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RENOLIT

1. INTRODUCTION

1.1. Scope of the Work

The estimated reserve of water is 1.500 billion m², but only 0,3 % is usable fresh water. 97,3 % of the water is salty, 2,15 % appears as polar or glacier bound water, 0,65 % is in the ground water table or shows up as water on the surface. Around 12 millions of people die yearly due to lack of potable water.
These numbers tell us it is time to act : too much water is wasted and polluted without reason, water which could save human lives.
A very effective method to conserve water is to build water basins for multiple uses. The water can be used as drinking water or water for irrigation, all purposes to save lives.
It also makes sense to apply in addition a floating cover to protect the stored liquids.
The purposes of such floating covers are to protect against:
- the evaporation of water
- the pollution of water
- the pollution of the environment
- the dilution of stocked liquids through rain water

This kind of geomembrane has been used for such purposes for over 20 years, it is mainly made out of soft PVC-P with an integrated Polyester grid. Also geomembranes with a base of PP and flexible PE can be used as floating covers. The technology of assembling this membrane is independent of the thickness. The usual welding technologies used are hot-air, hot-wedge and welding with liquid solvents.

1.2. Products of RENOLIT

RENOLIT presents a large offer of suitable plastic sheeting to carry out the waterproofing of water reservoirs, floating covers and similar projects:

- RENOLIT ALKORPLAN PVC-P geomembranes
- RENOLIT ALKORTENE PE geomembranes
- RENOLIT ALKORTOP PP geomembranes

The following type of projects can be carried out with the above mentioned products:

- Irrigation basins
- Artificial lakes
- Fire fighting ponds
- Drinking water basins
- Waste disposals for different waste (basic waterproofing as well as cover)
- Canals

- o Retention basins for all kind of liquids (rainwater, chemical products and similar)
- o Floating covers
- o Dams

1.3. Requirements on the waterproofing materials

The quality of the waterproofing depends on:

- **o** choice of geomembrane
- **o** waterproofing system including the preparation of the ground
- **o** how the work is carried out (ground, drainage, waterproofing system, protection).

1.3.1. Water tightness

Depends on the definition of geomembrane (product group, thickness) in order to withstand all influences (pressure, condition of underground).

1.3.2. Flexibility

This question has to be taken into consideration during projecting. Depending on the form, angles and settlements of the construction the type of membrane has to be chosen.

1.3.3. Chemical resistance

The waterproofing has to resist against the chemical influences of:
- stocked material
- pollution rising from the ground due to changing water levels of the water table.

1.3.4. Compatibility to drinking water

In case the waterproofing has to serve in connection with drinking water the geomembrane has to correspond to the national standards.

1.3.5. Geography

The described waterproofing systems are suitable for all geographical regions and climate zones. In any case it is recommended to ask for technical advice from the technical team of RENOLIT concerning questions of choice of material, situation concerning UV radiation or cold temperatures.

2. GEOMEMBRANES OF RENOLIT

2.1. Geomembranes RENOLIT ALKORPLAN

The type RENOLIT ALKORPLAN represents all geomembrane of soft, homogeneous and reinforced PVC-P.

2.1.1. References of Geomembranes RENOLIT ALKORPLAN

- 35052, drinking water geomembrane. Light grey or dark grey. Homogeneous and reinforced with protection against UV radiation.
- 35254 PES, reinforced geomembrane for floating cover and hydraulic works. Light grey or dark grey with protection against UV radiation.
- 35053, geomembrane for hydraulic works. Light grey or dark grey. Homogeneous without protection against UV radiation.
- 35054 / 35254, geomembrane for hydraulic works. Light grey or dark grey. Homogeneous with protection against UV radiation.
- 02339 geomembrane for hydraulic works, homogeneous with protection against UV. Dark grey or black.
- 35038, geomembrane resistant against temporary influences of hydro carbonates and can be applied directly in contact with bitumen (non UV resistant). Black.

The above mentioned geomembranes can also be produced:

- With reinforcement (polyester grid or glass fibres).
- Fleece backed with a PES (polyester) or PP (polypropylene) geotextile.

The mechanical characteristics change due to the reinforcement and/or the fleece backing.

2.1.2. Properties

RENOLIT ALKORPLAN geomembranes are PVC-P soft membranes, calendared or extruded, enrolled on a hard box, width of 2,05m.

