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GEOMEMBRANE INSTALLATION

QUALITY ASSURANCE MANUAL

Revised 09.23.2020

CONTENT

1. OVERVIEW

1.1. This manual is a guide to the duties and responsibilities of the Layfield Project Manager, Layfield Project Supervisor, Layfield QA/QC Designate, and Layfield Technician on every project.

1.2. This document is not intended to be prescriptive for every possible application, project or material. Each practice, standard, and/or test method should be guided by (and applied with) good engineering principles and judgment, project specifications and the expertise of qualified Layfield personnel.

1.3. This document does not address any health, safety or environmental concerns related to practices, standards, test methods, regional regulations, or site-specific rules.

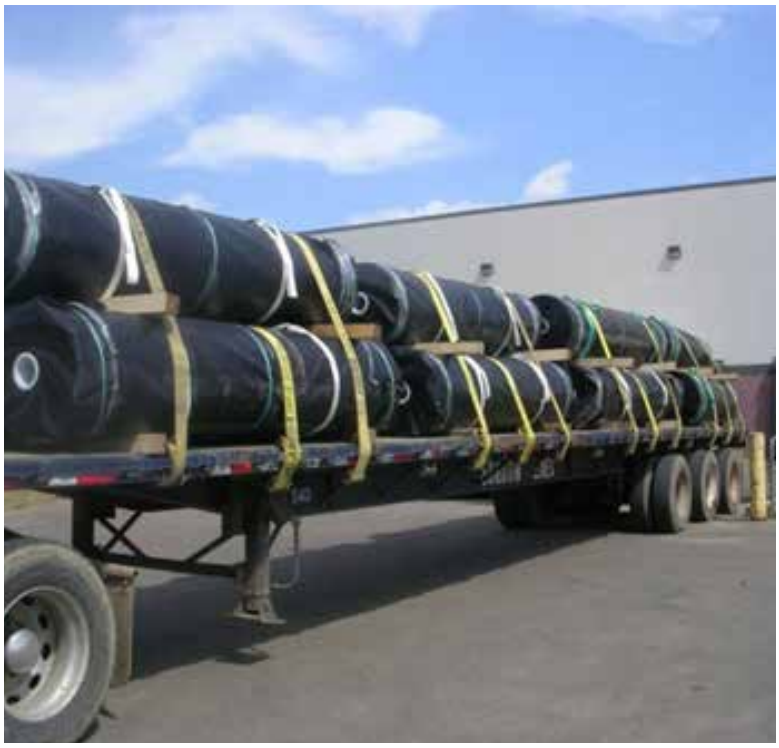
2. REFERENCES

ASTM D4437	Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Membranes
ASTM D4439	Terminology for Geosynthetics
ASTM D4873	Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
ASTM D5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D6214	Standard Test Method for Determining the Integrity of Field Seams Used in Joining Geomembranes by Chemical Fusion Methods
ASTM D6365	Standard Practice for the Nondestructive Testing of Geomembrane Seams Using the Spark Test

ASTM D6392	Standard Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D6497	Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures
ASTM D7177	Standard Specification for Air Channel Evaluation of Polyvinyl Chloride Dual Track Seamed Geomembranes
ASTM D7272	Standard Test Method for Determining the Integrity of Seams Used in Joining Geomembranes by Pre-manufactured Taped Methods
ASTM D7408	Standard Specification for Non-Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams
ASTM D7700	Standard Guide for Selecting Test Methods for Geomembrane Seams
ASTM D7747	Standard Test Method for Determining Integrity of Seams Produced Using Thermo-Fusion Methods for Reinforced Geomembranes by the Strip Tensile Method
ASTM D7865	Standard Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels
GRI Standard GM 6	Pressurized Air Channel Test for Dual Seamed Geomembranes
GRI Standard GM13	Test Methods, Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GRI Standard GM14	Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
GRI Standard GM17	Test Methods, Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GRI Standard GM18	Test Methods, Properties and Testing Frequency for Flexible Polypropylene (fPP and fPP-R) Non-reinforced and Reinforced Geomembranes
GRI Standard GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
GRI Standard GM 25	Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes
GRI Standard GM 29	Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Nondestructive Testing

3. MATERIAL DELIVERY

3.1. Overview



3.1.1. Layfield is usually responsible for geosynthetic material transport to the work site. The Layfield Project Manager is responsible for ensuring that Layfield produced and procured materials are packaged and identified in a manner that complies with ASTM D4873 and/or ASTM D7865.

3.1.2. When Layfield is directly responsible for on-site geosynthetic material receiving, storage and handling, the Layfield Project Supervisor or QA/QC Designate will ensure that this is done in a manner that complies with ASTM D4873 and/or ASTM D7865. However, Layfield often does not have direct control of these activities on-site and the Project Supervisor or QA/QC Designate is only able to give guidance, which may or may not be followed.

3.2. Procedure

3.2.1. The Project Supervisor or QA/QC Designate shall perform an inventory of all materials on-site for use in the scope of work.

3.2.2. All geomembrane, geotextile, geonet, geocomposite, etc roll or panel numbers shall be entered in the Inventory Log (Appendix B) and will be cross-referenced with bills of lading.

3.2.3. The Inventory Log must be returned to the Layfield office along with the remainder of the project QA/QC documentation at the end of the project for inclusion in the final QA/QC turnover package.

3.2.4. All damages must be noted on the Geomembrane Inventory Log. If damages are substantial, notify the Project Manager immediately so that the appropriate claim process may be started and/or PIR process initiated.

4. SUBGRADE SURFACE INSPECTION

4.1. Overview

4.1.1. All projects must have all Certificate(s) of Subgrade Surface Inspection (Appendix A) signed by the Owner's Representative prior to the deployment of any covering material.

4.1.2. It is important to note that there are cases where a total work area cannot or will not be turned over to Layfield. The Certificate of Subgrade Surface Inspection does make provision for partial areas being turned over to Layfield. The Project Supervisor or QA/QC Designate shall ensure that the extents of the inspected area are clearly expressed on the Certificate of Subgrade Surface Inspection. A separate certificate shall be generated for each partial area.

4.1.3. The Certificate of Subgrade Surface Inspection is generated in duplicate with a white (original) and yellow (copy). The white copy is kept with Layfield's QA/QC documentation and is turned over to the Layfield Project Manager at the Project Closeout Meeting. The yellow copy is turned over to the countersigning party (Contractor's QA, Owner's Representative, etc) immediately upon signature for their records. Electronic copies may also be used in lieu of hard copy sheets.

4.2. Procedure

4.2.1. The General Contractor is responsible for preparing and maintaining the subgrade. The subgrade must be prepared and maintained per the individual project specifications.

