New Discovery Mines Ltd.
1909 108 West Cordova St.
Vancouver, B.C.
V6B 0G5

Structure Description and Construction Plan

For MV2020L2-0002

May, 2021

Executive Summary

The Structure Description and Construction Plan lacks a trigger, so all holes dug to contain control or divert water requires such a plan. This plan describes the digging of a hole, <12 m^3 in volume, the material it will be excavated into and its lining with an HDPE liner. Monitoring the several hours required to excavate and line this hole is covered, as well as performance and operation of the excavation. Once it becomes a sump (SNP-08) its operations of any waters into, held, or discharged are covered under other management plans, and links are provided.

Contents

1.0 Introduction

This Structure Description and Construction plan describes how to dig a hole, and line it with an impermeable membrane. All of the details into choosing where to dig this hole, where it is located. We explain what's beneath the hole, how we determine the hole is acceptable for its design purposes, and how we will operate and maintain the hole. A brief explanation why it is not needed to have an engineer design the hole. The schedule for digging the hole and a list of materials needed for this hole is presented including the sources, quantities, physical and geochemical characteristics of these materials.

The potential effects on the receiving environment are described as well as mitigation measures to mitigate these impacts. We describe how we monitor the construction of this hole, explaining where and how frequently inspections will take place, explaining the rationale in determining this monitoring program as well as linkages to other monitoring programs. A description of how the monitoring will be evaluated and what actions might occur as a result of this.

2.0 Facility Description

Location

The only excavated sump on the property will be at SNP-08 as shown on the attached Site Plan Map.

Background of area

A hole will be excavated into unconsolidated Quaternary sediments that are overlying Archean rocks of the Yellowknife Supergroup. The Quaternary sediments are composed of peat overlying minor boulders, gravels and sand on top of clays. This was exposed during construction of the historic tailings storage facility.

Specification

The hole has broad parameter specifications, but must be capable of containing 3 m^3 of water. The optimal design would be a linear trough approximately 4m x 2m x 2m which can contain between 4 m^3 to 5 m^3 of water with no freeboard. It will loose 1 m^3 of capacity to keep 0.5 m of freeboard. It will be lined with 1.5 mm HDPE

Operations

The sump will receive waters from an underground sump (SNP-07) and be used to hold that water for sampling prior to discharge into the receiving environment, or recycled for use underground. The liner will be examined for leaks by measuring its content and comparing it to previous measurements.

Engineering

We believe that a hole need not be designed by an engineer due to its broad parameters and simple minimal operations. Failure may result in waters being discharged into the receiving environment. The input into the sump comes from a different sump (SNP-07) whose discharge can be restricted in case issues arise. The hole's small size and minimal capacity provides comfort that environmental risks are minimized.

Construction Schedule

Construction will commence once approved, and will take 1 or two hours.

1. Organic layer removed and stockpiled adjacent to hole.
2. Inorganics removed and stockpiled adjacent to hole, and used to provide a berm
3. Liner is installed.

Materials required

An HDPE liner will be obtained locally in Yellowknife, together with sealing tape in the event there are tears in the liner.

The liner needs to be 6.86 m x 5 m before trimming. Full specifications of the liner are included in the Appendices.

Potential Effects on the Receiving Environment

The hole has a direct foot print of <12 m^2 and with spoil piles less than 20 m^2.

- The sides of the hole may slump when empty, as such it is recommended that fresh water be pumped into the sump to stabilize its construction.
- People or animals may fall into the sump, as such it is recommended that the hole be fenced.

Monitoring of the Construction

The Mine Manager or his designate will monitor the excavation and placement of the liner, plus any stabilization or fencing.

Records confirming:

- Where the hole was dug (GPS center point).
- Dimensions on completion of:
    - The disturbed area
    - The excavation
    - The fenced area
- Number of inspections (frequencies)
- Any observations, recommendations and conclusions

Linkages to other Monitoring Programs

This Structure and Design Plan is required under Schedule 3 of MV2020L2-0002 and affects the following plans:

A. Groundwater and Water Monitoring Plan
B. Waste Rock Monitoring and Geochemical Characterization Plan
C. Waste Management Plan
D. Spill Contingency Plan
E. Explosives Management Plan
F. Hydrocarbon-Stained Soil Operations and Management Plan

Evaluation of Monitoring

The Construction of the hole described in this Structure Description and Construction Plan, once approved will require several hours to complete. Monitoring of the hole under this plan requires confirmation the mitigation measures are effective, confirming the fence is in good repair and that the hole has not slumped.

This will be reviewed monthly in reports from the Mine Manager to head office.

Appendixes

Site Map

Structure design

Specifications of HDPE Liner.

0 100
meters

Borehole
SNP-05

SNP-04
SNP-02
Natural Sump

SNP-06a
Borehole

Natural Sumps
SNP-03b
SNP-03a
SNP-06b
Bore hole

SNP-01
Pipeline discharge

Mining Lease

Probable
Sump Loc.

