



GEOMEMBRANE FIELD INSTALLATION



**Corporate Member
International Geosynthetic Society**





CONTENTS

Introduction	3
Quality Control and Quality Assurance	3
Types of lining systems	3
Basic Lining Design	3
Executive Lining Design	4
Basic Lining Design Specification	4
Executive Lining Design Specification	4
Prior to the Field Installation	5
Rolls Reception, Storage and Handling	5
Geomembrane Installation	6
1. Earthwork	6
2. Concrete Surfaces Anchor	7
3. Interferences	7
4. Liner Deployment	8
5. Field Seaming	8
6. Field Tests Procedures	9
6.1. Non-Destructive Seam Testing	9
6.2. Destructive Seam Testing	10
Installation Quality Control	11
Quality Assurance Inspection	11



Introduction

The purpose of this manual is to give information to the designers of the correct way to have a well succeeded geomembrane field installation, having in mind the good performance of the liner system as a whole.

This information does not address design guidelines, selection of geomembrane and installation specifications.

This manual reflects the IGS-Brazil topics for Thermoplastic Geomembranes Installation – Design Recommendations, still in discussion at the IGS-BR and at ABNT – Technical Standard Brazilian Association in the Geomembranes Committee.

Quality Control and Quality Assurance

Quality Control: A collection of procedures and tests done by the manufacturer or installer, according to appropriate standards, that give the guarantee of the good product or field installation services quality.

Quality Assurance: A collection of activities scheduled to verify if the manufactured product, the product delivered or the field installation services are being carried out in agreement with the appropriate technical standard and the executive design specifications.

Types of lining systems

For classification, in this recommendation, one defines three construction types:

I: Construction in which the lining system failure causes environmental and heritage outstanding damage.

II: Construction with intermediary risks between me and III.

III: Construction in which the lining system failure doesn't cause environmental damage and can be easily repaired.

Basic Lining Design

The basic lining design shall analyze the following items:

1. The conception of the whole lining system.
2. Geotechnical aspects considering: the local characteristics and its peculiarities, the accidental previous contamination, the support soil bearing capacity, the slopes and covers (protection systems, drainage layers and cover) stability.
3. The water presence by the water level elevation or by gases and liquids previous contamination.
4. The construction types I and II, one must verify the following: the waste and wastewater characteristics that will be storage, evaluating its risks, the elements that could have dangerous interactions and its maximum concentration, from a judgement characterization carried out by specialists.
5. The local environmental characterists.



The basic lining design shall define:

1. The geometry of the lining area.
2. The interferences (pipes, concrete attachment, etc.) location.
3. The several drainage systems for fluid and gases collection and conduction under and above the geomembrane, in the cover cap and in the periphery lining system.
4. For the construction I and II, the mechanical and physico-chemical solicitation acting in the geomembrane.
5. The reduction factors when necessary.
6. The minimum possible interferences (see item Interferences).

Executive Lining Design

The executive lining design shall detail all items defined in the basic lining design plus the geomembrane selection and its specification, the installation plan, the lining acceptance criteria, the anchorage details, the interferences and others, the execution recommendations and notes about the care with the lining operation and maintenance.

Basic Lining Design Specification

For the geomembrane specification, in the basic design, one shall take into account the mechanical and physico-chemical solicitations, the diffusion characteristics required, as well as the solicitations lasting, considering the installation and the lifetime phases.

The basic design specifies the properties of the geomembrane and the other geosynthetics and products involved, in relation to the lining installation and lifetime solicitations.

Note: When the support soil is compacted clay, one shall indicate the granulometry zone of the clay, which will be used, to prevent damage or puncture from the soil particles.

Executive Lining Design Specification

The executive design shall indicate the qualification and the quantification of the selected geomembrane, including the polymer type, the density, and thickness according to the construction use. It also shall indicate the items to be verified in the field installation quality control, the recommendations about the geomembrane reception, as well as its verification related with the visual and physical characteristics. The manufacture quality certificate, delivered with the geomembrane, shall be checked, and it is important also the definition of the lining acceptance criteria and the rolls storage conditions.