4.2.2. The Project Supervisor or QA/QC Designate will be responsible for visually inspecting the subgrade surface.

4.2.2.1. If the subgrade is deemed unsuitable by the Project Supervisor or QA/QC Designate, they must alert the Owner's Representative and/or General Contractor as soon as possible. The Project Supervisor or QA/QC Designate shall communicate why the subgrade is unsuitable and may give some guidance for subgrade remedy.

4.2.2.2. Alternatively, the Owner's Representative may direct the Project Supervisor to begin deployment despite the unsuitable subgrade. The Project Supervisor will confer with the Project Manager prior to deployment.

4.2.3. When the subgrade has been inspected and deemed acceptable, the Project Supervisor or QA/QC Designate will complete and sign the Certificate of Subgrade Surface Inspection and submit to the Owner's Representative for countersignature.

4.2.3.1. The Certificate(s) of Subgrade Surface Inspection must be completed, signed and countersigned prior to beginning any deployment.

4.2.4. Prior to material installation, the Layfield Supervisor or QA/QC Designate should measure the area to be covered and compare it to the area included in the contract. Any differences must be communicated immediately to the Layfield Project Manager.

5. DEPLOYMENT

5.1. Overview

5.1.1. Material shall be deployed under the direction of the Project Supervisor or QA/QC Designate.

5.1.2. Material shall be deployed in a logical sequence and in a manner that allows for efficient seaming.

5.1.3. Equipment used to handle geomembrane panels or rolls shall not contact the material directly and shall not cause damage to the material.

5.1.4. Adjacent rolls will be overlapped by an amount suitable for the material and the seaming method being used.

5.2. Procedure

5.2.1. Each prefabricated panel or roll stock length shall be assigned a unique Panel Number as detailed below.

5.2.1.1. It is essential that Layfield's identification system and the Owner's Representative are the same. Do not use different systems.

5.2.2. Panel numbers shall be written in large block letters in the center of each deployed panel. The roll number, date of deployment and length (gross) should be noted below the panel number. Panel numbers should be made so that they are easily visible from a distance. On long panels this information should be written at both ends.

5.2.3. Panel Numbers shall be logged on the Geomembrane Deployment Log (Appendix C) along with the deployment date, roll number, length, width, and air temperature.

5.2.4. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

5.2.4.1. Unroll geomembrane using methods that will not damage geomembrane and will protect the underlying surface from damage.

5.2.4.2. To prevent wind uplift, place ballast that will not damage the geomembrane (usually sandbags).

5.2.4.3. Personnel walking on geomembrane shall not engage in activities or wear footwear that could damage the material. Smoking is not permitted on the geomembrane.

5.2.4.4. Do not allow heavy equipment or road vehicle traffic directly on geomembrane. Rubber-tired/ tracked UTVs are acceptable if ground pressure is less than 8 psi.

5.2.4.5. If required, place a protective cover over the geomembrane in areas of heavy traffic. The type of cover will vary according to material and traffic types.

5.2.4.6. All tires/tracks shall be inspected for sharp edges, embedded rocks or other potentially damaging materials prior to driving on any geosynthetic layer.

5.2.4.7. All UTVs must drive as straight as possible while on any geosynthetic layer. No sharp turns, sudden stops or quick starts.

5.2.4.8. Areas, where driving occurs, shall be continuously and thoroughly inspected throughout the deployment process by the Layfield Project Supervisor or QA/QC Designate and the Owner's Representative.

6. QUALIFICATION WELDS

6.1. Overview

6.1.1. Wedge, Hot Air and Extrusion Qualification Welds

6.1.1.1. When performing Wedge, Hot Air, and/or Extrusion Qualification Welds, each welding apparatus will be assigned to a Layfield Technician.

6.1.1.2. Each welding apparatus along with its designated Layfield Technician must pass a qualification weld prior to use for production welds. This will occur prior to any production seaming and in 4.0 hour increments as a minimum.

6.1.1.2.1. In addition, qualifications must be performed whenever there is a power interruption, dramatic change in climate conditions, if equipment settings are modified or adjusted, or a technician (operator) change.

6.1.1.3. Wedge, Hot Air, and Extrusion Qualification Welds must be destructively tested by a calibrated tensiometer. The tensiometer shall be calibrated by a certified third-party calibration agency. The Project Manager shall ensure that the Project Supervisor or QA/QC Designate is in possession of a copy of the calibration certificate prior to mobilization to the worksite.

6.1.1.4. Wedge, Hot Air, and Extrusion Qualification Welds shall be tested in accordance with ASTM D6392, ASTM D7177, ASTM D7408, ASTM 7747, GRI Standard GM6, GRI Standard GM13, GRI Standard GM17, GRI Standard GM19, or GRI Standard GM25; whichever is applicable to the material being welded.

6.1.2. Chemical Fusion Qualification Welds

6.1.2.1. Chemical Fusion is a versatile technique, but is only applicable to materials containing PVC, EVA, and CSPE.

6.1.2.2. Chemical Fusion does not provide the same peel strengths as thermo-fusion welding methods. For example, it is possible to create a wide chemical fusion bond that will develop the same shear strength as the material, but peel strengths will be lower than thermo-fusion welded samples.

6.1.2.3. Chemical Fusion welds typically require 8 to 24 hours curing time. As such, it is not usually practical to perform QA Chemical Fusion Qualification Welds in the field.

6.1.2.4. Chemical Fusion welds can be tested as a QC measure as part of Field Destructive Testing, which is covered below in this document.

6.1.3. Prepared Tape Seams

6.1.3.1. Prepared Tape seams are only used on materials such as vapor barrier and RPE type materials where Thermo-Fusion techniques cannot be used due to material properties.

6.1.3.2. Prepared Tape seams do not provide the same peel or shear strength values as thermo-fusion welding methods. The joint must be secured in some other fashion to create strength.

6.1.3.3. If Qualification Welds are required by the project specifications, Prepared Tape seams shall be tested in accordance with ASTM D7272.

6.2. Wedge, Hot Air, and Extrusion Qualification Procedure

6.2.1. All welding equipment shall be allowed to warm up a minimum of 15 minutes before performing Qualification Welds.

6.2.2. The Project Supervisor, QA/QC Designate and/or Technician must verify:

6.2.2.1. The equipment used is functioning properly and is the correct style for the welding to be performed.

6.2.2.2. Welding personnel are competent, working in a professional manner and are attentive to their duties.

6.2.2.3. Welding will only be performed when conditions allow for the conclusion of successful welds which will meet the project specifications.

6.2.3. Wedge welds must be performed on samples at least 5’ long. Hot Air Welds must be performed on samples at least 2’ long and the welded width must be at least 2”. Extrusion welds must be performed on samples at least 3’ long.