Historic sump
SNP 1598-5

Natural sump
SNP-09

SNP-12

Excavated sump
SNP-08

Naturald sump
SNP-10

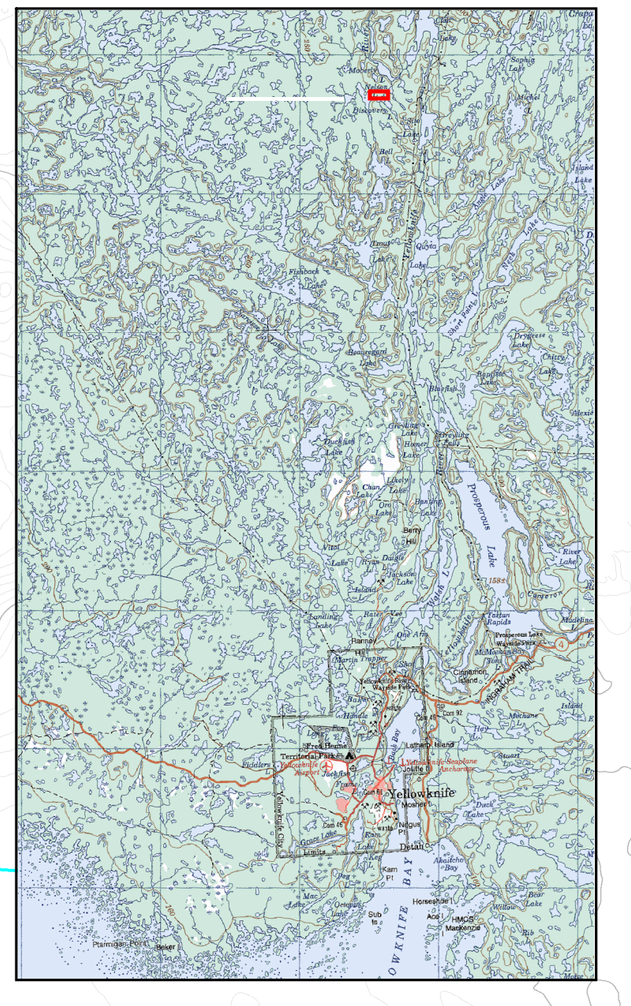
SNP-11

Camera 1

Camera 1

Camera 2

Discovery Lake



Legend

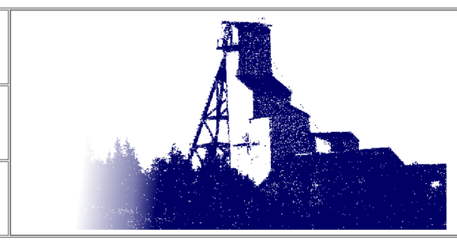
- 1 m Contours
- 10 m Contours
- Roads
- WaterCourse
- WaterBody
- Tailings Storage
- Hydrocarbon-Contaminated Soils
- Mineral Claims
- Fuel_Storage
- Shops
- 75k Storage Tank
- Bioreactor
- Camp Trailers
- SNP_Stations
- Historic Tailings
- Ore_Storage
- Gravel Quarry
- Esker
- Mine Shaft
- ANFO
- Waste Rock Storage
- Water Flow Direction
- SpillKit
- Concentrate Storage
- Shops
- Mill_Site
- Portal North Adit
- Underground, Ramp
- Water_Lines
- Sewage Lines
- Water_Tank

