AQUAMASTER®
INSTALLATION GUIDE

AquaMaster®

FGI Fabricated Geomembrane Institute

I. GENERAL

A. Scope

The following information is a general installation guideline for IPG'S Aquamaster geomembranes. This guideline is consistent with industry accepted standards. This manual will help Aquamaster geomembrane installers achieve a durable liner installation. Whenever a geomembrane installation is conducted under detailed engineering specifications, those specifications should take precedence over this installation guideline and the project should be performed in strict accordance with those specifications. For information related to a specific project, please contact our technical department at the number below:

Intertape Polymer Group
50 Abbey Avenue
TRURO, NS, CANADA
B2N 6W4
Tel: 902-896-1086

B. Applications

Some of the typical applications for Aquamaster geomembranes include but are not limited to:

- Irrigation and canal liners
- Reservoir liners
- Golf course and decorative pond liners
- Storm water management pond liners
- Athletic field & golf green covers
- Temporary landfill rain covers
- Oil & Gas liners for shale developments (drill pads, frack tank liners, temporary containment)
- Various mining application liners & covers

C. References

- ASTM D1238- 13, Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
- ASTM D3218-07, Standard Specification for Polyolefin Monofilaments
- ASTM D2646-11, Standard Test Methods for Backing Fabric Characteristics of Pile Yarn Floor Coverings
- ASTM D751-06, Standard Test Methods for Coated Fabrics
- ASTM D1777-96, Standard Test Method for Thickness of Textile Materials
- ASTM D7003-03, Standard Test Method for Strip Tensile Properties of Reinforced Geomembranes
- ASTM D7004-03, Standard Test Method for Grab Tensile Properties of Reinforced Geomembranes
- ASTM D4533-15, Standard Test Method for Trapezoid Tearing Strength of Geotextiles
- ASTM D5884-04, Standard Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes
- ASTM D4833-07, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
- ASTM D6636-01, Standard Test Method for Determination of Ply Adhesion Strength of Reinforced Geomembranes
- ASTM D7272-06, Standard Test Method for Determining the Integrity of Seams Used in Joining Geomembranes by Pre-Manufactured Taped Methods
- ASTM D4437-08, Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
- ASTM D5641-94, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
- ASTM D7747-11 Standard Test Method for Determining Integrity of Seams Produced Using Thermo-Fusion Methods for Reinforced Geomembranes by the Strip Tensile Method

II. PRODUCTS & WARRANTIES

A. NovaLiner™

NovaLiner is IPG'S range of short term geomembranes with products ranging from 8 to 20 mils. All products are made of HDPE oriented scrim with LDPE coating that also includes UV protection.

NovaLiner 8
NovaLiner 12
NovaLiner 16
NovaLiner 20

B. ArmorLiner™

ArmorLiner is IPG'S range of long term geomembranes with products ranging from 24 to 45 mils. All products are made of an HDPE oriented scrim with LDPE coating that also includes increased UV protection for up to 20 years exposed protection. ArmorLiner 40 and 45 are made with 2 reinforced scrims and 3 coating layers in a unique 5-layer combination that gives extra strength and reliability. ArmorLiner 30SFL (Single Film Laminate) includes a 5.5mils LDPE/LLDPE film on one side for extra longevity.

ArmorLiner 24
ArmorLiner 30
ArmorLiner 30SFL
ArmorLiner 40
ArmorLiner 45

C. ArmorPad®

ArmorPad is a range of IPG'S geocomposites that consist of one or two layers of needle-punched non-woven material laminated onto an ArmorLiner 24 geomembrane.

ArmorPad 3NWL (3oz Non-Woven Laminate single side)
ArmorPad 3NWLD (3oz Non-Woven Laminate Double side)
ArmorPad 6NWL (6oz Non-Woven Laminate single side)
ArmorPad 6NWLD (6oz Non-Woven Laminate Double side)
ArmorPad 8NWL (8oz Non-Woven Laminate single side)
ArmorPad 8NWLD (8oz Non-Woven Laminate Double side)

D. NovaGrip™

NovaGrip is a textured 30 mil geomembrane for applications requiring increased interface shear resistance or for slip protection.

E. Warranties

Aquamaster Geomembranes come with warranties from 2 to 20 years for exposed applications and 5 to 25 years for covered applications, contact us for details to match your specific application.

Please contact us directly for available roll length, width and colors.