6.2.4. All Qualification Welds must be performed in the same conditions that exist on the worksite.

6.2.5. Use a 1" (25 mm) die cutter to cut ten (10) test specimens (or coupons) from the Qualification Weld samples. The Qualification Weld samples should be free of sand and grit prior to cutting sample. Cut one sample at a time to avoid damaging the coupons and/or the die cutter.

6.2.5.1. Because of the thickness of Embedment liner precludes doing "standard" Qualification procedures (I.e. testing peel and shear via a tensiometer), Qualification Welds will be checked with a Point Stress test to ensure proper bonding of extrudate to the Embedment liner.

6.2.6. When cutting coupons from the Qualification Weld samples, the inside and outside tracks on the coupon must be identified to assist in troubleshooting if the weld fails. This only applies to a dual track wedge welding apparatus.

6.2.6.1. The outside track will be identified as the track which is closest to the edge of the top sheet. The inside track will be identified as the track closest to the edge of the bottom sheet. Inside/outside labeling only applies to a dual track wedge welding apparatus.

6.2.7. Allow coupons to cool prior to testing.

6.2.8. Qualification Weld testing should occur at 21oC (+/- 4oC). Coupon temperatures greater than 21 degrees may result in artificially low strengths while colder temperatures lower may result in artificially high test values. If possible, allow the coupons to temperature stabilize to these conditions prior to testing.

6.2.9. Visually inspect the coupons for squeeze-out, footprint, pressure and general appearance.

6.2.10. Five (5) coupons will be tested in peel, and five (5) more coupons will be sampled in shear on the calibrated field tensiometer at a separation rate dictated by the applicable ASTM or GRI test method.

6.2.11. Criteria for passing Qualification Welds will be as follows:

6.2.11.1. Weld must exhibit a film tear bond (FTB). Qualification Welds must have no more than 25% incursion into the weld in all samples.

6.2.11.2. Peel and shear values must meet or exceed the values that are applicable to the geosynthetic material. Peel and Shear values for the following typical materials can be found in:

6.2.11.2.1. HDPE, Smooth and Textured – GRI Standard GM 19

6.2.11.2.2. LLDPE, Smooth and Textured – GRI Standard GM 17

6.2.11.2.3. LLDPE, Reinforced – GRI Standard GM 25

6.2.11.2.4. EnviroLiner® Series – GRI Standard GM17

6.2.11.2.5. Nonreinforced PVC – ASTM D7408

6.2.11.2.6. Reinforced Geomembranes - ASTM D7747

6.2.11.2.7. Flexible Polypropylene, Reinforced & Nonreinforced – GRI Standard GM18

6.2.11.3. Both tracks of Dual Track wedge welded samples must pass for the Qualification Weld to be considered acceptable. If the applicable specification passing criteria is not met, the Qualification Weld must be re-done. Repeat the Qualification Weld process until passing values are obtained.

6.2.11.4. Solid Wedge, Hot Air Welded, Chemical Bonded and Hot Shoe Welded samples must pass for the Qualification Weld to be considered acceptable. If the applicable specification passing criteria is not met, the Qualification Weld must be re-done. Repeat the Qualification Weld process until passing values are obtained.

6.2.12. The Layfield Project Supervisor or QA/ QC Designate will give the approval to proceed with welding after observing and recording all Qualification Weld results.

6.2.13. All qualification weld data shall be recorded on the following logs:

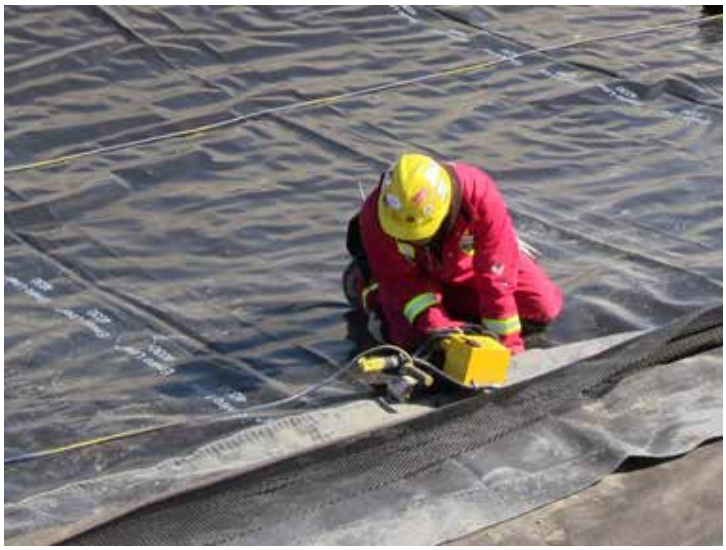
6.2.13.1. Wedge Qualification Weld data will be recorded in the Geomembrane Seam & Test Log (Appendix D).

6.2.13.2. Extrusion and Hot Air Qualification Weld data will be recorded in the Geomembrane Detail & Test Log (Appendix E)

7. FIELD PRODUCTION SEAMING

7.1. Overview

7.1.1. All seams shall be recorded.



7.1.2. Field wedge welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D).

7.1.3. Extrusion welds are usually performed on details, defects or repairs and as such will be recorded on the Geomembrane Detail & Test Log (Appendix E).

7.1.4. Chemical Fusion welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D). If they are performed as part of a detail or repair, they shall be recorded on the Geomembrane Detail & Test Log (Appendix E).

7.1.5. Prepared Tape welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D) if they are production welds. If they are performed as part of a detail or repair, they shall be recorded on the Geomembrane Detail & Test Log (Appendix E).

7.1.6. Hot air welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D). If they are performed as part of a detail or repair, they shall be recorded on the Geoemembrane Detail & Test Log (Appendix E).

7.2. Wedge Welding Procedures

7.2.1. All wedge welding equipment must use the same settings that were used during the Qualification Weld process. If changes are made to any settings, the wedge welder must be re-qualified.

7.2.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Seam & Test Log.

7.2.3. Welding Technicians will mark their initials, machine number, date and time at the start of every seam.

7.2.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.2.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, material specifications and/or the successful geomembrane Qualification Weld.

7.2.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.2.5. The Layfield Technician shall verify the following as part of weld preparation:

7.2.5.1. Ensure that the seam is overlapped properly for Wedge welding.

7.2.5.2. Clean the seam area as required. The seaming area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.2.5.2.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.2.5.3. Align wrinkles on seams to minimize unmatched wrinkles or “fish mouths”.

7.2.6. Proceed with Wedge weld.

7.3. Hot Air Welding Procedures

7.3.1. All Hot Air welding equipment must use the same settings that were used during the Qualification Weld process.

7.3.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Detail & Test Log.