Site Plan
As Placed May 24, 2021

Date: April 2021

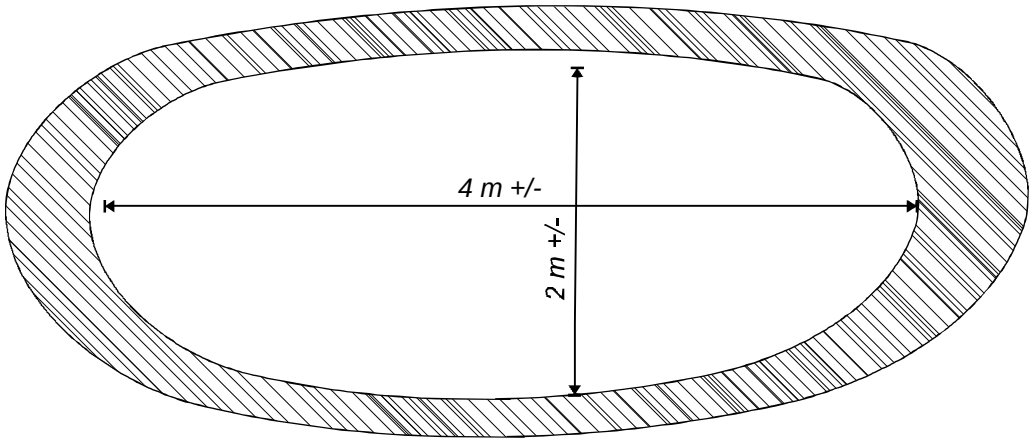
Author: DRW

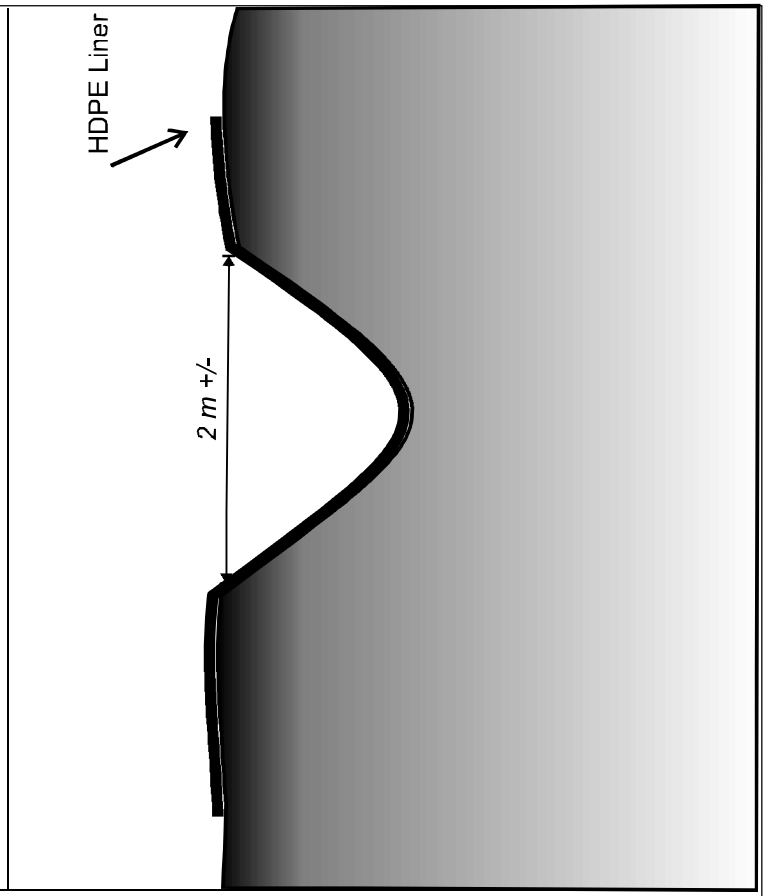
Office: Vancouver, B.C.

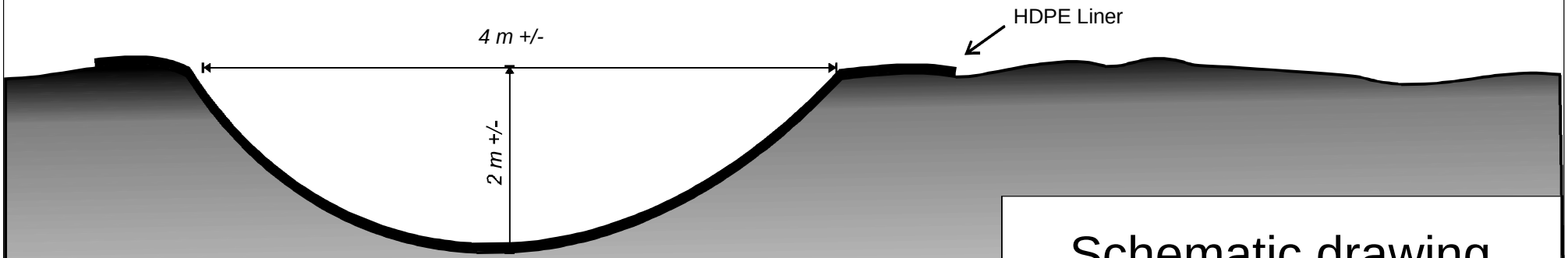


Scale: as shown

Projection: UTM Nad 83, Zone 11







Schematic drawing for excavated sump Mon Property

April 23, 2021

DRW

Guidelines for Installation of:

HDPE and LLDPE Geomembrane Installation Specification

International Association of Geosynthetic Installers

www.iagi.org

Revised November 1, 2015

Guidelines for Installation of:

HDPE and LLDPE Geomembrane Installation Specification

International Association of Geosynthetic Installers

8457 N. Rampart Range Road, Unit 106, PMB #154

Roxborough, CO 80125 USA

Telephone: +1 (720) 353-4977 / Fax: +1 (612) 235-6484

Email:iagi@iagi.org

www.iagi.org

Date: November 1, 2015

TABLE OF CONTENTS

Part 1 — GENERAL

1.01 Guideline Scope

A.

This specification includes furnishing and installing HDPE and LLDPE geomembranes with a formulated sheet density of 0.940 g/cc or greater associated with HDPE geomembranes and a formulated sheet density of 0.939 or less for LLDPE geomembranes. Geomembranes with both smooth and textured surfaces are included.

1.02 References

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

1. D 638, Standard Test Method for Tensile Properties of Plastics.
2. D 4439 Terminology for Geosynthetics.
3. D 751, Standard Test Methods for Coated Fabrics.
4. D 792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
5. D 1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
6. D 1204, Standard Test Method for Linear Dimensional Changes of Non Rigid Thermoplastic Sheeting or Film at Elevated Temperature.
7. D 1238, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
8. D 1505, Standard Test Method for Density of Plastics by Density-Gradient Technique.
9. D 1603, Standard Test Method for Carbon Black in Olefin Plastics.
10. D 3895, Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.