- No point of yield will be reached before breakage: after elongation under stress, PVC-P is able to relax and adapt to the ground.
- High performance concerning bi-directional deformation due to its elasticity (>170%).
- Very high resistance against hydrostatic puncture (>950 kPa/mm).
- Good resistance against chemicals like acid bases and salts, aging, roots and against environmental influences.
- PVC-P Geomembranes resist permanent contact of pH levels between 2 and 10.
- Geomembrane without UV protection can resist 1 month in direct exposure to UV radiation without loosing its mechanical characteristics.
- UV protected geomembranes may be used for permanent exposure to sunlight.
- Very good weld ability with hot air hand welder (type Triac) and automatic machine (hot wedge and/or hot air), even after many years of use, with large window of temperature and speed.
- Limited thermal dilatation : 1.5 10-4 cm/cm/°C
- Very good angle of friction (+- 28°).

2.1.3. Characteristics

See technical data sheets.

2.2. Geomembranes RENOLIT ALKORTOP

This type of geomembrane is made of flexible Polypropylene.

2.2.1. References of RENOLIT ALKORTOP geomembranes

03550, homogeneous geomembrane, black, extruded, 5.80 m and 6.00 m width.
35080, homogeneous geomembrane, grey, calendared, 2.10 m width.
35086, reinforced geomembrane with Polyester grid, grey, calendared, 2,10 m with, UV resistant.
35087, reinforced geomembrane with glass fiber, grey, calendared, 2,10 m width, non UV resistant.

2.2.2. Properties

Geomembranes made of flexible PP, homogeneous or reinforced.

- FPP is less flexible than PVC-P.
- A pseudo yield point can be observed after a certain elongation of the material (+-40%).
- Homogeneous geomembranes show good performance concerning bi-directional deformation due to their relative flexibility, especially in cold temperatures.
- Good chemical resistance.
- Medium hydraulic puncture resistance (600 kPa/mm).
- FPP can be welded with hot air and hot wedge automatic machines and with hot air hand welder, with a narrow window of temperature.

2.2.3. Characteristics

See technical data sheet.

2.3. Geomembranes RENOLIT ALKORTENE

This type of geomembrane is made of Polyethylene (PE)

2.3.1. References of RENOLIT ALKORTENE geomembranes

- 00251, geomembrane HDPE, black
- 00274, geomembrane LDPE black

2.3.2. Properties

Geomembranes made of PE, extruded, black.

- High resistance against chemical influence, especially hydro carbonates, acids and bases.
- Not resistant against active oxygen.
- Capability of deformation is reduced due to its low flexibility, especially on uneven and rough ground.
  To initiate an elongation of the material, substantial power has to be applied due to its stiffness. After an elongation of around 8% (one-direction) the point of yield is reached and the material starts to flow. The

elongation happens at the weakest point of the material until breakage. In the flowing state HDPE is very sensitive to any mechanical influence.
- Medium hydraulic puncture resistance (675 kPa/mm).
- Poor friction angle (+- 18°)
- High thermal dilatation (+- 2.6 10-4 cm/cm/°C)
- PE-HD has to be welded by hot air or hot wedge welding machines with high pressure. Details have to be welded by extrusion. It is not possible to weld this material by hand with hot air.

2.3.3. Characteristics

See data sheets

2.4. Accessories

Geomembranes are the most important part of a waterproofing system. To make it function in a correct way different accessories, depending on the type of construction is being water proofed, complete the whole system. All accessories have to be compatible with the used geomembrane.
Following accessories are part of such a system:

- Protection layer (geotextile, plastic sheeting made of regenerates and similar)
- Drainage layer (all kind of geo-grids)
- Fixation elements (laminated metal sheet, water stop, inoxidable metal plates, anchor and more)
- Floating elements (Polystyrene blocks)
- Weights (steel bars with plastic cover, sand bags welded in geomembrane)

2.5. RENOLIT Production

The whole procedure of production including the management and the purchase of raw materials has to conform to the demands of ISO 9001.
The control of production starts with the supply of raw materials, the proceeds to the laboratory responsible for the mixing of the compound, then goes to production, the logistic department and also the management department.
After the mixing and melting unit the compound is transported to the calendaring or extrusion unit. After numerous calendaring drums the final membrane, controlled by many electronic devices for thickness, heat and speed is extracted and rolled.
The production of geomembranes suitable for drinking water requires a very careful procedure. The mixing unit has to be completely emptied and clean of rests of recent production, in order not to influence the quality of the geomembrane.
A PES reinforced geomembrane is produced on laminating machinery where the Polyester grid is introduced between two layers of geomembrane. Exact heat and pressure are important to receive a perfect lamination between the 2 layers of geomembrane and the Polyester grid.