7.3.3. Welding Technicians will mark their initials, machine number, date and time at the start of every seam or weld.

7.3.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.3.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, material specifications and/or the successful geomembrane Qualification Weld.

7.3.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.3.5. The Layfield Technician shall verify the following as part of weld preparation:

7.3.5.1. Ensure that the seam or weld area is overlapped properly for Hot Air welding.

7.3.5.1.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.3.5.2. Clean the seam or weld area as required. The seam or weld area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.3.5.3. Weld the seam or weld area by heating using the Hot Air Welder and apply continuous downward pressure along the area (roller apparatus for applying even pressure is recommended for thinner, flexible materials). Weld width should be a minimum of 2" wide continuous throughout the weld.

7.4. Extrusion Welding Procedures

7.4.1. All Extrusion welding equipment must use the same settings that were used during the Qualification Weld process.

7.4.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Detail & Test Log or Seam & Test Log depending on the nature of the work.

7.4.3. Welding Technicians will mark their initials, machine number, date and time at the start of every seam or weld.

7.4.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.4.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, material specifications and/or the successful geomembrane Qualification Weld.

7.4.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.4.5. The Layfield Technician shall verify the following as part of weld preparation:

7.4.5.1. Ensure that the seam or weld area is overlapped properly for Extrusion welding.

7.4.5.1.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.4.5.2. Clean the seam or weld area as required. The seam or weld area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.4.5.3. Tack the seam or weld in place by using a Hot Air welder.

7.4.5.4. Abrade the welding surface(s) by either grinding or abrasion. For Embedment Liner, ensure that the sheets/cap/patch has been beveled to allow weld penetration.

7.4.5.5. Purge the machine of heat-degraded extrudate prior to use.

7.4.6. Proceed with Extrusion weld.

7.5. Chemical Fusion Welding Procedures

7.5.1. Chemical Fusion Welding requires the use of solvents or bodied solvents.

7.5.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Seam & Test Log or Geomembrane Detail & Test Log, as applicable.

7.5.3. Welding Technicians will mark their initials, date and time at the start of every seam or weld.

7.5.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.5.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, Chemical Fusion manufacturer specifications, and/or material specifications.

7.5.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.5.5. The Layfield Technician shall verify the following as part of weld preparation:

7.5.5.1. Ensure that the seam or weld area is overlapped properly for Chemical Fusion welding.

7.5.5.1.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.5.5.1.2. If the subgrade is not rigid enough, a rigid slip sheet can be used to help with compression during the seaming process.

7.5.5.2. Clean the seam area or weld area as required. The area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.5.6. Proceed with Chemical Fusion weld.

7.6. Prepared Tape Seaming Procedures

7.6.1. Prepared Tape Seaming requires the use of mastics, putties, asphalt, or butyl tapes.

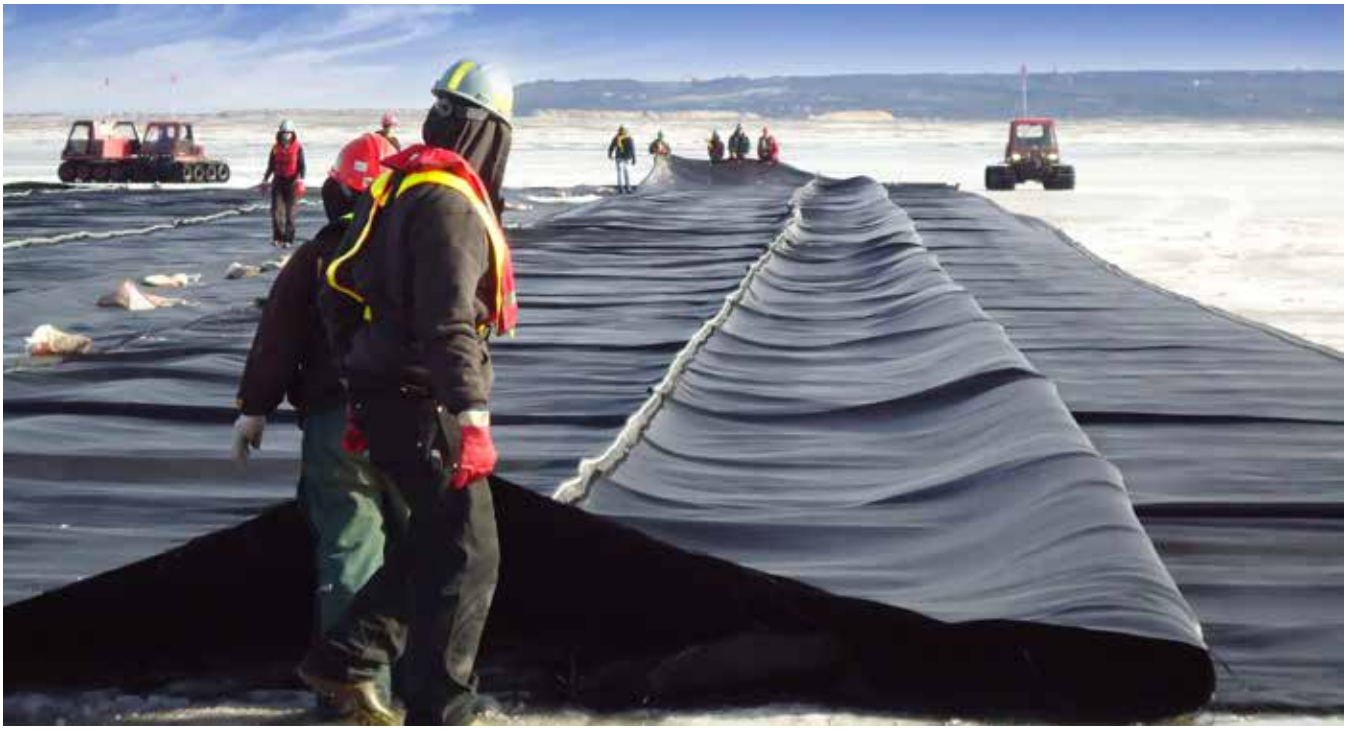
7.6.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Seam & Test Log or Geomembrane Detail & Test Log, as applicable.

7.6.3. Welding Technicians will mark their initials, date and time at the start of every seam.

7.6.4. Seaming should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.6.4.1. Allowable seaming temperatures and/or weather conditions shall be dictated by the project specifications, Prepared Tape manufacturer specifications, and/or material specifications.

7.6.4.2. Seaming may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.



7.6.5. The Layfield Technician shall verify the following as part of seam preparation:

7.6.5.1. Ensure that the seam is overlapped properly for Prepared Tape seaming.

7.6.5.2. Clean the seam area as required. The seaming area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.6.6. Proceed with Prepared Tape seam.