Connect with an IPG Specialist 1-888-898-7834

or view products at www.itape.com/aquamaster

III. QUALITY POLICY

Intertape Polymer Group is committed to providing Geomembrane products that consistently meet or exceed customer and regulatory requirements. Intertape Polymer Group has established a Quality Management System that is certified to ISO 9001:2008 standards. It is Intertape Polymer Group's goal to continue meeting industry standards and providing our customers with world class geomembrane products.

Intertape Polymer Group® purchases resins and additives for the manufacturing of Geomembranes. All purchased materials are purchased from approved suppliers (IPG maintains an Approved Suppliers List).

During each step of the manufacturing process, our quality control department ensures that all materials meet our required standards. Samples are tested at three different stages during manufacturing:

- Tape Extrusion

At this stage, we extruded our HDPE material into tape which will be the basic component of our fabric. This stage is critical in giving our geomembrane it's high mechanical properties. Our tapes recipes are extruded and wound in 15,000 linear yard individual rolls. Rolls are palletized and identified for traceability.

- Woven fabric

At this stage, a number of individual rolls are beamed on a single mandrel depending on the weaving pattern required for the final product. The beam is then placed on a loom and the fabric pattern is woven, rolls of fabric are inspected before the next operation.

- Coated Geomembrane

At this stage, our fabrics are placed in the extrusion coater where they are coated with our special recipes. Depending on the product, it might require multiple coating or laminating stages before the geomembrane product is ready to be inspected.

Intertape Polymer Group has implemented a quality management system that guarantees traceability of our products throughout the manufacturing process.

Material/product traceability is achieved utilizing electronic management systems and production reports. All products are identified by Warehouse Management System (WMS) tags with a unique system generated number and barcode for traceability purposes.
Resin is drawn from raw material inventory for production. The resin lot number is recorded. Additives, concentrates That are added to the extrusion process are also identified by lot number and box number.

Tape is packaged in doffs that are identified by production line, and sequential number. Beams are also identified by production line and sequential number.

An uncoated roll of fabric is given a roll identification. Other production areas number the rolls with an identification number that contains the date and consecutive roll number for the day.

Each successive operation results in the generation of a new roll number because input rolls are often split or spliced to other rolls of specific width and/or length. Input and output roll numbers in each operation are recorded in production.

This system allows IPG to have both upward traceability and downward traceability throughout the whole manufacturing process. Any material, product or sub-component that is identified as non-conforming to a requirement is immediately tagged and quarantined by our Quality Assurance Supervisor. This will prevent non-conforming material or sub-component from being processed and non-conforming product from being shipped to our customer.

