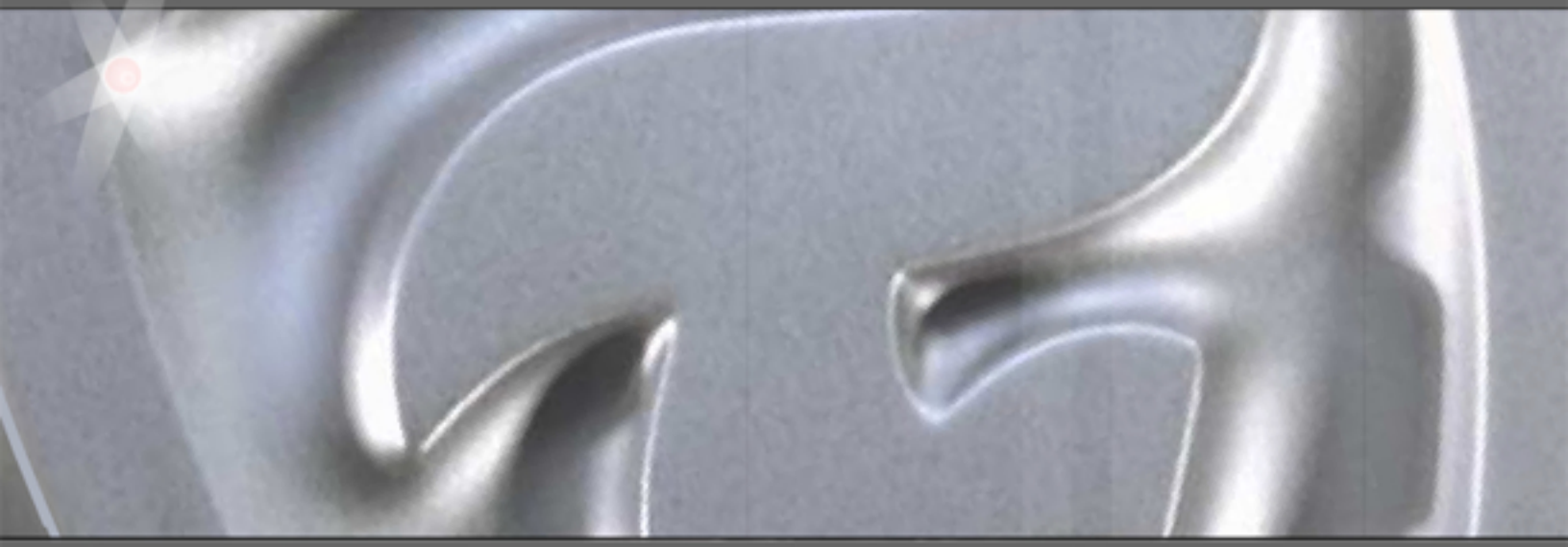

Firestone

BUILDING PRODUCTS EUROPE

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Table of contents

Introduction

This manual contains information on lining systems using **Firestone EPDM Geomembranes**. Apart from general recommendations on the use of the Geomembrane, it also gives information on site preparation and excavation works.

At first sight, the design and the execution of a hydraulic construction may look simple. For this reason, the contractor, the designer and the builder may be in for a rude awakening if all the parameters regarding the design and the installation are not taken into account.

Generally, for simple projects, the design may be carried out by the owner or the contractor.
However, in the case of larger ponds the problem is often considerably more complex, and the contractor should request the advice of a specialist in hydraulic structures. The specialist should be able to answer specific questions on excavation, drainage, protection of the liner, etc.

Before initiating any project, a study of the site should be carried out for the purpose of obtaining correct information regarding :

- *Nature of the soil*
- *Presence of cavities (chalk rocks, chalky soil,...)*
- *Depth and variation of the groundwater level*
- *Presence of gases in the soil (peat, organic matter,...)*
- *Risk of differential settling (poorly consolidated soil, recent backfill,…)*
- *Risk of internal erosion (karst soil, sand,...)*

In any case, the rules of soil mechanics must be complied with in order to ensure the stability of the support and consequently, a durable lining system. All these subjects are covered in the first part of this manual.

The second part of this manual deals with the installation of the Firestone Geomembrane System. This section covers site preparation, compaction of the soil, installation of the drainage, installation of the Geomembrane, splicing , jointing and execution of details.

Finally, the manual is completed with 3 attachments dealing respectively with :

- *Attachment 1 : Technical data sheets*
- *Attachment 2 : Installation tools*
- *Attachment 3 : Chemical resistance chart*

The Firestone Geomembrane must be installed by an authorized Firestone contractor in accordance with Firestone's specifications. It is also essential that all regulations and codes are complied with.

1 • Design

1.1. Field of application

The recommendations in this manual mainly apply to decorative and landscape ponds, agricultural ponds, canals and other water features.

Applications where gas generation or hydrostatic pressure might disturb the function of the Firestone Geomembrane must be avoided, as well as projects where the Geomembrane could be in contact with chemical substances that could affect the Geomembrane.