8. FIELD NONDESTRUCTIVE TESTING

8.1. Overview

8.1.1. Layfield shall non-destructively test the entire length of all seams and welds using the applicable non-destructive test method for the material as indicated by ASTM D7700. The table below can be used as a quick reference

Material	ASTM Test Method				
	D5641 Vacuum Chamber	D4437 Air Lance	D4437 Point Stress	D5820 Pressurized Air Channel[3]	D6365 Spark Test
HDPE	X	X	X	X[2]	X
LLDPE & fPP	X	X	X	X[2]	X
Embedment Liner	X		X		X[4]
Non-reinforced PVC	X	X	X		X
Reinforced Geomembrane	X	X	X	X	X
Reinforced PVC	X	X	X		X
fPP-R	X	X	X	X	
EnviroLiner® Series	X	X	X	X[2]	X

[1] Layfield will usually restrict the use of ASTM D5641 (Vacuum Chamber) to Extrusion welds and other short weld lengths such as details and repairs.

[2] Layfield will usually perform Dual Track Wedge welds on this material if the thickness is 40mil or greater. Layfield will usually perform Solid Wedge welds if the material thickness is below 40mil.

[3] GRI Standard GM6 is also applicable to this test method.

[4] Spark Testing is the standard test method for Embedment liner.

8.2. Procedure

8.2.1. Vacuum Chamber

8.2.1.1. This method is used to inspect welds and seams for unbonded areas and/or pinholes. A Vacuum Chamber consists of a rectangular box with an open bottom, a soft rubber type gasket along the perimeter of the open bottom, a clear plastic viewing panel at the top, and a vacuum gauge.

8.2.1.2. Apply a soap solution (or other approved foaming agent) to the area to be tested.

8.2.1.3. Place Vacuum Chamber over the area to be tested.

8.2.1.3.1. This test method is performed in increments of approximately 18” with a 6” overlap of the previous length tested.

8.2.1.4. Apply a vacuum to the Vacuum Chamber.

8.2.1.5. Inspect the testing area through the clear plastic viewing panel for bubbles at unbonded areas or pinholes.

8.2.1.5.1. Bubbles near the edge of the vacuum chamber may be caused by an incomplete seal. If bubbles are detected near the edges of the vacuum chamber, move the vacuum chamber and retest to verify if the bubbles were caused by an actual defect or pinhole.

8.2.1.6. Mark all unbonded areas or pinholes for repair with a white paint marker.

8.2.1.7. Record results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

8.2.2. Air Lance

8.2.2.1. This method is used to test welds and seams for unbonded areas by using an air nozzle directed on the upper edge and surface. Layfield typically uses this test method on Solid Wedge welds, Chemical Bonding and Hot Air Welds.

8.2.2.2. Use a minimum 50 psi (345 kPa) air supply directed through a 3/16” nozzle. Hold the nozzle approximately 2” away from the edge and surface.

8.2.2.3. While performing Air Lance testing, inspect testing areas for loose edges, riffles indicating unbonded areas, and other unacceptable conditions.

8.2.2.4. Mark all unbonded areas for repair.

8.2.2.5. Record results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

8.2.3. Point Stress

8.2.3.1. This method is used to manually inspect and test seam and weld edges with a rounded screwdriver (or similar device).

8.2.3.2. Layfield requires this to be done on all seams and welds in addition to other applicable testing methods.

8.2.3.3. Using the appropriate tool, manually test the edges of seams and welds.

8.2.3.3.1. Ensure that this procedure does not puncture or otherwise damage the sheet material, seams or welds, but enough pressure is applied to perform the test.

8.2.3.4. While performing Point Stress testing, inspect for signs of unbonded areas.

8.2.3.5. Mark all unbonded areas for repair.

8.2.3.6. Record results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

8.2.4. Pressurized Air Channel

8.2.4.1. This method is used to test Dual Track Wedge welded seams. A Dual Track Wedge weld consists of parallel thermo-fusion welds separated by an unwelded air channel.

8.2.4.2. After a Dual Track Wedge weld has been completed and allowed to cool, perform the following:

8.2.4.2.1. Seal the two ends of the continuous air channel.

8.2.4.2.2. Connect the air pressure gauge assembly directly to the air channel.

8.2.4.2.3. Connect an air pump to the air pressure gauge assembly and pressurize the air channel to the appropriate pressure for the geomembrane material.

8.2.4.2.4. Disconnect the air pump from the air pressure gauge assembly.

8.2.4.2.5. Allow the air channel pressure to stabilize.

8.2.4.2.5.1. If required, increase or decrease the pressure to the specified starting value.

8.2.4.2.6. Record the test start time and pressure, and seam location.

8.2.4.2.7. Wait 5 minutes. During this period perform the following:

8.2.4.2.7.1. Visually inspect the air channel along its full length to ensure that pressure is present throughout the entire length of the seam.

8.2.4.2.7.2. Listen for escaping air along the full length of the air channel.

8.2.4.2.8. After the 5 minute testing period, observe and record the test end time and pressure.

8.2.4.2.9. For a seam to pass, it must meet the following criteria:

8.2.4.2.9.1. Compare the recorded test results against the Maximum Pressure Drop testing values table for the material. If the pressure does not drop below the value listed, proceed to the next step.

8.2.4.2.9.2. Open the air channel at the opposite end from the pressure gauge. Pressurized air should escape and the pressure gauge should register an immediate drop in pressure. This indicates that the entire length of the seam has been tested and the seam passes. If not, there is likely a blockage in the air channel.

8.2.4.2.9.2.1. If there is a blockage, the channel should be inflated up to the blockage. Cut the air channel on the gauge side of the blockage and verify pressure loss. Repeat as necessary until the blockage is identified. Retest all sections and repair as required.

8.2.4.2.9.3. If the pressure drops below the allowable pressure value, Layfield personnel must trace and identify the defect by following these steps:

8.2.4.2.9.3.1. Check the seals at the ends of the air channel. Reseal and retest if the seal was defective.

8.2.4.2.9.3.2. Inspect the seam for deficiencies in the weld tracks (spinouts, wrinkles, fish mouths, etc).

8.2.4.2.9.3.3. Remove the overlap and apply a soap solution. Retest the seam in increments to identify the defect location. If the defect is found, effect localized repairs.

8.2.4.2.9.3.4. If the defect in the air channel cannot be identified, reconstruct the seam (or part of the seam) by installing a Dual Track wedge welded cap strip and retest.

8.2.4.3. Record all test results on the Geomembrane Seam & Test Log (Appendix D).

8.2.5. Spark Test

8.2.5.1. This method is used to test an Extrusion weld that includes a conductive material (i.e. copper wire or similar) inserted into or behind the weld.