A. Storage & Handling

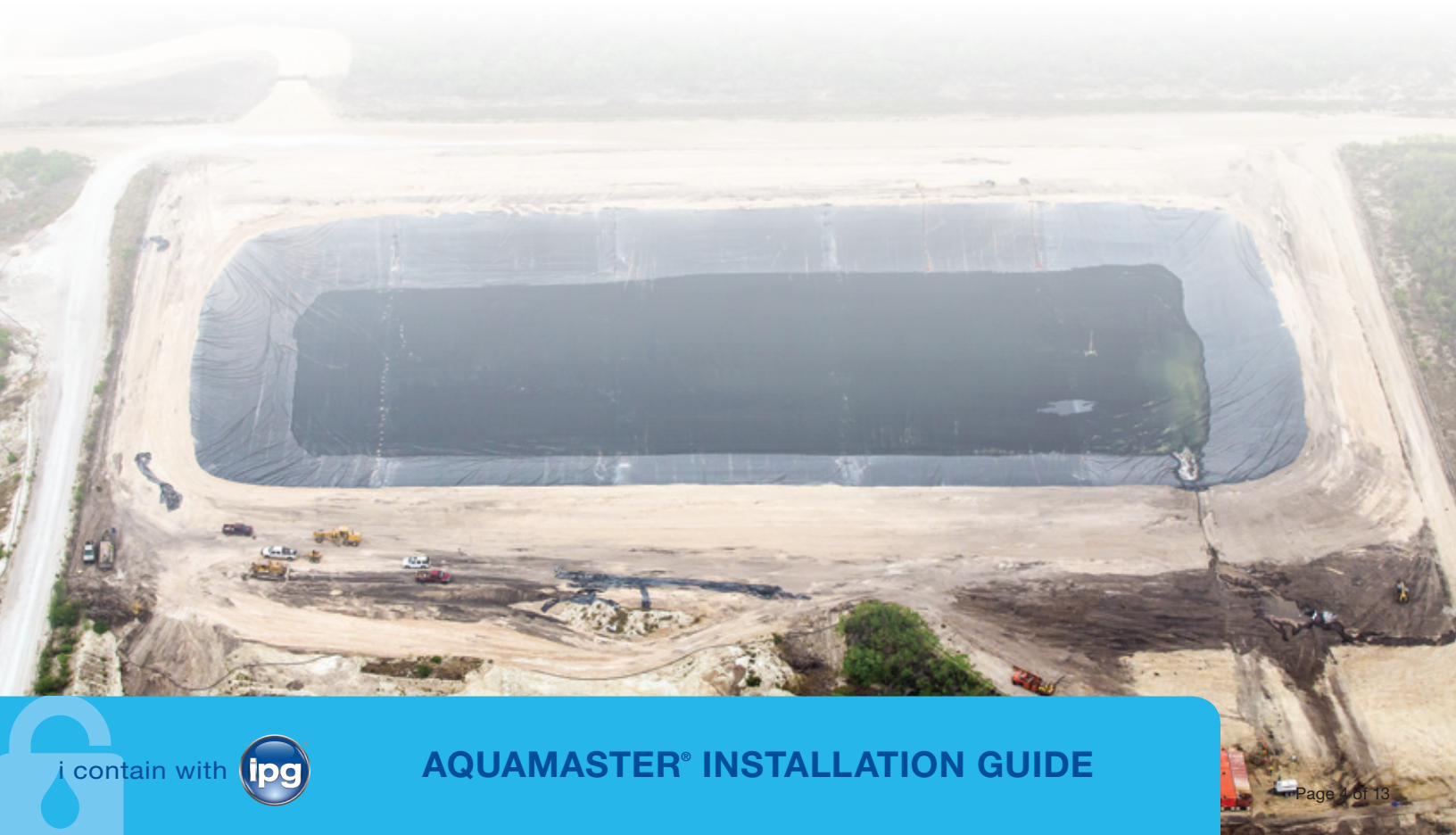
Intertape Polymer Group stores raw materials and products in areas that provide for a suitable environment, so as to prevent deterioration. The warehouse is inspected daily for damage to stored products.

Intertape Polymer Group uses appropriate equipment to handle its products and materials in consideration of volume, weight, vertical and horizontal distance of move, racking, etc... Lift trucks, dolly's, or pallet movers are used to prevent damage or deterioration of products.

B. Packaging & Shipping

Intertape Polymer Group has several packaging specifications depending on the size, weight and types of product. Special customer requirements for packaging can be included into packaging work instructions.

Finished products ready for shipping are identified with a Shipping Label and forwarded to the Shipping area. Products are then shipped per customer requirements.



IV. SUBMITTALS & QUALIFICATIONS

A. Submittals

Documents to be included in a submittal to the owner/engineer for review or approval:

- Example material warranty and Geomembrane installation warranty
- Sample of Geomembrane(s) to be installed including the technical data on the product
- Reports on the results of examinations and testing shall be prepared and submitted to the Owner's Representative
- Shop drawings/panel layout for Geomembranes with panel numbers, field seam locations and details, corresponding to shipping labels
- Submit resumes or qualifications of the installation supervisor and certified welding technicians
- Documentation of manufacturer's and installer's qualifications. It is recommended that the welding technicians hold an International Association of Geosynthetic Installers (IAGI) Certified Welding Technician (CWT) certification in reinforced geomembranes
- The documentation to be submitted by the Fabricator to the Owner varies depending on the Owner's requirements. Documentation may include copies of tested seam results, certifications, or any other document related to the quality of the geomembranes and their installation
- Fabricator and Installer QC Manuals

B. Intertape Polymer Group's Qualifications

Intertape Polymer Group has 20-years' experience in manufacturing woven reinforced polyethylene geomembranes. Additionally, Intertape Polymer Group has produced a minimum of 2,000,000 m^2 (21,527,820 ft^2) of geomembranes or similar product during the last 5 years.

C. Fabricators Qualifications

The fabricator of the geomembrane shall have fabricated a minimum of 500,000 m^2/year (5,381,955 ft^2/year) of the specified type or similar geomembranes.