In constructions types I and II, the executive design shall have the following items:

1. Indicate the minimum geomembrane selected characteristics. As a suggestion one recommends: density, nominal thickness, tensile properties at yield and at break, puncture resistance and tests that identify the relevant characteristics for the design aim, as the chemical and weathering resistance.
2. To set up the reception and the approval criteria for the geomembrane reception and installation works.
3. To set up the installation quality control tests including non-destructive and destructive frequency tests.
4. The quantity of geomembrane, the plan for liner deployment with panels' identification, seams location and the anchorage system. The geomembrane quantity also shall consider

the anchorage length, the seam overlap, the interferences (pipes, concrete walls ...) and the panels' loses modulation.

5. A good drainage system in the bottom, under the geomembrane, to fluids and gases drainage.

6. An additional geomembrane percentage (3 to 5%) quantification to take into account the dilatation x contraction behavior, for tropical climate.

Prior to the Field Installation

Several cares shall be taken for the geomembrane field installation success, besides the good seaming process. Before starting installation services, one shall verify some requirements and analyze the impermeabilization design in relation to:

1. Geomembrane specification, panels' modulation and anchorage system.
2. Geomembrane quantity.
3. Details: the interferences unions and others relevant details.
4. Quality assurance criteria for:
 - a) The product delivery quality.
 - b) The field installation stages.
 - c) The fabric and/or field seaming
 - d) The lining system acceptance and control.
5. Weather conditions

Rolls Reception, Storage and Handling

1. Reception: The rolls have to have the number and identification.
2. Quality control certificate: Every rolls batch received shall have the quality control certificate.
3. Rolls unloading: The rolls unloading shall be done with equipments that ensure its security transportation.
4. Visual rolls inspection: It is recommended to do the visual rolls inspection, just after the unloading. The external roll side shall have free of holes, tears and bubbles.
5. Storage surface: The rolls shall be laid down in wood platforms or in sandy mattress. The storage surface shall be plane and free of stones, puncture materials, mud and grease. It is recommended to avoid rolls storage near chemical agents and heat sources.
6. Location of storage space: The storage location shall be in a location such that site transportation and handling are minimized.



Geomembrane Installation

1. Earthwork

1.1. Surface Preparation

- The surface shall be prepared, prior to the liner installation, according to the executive design guidelines.
- The surface to be lined shall be smooth and free of sharp objects and stones, free of all foreign and organic material and debris of any kind.
- When the lining system includes compacted clay layer, the compacted surface shall have no sharp changes or abrupt breaks in grade and shall be free of sharp materials.
- Stones and rocks over 9,52 mm diameter shall not be allowed in the top 15 cm of soil sub grade.
- One recommends that the surface be lined immediately after its preparation to avoid deterioration caused by rain, wind, lost of moisture or local traffic.
- All surfaces shall be carefully inspected immediately before to be lined to verify if all above recommendations were followed.



1.2. Anchor Trench

The anchor trenches shall excavate a little before the geomembrane placement to avoid rain damages and in case of clay soil, its desiccation.

The anchor trench shall be excavated according to the design dimensions.

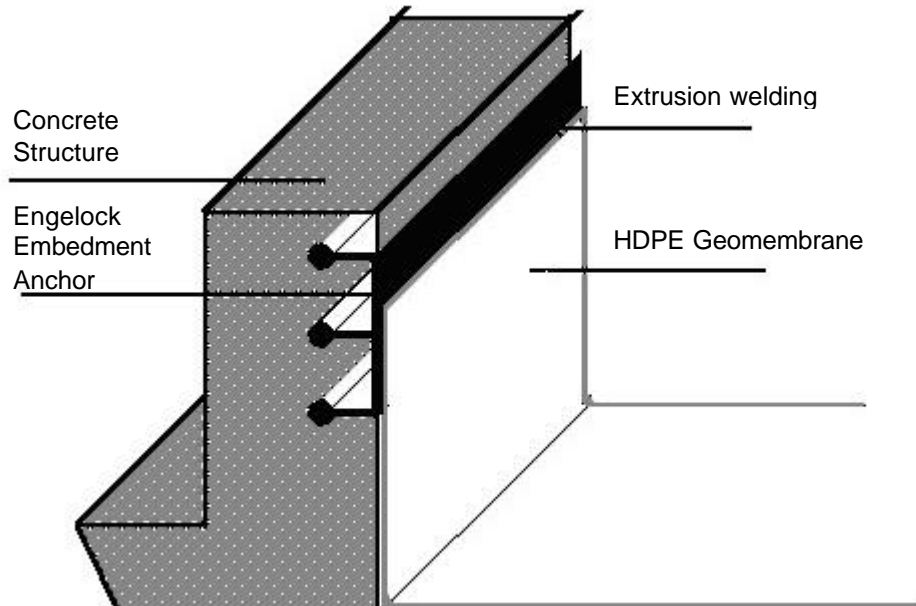
The anchor trenches corners shall be slightly rounded to avoid sharp bends in the geomembrane.