8.2.5.2. Set the voltage source to the voltage needed for the expected distance.

8.2.5.3. The spark tester shall be held and operated approximately ½" to 1" away from the weld.

8.2.5.4. Sweep the spark tester over the welded materials along the weld length.

8.2.5.5. Spark arcing indicates a suspect area in the weld.

8.2.5.6. Mark all pinholes or unbonded areas for repair.

8.2.5.7. Record all test results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

9. DETAILS, DEFECTS & REPAIRS

9.1. Overview

9.1.1. All seam and non-seam areas of the geomembrane shall be inspected for damages and defects.

9.1.1.1. At a minimum, all seams and welds shall be non-destructively tested. Where a seam is tested destructively, it shall be repaired and recorded as part of this process.

9.1.1.2. All non-seam areas shall be inspected throughout the work and as part of Final Inspection and Acceptance.

9.1.2. All details, defects and repairs shall be physically marked on the geomembrane and recorded on the Geomembrane Detail & Test Log (Appendix E) and their location recorded on the As-Built Drawing.

9.2. Identification

9.2.1. Details are identified in the Scope of Work, Construction Drawings, or another contract document. Examples are a pipe or pile penetrations, rub sheets, etc.

9.2.2. Damages and defects are identified in one of two ways: an inspection, or as part of a destructive or non-destructive test. Examples are punctures in the sheet, defects in a seam, etc.

9.3. Details & Repairs

9.3.1. Typical detail types include: grind & weld, patches, boots, caps, reconstructed seams and skirts.

9.3.2. All details must be constructed using equipment that has been through the Qualification Weld process, and follow the applicable welding procedures.

9.3.3. Any damage or defect found in a seam or on the sheet (pinholes, tears, punctures, etc) shall be marked on the geomembrane.

9.3.4. Each detail shall be assigned a unique Detail Code.

9.3.5. The detail shall be constructed and tested non-destructively using an appropriate method for the detail type, geomembrane material type and project specifications.

9.3.6. The location, detail type, repair date & time, test date, and test type shall be recorded on the Geomembrane Detail & Test Log.

9.3.7. The location and unique Detail Code shall be recorded on the As-Built Drawing.

10. FIELD DESTRUCTIVE TESTING

10.1. Overview

10.1.1. Destructive seam tests are performed to evaluate and confirm that production welds are conforming to the material and/or project specifications.

10.1.2. The sampling frequency of destructive testing shall be one (1) sample per 150 lineal meters of field welded seam, as guided by GRI Standard GM14 and GRI Standard GM29.

10.1.2.1. Project specifications and field considerations may modify this frequency.

10.2. Procedure

10.2.1. The Project Supervisor or QA/QC Designate shall identify the area from which the sample will be collected.

10.2.1.1. Alternatively, project specifications may dictate that the Owner's Representative shall be responsible for identifying the area from which the sample will be collected.

10.2.2. Each destructive test sample will be assigned a unique Destruct Sample Number.

10.2.3. The sample size should be approximately 300mm (12”) x 900mm (36”). This may vary based on project specification and sample distribution; however the typical distribution is as follows:

10.2.3.1. 300mm x 300mm sample for Layfield QA/QC Designate to be field tested.

10.2.3.2. 300mm x 300mm sample sent to Office for archiving or future testing if required.

10.2.3.3. 300mm x 300 mm sent to the third party for independent testing, if required.

10.2.4. All samples shall be labeled with the unique Destruct Sample Number, seam location, machine number, Layfield project number, date welded, Technician, and geomembrane roll numbers.

10.2.5. The sample shall be tested using the same procedure as Qualification Welds for that welding apparatus.

10.2.5.1. Each geomembrane material has its own pass criteria. References are given in Section 6.2.11.2

10.2.5.2. The mechanical values of four out of five specimens must meet or exceed the specified values, and the fifth specimen must meet or exceed 80% of the value. In addition, the average value of each set of five specimens must meet GRI GM 19 specifications.

10.2.6. All destructive test data will be recorded on the Geomembrane Destruct Log (Appendix F).

10.2.7. If a destructive test sample fails, it is necessary to destructively sample and test the seam until a pass is found on both sides of the defect.

10.2.7.1. Cut additional samples 3 meters on each side of the defect and retest. These will be labeled A (after) & B (before). This procedure continues until a passing sample in each direction is achieved. The total length of the defective seam between the two passing tests must be capped, or cut out and re-seamed.

10.2.7.2. After reconstructing the defective seam, the entire seam length must be non-destructively tested using the appropriate method for the repair type.

10.2.8. Destructive test samples should be repaired, but this may not be necessary depending on sample location (for example anchor trench or end of tie-in).

11. AS-BUILT DRAWING REQUIREMENTS

11.1. As-built Drawings can be done on Layfield drafting paper, or overlay an Owner supplied construction/survey drawing. Drawings may be done in ink or pencil, but writing must be neat.

11.2. The scale must be indicated and consistent throughout the drawing. Not to Scale (NTS) is acceptable if imperative dimensions are provided on the drawing. Each As-built drawing must also include a Legend and North Arrow.

11.3. Deployed geomembrane panels must be accurately located on the As-Built Drawing. The panels must be identified by the unique Panel Number that is physically written on the panel, and it must match the Geomembrane Deployment Log.

11.4. Details must be accurately located on the As-Built Drawing. The details must be identified by the unique Detail Codes that are recorded in the Geomembrane Detail & Test Log.

12. FINAL INSPECTION AND ACCEPTANCE

12.1. Overview

12.1.1. All projects must have all Certificate(s) of Final Inspection and Acceptance signed by, or on behalf of, both parties prior to the installation of any covering material.

12.1.2. It is important to note that there are cases where a total work area cannot or will not be completed and turned over to the Owner's Representative. The Certificate of Final Inspection and Acceptance does make provision for partial areas being completed and turned over to the Owner's Representative. The Layfield Site Supervisor shall ensure that the extents of the inspected area are clearly expressed on the Certificate of Final Inspection and Acceptance. A separate certificate shall be generated for each partial area.

12.1.3. The Certificate of Final Inspection and Acceptance is generated in duplicate with a white (original) and yellow (copy). The white copy is kept with Layfield's QA/QC documentation and is turned over to the Layfield Project Manager at the Project Closeout Meeting. The yellow copy is turned over to the countersigning party (Contractor's QA, Owner's Representative, etc) immediately upon signature for their records.

12.2. Procedure

12.2.1. The Project Supervisor or QA/QC Designate will arrange a final site inspection with Owner's Representative when the contracted Scope of Work has been completed.

12.2.2. The Project Supervisor or QA/QC Designate and Owner's Representative will inspect, measure, and validate all deliverables and components of the Scope of Work together.