D. Installer's Qualifications

The Geomembrane Installer shall be the Fabricator, approved Fabricator's Installer, or an Installer/contractor approved by the Owner's Representative. The geomembrane installer shall have installed at least 10 projects involving a total of 500,000 m^2 (5,381,955 ft^2) using the specified geomembrane.

E. Quality Assurance

Quality Assurance during installation of the woven reinforced polyethylene geomembrane will be provided by the Owner.

V. SITE REQUIREMENTS

A. Site Preparation

1. Subgrade

Subgrade shall be prepared in accordance with drawing requirements. It should provide a flat smooth surface free of sharp objects, rocks or other debris that could damage the liner by puncturing or tearing it. Where loose subgrade is located on slopes, it should be stabilized prior to installing the geomembrane. Where weak or compressible areas cannot be sufficiently compacted, they should be removed and replaced with fill that can be properly compacted and stabilized prior to liner installation. No abrupt transition or slope change that could damage the liner is allowed. Subgrade preparation should be part of the site approval process.

2. Vegetation and Wildlife

Vegetation shall be removed during subgrade preparation to avoid roots damaging the geomembrane and to prevent any growth under it. Aquamaster offers a range of products with very high puncture resistance and most products can withstand occasional animal traffic, however repeated animal traffic can damage exposed liners, please contact our technical team to best protect your exposed liner from wildlife and ensure optimal service life.

3. Ground Water

No standing water or frozen water should be present before installation. If there is a risk of ground water rising and applying backpressure on the liner, a drainage system should be in place to prevent it and/or the geomembrane should be ballasted to prevent uplift of the liner.

4. Pipe, Drains and Anchor Trenches

All pipes, drains and other details that are to be installed underneath the geomembrane should be installed prior to starting the geomembrane installation.

Anchor trenches should be completed prior starting the installation. As for the subgrade, there should be no sharp stones, rocks, or debris that could damage the liner or the anchor trench. It should also be free of standing water. The Aquamaster geomembrane shall be placed in contact with the front wall and down the bottom of the anchor trench and shall not be folded. Once the liner has been installed, the anchor trench shall be filled with soil that will not damage the liner in the anchor trench. Regular anchor trench and an V trenches design are appropriate designs for use with Aquamaster geomembranes.

5. Approval

Site preparation should be approved by all interested parties prior to beginning the installation, if preparation is deemed not acceptable it should be corrected before starting the installation. A walk over the complete site with all interested parties shall be done in order to verify that site preparation is acceptable. Owner, contractor and geomembrane installer or their representative shall all approve in writing site acceptance before moving to geomembrane installation.

B. Geomembrane Unloading, Handling and Storage

1. Unloading & Handling

Factory fabricated geomembrane panels can be accordion folded and then rolled up for shipment or panels may be double accordion folded onto a wooden pallet. Each panel is prominently and indelibly marked with the panel size and serial number for proper deployment location according to shop drawings. If the material is to be palletized, pallets have a protective layer on the surface of the pallet and between the liner and the banding to prevent damage to the liner. All panels will be packaged with a cover or outer wrap to protect the panel from weather and ultraviolet light.

Care should be taken when unloading the panels so as not to damage them. Use of heavy lifting equipment may be necessary and equipment driver should be cautious in handling panels and take all necessary precaution to minimize handling steps.

2. Storage

Fabricated panels delivered to the job site may be stored on the ground providing the ground is flat, dry and free of debris, sharp rocks, and any item that could damage the geomembrane. It is however recommended to store them on pallets on the ground when possible. When panels are accordion folded and rolled, they can easily and safely be handled using a spreader bar. Panels should be protected from the environment by use of a rain cover or storing them in a building until installation is ready to begin.

All care must be taken to keep the rolls dry prior to installation.

VI. GEOMEMBRANE INSTALLATION

A. Unfolding and Panels Deployment (Figure 1)

The geomembrane panels shall be placed on the outside limit of the area to be lined, only panels that will be seamed on that day should be deployed. Marking on the individual panels will indicate deployment directions. Care should be taken at all steps not to damage the panels during deployment.

Once ready to deploy, unfold panels one by one until fully deployed. Deployment should be done with the use of a spreader bar, whether by suspending it and pulling the material off the roll or by fixing the end of the roll then unrolling the material carefully on the subgrade. Sand bags or other non-damaging ballasts should be used to prevent wind uplift of the deployed panels; un-welded edges should also be ballasted at all time to protect the liner from uplift. When the liner is placed on a steep slope, a row of sandbags attached together with a rope anchored at the top of the slope can be used.

