approved pressure feed device inserted into the channel created by the double fusion weld. The air pump shall be adjusted to a pressure corresponding to the following chart based on temperature of the geomembrane and pressurized to the appropriate pressure. If air is held for the 2 minute test, the test is considered passing.



- d. If loss exceeds the acceptable level, the faulty area shall be located, repaired and retested by the geomembrane installer.
- e. Results of the air pressure testing shall be marked on the seam tested and logged on the air pressure testing record.

#### 6. Vacuum Box Testing

Vacuum Box testing is not used on PVC

### C. Destructive Field Seam Testing

1. When Air Lance Testing is done, a minimum of one test per 500 lineal feet of field seam or at another pre-determined length should be taken by the Geomembrane Installer from a location specified by the Owner's Representative. When Air Channel Testing is done, no destructive samples will be taken. 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 samples. All patches shall be repaired and tested using an air lance test. All destructive seam areas shall be patched and tested the same day as taken.
3. The destructive sample size shall be 300 mm (12" wide by 1m (36") long with the seam centered lengthwise. The sample shall be cut lengthwise. The sample shall be cut into three equal sections and distributed as follows; one section given to the owners representative as an archive sample, one section given to the owners representative for laboratory testing as specified in paragraph five (5) below, and one section given to the geomembrane installer for field testing as specified in paragraph four (4) below.
4. For field testing, the geomembrane installer shall cut 10 identical 25mm (1 inch) wide replicate specimens from his sample. The geomembrane installer shall test five replicate specimens for seam shear strength and five for peel strength. Peel tests will be performed on both the inside and outside of dual track welds. To be acceptable an average of five specimens must pass PGI 1103 specification field seam testing requirements.
5. If independent seam testing is required by the specifications, it shall be

conducted in accordance with ASTM D 6214 for chemical seams and/or ASTM D 6392 for thermal seams by an accredited laboratory who is a member of PGI.

6. Reports of the results of examinations and testing shall be prepared and submitted to the owner's representative.
7. For field seams, if laboratory tests fail, that shall be considered an indicator of the possible inadequacy of the entire seam length corresponding to the test sample. Additional destructive test portions shall be taken by the geomembrane installer at locations indicated by the owner's representative, typically 3 meters (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 either thermal welded, or chemically welded into place. All cap stripped seams shall be non-destructively tested with an air lance test or air pressurization for dual track welds.

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

1. Panels and seams shall be inspected by the geomembrane installer and the owner's representative during and after panel deployment to identify all defects, including holes, blisters, and undispersed raw materials.

**E. Evaluation of defects:** Each suspect location (both in geomembrane seam and non-seam areas) shall be non-destructively tested using an air lance test method. 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 weld or laboratory tests, the geomembrane installer shall repair the seam between the two nearest passed location on both sides of the failed destructive sample location.
2. Defective seams, tears, or holes shall be repaired by reseaming or applying a cap strip.
3. Reseaming may consist of either:
  - a. Removing the defective area and rewelding the parent material using the original welding equipment, or
  - b. Reseaming by cap stripping as described in section C, number 7.

4. Each patch shall extend a minimum of 150 mm (6 inches) beyond all defects.
5. All repairs shall be measured, located, and recorded.

**F. Verification of repairs on seams:** Each repair shall be non-destructively tested using an air lance test. Tests which pass the non destructive test shall be taken as an indication of a successful repair. Failed tests shall be resealed 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 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, technician name, 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 the pre-qualification test seams;
5. Results of non-destructive testing.
  - a. Destructive test results shall be reported prior to covering the lining or within 48 hours.

### **3.07 Liner Acceptance**

- A. The PVC Geomembrane liner will be accepted by the Owners Representative when:
1. The entire installation is finished or an agreed upon subsection if the installation is finished.
  2. All Installers 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.

### **3.08 Anchor Trench**

- A. Construct as specified on contract drawings.

### **3.09 Backfilling and Covering the Geomembrane**

- A. The anchor trench will be backfilled and compacted by the contractor as approved by the INSPECTOR. Trench backfill material should be placed in loose lifts and compacted.
- B. The PVC geomembrane must be covered with a minimum of 12 inches of clean soil, free of sticks, stones larger than ½ inch diameter, rubbish, or any other material which may damage the liner. The cover material should be placed over the liner as soon as practical after the liner is installed.
- C. Care should be taken when backfilling the trenches and covering the liner to prevent any damage to the geomembrane or other geosynthetics. At no time will construction equipment come into direct contact with the geomembrane. If damage occurs, it will be repaired, at the backfilling contractor's expense, prior to the completion and backfilling.
- D. Cover soil shall be placed over the geomembrane from the base of the slope up.