11. D 4218, Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
12. D4437 – 08, Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
13. D 4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
14. D 5199, Standard Test Method for Measuring Nominal Thickness of Smooth Geomembranes.
15. D 5397, Standard Test Method for Evaluation of Stress Crack. Resistance of Polyolefins using Notched Constant Tensile Load Test.
16. D 5596, Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.
17. D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
18. D 5721, Practice for Air-Oven Aging of Polyolefin Geomembranes.
19. D 5820, Test Method for Air Testing.
20. D 5885, Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
21. D 5994, Standard Test Method for Measuring Nominal Thickness of Textured Geomembranes.
22. D 6365, Standard Practice for the Nondestructive Testing of Geomembrane Seams using The Spark Test.
23. D5820-95, Pressurized Air Channel Test for Dual Seamed Geomembranes.
24. D 6392-08, Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
25. D7002, Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method.
26. D7007-15, Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials.

27. ASTM D7466, Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage

B. Geosynthetic Research Institute (GRI)

1. GRI GM 9, Cold Weather Seaming of Geomembranes
2. GRI GM 10, The Stress Crack Resistance of HDPE Geomembrane Sheet
3. GRI GM 13, Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
4. GRI GM 14, Test Frequencies for Destructive Seam Testing Selecting, variable intervals for taking geomembrane destructive samples using the method of attributes.
5. GRI GM 17, Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
6. GRI GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.
7. GRI GM 20, Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts.

1.03 Submittals

A. Submit under provisions of Section 1.03B an 1.03D

B. Submit the following to the Engineer or Owner, for review and approval, within a reasonable time so as to expedite shipment or installation of the Geomembrane:

1. Documentation of manufacturer's qualifications as specified in subsection 1.04A of this Section.
2. Manufacturer's Quality Control program manual or descriptive documentation.

3. A material properties sheet, including at a minimum all properties specified in GRI GM 13 or GRI GM 17, including test methods used.
4. Sample of the material.
5. Documentation of Installer's qualifications, as specified below and in subsection 1.04B of this Section.
   a. Submit a list of at least 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 the installed geomembrane.
   b. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and IAGI Certified Welding Technicians (CWTs) to be assigned to this project.
   c. Quality Control Program.
6. Example Material Warranty and Liner Installation Warranty.

C. Shop Drawings

1. Submit copies of shop drawings for engineer's approval within a reasonable time so as not to delay the start of geomembrane installation. Shop drawings shall show the proposed panel layout identifying seams and details. Seams should generally follow the direction of the slope. Butt seams or roll-end seams should not occur on a slope unless approved by the Owner's Representative. Butt seams on a slope, if allowed, should be staggered.
2. Placement of geomembrane should not be allowed to proceed until Owner's Representative has received and approved the shop drawings.

D. Additional Submittals (In-Progress and at Completion)

1. Manufacturer's warranty (refer to subsection 1.07).
2. Geomembrane installation warranty (refer to subsection 1.08).

3. Daily written acceptance of subgrade surface (refer to subsection 3.01.C).
4. Low-temperature seaming procedures if applicable (refer to subsection 3.03.A).
5. Prequalification test seam samples (refer to subsection 3.05.A.6).
6. Field seam non-destructive test results (refer to subsection 3.05.B.1).
7. Field seam destructive test results (refer to subsection 3.05.C.6).
8. Daily field installation reports (refer to subsection 3.05.G).
9. Installation record drawing, as discussed in subsection 3.05.

1.04 Quality Control

A. Manufacturer's Qualifications: The manufacturer of geomembrane of the type specified or similar product shall have at least five years experience in the manufacture of such geomembrane. In addition, the geomembrane manufacturer shall have manufactured at least 1,000,000 M^2 (10,000,000 FT^2) of the specified type of geomembrane or similar product during the last five years.

B. Installer's Qualifications

1. The Geomembrane Installer shall be the Manufacturer, approved Manufacturer's Installer or a contractor approved by the Owner's Representative to install the geomembrane.
2. The Geomembrane Installer shall have at least three years experience in the installation of the specified geomembrane or similar. The Geomembrane Installer shall have installed at least 10 projects involving a total of 500,000 M^2 (5,000,000 FT^2) of the specified type of geomembrane or similar during the last three years.

3. Installation shall be performed under the direction of a field Installation Supervisor who shall be responsible throughout the geomembrane installation, for geomembrane panel layout, seaming, patching, testing, repairs, and all other activities of the Geomembrane Installer. The Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 10 projects involving a total of 500,000 M^2 (5,000,000 FT^2) of geomembrane of the type specified or similar product.

4. 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 300,000 M^2 (3,000,000 FT^2) of geomembrane of the type specified or similar product, using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor and/or Master Seamer shall be present whenever seaming is performed.

5. All seaming, patching, other welding operations, and testing shall be performed by qualified technicians employed by the Geomembrane Installer.

1.05 Delivery, Storage and Handling

A. Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the manufacturer's name, product identification, material thickness, roll number, roll dimensions and roll weight.

B. Geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

C. Rolls shall be stored away from high traffic areas. Continuously and uniformly support rolls on a smooth, level prepared surface.

1.06 Project Conditions

A. Geomembrane should not be installed in the presence of standing water, while precipitation is occurring, during excessive winds, or when material temperatures are outside the limits specified in Section 3.03.