Figure 1: Unfolding Panels

When placed in a canal, seams must be placed in a shingle fashion in the direction of flow. Once deployed, panels should be welded as soon as it is possible.

B. Field Seaming

A main advantage of IPG'S factory fabricated panels is the reduced amount of field seams required compared to other materials, typically only 10% of seams are field seams while 90% are factory seams produced in a controlled environment. Field seams can be produced by wedge welding, hot air welding, tape seaming and for the particular case of Aquamaster ArmorPads by adhesive bonding.

1. Cleaning of Seaming Surfaces

After the panels are initially placed in the proper position, remove as many wrinkles as practical. The edges to be seamed need to be smooth and free of wrinkles to ensure good field seams and no "fish mouths". A minimum overlap of 4 to 6 inches must be cleaned of all dust, dirt, water, and foreign debris no more than 30 minutes prior to the seaming operation. Only clean, soft rags should be used for cleaning the areas to be seamed. The seaming operation requires a solid, dry, smooth subsurface to achieve the best seams.

2. Field Wedge Welding

Wedge welding is performed with a hot wedge welding machine, which uses a heated element to melt the geomembranes to be welded and then presses the two melted sheets together to form the bond. When performed properly, wedge welders produce high quality and consistent seams. The wedge in a hot wedge welder can be heated with hot air (hot air method), or with electric resistance heating (hot wedge method). All wedge welders employ a set point controller to accurately maintain the welding temperature within the most efficient welding temperature for the material. The pressure wheels should be adjustable to allow for good material bonding after heating. Only single or solid wedge arrangement is available for factory and field welding of Aquamaster reinforced geomembranes. Only single or solid wedge welding should be used for factory and field welding. Double track welding and air channel testing is not appropriate for this kind of geomembrane. These exposures can result in false pressure drops in completed seams that make a resulting air-channel test unreliable. The single (or solid) wedge arrangement produces a continuous bonded weld not less 1 inch wide.

Seaming with a wedge welder is to be undertaken only by persons that have been trained and qualified in the use of the equipment. Repairs, maintenance, adjustments, and modifications are to be performed only by trained personnel. Temperature controllers on the thermal welding device should be set according to the thickness of the geomembrane, ambient temperature, type of heating (air v. wedge), rate of seaming, and location of thermocouple within the device. It is necessary for the operator to keep constant visual contact with the temperature controls, as well as the completed seam exiting the welder to ensure adequate welding is occurring. Welding parameters should not be adjusted without first constructing and testing a trial seam. If the trial seam meets minimum acceptable values, the adjustments can be used on the field seam.

Properly functioning portable electric generators must be available within close proximity of the seaming region and with adequate extension cords to complete the entire seam. These generators should be of sufficient size or number to handle all seaming electrical requirements. The generator must have rubber tires, or be placed on a smooth plate such that it is completely stable and it does not damage the geomembrane. Fuel (gasoline or diesel) for the generator must be stored away from the geomembrane, and if accidentally spilled on the geomembrane it must be removed immediately. The areas should be inspected for damage to the geomembrane and repaired if necessary.

3. Field Tape Seaming

Aquamaster Geomembranes can be seamed using field tape seaming methods. Tape seaming is usually limited to products less than 30 mils thickness. Aquamaster geotape can be used as well as other type of tapes, please contact us for compatibility of your tapes to our products. Immediately after creating a tape seam, it should be loaded or secured to facilitate bonding. The preferred method for securing prepared tape joints is to backfill the geomembrane with a suitable soil cover so tensile stresses do not develop. The backfill creates a pressure seal between the geomembrane panels and tape which is usually effective. An alternative method of creating strength in a tape seam is to sew the seam first and then use prepared tapes to waterproof the joint. Even with a sewn seam; the recommended practice is to backfill the geomembrane to prevent shifting of the seam and to help adhere or bond
the tapes.

To create a tape seam, place one or two continuous lines of prepared tape between the sheet overlap. Press the sheet materials together to compress the tape using a rubber, nylon, or steel hand roller or similar tool. In areas where wrinkles cannot be removed, use tapes on all sides of the wrinkle to form a waterproof seal. Visually inspect the completed seam to ensure intimate contact between the tapes and the upper and lower sheet surfaces. Repair discontinuities by placing a patch over the damaged area with a prepared tape seal around the perimeter. The patch must be round, oval, or contain rounded corners and extend 6 inches around the defect. Supervise the backfilling of the seam area to prevent the seam from being placed in tension and pulled apart. Backfill should proceed in a direction that does not tend to pull the seams apart or create a shear or tensile stress in the seam.