### **3.10 Disposal of scrap materials**

- A. On completion of installation, the geomembrane installer shall dispose of all trash and scrap material in a location provided and 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 left on the PVC geomembrane surface.

### **4.01 Measurement and Payment**

As per project specification or contract.

### **5.01 PGI 1103 Specification**



## PVC GEOMEMBRANE SPECIFICATIONS PGI 1103 Specification<sup>1</sup>

Certified Properties <sup>2</sup>	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Thickness	D-5199	10 +/- 0.5 mil 0.25 +/- .013mm	20 +/- 1 mil 0.51 +/- .03 mm	30 +/- 1.5 mil 0.76 +/- .04 mm	40 +/- 2 mil 1.02 +/- .05mm	50 +/- 2.5 mil 1.27 +/- .06 mm	60 +/- 3 mil 1.52 +/- .08 mm
Tensile Properties <sup>3</sup>	D-882 <sup>4</sup> Min						
Strength at Break		24 lbs/in 4.2 kN/m	48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		250%	360%	380%	430%	430%	450%
Modulus at 100%		10 lbs/in 1.8 kN/m	21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	D-1004 <sup>4</sup> Min	2.5 lbs 11 N	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	D-1204 <sup>4</sup> Max Chg	4%	4%	3%	3%	3%	3%
Low Temperature Impact	D-1790 <sup>4</sup> Pass	-10° F -23° C	-15° F -26° C	-20° F -29° C	-20° F -29° C	-20° F -29° C	-20° F -29° C
Index Properties <sup>5</sup>	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Specific Gravity	D-792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction Percent Loss (max)	D-1239 <sup>4</sup> Max Loss	0.15%	0.15%	0.15%	0.20%	0.20%	0.20%
Volatile Loss	D-1203 <sup>4</sup> Max Loss	1.5%	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial	G160 <sup>4</sup> Max Chg						
Break Strength		5%	5%	5%	5%	5%	5%
Elongation		20%	20%	20%	20%	20%	20%
Modulus at 100%		20%	20%	20%	20%	20%	20%
Hydrostatic Resistance	D-751 <sup>4</sup>	42 psi 290 kPa	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa
Seam Strengths	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Seam Shear Strength	D-882 <sup>4</sup> Min	20 lbs/in 3.47 kN/m	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20 kN/m
Seam Peel Strength	D-882 <sup>4</sup> Min	10 lbs/in 1.8 kN/m	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

- Notes:
1. PGI 1103 replaces PGI 1197 Specification effective 1/1/03.
  2. Certified properties are tested by lot as specified in PGI 1103 Appendix A.
  3. Metric values are converted from US values and are rounded to the available significant digits.
  4. Modifications or further details of test are described in PGI 1103 Appendix B.
  5. Index properties are tested once per formulation as specified in PGI 1103 Appendix A.

The PGI 1103 Specification was developed with the cooperation of PGI member companies in order to meet the stringent requirements of today's geosynthetic applications. To assure this level of quality, be sure to specify that your PVC geomembrane is produced and fabricated by a PGI member.

## PGI 1103 APPENDIX A MANUFACTURING TESTING FREQUENCIES

### Certified Properties

Certified test properties are tested based on a quantity of material produced. Certified properties are tested once per lot, or once every 40,000 lbs of material (18,000 kg), whichever is more frequent. The certification properties include thickness, tensile break strength, elongation at break, modulus at 100% strain, tear resistance, dimensional stability, and low temperature impact. Thickness is to be tested once per roll unless automatic thickness measuring equipment is installed on the production equipment. Certified test reports (Mill Certificates) for the tested properties are to be provided with every order on request.

### Index Properties

Index tests are performed when preparing and approving a geomembrane formulation. The tests are performed on the final production formulation of a geomembrane. The index properties include specific gravity, water extraction, volatile loss, hydrostatic resistance, and soil burial resistance. A certified statement of the test results for the formulation is to be made available to the customer on request.

## PGI 1103 APPENDIX B TESTING CLARIFICATIONS AND DETAILS

**General:** When both US and metric values are shown the value for acceptance is the US value. Metric values are conversions and may contain rounding errors.