1.07 Material Warranty

A. As agreed by project participants.

1.08 Geomembrane Installation Warranty

A. The Geomembrane Installer shall guarantee the geomembrane installation against defects in the installation and workmanship for 1 year commencing with the date of final acceptance.

1.09 Geomembrane Pre-Construction Meeting

A. A geomembrane pre-construction meeting shall be held at the site prior to installation of the geomembrane. At a minimum, the meeting shall be attended by the Geomembrane Installer, Owner, Owner's representative (Engineer and/or CQA Firm), and the Earthwork Contractor.

B. Topics for this meeting shall include:

1. Health and Safety
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 time schedule for all installation and testing.
6. Review of panel layout and numbering systems for panels and seams including details for marking on geomembrane.
7. Procedures and responsibilities for preparation and submission of as-built panel and seam drawings.
8. Temperature and weather limitations. Installation procedures for adverse weather conditions. Defining acceptable subgrade, geomembrane, or ambient moisture and temperature conditions for working during liner installation.
9. Subgrade conditions, dewatering responsibilities and subgrade maintenance plan.
10. Deployment techniques including allowable subgrade for the geomembrane.
11. Plan for controlling expansion/contraction and wrinkling of the geomembrane.
12. Covering of the geomembrane and cover soil placement.
13. Measurement and payment schedules.
14. Responsibilities of each party.

C. The meeting shall be documented by a person designated at the beginning of the meeting and minutes shall be transmitted to all parties.

PART 2 - PRODUCTS

2.01 Source Quality Control

A. Manufacturing Quality Control

1. The test methods and frequencies used by the manufacturer for quality control/quality assurance of the above geomembrane prior to delivery, shall be in accordance with GRI GM 13 for HDPE geomembrane or GRI GM 17 for LLDPE geomembrane, or modified as required for project specific conditions.

2. The manufacturer's geomembrane quality control certifications, including results of quality control testing of the products, as specified in subsection 2.01.A.3 of this Section, must be supplied to the Owner's Representative to verify that the materials supplied for the project are in compliance with all product and or project specifications in this Section. The certification shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

3. The Manufacturer will provide Certification that the geomembrane and welding rod supplied for the project are made from the same material type and are compatible.

2.02 Geomembrane

A. The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane rolls shall be seamless, high density polyethylene (HDPE - Formulated Sheet Density ≥ 0.940g/cc) or linear low density pol-

yethylene (LLDPE - Formulated Sheet Density ≤ 0.939 g/cc) containing no plasticizers, fillers or extenders and shall be free of holes, blisters or contaminants, and leak free verified by 100% in line spark or equivalent testing. The geomembrane shall be supplied as a continuous sheet with no factory seams in rolls. The geomembrane will meet the property requirements as shown in Table 1a or 2a (GRI GM 13) or Table 1a or 2a (GRI GM 17).

B. Material conformance testing by the Owner's Representative, if required, will be conducted using in-plant sampling or as specified for the project.

C. The geomembrane seams shall meet the property requirements as shown in Table 2, (Attachment B) or as required by project specifications.

Interesting Historical Fact:

Before Australia adopted the metric system, they used the term "thou" to mean thousandth of an inch instead of using the term "mil." So 30 mil geomembranes would be referred to as "30 thou." For clarification, the use of the term mil in this guideline means "thousandth of an inch."

PART 3 - EXECUTION

3.01 Subgrade Preparation

A. The subgrade shall be prepared in accordance with the project specifications. The geomembrane subgrade shall be uniform and free of sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.

B. The Geomembrane Installer and Owner’s Representative shall inspect the surface to be covered with the geomembrane on each day's operations prior to placement of geomembrane to verify suitability.

C. The Geomembrane Installer and Owner’s Representative shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner, during geomembrane installation, to ensure subgrade suitability.

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 and the Geomembrane Installer. This damage, repair, and the responsibilities of the contractor and Geomembrane Installer shall be defined in the preconstruction meeting.

3.02 Geomembrane Placement

A. No geomembrane shall be deployed until the applicable certifications and quality control certificates listed in subsection 1.03 of this Section are submitted to and approved by the Owner's Representative within the timeframe specified in the contract documents. If the material does not meet project specifications it shall be removed from the work area.

B. The geomembrane shall be installed to the limits shown on the project drawings and essentially as shown on approved panel layout drawings.

C. No geomembrane material shall be unrolled and deployed if the material temperatures are lower than 0 degrees C (32 degrees F) unless otherwise approved by the Owner's Representative. The specified minimum temperature for material deployment may be adjusted by the Owner's Representative. Temperature limitations should be defined in the preconstruction meeting. Typically, only the quantity of geomembrane that will be anchored and seamed together in one day should be deployed.

D. No vehicular traffic shall travel on the geomembrane other than an approved low ground pressure vehicle or equivalent.

E. Sandbags or equivalent ballast shall be used as necessary to temporarily hold the geomembrane material in position under the foreseeable and reasonably expected wind conditions. Sand bag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geomembrane.

F. Geomembrane placement shall not be done if moisture prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations should be defined in the preconstruction meeting.