2.6. Geomembrane recommended

RENOLIT group manufactures and markets a complete range of PVC-P, PE or PP geomembranes in response to a wide variety of applications. Experience has shown that the geomembrane PVC-P reinforced with a polyester scrim is one of the best suited to achieve a floating cover due to its excellent mechanical behaviour, weldability, resistance to UV and durability : RENOLIT ALKORPLAN 00414.
If necessary, the geomembrane is also available with a special formulation for storage of potable water: RENOLIT ALKORPLAN 00312.

3. INSTALLATION OF FLOATING COVER

3.1. Conception of Floating cover

The floating cover is composed of a reinforced geomembrane in which are incorporated floaters and weights. The floaters and weights are placed on the geomembrane to adjust the size of the floating cover regardless of the level of water in the basin in order to ensure always its tension on the water surface.
The size of the floating cover corresponds to the size of the basic lining of the basin. After the installation the liquid will be pumped between the basic waterproofing and the floating cover.
In case a floating cover is projected after the basin has been filled with liquids, it can still be installed afterwards.

3.2. Technical Approach

The target of the technical solution is to avoid as many dangers as possible which could cause the waterproofing system to fail, as for example.:
- Hand welding on site
- Reduction of T-crossings to a minimum
- The use of materials that are not compatible with each other

A maximum use of machine welding reduces the possibility of failures in the assembling of the panels in an important way.

3.3. Preconditions for the installation of the lining system

- Basic waterproofing of basin is completed.
- Preparation of clean area outside the basin to execute prefabrication.

3.4. Installation

3.4.1. Prefabrication

It is absolute recommended to prepare as much as possible in prefabrication. Especially the sections with floaters and weights have to be prepared in prefabrication. To work in the inside of the basin endangers the basic waterproofing. The prefabrication of panels should take place possibly in a hall with flat and clean surfaces.

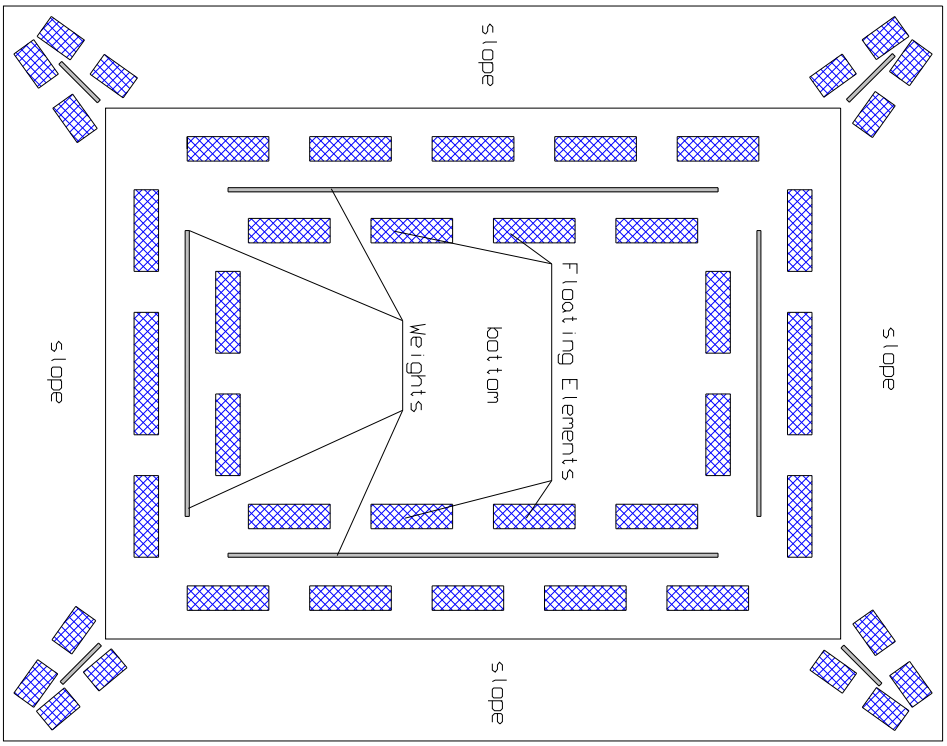
When panels of the floating cover are assembled inside the basin precautions have to be taken not to damage the basic geomembrane. During welding process an additional strip of geomembrane under the welding area helps to avoid damage to the geomembranes. Prefabricated panels have to be welded together with a welding machine; each welding is controlled by air pressure and noted on a welding protocol.