12.2.2.1. If any deficiencies are found, they shall be remedied as soon as practical using the applicable procedures detailed above.

12.2.2.2. When the deficient item(s) have been remedied, the Project Supervisor or QA/QC Designate and Owner's Representative can re-inspect. Repeat this step as necessary.

12.2.3. When all deliverables and components have been inspected, measured and validated by the Owner's Representative, the Project Supervisor or QA/QC Designate will complete and sign the Certificate of Final Inspection and Acceptance and submit to the Owner's Representative for countersignature.

12.2.3.1. A Certificate of Final Inspection and Acceptance must be signed prior to Layfield demobilization.

Appendix A – Certificate of Subgrade Surface Inspection

CERTIFICATE OF SUBGRADE SURFACE INSPECTION
PROJECT NAME: _____
PROJECT NUMBER: _____
OWNER/CONTRACTOR: _____
LOCATION: _____

I, the undersigned, a duly appointed representative of Layfield Canada Ltd. (Layfield), have visually observed the subgrade surface described below, and:

- ☐ *found it to be an Acceptable surface on which to install geomembrane; OR*
- ☐ *found it to be an Unacceptable surface on which to install geomembrane*

Area Inspected (☐ Partial ☐ Complete): _____
Dimensions of Subgrade Inspection: _____
Anchor Trench Dimensions: _____
Comments: _____
_____

This certification is based on observations of the surface of the subgrade only. No subterranean inspections or tests have been performed by Layfield and Layfield makes no representations or warranties regarding conditions which may exist below the surface of the subgrade. Layfield accepts no responsibility for conformance of the subgrade to this project's specifications.

The subgrade inspected on this date refers to its present condition. Any changes in the subgrade condition that result from the effects of inclement weather and/or other forces beyond the control of Layfield and remedial work to correct the resulting deficiencies, will be the direct responsibility of the General Contractor.

LAYFIELD REPRESENTATIVE:
Date: _____
Signature: _____
Name: _____
Title: _____

OWNERS REPRESENTATIVE:
I, the undersigned, a duly appointed representative of the Owner, hereby understand the subgrade surface inspection described above and authorize Layfield to proceed with deployment of Geosynthetics on the subgrade provided.
Date: _____
Signature: _____
Name: _____
Title: _____
Company: _____

Appendix B – Inventory Log

PROJECT NUMBER _____

PROJECT TITLE _____

DATE OF INVENTORY _____

PRODUCT TYPE _____

MATERIAL MANUFACTURER _____

#	ROLL NUMBER	MATERIAL DIMENSIONS			REMARKS
		THICKNESS	LENGTH (m)	WIDTH (m)	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

QC Tech _____ **Sheet Number** _____

Submission Date _____

Supervisor Date _____ **Total Page Area** _____ **m**

GEOMEMBRANE DEPLOYMENT LOG

PROJECT NUMBER _____ AREA / LAYER _____

PROJECT TITLE _____ DEPLOYMENT DATE _____

PANEL NUMBER	ROLL NUMBER	LENGTH (m)	WIDTH (m)	AIR TEMP °C	PANEL CONDITION	CHECKED BY	SUBGRADE CONDITION

TOTAL PAGE AREA _____ m^2

QC TECH _____

SUPERVISOR _____

SUBMISSION DATE _____

SHEET NUMBER _____

GEOMEMBRANE SEAM & TEST LOG

PROJECT NUMBER _____ AREA / LAYER _____

PROJECT TITLE _____ SEAM DATE _____

TRIAL SEAMS

#	MACHINE NUMBER	TIME	WELD TECH	AIR TEMP °C	SPEED	WEDGE TEMP °F	INSIDE PEEL (PPI)					OUTSIDE PEEL (PPI)					SHEAR (PPI)					CHK'D BY	LINER TO LINER TYPE AND REMARKS

WELD SEAMS

PANEL NUMBERS	SEAM SECTION FROM	SEAM SECTION TO	START TIME	AIR TEMP	WELD TECH	MACHINE NUMBER	WELD LENGTH	DESTRUCT NUMBER
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
/								
PAGE TOTAL								

QC

TEST METH.	TEST DATE Y-M-D

AIR PRESSURE TEST (PSI)

TIME START	TIME END	PRESSURE START	PRESSURE END

VERIFY

PASS	QC TECH

TEST METHOD

AL - AIR LANCE	ST - SPARK TEST
AP - AIR PRESSURE	VB - EXTRUDED & VAC BOX
PS - POINT STRESS	

REMARKS:

QC TECH _____

SUPERVISOR _____

SUBMISSION DATE _____

SHEET NUMBER _____

LS-10-QF-004

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GEOMEMBRANE DETAIL & TEST LOG

PROJECT NUMBER _____ AREA / LAYER _____

PROJECT TITLE _____

TRIAL SEAMS

#	MACHINE NUMBER	DATE YYYY-MM-DD	TIME	WELD TECH	AIR TEMP °C	PREHEAT TEMP °F	EXTRUSION TEMP °F	PEEL (PPI)					SHEAR (PPI)					CHK'D BY	REMARKS
1																			
2																			
3																			
4																			
5																			
6																			

DETAIL CODE	PANEL NUMBER(S)	LOCATION DESCRIPTION	DETAIL TYPE	REPAIR TYPE	MACHINE NUMBER	REPAIR DATE YYYY-MM-DD	START TIME	WELD TECH	AIR TEMP °C	TEST DATE YYYY-MM-DD	TEST METH.	QC TECH
A	/											
B	/											
C	/											
D	/											
E	/											
F	/											
G	/											
H	/											
I	/											
J	/											
K	/											
L	/											
M	/											
N	/											
O	/											
P	/											
Q	/											
R	/											
S	/											
T	/											

DETAIL TYPE:

AD - ANIMAL DAMAGE	DS-# - DESTRUCT SAMPLE NUMBER	IO - INSUFFICIENT OVERLAP	T - THREE PANEL INTERSECTION
ATL - AIR TEST LEAK	EE - EARTHWORK EQUIPMENT DAMAGE	MD - MANUFACTURER/DELIVERY DAMAGE	VL - VACUUM TEST LEAK
BO - FUSION WELDER BURN	EXT - EXTENSION	P - PENETRATION	WR - WRINKLE
CR - CREASE	FM - FISHMOUTH	PT - PRESSURE TEST CUT	WS - WELDER RESTART
D - INSTALLATION DAMAGE	FS - FAILED SEAM LENGTH	SI - SOIL SURFACE IRREGULARITY	OTHER:

TEST METHOD:

AL - AIR LANCE	VB - VAC BOX
PS - POINT STRESS	ST - SPARK TEST

REPAIR TYPE:

B - BOOT	G&W - GRIND & WELD
C - CAP	RS - RECONSTRUCTED SEAM
P - PATCH	S - SKIRT

REMARKS

QC TECH _____

SUPERVISOR _____

SUBMISSION DATE _____

SHEET NUMBER _____

GEOMEMBRANE DESTRUCT LOG

PROJECT NUMBER _____ AREA / LAYER _____

PROJECT TITLE _____ 3RD PARTY _____

ARCHIVE LAYFIELD ☐ OWNER ☐ ENGINEER ☐

DESTRUCT SAMPLE NUMBER	TYPE OF SEAM	PANEL NUMBERS	TEST DATE YYYY-MM-DD	TEST TEMP °C	INITIALS				INSIDE PEEL STRENGTH (PPI)					OUTSIDE PEEL STRENGTH (PPI)					SHEAR STRENGTH (PPI)				
SAMPLE LOCATION					3RD PARTY PRESENT	LAYFIELD PASS	3RD PARTY PASS		LOCUS OF BREAK					LOCUS OF BREAK					LOCUS OF BREAK				
DS-																							
DS-																							
DS-																							
DS-																							
DS-																							
DS-																							
DS-																							
DS-																							

TYPE OF SEAM: SPF - SPLIT FUSION SOF - SOLID FUSION SLV - SOLVENT
EXT - EXTRUSION HAF - HOT AIR FUSION

QC TECH _____
SUBMITTED BY _____
SUBMISSION DATE _____
SHEET NUMBER _____

Appendix G – Certificate of Final Inspection and Acceptance

PROJECT NAME: _____
PROJECT NUMBER: _____ **DATE:** _____
OWNER: _____
LOCATION: _____

Scope of Installation(s): **THE WORK**
Area/Layer: _____ Area Inspected: ☐ Partial or ☐ Complete
Dimensions: _____
_____
_____
_____

Part 1 – LAYFIELD CANADA LTD.

I, _____, a duly appointed representative of Layfield Canada Ltd. (Layfield), have visually observed the installations (as outlined above), and have found the Work to be complete and free of defects and declare that the Work was completed in accordance with the project specifications, Layfield's QC program and the terms and conditions of the contract.

Layfield Representative:

Name: _____
Title: _____
Date: _____ **Signature:** _____

Part 2 – OWNER (or Representative)

I, _____, a duly appointed representative of _____
_____, do hereby accept and receive the installation(s) described above, and confirm that the work has been completed in accordance with the project specifications and the terms and conditions of the contract.

I have evaluated and measured the work together with the Layfield representative, and agree that the measurements shown are both true and correct, and that the installation has met our approval.

Owners Representative:

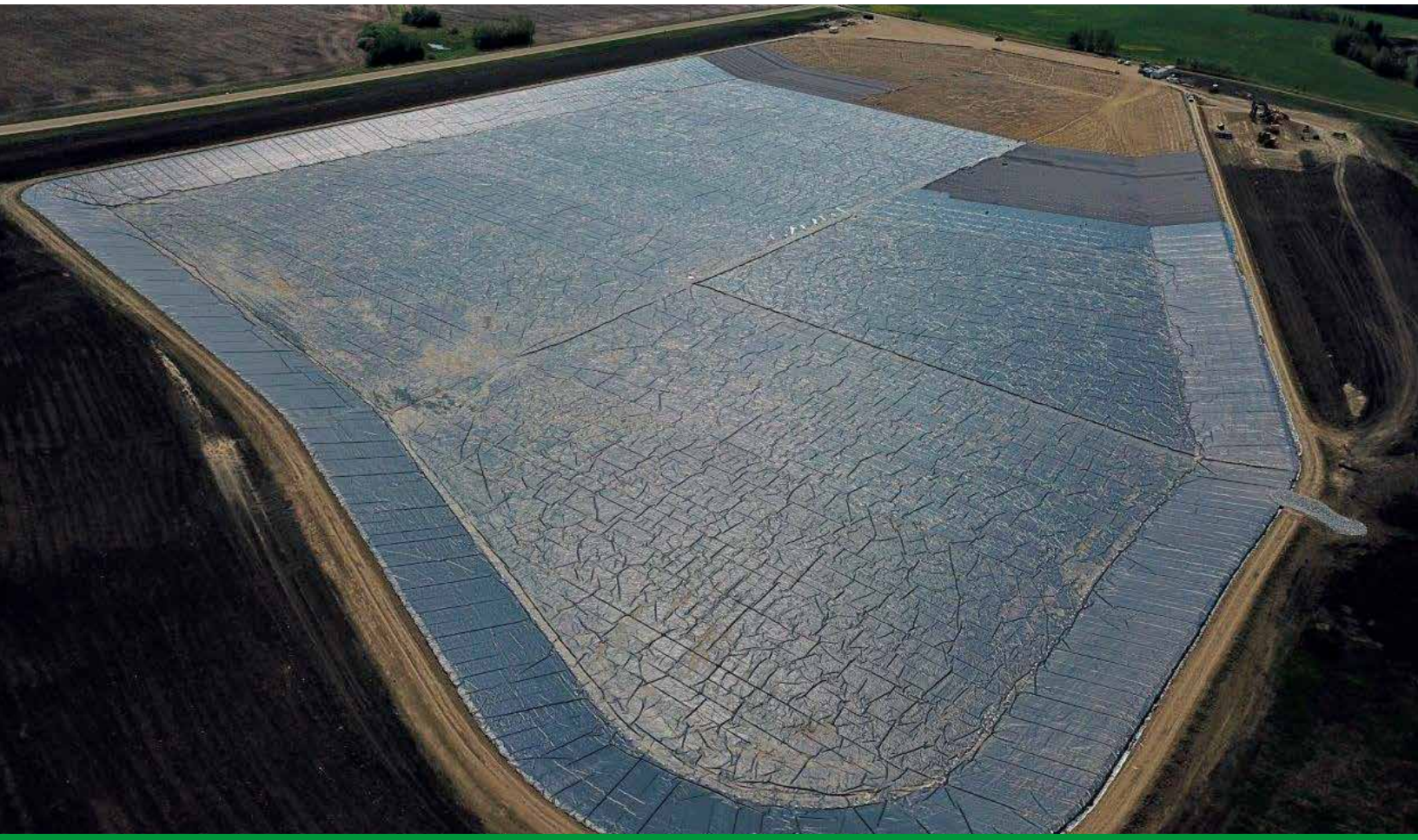
Name: _____
Title: _____
Company: _____
Date: _____ **Signature:** _____

Comments: _____
_____
_____

Notes:

Notes:

LAYFIELD
GEOSYNTHETICS



About Layfield: The Layfield Group is the only integrated organization that provides tailored polymer-based solutions that are proven to protect our families, communities, and environment.

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