4. Field Seaming Quality Control & Test Requirements

a) Test Seams (Trial Seams)

Test seams shall be prepared and tested by the Geomembrane Installer to verify that the seaming parameters meet accepted seam values at the start of each welding session or at the beginning of each working day. Test seams also may be made whenever personnel or equipment are changed and when climatic conditions reflect wide changes in geomembrane temperature or other conditions that could affect seam quality. A minimum of one test strip per seaming apparatus shall be conducted at the start of each welding session during a day and at least every 4 hours or 3000 lineal feet of field seam per machine, whichever is more frequent.

Field test seams shall be made using “scrap” material from the same lot as the geomembrane being welded in the field because the geomembrane is pre-fabricated into panels in a factory. This requirement is necessary to ensure that the installed geomembrane panels are not damaged prior to the onset of the field welding process because no destructive seam tests shall be conducted on factory fabricated seams to preserve integrity of the fabricated panels. Test seaming shall be conducted under ambient conditions and with the same equipment, geomembrane, and operator as field seaming on the fabricated panels. The test seams shall be at least 6 feet long for all types of field seams. If there is no area or equipment on site to provide for these seam requirements, seam strength can be verified for production using trial welds sent to an independent testing laboratory to verify quality. If a test seam fails, an additional test seam shall be immediately completed.

If the additional test seam fails, the seaming apparatus shall be rejected and not used until the deficiencies are corrected and a successful full test seam is produced. Each test seam shall be labeled with date, geomembrane temperature, weather conditions, number of seaming unit, panel identification, seam number or test location, technician performing the test seam, and a pass or fail description. Pre-qualification seams for tape seams shall be in accordance with ASTM D7272.

b) Seam Non-Destructive Testing (NDT)

When required, field seams can be non-destructively tested by the Geomembrane Installer over the full length of the seams before the seam is covered. When Seam NDT is to part of the requirements, each seam shall be numbered or otherwise designated. The location, date, test unit, name of the technician, name of QC person, and outcome of all NDT shall be recorded and submitted to the Owner's Representative. Testing should be performed as the seaming progresses, not at the completion of all field seaming, unless agreed to in advance by the Owner's Representative. All defects found should be repaired, re-tested, and remarked to indicate acceptable completion of repair.

NDT of field seams shall be performed using one or more of the following methods, the Air Lance testing method should be preferred to the vacuum box method whenever possible:

(1) Air Lance Testing (ASTM D 4437)

The Geomembrane Installer shall provide an air compressor, air hose, and air lance wand with a pressure gauge capable of measuring air flow to the tip. The testing shall be performed by experienced technicians familiar with this testing procedure. This non-destructive test involves placing the air lance wand approximately ¼ to ½ inch from the edge of a completed seam (not more than 2 inches and closely monitoring the backside of the sheet for any air penetration through the seam, loose edges, riffles, and/or noise. If air penetrates the seam area, the technician will either see this visibly or hear it audibly and the area shall be marked for repair.

(2) Vacuum Box Testing (ASTM D5641) (Vacuum box testing is not appropriate for Aquamaster materials thinner than 30 mil.)

Apply soapy solution to seam area to be tested. Place vacuum box with clean viewing glass along seam. Ensure sealing foam around bottom of box is well seated and provides a good seal. It may be necessary to "work" the box into place and to use some wet rags to get a good seal. Apply a minimum pressure in the box of about 4 psi to test the seams. Monitor the seam for soap bubbles for at least 5 seconds. Mark any locations where bubbles indicate leaks for repairs. If no bubbles occur after 5 seconds, relieve vacuum and move to next seam section. An overlap of about 3 inches should be tested between two consecutive testing sections along the field seam being tested.

c) Destructive Field Seam Testing

One destructive test sample per 150 lineal meters (492 linear feet) of field seam length or another predetermined length in accordance with GRI GM 14 shall be obtained 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. Testing should be arranged such that test results are provided prior to completion of geomembrane installation. Samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative as seaming progresses. 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 of the holes in the geomembrane created during the seam sampling process. All patches shall be Air Lance tested or vacuum box teste to ensure no leakage. If a patch cannot be permanently installed over the test location the same day of sample collection, a temporary patch shall be tack welded until a permanent patch can be affixed.