The backfilling of the anchor trench shall be carefully to avoid the geomembrane damage.



2. Concrete Surfaces Anchor

The concrete surfaces anchor is done by put in concrete an extruded HDPE profile, named embedment anchor. The geomembrane is welded to this anchor by extrusion welding.



3. Interferences

The interferences with pipes, entrance and exit boxes and other surfaces shall be treated according to the design details.



4. Liner Deployment

Immediately before the liner deployment one shall be verify if the surface is according to the recommendations the item surface preparation.

1. Panel identification: One shall be registered the number, the location and the placement date of each panel and shall be done the daily geomembrane deployment as built.

2. Deployment:

- The panels shall be placement according to its number and position in the executive design.
- The geomembrane shall be deployed vertically up and down the slope.
- The geomembrane shall be deployed in such a way that has a minimum of wrinkle.

- Adequate temporary anchoring (sand bags or tires), that cause no damage to the geomembrane, shall be placed to prevent uplift by the wind. In cases of high wind, continuous loading is recommended along the edges of panels to minimize risk of wind flow under the panels.
- If it is inevitable the vehicle traffic on the deployed geomembrane, one shall be foresee a protection layer above it (geotextile, extra geomembrane or soil layer), in such a way that the vehicle passes on that layer.



5. Field Seaming

3.1. The seaming shall be done vertically up and down the slope.

3.2. In corners and odd-shaped geometric locations, the numbers of seams shall be minimizing.

3.3. One recommends that no horizontal seam shall be done less than 1,50 m from the toe of the slope or areas of potential stress concentration.

3.4. The overlaps between panels shall be 10 cm for fusion welding and 7,5 cm for extrusion welding.

3.5. Immediately before welding start the overlaps shall be dry and clear.

3.6. Trial seams

- Trial seams are done to verify the equipment and the operator. This verification shall be made at the beginning of each seaming period (start of day, midday and anytime equipment is turned off and allowed to cool down) for each seaming equipment used. Trial seams shall be done under the same conditions as panels' seams.

- The trial seam sample shall be 1 m long and 0,30 m wide, with the seam centered lengthwise. The seam overlap shall be 10 cm for hot wedge welding and 7,5 cm for extrusion welding.

- From the welding sample shall be cut five (2,5 cm wide and 30 cm long) specimens to be tested respectively in shear and peel, using a field tensiometer. These samples should not fail in the seam. If one specimen fails, the entire operation shall be repeated and the equipment and its operator should be accepted only when all lacking be corrected and the test is well done.

- In cases of "fish mouths" or wrinkles at the seam overlaps, they shall be cut along the ridge of the wrinkle, in order to achieve a flat overlap. The geomembrane portion cut shall be seamed and any portion where overlap is inadequate shall be patched with an oval or round patch of the same geomembrane, extending a minimum of 15 cm beyond the cut in all directions.



6. Field Tests Procedures

6.1. Non-Destructive Seam Testing

All field seams shall be tested over its full length. Non-destructive testing check the integrity of the weld by using air-pressure testing to the fusion welds, vacuum testing to extrusion welds and sometimes the spark test for some extrusion one. These testing shall be carried out at the same time the seams works as.