**ASTM D751:** Test Methods for Coated Fabrics

- o For Hydrostatic Burst use Section 33, Procedure A, "Pressure Application by Mullen Type Hydrostatic Tester"
- o Units of pressure in pounds per square inch (psi) or kiloPascals (kPa)

**ASTM D882:** Tensile Properties of Thin Plastic Sheeting

- o Use Method A
- o D882 method may be used for PVC film up to 60 mil (1.5mm) thick
- o Units are in pounds of force per inch of width (lbs/in)
- o Metric units are in kiloNewtons per meter of width (kN/m), or Newtons per millimeter of width (N/mm) which are equivalent units
- o Seam Shear Testing
  - Use ASTM D882 Method A
  - ASTM D882 may be used for thicknesses greater than 1.0 mm (40 mil) for seam testing
  - Use 25.4 mm wide (1") specimens
  - Use grip separation of 51 mm (2 in) plus the seam width
  - Crosshead speed of 510 mm/min (20 in/min)
- o Seam Peel Testing
  - Use ASTM D882 Method A
  - Use 25.4 mm wide (1") specimens
  - Position grips 13 mm (1/2") on either side of seam
  - Crosshead speed of 51 mm/min (2 in/min)

**ASTM D1004:** Initial Tear Resistance of Plastic Film and Sheeting

- o Units are in pounds of force to initiate tear in the specially die-cut specimen (lbs) or in Newtons of force (N)

**ASTM D1203:** Volatile Loss from Plastics Using Activated Carbon Methods

- o Use method A

**ASTM D1204:** Linear Dimensional Changes of Thermoplastic Film at Elevated Temp.

- o Test specimens at 100 degrees C for 15 minutes
- o Measure percent change in two lineal dimensions (length & width)

**ASTM D1239:** Resistance of Plastic Films to Extraction by Chemicals

- o Test specimens in 50 degrees C (122 degrees F) water for twenty-four hours
- o Measure percent change in weight

**ASTM D1790:** Brittleness Temperature of Plastic Sheeting by Impact

- o 50% of specimens must pass at specified temperature

**ASTM D5199:** Measuring the Nominal Thickness of Geosynthetics

- o US units of thousandths of an inch (0.001 inches = 1 mil)
- o Metric unit of millimeters of thickness (mm)

**ASTM G160:** Evaluating Microbial Susceptibility of Nonmetallic Materials by Soil Burial

- o Bury sample in prepared soil for 30 days
- o Perform test on actual liner sheet samples
- o Measure maximum change in properties as shown in specification

## **Specifications for Thermal Welding PVC Geomembranes**

**All geomembranes require some field seaming. One of the advantages of PVC geomembranes is that the amount of field seaming can be 70 to 80 percent less than that required for an HDPE geomembrane. The manufactured rolls of PVC are seamed under controlled conditions in a fabrication plant prior to field deployment. This fabrication results in large geomembrane panels that reduce the number of required field seams. (The photograph below shows large PVC geomembrane panels being placed in a liner system at an operating municipal solid waste facility.) It is generally recognized that field-prepared seams are the most problematic aspect of all lining systems and thus reducing the amount of field seaming is beneficial.**

**Presently, field PVC seams are being constructed with good results using chemical systems (adhesive or solvent). In recent years, thermal welding has also proven to be an efficient and cost-effective method of field seaming PVC geomembranes. The thermal fusion method of joining PVC geomembranes has been used for many years in the roofing industry and in the European geomembrane and tunneling industries. The use of wedge and hot air welding allows the same equipment and preferred QA/QC techniques for HDPE geomembranes to be used for PVC geomembranes. In addition thermal welding can be used in colder environmental conditions than chemical welds.**

**The principle of a thermal weld is that both surfaces to be joined come into intimate contact with the hot wedge. This melts the upper and lower layer surfaces of the viscous polymer sheets. Fusion is brought about by compressing the two melted surfaces together by nip rollers, causing an intermingling of the polymers from both sheets and a permanent bond. The relatively new use of thermal welds in the United States for PVC geomembranes has created the need for presenting some "standard" specifications for thermal welding of PVC geomembranes.**

**At present, two types of wedge welding are used in practice: solid and dual track wedge welding. Both types of wedge welding allow destructive and nondestructive testing to be carried out as soon as the seam has cooled. This rapid assessment of quality allows immediate changes to be made in the seaming process to ensure optimal productivity.**

**Solid thermal welding is frequently used in practice to field seam PVC geomembranes. Solid thermal welding provides a wide seam and is tested with the air lance test method, which is also used to test field chemical seams. The minimum seam width for a single thermal weld is a nominal one inch (25-mm). The seam is tested for integrity by air lance testing in accordance with ASTM Test Method D-4437. Air lance testing can be performed immediately after the wedge seam has been completed. The test utilizes a combination of air pressure (55 psi) and visual inspection. A pressurized stream of air is placed perpendicular to the seam edge and any unbonded or loose areas will visibly flap on the inside sheet showing an air channel or imperfection through the weld.**

**Thermal dual track (split) welds consist of two nominal 0.5 inch (12.5 mm) wide welds running parallel and an unwelded 0.5 (12.5 mm) inch air channel between them. The seam is tested for integrity by filling the channel with air, which is an efficient method of nondestructive testing**

currently used to evaluate field seams in other geomembranes. This facilitates the use of well-established QA/QC procedures developed for air channel testing.