Prefabricated and folded panels

Welding protocol of prefabricated panel

3.4.2. Installation on Site

Floaters and weights have to be positioned at the correct places of the floating cover in order to work properly with changing water levels. The placing of floaters and weights depends on the geometry of the basin. The distance of weights from the floaters depends on the highest water level of the basin.



Position of floaters and weights in rectangular basin

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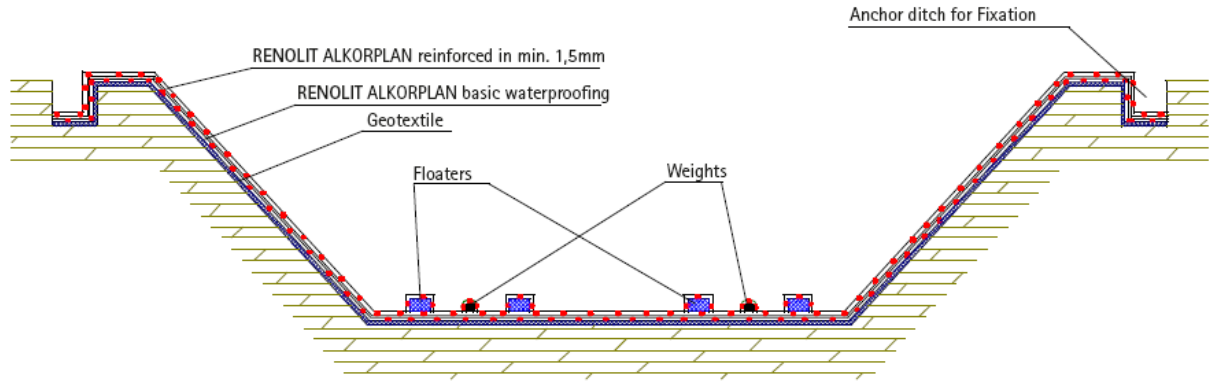
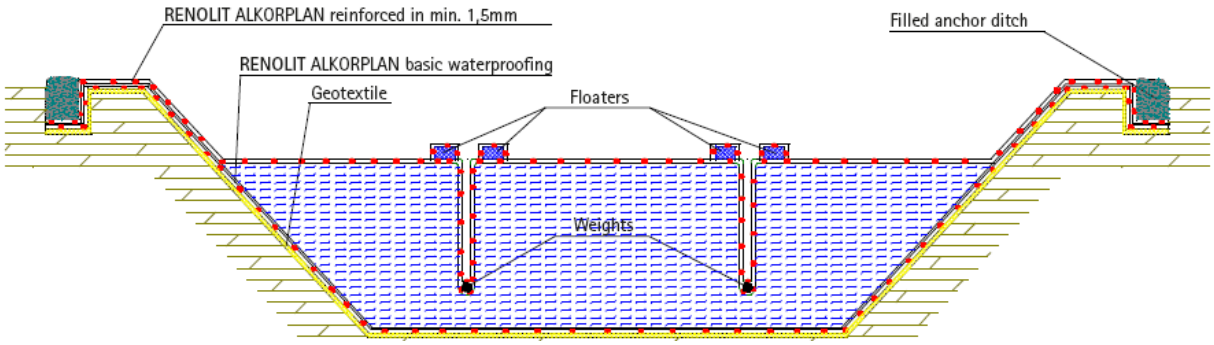
Different positions of floaters and weights

The usual procedure of installing the floating cover is when the basin is empty.