The destructive sample size shall be 12 inches wide by 39 inches long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows:

- One section given to the owner's representative as an archive sample.
- One section given to the owner's representative for laboratory testing as specified below.
- One section retained by the Geomembrane Installer for field testing as specified below.

For field testing, the Geomembrane Installer shall cut replicate specimens from his sample in accordance with ASTM D7747 for wedge welded seams and ASTM D7272 for tape seams. The Geomembrane Installer shall test five specimens for seam shear strength and five for seam peel strength. To be acceptable, 4 of 5 test specimens must pass the specified Geomembrane Manufacturer's strength criteria with less than 25% separation. If 4 of 5 specimens pass, the sample qualifies for testing by the testing laboratory if required.

Standard ASTM non-destructive test (NDT) methods shall be used to evaluate seams (See section VI.B.4.b of this installation guide). The Engineer shall designate the appropriate standard NDT method dependent on the type of geomembrane to be installed. Reports of the results of examinations and testing shall be prepared and submitted to the Owner's Representative.

For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Engineer; typically, 10 feet on either side of the failed sample and laboratory seam tests shall be performed.

Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be nondestructively tested until adequacy of the seams is achieved. Cap strip seams exceeding 164 feet shall be destructively tested.

d) Evaluation of Defects

Each suspect location (both in geomembrane seam and non-seam areas) shall be non-destructively tested. Each location which fails non-destructive testing shall be marked, numbered, measured, and posted on the daily installation drawings and subsequently repaired. Defective seams, tears or holes shall be repaired by capping or cutting out the defective seam and re-seaming.

Single seams in excess of 20% of their length requiring repair should be entirely removed and re-welded. Each patch or capping shall extend a minimum of 6 inches in all directions beyond the defect. All repairs shall be located, measured, non-destructively tested, and recorded.

C. Anchoring and Concrete Attachments (Figure 2)

Anchor trenches should be used on top of slopes to ensure proper anchoring of the geomembrane and prevent wind uplift. The geomembrane must be secured at all time during the anchoring process by use of sandbags or other ballasts until the trench has been filled. The anchor trenches shall be filled with soil that doesn't damage the liner after it is compacted. The type and dimensions of anchor trench (regular square or V shaped trenches) to be used shall be defined by the designing engineer to prevent slippage of the geomembrane.

The geomembrane can be attached to concrete by using steel batten strips (1.375 in wide and 0.25 in thick minimum) with expansion anchors. Details of liner attachment to concrete are the responsibility of the project Engineer.

Figure 2: Ballasted edge of liner to prevent from wind uplift

The concrete surfaces shall be clean, smooth and not friable. Geotape or neoprene gaskets shall be placed on both sides of the geomembrane where the attachment will be made to protect it from both the batten strip and the concrete. Holes in the geomembrane shall be cut or stamped carefully to a diameter a bit smaller than the bolts to be used. Bolts should be tight enough to provide uniform compression on the gasket (or geotape). Butt joints in batten strips should be kept to a minimum width and should not be in the same location as gasket or geotape joints.

Once batten strips installation is complete, it should be inspected for loose bolts and visible defects.
The geomembrane fixed to a concrete structure must be on firm soil subgrade that will not deform and stretch the geomembrane. Compacting of the soil subgrade around such structures must be performed with particular care so excessive differential movement between the concrete and soil subgrade does not occur.

D. Pipe Penetrations

Whenever possible, avoid slitting geomembrane panels for piping details until a prefabricated pipe boot is ready for immediate installation. Cuts made in the geomembrane for clearance over penetrations should always be made as small as possible to minimize patch work. Generally, it is preferred to let the geomembrane straddle a relatively small protrusion (for later detail work) provided that a rag or towel is taped over the pipe to avoid damage to the geomembrane.

Whenever there is a pipe penetration into the geomembrane, pipe boots should be prepared with excess material to fit the pipe tightly but not require excessive force to pull over the pipe. The number of welds made to fabricate a boot shall be minimized. The boot shall be fabricated such that when installed, it is fully supported by the pipe and the surrounding subgrade.