The air channel testing is conducted in accordance with the Geosynthetic Research Institute's Test Method GM-6 (revised July 1994). This test method quickly shows a failure, since any hole will not allow the air channel to inflate the full length of the seam. The method also accounts for the increased flexibility of PVC by reducing the minimum and maximum air pressures used for testing more rigid geomembranes. The maximum allowable pressure drop over the two-minute monitoring period is related to geomembrane thickness as shown in Table 1.

*Table 1*

*Air Pressure Inflation and Maximum Pressure Drop Schedule for PVC Geomembrane  
from Test Method GM-6*

<b>PVC Geomembrane Thickness</b>	<b>Minimum Pressure (lb/in<sup>2</sup>) (kPa)</b>	<b>Maximum Pressure (lb/in<sup>2</sup>) (kPa)</b>	<b>Maximum Pressure Drop in 2 Minutes (lb/in<sup>2</sup>) (kPa)</b>
20 mil	10/70	20/140	5/35
30 mil	15/105	25/170	5/35
40 mil	20/140	30/210	4/30
50 mil	25/170	35/240	4/30
60 mil	25/170	35/240	3/20

During testing, air channel pressures may drop more than normal due to the flexible nature of PVC. As a result, it may be possible to measure a 5 psi (35 kPa) drop in air pressure between the tracks even though the seam does not leak. During a successful test, this pressure drop will occur during the first 2 minutes. Therefore, a failed test is signified by a continued drop in pressure until equilibrium is reached with the outside air or an immediate pressure drop if a larger leak is present.

It has been reported that extremely high temperatures may affect the performance and results of air channel testing in PVC geomembranes. As with all flexible geomembrane materials, PVC exhibits increased flexibility as the ambient temperature increases. However, recent observations and data show that the air channel will develop the necessary air pressure even

at high temperatures. In fact the air channel will not expand beyond a certain diameter at elevated temperatures and thus the air channel pressure can be achieved and maintained.

Both solid and dual track wedge welded seams must meet or exceed the minimum PGI Specification for bonded seam shear strength and peel adhesion (see Table 2). An important difference between PVC and HDPE peel testing is that failure does not have to occur in the PVC sheet on either side of the seam, which is referred to as a film tear bond or FTB. PVC only requires that the shear and peel strengths exceed the minimum values shown in Table 2. An FTB is not required because PVC does not yield or exhibit a brittle failure condition, as does HDPE.

*Table 2*

*Minimum Shear and Peel Strengths for PVC Geomembrane Seams using ASTM Test Method D882*

<b>PVC Geomembrane Thickness</b>	<b>Bonded Seam Shear Strength (lbs/inch width)</b>	<b>Peel Strength (lbs/inch width)</b>
<b>20 mil</b>	<b>38.4</b>	<b>12.5</b>
<b>30 mil</b>	<b>58.4</b>	<b>15</b>
<b>40 mil</b>	<b>77.6</b>	<b>15</b>
<b>50 mil</b>	<b>96</b>	<b>15</b>
<b>60mil</b>	<b>116</b>	<b>15</b>

### **Additional Field Seaming Techniques or Specifications**

Temperature controllers on the welding device should be set according to type of geomembrane, thickness, ambient temperature, rate of seaming, and location of thermocouple within the device. Ambient factors such as clouds, wind, and sun require temperature and rate of travel settings to vary. As a result, it is necessary that the operator keep constant visual contact with the temperature controls, as well as the completed seam coming out of the machine.

A five-foot test strip should be fabricated and specimens manually tested prior to constructing each seam, or at the beginning of each shift change (e.g., morning or lunch). A minimum of one test strip should be made each morning and afternoon prior to commencement of

welding. Single thermal welds must exceed minimum shear and peel specifications, and both tracks of a dual track weld must exceed minimum specifications.

Records for each test strip, seam, and each destructive test sample should include welder designation, technician, temperature, and travel rate.

On T Seams across ends of panels, it may be necessary to trim any loose edges of the factory or field seams prior to welding.

Any area of the weld that fails air lance testing or air channel testing should be patched using the same liner material with cold applied PVC to PVC welding adhesive, chemical fusion agent, or bodied chemical fusion agent. All repairs should be air lance tested in accordance with ASTM Test Method D-4437.

In summary the increased use of thermal welding techniques for the field seaming of PVC geomembranes has allowed seams to be checked immediately with measurable results using well established QA/QC techniques. PVC geomembrane seaming using the thermal method also offers higher seam strength values without the concerns of stress cracking in the seam area associated with other geomembranes.