G. Damaged panels or portions of the 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 "bridge over" voids or low areas in the subgrade. The geomembrane shall rest in intimate contact with the subgrade.

I. Wrinkles caused by panel placement or thermal expansion should be minimized in accordance with section 1.09 B11.

J. Considerations on site geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric loca-

tions, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations and if approved by the Owner's Representative.

K. Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to affect a good weld and allow for proper testing. In no case shall this overlap be less than 75 mm (3 in.).

3.03 Seaming Procedures

A. Cold weather installations should follow guidelines as outlined in GRI GM9.

B. No geomembrane material shall be seamed when liner temperatures are less than 0 degrees C (32 degrees F) unless the following conditions are complied with:

1. Seaming of the geomembrane at material temperatures below 0 degrees C (32 degrees F) is allowed if the Geomembrane Installer can demonstrate to the Owner's Representative, using pre-qualification test seams, that field seams comply with the project specifications, the safety of the crew is ensured, and geomembrane material can be fabricated (i.e. pipeboots, penetrations, repairs. etc.) at sub-freezing temperatures.

2. The Geomembrane Installer shall submit to the Owner's Representative for approval, detailed procedures for seaming at low temperatures, possibly including the following:
   a. Preheating of the geomembrane.
   b. The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.
   c. Number of test welds to determine appropriate seaming parameters.

C. No geomembrane material shall be seamed when the sheet temperature is above 75 degrees C (170 degrees F) as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Owner's Representative. This approval will be based on recommendations by the manufacturer and on a field demonstration by the Geomembrane Installer using prequalification test seams to demonstrate that seams comply with the specification.

D. Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams.

E. Fishmouths or excessive wrinkles at the seam overlaps shall be minimized and when necessary cut along the ridge of the wrinkles back into the panel so as to effect a flat overlap. The cut shall be terminated with a keyhole cut (nominal 10 mm (1/2 in) diameter hole) so as to minimize crack/tear propagation. The overlay shall subsequently be seamed. The key hole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm (6 in.) beyond the cut in all directions.

3.04 Pipe and Structure Penetration Sealing System

A. Provide penetration sealing system as shown in the Project Drawings.

B. Penetrations shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Project Drawings. The pre-fabricated or field fabricated assembly shall be field welded to the geomembrane as shown on the Project Drawings so as to prevent leakage. This assembly shall be tested as outlined in section 3.05.B. Alternatively, where field non-destructive testing cannot be performed, attachments will be field spark tested by standard holiday leak detectors in accordance with ASTM

6365.

C. Spark testing should be done in areas where both air pressure testing and vacuum testing are not possible.

1. Equipment for spark testing shall be comprised of but not limited to a hand held holiday spark tester and conductive wand that generates a high voltage.

2. The testing activities shall be performed by the Geomembrane Installer by placing an electrically conductive tape or wire beneath the seam prior to welding. A trial seam containing a non-welded segment shall be subject to a calibration test to ensure that such a defect (non-welded segment) will be identified under the planned machine settings and procedures. Upon completion of the weld, enable the spark tester and hold approximately 25mm (1 in) above the weld moving slowly over the entire length of the weld in accordance with ASTM 6365. If there is no spark the weld is considered to be leak free.

3. A spark indicates a hole in the seam. The faulty area shall be located, repaired and retested by the Geomembrane Installer.

4. Care should be taken if flammable gases are present in the area to be tested.

3.05 Field Quality Control

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

A. Prequalification Test Seams

1. Test seams shall prepare and tested by the Geomembrane Installer to verify that seaming parameters (speed, temperature and pressure of welding equipment) are adequate.

2. Test seams shall be made by each welding technician and tested in accordance with ASTM D 4437 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.3 meters (10 feet) long for fusion welding and 1 meter (3 feet) long for extrusion welding with the seam centered lengthwise. At a minimum, tests seams should be made by each technician 1 time every 4–6 hours; additional tests may be required with changes in environmental conditions.

3. Two 25 mm (1 in) wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and also for shear strength. Each specimen should fail in the parent material and not in the weld, “Film Tear Bond"(F.T.B. failure). Seam separation equal to or greater than 25% of the track width shall be considered a failing test.

4. The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Subsection 3.05.C.4 of this Section. Four specimens shall pass and the fifth specimen must meet or exceed 80% of the required seam strength for the test seam to be a passing seam.

5. If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam can be produced.

6. A sample from each test seam shall be labeled. The label shall indicate the date, geomembrane temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The sample shall then be given to the Owner's Representative for archiving.

B. Field Seam Non-destructive Testing

1. All field seams shall be non-destructively tested by the Geomembrane Installer over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester and outcome of all non-destructive testing shall be recorded and submitted to the Owner's Representative.

2. Testing should be done as the seaming work progresses, not at the completion of all field seaming, unless agreed to in advance by the Owner's Representative. All defects found during testing shall be numbered and marked immediately after detection. All defects found should be repaired, retested and remarked to indicate acceptable completion of the repair.

3. Non-destructive testing shall be performed using vacuum box, air pressure or spark testing equipment.

4. Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods. The Geomembrane Installer shall demonstrate to the Owner's Representative all test methods to verify the test procedures are valid.

