

PVC Geomembrane Fabrication and Installation

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PART 1 GENERAL

1.1 Description

- A. This section includes the following:
 - 1. Fabrication and installation of polyvinyl chloride (PVC) geomembranes.
- B. All work shall be done in strict accordance with the drawings and these specifications and are subject to the terms and conditions of the contract. It is the intent of these specifications to ensure a first quality finished product is provided. It shall be the responsibility of the Contractor to ensure that this requirement is met.

1.2 References

- A. ASTM D4437, "Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes", American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA.
- B. ASTM D6214, "Standard test method for determining the integrity of field seams used in joining geomembranes by chemical fusion methods", American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA
- C. ASTM D6392, "Standard test method for determining the integrity of nonreinforced geomembrane seams produced using thermo-fusion methods", American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA
- D. ASTM D7177, "Standard test method for air-channel testing of field PVC Geomembrane Seams", American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA
- E. PVC Geomembrane Institute (PGI), 2004, "PVC Geomembrane Material Specification 1104", University of Illinois, Urbana, IL, www.pvcgeomembrane.com, January 1, 2004.

1.3 Submittals

- A. 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 PVC Geomembrane.
 - 2. Documentation of the manufacturer's qualifications as specified in Section 1.4 of this specification.
 - 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 installer's experience, as specified in Section 1.4 of this specification.
 - 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 familiar with the geomembrane installation; type and thickness of

- geomembrane, type of field seaming, 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.
- B. 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 drawings 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.
- C. Additional submittals (in progress and at completion)
- 1. Manufacturer's warranty (refer to Section 1.7).
 - 2. Fabricated seam warranty – 1 Year.
 - 3. Field seam warranty – 1 Year.
 - 4. Installation warranty – 1 Year.
 - 5. Daily written acceptance of subgrade
 - 6. Low temperature deployment and seaming process
 - 7. Daily field weld test results
 - 8. Field seam destructive test results (if applicable)
 - 9. Field repair/patching of defects
 - 10. Daily field installation reports
 - 11. As-built drawings

1.4 Qualifications

- A. Manufacturer Qualifications:
- 1. Required minimum qualifications for approval: The manufacturer of the PVC geomembrane of the type specified shall have at least five years of experience in the manufacture of PVC geomembranes. In addition, the geomembrane manufacturer shall have manufactured at least one million square feet of the specified type of geomembrane in the last five years and be a member of the Fabricated Geomembrane Institute (FGI).
- B. Fabricator:
- 1. The fabricator shall be Lange Containment Systems, Inc. of Denver, Colorado (1-800-

446-4898), or approved equal.

2. Required minimum qualifications for approval: The Fabricator of the proposed PVC geomembrane shall have a minimum five million square feet of fabrication experience over the last 5 years and be a member of the FGI.
- C. Installer Qualifications:
- a. The Geomembrane Installer shall have at least three years of 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 approved/certified by the fabricator to install fabricated products.
 - b. 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, anchorage, seaming, patching, testing, repairs, and all other daily activities of the Geomembrane Installer.
 - c. 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.
 - d. All seaming, patching, other welding operations, and testing shall be performed by a qualified technician employed by the Geomembrane Installer.

1.5 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 manufacturers name, material thickness, panel identification number corresponding to panel placement layout, panel dimensions, weight, 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.

1.6 On – Site Conditions

- A. No standing water, mud, snow, or excessive moisture will be allowed on the site. 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 3.3 of this specification.

1.7 PVC Geomembrane Material Warranty

- A. As required by specification.

1.8 Factory and Field Fabricated Seam Warranty

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

1.9 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 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. Meeting topics should include the following:
 - 1. Responsibilities of each party.
 - 2. Lines of authority and communication for the project. Procedures for 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, deployment, 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 condition for geomembrane placement.
 - 11. Anchor trench construction, material placement, and backfilling.
 - 12. Plan for minimizing and addressing wrinkles, if any, in the placed geomembrane.
 - 13. Measurement and payment schedules.
 - 14. Covering of the Geomembrane and cover soil placement.
 - 15. Health and safety.