Completely installed floating cover



Floating cover with high water level

Floaters:

Floating elements keep the geomembrane on the surface of the liquids. They are made of polystyrene and are fully dressed with geomembrane. They are welded to the cover in an optimal position. The floaters are designed in size and number depending on the surface and the weight of the floating cover (thickness of geomembrane).

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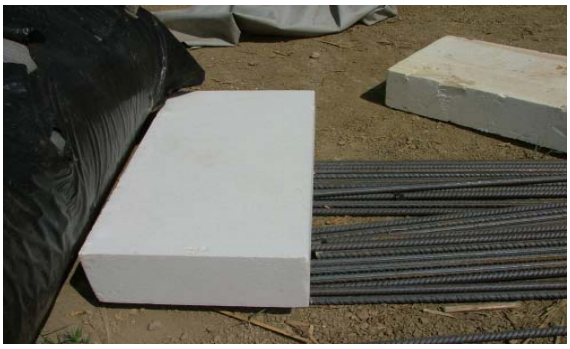

Floaters

Weights:

Their task is to adjust the floating cover in order to keep it flat and straight regardless of the water level. Different materials can be used as weights, sand bags and steel bars are the most common. The weights have to be protected – as the floaters – with geomembrane or plastic tubes.

Sand bags

Plastic tubes

3.4.3. Fixation

The floating cover has to be fixed at the crest of the basin. This can be done in different way, depending on the construction plans.

Generally the geomembrane will be placed into an anchor ditch which is filled with sand and backfill.

In case the perimeter is made of concrete the floating cover is fixed with a flange construction between two compressible layers.

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Anchor ditch

Mechanical fixation

3.4.4. Details

To complete the system of a floating cover some other installations have to be introduced :

- Aeration and evacuation of gas:
  Depending on the stocked material it is necessary to install hoses to prevent the development of polluted air or gas.

Aeration and evacuation of gas

- Inlet for rainwater:
  It is recommended to foresee inlets for rainwater in case the stocked liquid allows it. In case the stocked liquid may not be diluted with rainwater it can be evacuated with pumping from the canals created by the weights.

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Rainwater inlet *Evacuation of rainwater from deepest point*

- Man-hole:
  Basins covered with a floating cover also need maintenance for repair, cleaning and other services. For this reason man-holes have to be installed in order to enter under the floating cover. This man-hole is a special construction placed on floaters and fixed with a flange construction. Due to the strength of the geomembrane it is possible to walk on the floating cover.

Man-hole

Walking on the floating cover

3.4.5. Installation of floating cover on filled basin

In case the floating cover is installed when the basin is already filled the prefabricated floating cover will be pulled over the filled basin. To make this procedure possible a floater (number depends on the size of the basin) will be positioned under the floating cover during the installation process. The floater has the task to keep the floating cover over the liquid.

Installation floater under floating cover

To be able to pull the floating cover without damaging it loops have to be welded to the side of the geomembrane.

Loops for pulling the floating cover

pulling process

This procedure of installation happens in the case of an existing basin already filled and can not be emptied, which is frequently the case in the chemical industry.

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4. CONSTRUCTION QUALITY CONTROL MANUAL

This manual addresses the quality Control Program to assure the quality of workmanship and the installation integrity of geomembranes and other geo-synthetic products.

4.1. Material Delivery

A representative should be present, whenever possible, to observe and assist in material delivery and unloading on site. The representative is to note any material received in a damaged state and to remove any necessary conformance samples. Upon mobilisation to site a representative shall:

- Verify the equipment used on site is adequate and does not risk damage to the geocomposite or other materials.
- Mark rolls or portions of rolls which appear damaged.
- Verify that storage of materials ensures adequate protection against dirt, theft, vandalism, and passage of vehicles.
- Ensure that rolls are properly labelled and that labelling corresponds with QC documents.
- Complete roll numbers, date, roll size and any damage and log this in the Material Delivery Checklist.

4.2. Geomembrane Installation

The general contractor shall be responsible for preparing the concrete surface suitable for installation of the liner unless specifically agreed otherwise.

4.2.1. Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and general location of field seams for the project.