5. Extrusion seams shall be vacuum box tested by the Geomembrane Installer in accordance with ASTM D 4437 and ASTM D 5641 with the following equipment and procedures:

    a. Equipment for testing extrusion seams shall be comprised of but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base, port hole or valve assembly and a vacuum gauge; a vacuum pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and connec-

tions; a plastic bucket; wide paint brush or mop; and a soapy solution.

b. The vacuum pump shall be charged and the tank pressure adjusted to approximately 35 kPa (5 psig).

c. The Geomembrane Installer shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3m (12 in) by 1.2m (48 in) (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa (5 psig) for approximately five (5) seconds. The geomembrane should be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after five (5) seconds, the area shall be considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.

d. All areas where soap bubbles appear shall be marked, repaired and then retested.

e. At locations where seams cannot be nondestructively tested, such as pipe penetrations, alternate nondestructive spark testing (as outlined in section 3.04.B) or equivalent should be substituted.

f. All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

6. Double Fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D 5820 and ASTM D 4437 and the following equipment and procedures:

a. Equipment for testing double fusion seams shall be comprised of but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa (30 psig), mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.

b. The testing activities shall be performed by the Geomembrane Installer. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of 210 kPa (30 psig), and the valve closed. Allow two (2) minutes for the injected air to come to equilibrium in the channel, and sustain pressure for five (5) minutes. If pressure loss does not exceed 28 kPa (4 psig) after this five minute period the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.

NOTE: Historically, destructive seam testing has been conducted every 150 lineal meters. (approximately 500 lineal feet). There is a movement toward doing less destructive testing mid field seam. The rationale behind this change is that when a hole is cut from a seam, it is repaired with a seam that is not as good as the original. There are several methods used within the industry to reduce the amount of destructive seam sampling done. One method involves the use of both destructive and non-destructive methods for testing seam integrity. First, the seam must be made with split-wedge welder and successfully air channel tested. Also a destructive seam sample is taken from the anchor trench and tested. If both tests are successful, then no destructive seams are taken from the field seam. If either test fails, then destructive sampling is conducted on the field seam. A second method is detailed in GRI's GM 14 guideline "Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes." A simplified explanation of this method is that good seaming performance is rewarded by extending the de-

c. If loss of pressure exceeds 28 kPa (4 psig) during the testing period or pressure does not stabilize, the faulty area shall be located, repaired and retested by the Geomembrane Installer.

d. Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

C. Destructive Field Seam Testing

1. One destructive test sample per 150 linear m (500 linear ft) seam length or another predetermined length in accordance with GRI GM14 or GRI GM20 shall be taken by the Geomembrane Installer from a location specified by the Owner's Representative. The Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative as seaming progresses.

2. All field samples shall be marked with their sample number and seam number. The sample number, date, time, location, and seam number shall be recorded. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If a patch cannot be permanently installed over the test location the same day of sample collection, a temporary patch shall be tack welded or hot air welded over the opening until a permanent patch can be affixed.

3. The destructive sample size shall be 300 mm (12 in) wide by 1 m (36 in) long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Owner's Representative as an archive sample; one section given to the Owner's Representative for laboratory testing as specified in paragraph 5 below; and one section retained by the Geomembrane Installer for field testing as specified in paragraph 4 below.

4. For field testing, the Geomembrane Installer shall cut 10 identical 25 mm (1 in) wide replicate specimens from the sample. The Geomembrane Installer shall test five specimens for seam shear strength and five for peel strength. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, 4 of 5 test specimens must pass the stated criteria in section 2.02 with less than 25% separation. The fifth specimen must meet or exceed 80% of the required seam strength.

5. If independent seam testing is required by the specifications it shall be conducted in accordance with ASTM 5820 or ASTM D4437.

6. Reports of the results of examinations and testing shall be prepared and submitted to the Owner's Representative.

7. For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Engineer; typically 3 m (10 ft.) on either side of the failed sample and laboratory seam tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 M in length (150 FT) shall be destructively tested.

D. Identification of Defects

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

E. Evaluation of Defects: Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described in Section 3.05.B. Each location which fails non-destructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

1. If a destructive sample fails the field or laboratory test, 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 an extrusion welded cap strip.
3. Reseaming may consist of either:
    a. Removing the defective weld area and rewelding the parent material using the original welding equipment; or
    b. Reseaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.
4. Blisters, larger holes, and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm (6 in) beyond all edges of the defects.
5. All repairs shall be measured, located and recorded.

F. Verification of Repairs on Seams: Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be reseamed and retested until a passing test results. The number, date, location, technician and test outcome of each patch shall be recorded.

G. Daily Field Installation Reports: At the beginning of each day's work, the Installer shall provide the Engineer with daily reports for all work accomplished on the previous work day. Reports shall include the following:

1. Total amount and location of geomembrane placed;
2. Total length and location of seams completed, name of technicians doing seaming and welding unit numbers;
3. Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing;
4. Results of pre-qualification test seams;
5. Results of non-destructive testing; and
6. Results of vacuum testing of repairs.