PART 2 PRODUCTS

2.1 Description of Materials

- A. The PVC geomembrane shall be constructed of 30-mil, PVC (polyvinyl chloride) geomembrane consisting of 72" minimum, widths of calendared polyvinyl chloride sheeting fabricated in to large section by means of special factory-bonded seams into a single panel, or into the minimum number of large panels required to complete the project.
- B. 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 1104 specifications.

2.2 Physical Characteristics

- A. Geomembrane shall be uniform in size and thickness. The material shall have the minimum physical property characteristics, as outlined in the specifications. Manufacturer test results showing that the sheeting meets or exceeds the specification shall be supplied.
- B. The finished geomembrane shall have the minimum property values listed in the following table:

PVC Geomembrane Specifications PGI 1104 Specifications¹

Certified Properties ²	ASTM	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Thickness	D-5199	20 ±1 mil 0.51 ± .03 mm	30 ± 1.5 mil 0.76 ± .04 mm	40 ± 2 mil 1.02 ± .05 mm	50 ± 2.5 mil 1.27 ± .06 mm	60 ± 3 mil 1.52 ± .08 mm
Tensile Properties ³	D-8824 Min					
Strength at Break		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		360%	380%	430%	430%	450%
Modulus at 100%		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 ⁴ Min	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	D-1204 ⁴ Max Chg	4%	3%	3%	3%	3%
Low Temperature Impact	D-1790 ⁴ Pass	-15o F -26o C	-20o F -29o C	-20o F -29o C	-20o F -29o C	-20o F -29o C
Index Properties⁵	ASTM	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
Water Extraction Percent Loss (max)	D-1239 ⁴ Max Loss	0.15%	0.15%	0.20%	0.20%	0.20%
Average Plasticizer Molecular Weight	D-2124 ^{4,5}	400	400	400	400	400
Volatile Loss Percent Loss (max)	D-12034 Max Loss	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial	G1604 Max Chg					
Break Strength		5%	5%	5%	5%	5%
Elongation		20%	20%	20%	20%	20%
Modulus at 100%		20%	20%	20%	20%	20%
Hydrostatic Resistance	D-7514 Min	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa
Seam Strengths	ASTM	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Shear Strength ³	D-882 ⁴ Min	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 20kN/m
Peel Strength ³	D-882 ⁴ Min	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 1104 replaces PGI 1103 Specification effective 1/1/04.
 2. Certified properties are tested by lot as specified in PGI 1104 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 1104 Appendix B.
 5. Index properties are tested once per formulation as specified in PGI 1104 Appendix A.

2.3 Factory Fabrication

- A. Individual calendared widths of PVC shall be factory fabricated into large panels so as to minimize field seaming during installation.
- B. Factory fabricated seams shall be accomplished by the use of dielectric or thermal bonding methods.
- C. Seams shall have minimum of one inch (1") nominal width.
- D. Production records shall identify each factory pre-assembly panel by panel number, size, date of pre-assembly, material lot number and seam station identification. Mark each panel prominently with the panel number and panel size to coincide with production records.

2.4 Inspection and Testing of Factory Seams

- A. The fabricator shall perform 100% continuous visual inspection of each lineal foot of seam as it is produced.
 - 1. Upon discovery of any defective seam, the fabricator shall stop production of panels used in this work and shall repair the seam and determine and rectify the cause of the defect prior to continuation of the seaming process.
- B. A 48 inch sample shall be taken from each factory seam welding unit used in this work at the beginning of each work shift and every four hours of production thereafter.
 - 1. Samples shall be non-destructive, i.e., will not require patching of fabricated panels.
 - 2. Test specimens shall be cut at quarter points from each 48 inch seam sample (a total of three places) and tested for seam strength requirements as specified in the table in Section 2.2 of this specification.
 - 3. A log shall be maintained showing the date, time, panel number and test results. This log shall be made available to the Owner or Engineer upon request.

2.5 Certification and Test Reports

- A. Prior to installation of the PVC panels, the fabricator shall provide the Engineer with the following certification and test reports:
 - 1. Written certification that the material meets all of the requirements of Section 2.1 and 2.2 of this specification.