- Vacuum Testing

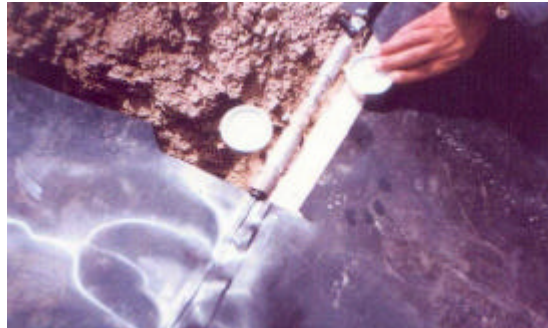
It consists of placing the vacuum box assembly over a wetted area, with a soapy solution, and compress. Create a vacuum of 20 kPa, having ensured that a leak tight is done. For a period of 10 -15 seconds observed the geomembrane through the viewing box for the presence of soap bubbles. If no bubbles occur after this time, one move the box the next adjoining area with a minimum of 7,5 cm overlap and one repeats the process. The areas where have bubbles formation shall be marked and repaired and then retested.

- Spark Test

It is used when the seam cannot be tested by vacuum test, as irregular surfaces or curves. In this test, one puts a thin conductor wire through the superior geomembrane edged with the diameter smaller than its thickness, so that when the extrusion weld is done it keep in the seam. A device similar to a metal brush, connected to a 20 kV electric source, shall be guided through the seam. If there is defect in the seam there will be a spark.

- Air Pressure Testing

It is done through the tunnel created by the fusion weld, energizing the air pump to a pressure between 160 to 200 kPa, sealing both ends of the seam and inserting the pressure feed device in one of them. One energizes the air pump to a pressure between 160 and 200 kPa and close valve. Allow 2 minutes for the injected air to come to equilibrium in the channel, and sustain pressure for approximately 5 minutes. The loss pressure cannot exceed 30 kPa. If the loss pressure exceeds this limit value, the faulty area shall be locate, repaired and retested.



6.2. Destructive Seam Testing

The purpose of these tests is to evaluate the seam strength by specimens 2,5 cm wide and 30 cm long, with the seam centered lengthwise. The tests shall be done to five specimens. Destructive tests should be minimized to preserve the integrity of the liner. Usually these test are done once per 150 m of seam length, but is recommended to follow the design specifications. These tests shall follow the standards recommendations ASTM D 4437, ASTM D 413, ASTM D 3083 and ASTM D 638, and to attend the two basics properties:

- **Shear Testing**

Consists in apply a tensile stress from the top sheet through the weld and into the bottom sheet, at a speed depending on geomembrane raw type, and register the maximum resistance and location the fail occurs. This property is verified by ASTM D 3083 modified according to NSF54 – Appendix A. In this test to take the adequate resistance, one recommend results upper then 80 to 95 % from geomembrane yield resistance. There are designs that specify 95% of the geomembrane yield stress.

- **Peel Testing**

It peels the top sheet back against the overlapped edge of the bottom sheet in order to observe how separation occurs. This test is verified by ASTM D 413 modified according to NSF54 – Appendix A. One considers attended the resistance if the result be greater than 70% of the geomembrane yield resistance.

Pass – Fail Criteria

1. For out five specimens shall be considered approved.
2. The specimens shall not fail within the seam area. The fail shall be by geomembrane tear FTB.



Installation Quality Control

The installer shall prove the installation quality by presentation tables with register of all tasks executed, including the non-destructive and destructive tests.

Quality Assurance Inspection

The Quality Assurance inspection shall verify all installation steps at the same time the works are going executed. One shall check if the steps follow the design specifications and standards. One suggests verify the follow items:

1. Surface condition immediately before the geomembrane placement
2. Geomembrane deployment and panel's identification
3. Temporary anchorage
4. The anchor trench conditions and the geomembrane placement in it
5. Welding equipments type and operation conditions:
 - Fusion welding
 - Extrusion welding
 - Hot air apparatus
6. Quality Control tests devices
 - Air pressure
 - Vacuum test
 - Spark test
 - Tensiometer
7. Fusion welding seaming
8. Extrusion welding seaming
9. Repairs
10. Pipe penetrations
11. Seam crossing
12. As built
13. Documentation
 - Panel's deployment identification
 - Seaming control
 - Non-destructive and destructive tests
 - Daily report