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

3.06 Liner Acceptance

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

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

3.07 Anchor Trench

A. Construct as specified on the project drawings.

3.08 Disposal of Scrap Materials

A. On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap material in a location approved by the Owner, remove equipment used in connection with the work herein, and shall leave the premises in a neat acceptable manner. No scrap material shall be allowed to remain on the geomembrane surface.

PART 4 - MEASUREMENT AND PAYMENT

As per project specifications.

PART 5 - GSI GM13 SPECIFICATION

"This section shall include the current GSI GM13 manufacturer's specification or a revision of GSI GM13 specific to the unique project requirements and/or standards, as determined by the owner or owners' agent."

Attachment A.

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

Geomembrane Nominal Thickness	**20 mils**	**30 mils**	**40 mils**	**50 mils**	**60 mils**	**80 mils**	**100 mils**	**120 mils**
Hot Wedge Seams [1]								
shear strength[2], lb/in.	**30**	**45**	**60**	**75**	**90**	**120**	**150**	**180**
shear elongation at break[3] , %	50	50	50	50	50	50	50	50
peel strength [2], lb/in.	**25**	**38**	**50**	**63**	**75**	**100**	**125**	**150**
peel separation, %	25	25	25	25	25	25	25	25
Extrusion Fillet Seams [1]								
shear strength[2], lb/in.	**30**	**45**	**60**	**75**	**90**	**120**	**150**	**180**
shear elongation at break[3] , %	50	50	50	50	50	50	50	50
peel strength [2], lb/in.	**22**	**34**	**44**	**57**	**66**	**88**	**114**	**136**
peel separation, %	25	25	25	25	25	25	25	25

Table 1(b) – Seam Strength and related Properties of Thermally Bonded Smooth and Textured **Linear Low Density Polyethylene (LLDPE)** Geomembrane **(S.I. Units)**

Geomembrane Nominal Thickness	**0.50 mm**	**0.75 mm**	**1.0 mm**	**1.25 mm**	**1.5 mm**	**2.0 mm**	**2.5 mm**	**3.0 mm**
Hot Wedge Seams [1]								
shear strength[2], N/25mm	**131**	**197**	**263**	**328**	**394**	**525**	**657**	**788**
shear elongation at break[3] , %	50	50	50	50	50	50	50	50
peel strength [2], N/25mm	**109**	**166**	**219**	**276**	**328**	**438**	**547**	**657**
peel separation, %	25	25	25	25	25	25	25	25
Extrusion Fillet Seams [1]								
shear strength[2], N/25mm	**131**	**197**	**263**	**328**	**394**	**525**	**657**	**788**
shear elongation at break[3] , %	50	50	50	50	50	50	50	50
peel strength [2], N/25mm	**95**	**150**	**190**	**250**	**290**	**385**	**500**	**595**
peel separation, %	25	25	25	25	25	25	25	25

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

1. Also for hot air and ultrasonic seaming methods
2. Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

Table 2(a) – Seam Strength and related Properties of Thermally Bonded Smooth and Textured **High Density Polyethylene (HDPE)** Geomembrane **(English Units)**

Geomembrane Nominal Thickness	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams[1]							
Shear strength[2], lb/in.	**57**	**80**	**100**	**120**	**160**	**200**	**240**
Shear elongation at break[3], %	50	50	50	50	50	50	50
Peel strength[2], lb/in.	**45**	**60**	**76**	**91**	**121**	**151**	**181**
Peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
Shear strength[2], lb/in.	**57**	**80**	**100**	**120**	**160**	**200**	**240**
Shear elongation at break[3], %	50	50	50	50	50	50	50
Peel strength[2], lb/in.	**39**	52	**65**	**78**	**104**	**130**	**156**
Peel separation, %	25	25	25	25	25	25	25

Table 2(b) – Seam Strength and related Properties of Thermally Bonded Smooth and Textured **High Density Polyethylene (HDPE)** Geomembrane **(S.I. Units)**

Geomembrane Nominal Thickness	**0.75 mm**	**1.0 mm**	**1.25 mm**	**1.5 mm**	**2.0 mm**	**2.5 mm**	**3.0 mm**
Hot Wedge Seams [1]							
shear strength[2], N/25mm	**250**	**350**	**438**	**525**	**701**	**876**	**1050**
shear elongation at break[3] , %	50	50	50	50	50	50	50
peel strength [2], N/25mm	**197**	**263**	**333**	**398**	**530**	**661**	**793**
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams [1]							
shear strength[2], N/25mm	**250**	**350**	**438**	**525**	**701**	**876**	**1050**
shear elongation at break[3] , %	50	50	50	50	50	50	50
peel strength [2], N/25mm	**170**	**225**	**285**	**340**	**455**	**570**	**680**
peel separation, %	25	25	25	25	25	25	25

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

1. Also for hot air and ultrasonic seaming methods
2. Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

International Association of Geosynthetic Installers

www.iagi.org

For the most recent version of this document, visit www.iagi.org.

International Association of Geosynthetic Installers

8457 N. Rampart Range Road, Unit 106, PMB #154

Roxborough, CO 80125 USA

Telephone: +1 (720) 353-4977 / Fax: +1 (612) 235-6484

Email:iagi@iagi.org