4.2.2. Identification

Each panel used for the installation will be given a number which correlates with a batch or roll number. This panel identification number shall be related to the panel placement form, which will be used when required. A plan given by the contractors shows the straight sections of the canal that are in condition, identifying these specific rolls for controlling, identifying and deliberating for the prefabrication works.

4.2.3. Field Panel Placement

4.2.3.1. Weather conditions

Geomembrane deployment will generally not be done during precipitation, in the presence of excessive moisture, in an area of

standing water, or during high winds.

4.2.3.2. Location

The installer will attempt to install field panels as indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location will be noted in the field.

4.2.3.3. Damage repairs

Any area of a panel seriously damaged will be marked and repaired in accordance with Paragraph 2.4 of this document.

4.2.4. Geomembrane Field Seaming

4.2.4.1. Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam as described in Paragraph 2.6

4.2.4.2. Equipment

a) Welding in Prefabrication

Before starting the daily welding work a trial has to be executed in order to regulate the welding equipment concerning the important parameters such as temperature and welding speed. The used welding machine is a device applied for lining works of flat roof (Type Leister Variant or X 10). The welding machine produces simple seams.

b) Welding on site with hot wedge welding machine

This type of machine delivers welding with testing canal. It will be employed for the assembling of geomembrane and the prefabricated panels.

c) Hand Welding

T-joints, transversal strips, connection of geomembrane of the slopes with bottom elements in areas of curves, and details have to be executed by hand welding. Recommended device is a hot air hand welder from the Leister company. Hand welding with hot air only can be used in connection with PVC-P and PP geomembranes. PE geomembranes will be welded with the help of an extrusion welder.

4.2.5. Seam preparation

The overlapping of the geomembrane has to be done in such a way that a safe welding with the machine is guaranteed and has to ensure a welding of 30 mm for simple welding, and 40 mm for the double welding.
Clean the seam area prior to seaming to ensure the area is clean and free of moisture, dust, dirt, and debris of any kind.

Adjust the geomembrane (panels) so the seams are aligned with the fewest possible number of creases.

4.2.6. Trial welding

Every working day - before starting the seaming works - the machinery has to be checked and adapted following the daily circumstances (temperature, air humidity). This is done through daily trials to determine speed and temperature of the welding equipment, as well as pressure applied on the seam for the hot wedge machine. These parameters should not be changed during the day unless the weather conditions change drastically.

Trial Welding

4.2.7. Samples Procedure

Cut 2 of 2,5 cm wide specimen and proceed to carry out a peeling test with a field traction device. The welding may not separate; the specimen must show the break of the material.

Testing device and testing specimen

4.2.8. Seaming Documentation

The welding technicians have to fill out all important parameters into the form of seam control:

- outside temperature in the morning, at noon and in the evening;
- data like welding temperature, pressure and speed of the machine determined through the daily testing procedure (controlled through peeling test and tear resistance);
- time of beginning and ending of welding works;
- numbers of the seam;

- o data of the welding result after testing (reduction of pressure after 15 minutes of testing);
- o destructive tests of welding seam (peeling test and tear resistance);
- o repair measurements if seams do not pass the test;
- o signature of representative of the client and the installer.

4.3. Seam Testing – Geomembrane

4.3.1. Control of seams executed in prefabrication

4.3.1.1. Double seams

Double seams are controlled through air pressure. The air canal has to be closed on both sides of the testing distance. A testing needle (e.g. type Leister) is introduced into the testing channel. The needle has a conical form to avoid the evacuation of the air under pressure. During the testing time the needle may not be removed or manipulated. The applied testing pressure depends on the thickness of the geomembrane and the outside temperature. The testing has to be done one hour after execution of the welding. The applied pressure may not decrease more than 20 % for PVC-P geomembranes.

4.3.1.2. Simple seams

In case of a single seam, a steel pipe connected to a compressor with a diameter of 3 to 4 mm is drawn along the seam under an air pressure of 5 bars. This kind of testing is only suitable for flexible geomembranes not for PE. Leakages are immediately detected through the developing air bubble caused due to the applied air pressure.

4.3.2. Control of double seam on site through air pressure

See point **4.3.1.** Control of seams executed in prefabrication.
After successful testing, a patch of geomembrane has to be welded over the penetration hole of the testing needle. The testing data will be noted in the testing document.