PART 3 EXECUTION

3.1 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 geomembrane with no sudden, sharp, or abrupt changes or break in grade.
- B. The stability of PVC geomembrane slopes should be carefully evaluated because the maximum allowable slope depends on the characteristics of the materials underlying and overlying the PVC geomembrane as well as other factors such as rainfall and gas pressure. However, maximum slopes less than 3 horizontal to 1 vertical have been observed to be stable in some applications.
- C. 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 under-drain system to prevent ground water pressure from developing beneath the geomembrane. Excessive ground water can force the geomembrane upwards through the cover soil and any liquid contained in the impoundment.
- D. The geomembrane installer and the owner's representative shall inspect the subgrade surface to be covered with geomembrane on each day's operation prior to placing the geomembrane to verify suitability.
- E. The Geomembrane installer and Owner's Representative shall provide daily written acceptance for the subgrade surface to be covered in that day's operation. The surface shall be maintained in a manner to ensure subgrade suitability.
- F. 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 preparation, repairs, and maintenance of the subgrade shall be defined in the preconstruction meeting.

3.2 Geomembrane Placement

- A. PVC geomembrane shall not be deployed until all applicable submittals, certifications, and quality control certificates listed in Section 1.3 of this specification 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.
- 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. Typical equipment that is usually used during

- installation and testing and allowed on the geomembrane include air compressors, generators, etc.
- E. Sandbags or equivalent ballast shall be used as necessary to temporarily hold the PVC geomembrane in position.
 - F. Geomembrane placement shall not be performed 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 or the subgrade repaired.
 - I. Wrinkles cause by panel placement should be minimized.
 - J. In general, seams shall be oriented parallel to the line of the maximum slope, i.e., the seam should run down the 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.
 - K. Panel Overlapping for Seaming:
 - a. Chemical Seam: 6-8" overlap with a 4" wide seam.
 - b. Thermal Seams:
 - i. Single Track weld – 4 to 6" overlap and a minimum 2" (nominal) wide seam.

3.3 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 welds to determine if field seams can be created to meet the PGI 1104 requirements.
 - 4. The Owners representative shall approve the cold weather procedures and be available to verify that seam quality parameters can be achieved.
- B. High temperature seaming procedures may include the following:
 - 1. Suspension of work if temperatures create a dangerous work environment for the installation crew and inspectors.
 - 2. Preparation of additional qualification strips to determine if welding can be completed and made to meet PGI 1104 seam strength requirements.
- C. Fishmouths shall be kept to a minimum and when necessary be cut out and repaired so as to create a flat overlap.

- D. All repairs shall extend a minimum of 6" past any cut in all directions. Thus, a circular patch will have a diameter of at twelve inches, i.e., a radius of six inches, for a small hole.

3.4 Seaming Specifications

A. Chemical Seaming

1. Prior to starting any field welds each seam crew shall prepare a test seam to verify quality and temperature requirements can be met.
2. Panels to be welded using chemicals shall be overlapped a minimum of 6".
3. Care should be taken to clean all areas with a rag prior to applying chemicals.
4. A sufficient amount of chemical shall be placed on both sheets of the PVC geomembrane to be joined with either a squeeze bottle or paintbrush and form a continuous wide weld path of at least 1.5 inches in width.
5. 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 or weld to the prior chemical seam area as they continue along down the seam.
6. Upon completion of each seam, the seam shall be inspected and any loose areas re-rolled and/or chemical added as required to complete the seam.

B. Thermal Welding Specifications

1. Each Master Seamer shall complete a trial weld of 5' long and each sample shall be tested in accordance with the PGI 1104 Specification.
2. Panels to be seamed together by a thermal weld shall be overlapped 4" to 6".
3. Panels shall be wiped clean removing dirt and dust prior to seaming. This can be facilitated with the use of hot air welders that blow dirt and dust from the seam area.
4. Panels should be positioned and all wrinkles pulled out of the seam area prior to seaming.
5. Master Seamer shall walk with welder at all times and continually check overlap, temperature, and weld quality.
6. 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 thermally welded seam when Air Lance Testing using ASTM D4437 is performed. When Air Channel Testing is performed on the thermally welded seam in accordance with ASTM D7177, no destructive samples will be taken from the production liner. However, destructive samples will be obtained from test welds and/or welds in the anchor trench at the beginning and end of each day.
7. If destructive sampling is specified, both sides of the weld shall be tested for shear and peel strength sample in accordance with ASTM D6392.
8. Samples shall be tested and evaluated in accordance with the PGI 1104 Specification.