If a pipe boot feels overly snug but workable, try applying either talc powder or using compressed air with a nozzle to float the boot sleeve over and along the pipe. Pipe boots should never be used if the force required to install them stresses or weakens the boot. When properly installed, the pipe boot will lay flat against grade surrounding pipe without leaving pockets that may become stressed during or after placement of backfill.

The pipe boot sleeve should be attached to the pipe using butyl geotape tape between the pipe and boot and two stainless steel clamps. Proper leak-proof sealing of pipe boots should be verified by using the air lance test method described in section VI.B.4.b.1.

When cover materials are not used, splash pads or additional geomembrane layers shall be used for all inflow pipes to prevent long term wear and damage to the geomembrane caused by the direct impact of the inflow on the geomembrane panels. The pads should be welded on top of the geomembrane panels and tested using the same air lance method. Common splash panel sizes are 4 to 6 ft in all directions. However, larger sizes may be required depending on the amount of inflow pipes and the height to the discharge point.

E. Inspection and Installation Approval

Geomembrane installation should be approved by all interested parties prior to covering it or filling the canal or reservoir, if installation is deemed not acceptable it should be corrected before covering it. A walkover the complete site with all interested parties shall be done in order to verify that liner installation is acceptable. Owner, contractor and geomembrane installer or their representative shall all approve in writing installation acceptance before moving on with the next step of the project.

F. Covering The Geomembrane (Figure 3)

When placing cover material or initially filling the containment area, it is important to ballast the geomembrane into the perimeter anchor trench before covering or filling. The anchor trench or perimeter shelf area should be the last area covered to complete the cover process.

Under all operating conditions, protection of the geomembrane will be required. Care should be taken when covering the geomembrane to prevent any damage. At no time will construction equipment be allowed to operate or drive directly on the geomembranes.

Access roads for clean soil cover should be maintained to provide 0.45 m (18 inch) minimum and for heavier equipment on haul roads a minimum of 0.90 m (36 inch) preferable between the excavation equipment and geomembrane at all times. Cover soil requirements should be verified before placement with the Design Professional and geomembrane installer.

Figure 3: Soil covering the liner

Additionally, a protection geotextile layer may be needed in rougher soil conditions between the geomembrane and the cover materials. The use of a protection layer should be verified with the Design Professional and geomembrane fabricator.

Cover material shall consist of 12 mm (0.5 inch) minus particles, clean rounded soils or gravels free of sharp edges, sticks, metal, rubbish, and debris or foreign materials. Site specific materials or sizes may be acceptable. It is recommended that the contractor receive prior written approval of acceptance of the cover materials from a geomembrane representative and/or Design Professional before covering the geomembrane.

Cover soils should be dumped and leveled over the geomembrane and not pushed from one end to the other to minimize rolling and wrinkling of the geomembrane beneath the soils. Cover soil should always be placed from the bottom to the top of slopes to avoid stressing the geomembrane and slope stability problems.

Equipment should be turned in long sweeping turns and not spun quickly to eliminate the chance of tires digging down to the geomembrane thru the cover soil and wrinkling or stretching the geomembrane.

If geomembrane damage does occur during construction, cover placement, and/or filling, **DO NOT COVER IT UP**. Advise the foreman and CQA personnel so repair can be made and documented which will make doing the repair a lot easier than after cover soil placement or filling.

G. Shotcreting On ArmorPads (Figure 4)

ArmorPad materials can have concreted poured directly on it or be shotcreted for extra longevity. The non-woven layer provides a very strong bond for concrete adhesion.

Figure 4: Reinforced concrete being poured onto ArmorPad 3NWLD

H. Field Acceptance

The Geomembrane will be accepted by the Owner's Representative when all of the following have been completed:

- The entire installation is finished or on agreed upon subsections of the installation are finished
- All Installer's QC documentation is complete and submitted to the Owner
- Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

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CORPORATE PROFILE

Intertape Polymer Group® Inc. (IPG®) is an acknowledged leader in the packaging industry. Leveraging its advanced manufacturing and technologies, extensive research and development capabilities and a comprehensive strategic acquisition program, the company believes it has assembled the broadest and deepest range of products in the industry. IPG is widely recognized for its development and manufacture of specialized polyolefin, plastic and paper-based packaging products, as well as complementary packaging systems for industrial and retail use. Additionally, IPG is a leader in the woven coated fabrics industry. Its performance products, including tapes and cloths, are designed for demanding aerospace, automotive and industrial applications and are sold to a broad range of industry/specialty distributors, retail stores and large end-users in diverse industries.

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