4.3.3. Control of hand welding

Follow the procedure of control of seams described under Paragraph **4.3.1.2.** Simple seams. Repair patches and short hand seams are easyly controlled with a vacuum bell.

4.3.4. Repair of detected leakage

The detected leakages have to be repaired with homogeneous geomembrane patches. This welding has to be tested following the procedure mentioned under **4.3.3.** Control of hand welding.

4.3.5. Destructive testing (Pealing test)

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

- Depending on the size of the project it will be determined after how many meters of welding a pealing test has to be executed. A test sample will be extracted by noting date, time and location.
- Destructive samples should be taken and tested as soon as possible after the seams are welded after one hour in order to receive test results in a timely manner.
- All destructive test locations with pass/fail designation will be marked on the geomembrane with permanent mean streak markers.

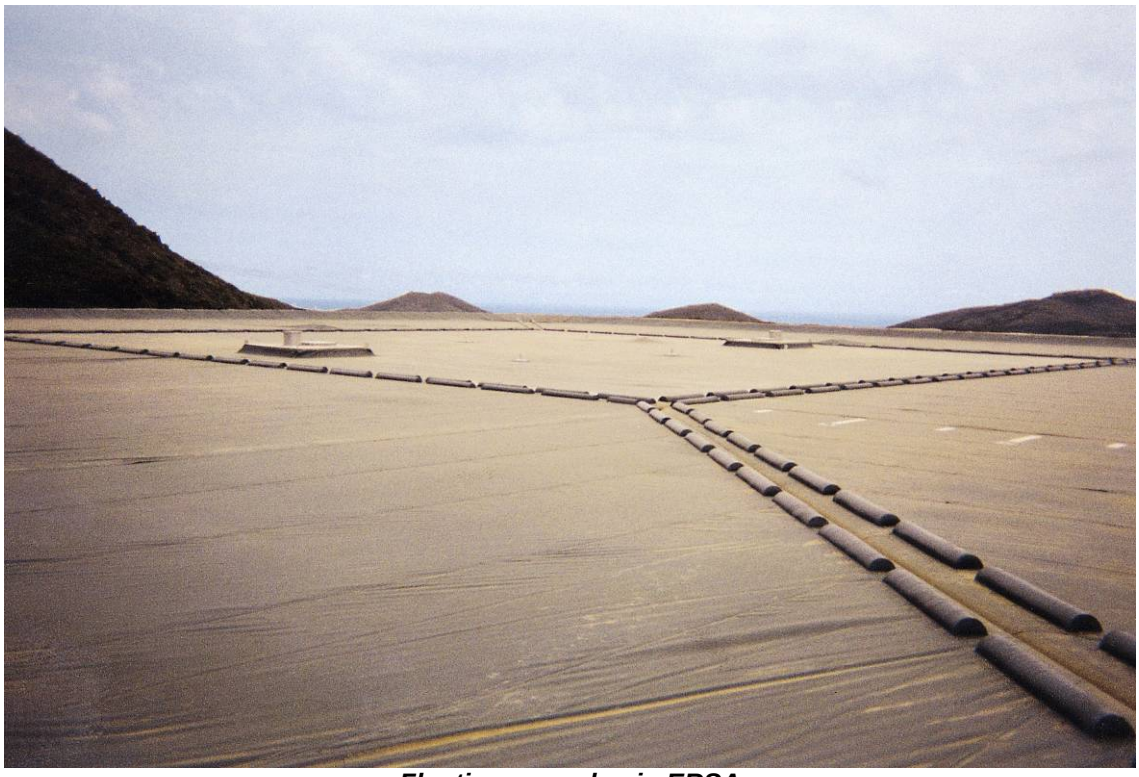
Testing method:

The material has to break outside of the welding area. Following values are recommended:

- PVC-P and PP geomembranes: > 4 N/mm for machine welding
  > 3,5 N/mm for hand welding
- PE geomembranes > 15 N/mm

5. CONCLUSION

The planning and installation of floating covers is a highly technical work. Only experts are allowed to carry out the welding works.
The technical support from the side of RENOLIT Ibérica S.A, starting already at the design of the project until the end of the waterproofing works is a guarantee of delivering a successful work. The experience is high and is an advantage for the client. Many projects have been successfully executed in the past as shown from the long list of references.



Floating cover basin ERSA

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