3.5 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 3.4.
- D. All sealed areas shall be Air Lance tested using ASTM D4437 and verified to be leak free.

3.6 Field Quality Control

- A. 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.
- B. 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 and evaluated in accordance with the PGI 1104. 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 using trial welds sent to an independent lab to verify quality.
 - 5. For peel and shear testing see Destructive Field Seam Testing Section 3.6 of this document. Field peel and shear strength values should meet the requirements of PGI-1104.
 - 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, technician performing the test seam and a pass or fail description.
- C. 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 performed as the seaming progresses, not at the completion of all field

seaming, unless agreed to 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 (ASTM D4437) or air-channel pressure test method (ASTM D7177).

D. Air Lance Testing

1. Chemical and solid thermal, i.e., single track, welds can be tested utilizing the Air Lance Test Method ASTM D 4437.. The Geomembrane Installer 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.
2. 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, loose edges, ruffles, and/or noise . If air penetrates the seam area, the technician will either see this visibly or hear it audibly.
3. 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.

E. Destructive Field Seam Testing (if applicable)

1. When Air Lance Testing is performed using ASTM D4437, a minimum of one destructive sample per 500 lineal feet of field seam or at another pre-determined length should be obtained and tested in accordance with ASTM D6392 by the Geomembrane Installer from a location specified by the Owner's Representative. To obtain test results prior to completion of geomembrane installation, destructive samples shall be cut by the geomembrane installer as directed by the owner's representative as seaming progresses. The Geomembrane Installer shall not be informed in advance of the sample location. When Air Channel Testing is performed, no destructive samples will be taken from the production liner but destructive samples can be obtained from the anchor trench or test welds.
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 the destructive sample.
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 length-wise. 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) of this section and one section given to the geomembrane installer for field testing as specified in paragraph four (4) of this section.

4. For field testing of destructive samples, 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 strength 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 1104 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 ASTM D 6392 for thermal seams by an accredited laboratory who is a member of the FGI.
 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 possible inadequacy of the entire seam length corresponding to the test sample. Additional destructive samples of the subject seam shall be taken by the geomembrane installer at locations indicated by the owner's representative; typically 10 feet (3 meters) 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 inadequate seams. All destructive sample locations shall be repaired with a cap strip either thermally or chemically welded into place. All cap stripped seams shall be non-destructively tested with an air lance test.
- F. 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.
- G. Evaluation of defects: Each suspect location (both in geomembrane seam and non-seam areas) shall be non-destructively tested using the air lance test method in ASTM D4437. 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 tests, the geomembrane installer shall 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 re-seaming or applying a cap strip.
 3. Re-seaming may consist of either:
 - a. Removing the defective area and rewelding the parent material using the original welding equipment, or
 - b. Re-seaming by cap stripping as described in section 3.6.
 4. Each patch shall extend a minimum of 150 mm (6 inches) in all directions beyond the defect.
 5. All repairs shall be measured, located, and recorded.
- H. Verification of repairs on seams: Each repair shall be non-destructively tested using the air

lance test in ASTM D4437. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be re-seamed and retested until a passing test result is obtained. The number date, location, technician, and test outcome of each patch shall be recorded.

- I. 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.
 6. Results of destructive testing.
 - a. Destructive test results shall be reported prior to covering the lining or within 48 hours.

3.7 Liner Acceptance

- A. The PVC Geomembrane will be accepted by the Owners Representative when all of the following have been completed:
 1. The entire installation is finished or an agreed upon subsection of 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.

3.8 Anchor Trench Construction and Backfilling

- A. Construct and line anchor trench as specified on contract drawings.
- B. The anchor trench should be backfilled and compacted by the contractor as approved by the INSPECTOR. Trench backfill material should be placed in loose lifts and compacted.
- C. Care should be taken when backfilling the anchor trench 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 of the anchor trench.

3.9 Disposal of scrap materials

- A. On completion of installation, the geomembrane installer shall dispose of all waste and scrap material in a location provided and approved by the owner. The installer should also remove

all 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 completed surface of the PVC geomembrane.

- END OF SPECIFICATION -