1.2 Geomembrane selection

The Firestone Geomembrane is a synthetic rubber membrane. The panels are assembled in the factory prior to vulcanization, in order to limit on-site splicing. The rubber sheets are folded and packed on 3,30 m long cores. Each roll is labelled with the brand name, thickness, dimensions, date and production lot, as well as an arrow indicating the direction for unrolling.

The sheets are available in the following ticknesses and sizes :

- *thickness (mm) : 1,02 - 1,14 - 1,52*
- *width (m) : 3,05 - 6,10 - 7,62 - 9,15 - 12,20 and 15,25*
- *length (m) : 30,50 - 45,75 and 61,00*

The 1.02 mm thick Firestone EPDM Geomembrane is specifically designed for decorative pond applications. It is commercialized under the trade name **Firestone Pond Liner™**.

Because of its specific formulation and production process, **only the Firestone Pond Liner™ membrane is guaranteed to be compatible with aquatic life** in accordance with testing reports published by the Water Research Centre in the UK.

1.3 Site selection

When selecting the construction site, several elements must be considered to ensure long-term performance of the lining system and to avoid any future problems. Site selection is the responsibility of a specialist engineer.

The following is a general overview of a few of the critical site selection parameters which should be investigated:

1.3.1 Nature of the soil

A thorough investigation of the site must be carried out in order to ensure underlying soil stability under all circumstances.

The type of soil, permeability and thickness of the geological strata under the Geomembrane must be known. The table below outlines some risks associated with general soil type:

Soil Type	Risk	Solution
• Compressible (peat, fine sand, ...)	• Considerable gas generation • Pressure under the Geomembrane	• Gas drainage • Slope must be adapted to facilitate gas drainage
• Loose backfill	• Settling • Over-consolidation of the backfill materials	• Appropriate compaction
• Soil containing organic matter (old sugar or paper industry ponds, landfill)	• Fermentation • Pressure under the Geomembrane (gas)	• Gas drainage
• Soil with internal erosion hazard (backfill material containing waste, limestone-type soil, gypsum chalk)	• Dissolution of the soil by liquid in case of a leaking system • Collapse caused by eroding water circulation	• Change sites or provide a good geological assessment in order to find cavities, if any • Special compaction or double waterproofing layer
• Volcanic soil (soft clay, compressible silt)	• Absorption capacity • Differential settling provoking tearing of the Geomembrane at the splices	• An intermediate layer • Particular drainage and special compacting around the details

1.3.2 Groundwater level

If the groundwater level is higher than the bottom of the water feature, the Firestone Geomembrane System will be subject to hydrostatic pressure. Also, air may be entrapped, causing gas pressure if the ground water level rises.

For this reason, the depth of the groundwater level must be known (both the average level and the extreme level). If the groundwater level exceeds the level, the Geomembrane risks being lifted and the functioning of the gas drainage system can be disturbed. In this case, an appropriate drainage system under the Geomembrane must be provided. Groundwater drainage systems must be designed by the project engineer.

1.4. Site geometry

1.4.1 Bottom

A fall of 2 % is recommended for the following reasons:

- *Correct operation of the drainage system*
- *Easy maintenance of the pond (if unprotected)*
- *Positive gas movement*

The fall becomes more important the larger the pond surface, and must be adapted to the calculated settling level.

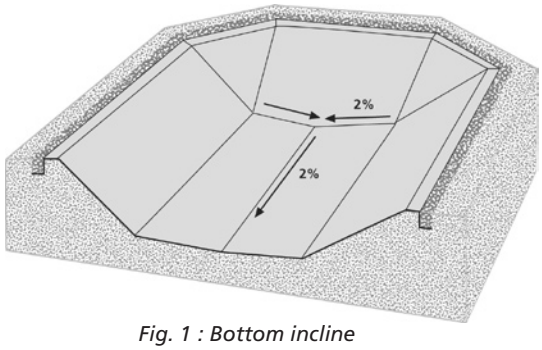

Fig. 1 : Bottom incline

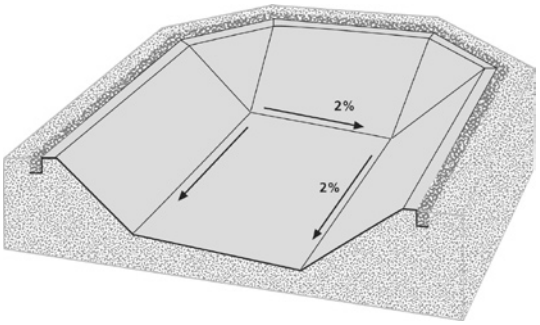

Fig. 2 : Bottom incline

1.4.2 Embankment incline or side slopes

Stability of the embankment is a geotechnical issue. The presence of groundwater and the nature of the soil play an important part in the stability of the embankment. The Firestone Geomembrane must not be used to provide stability of the embankment.

The stability study must deal with the following:

- *Stability of the drainage system and of other layers between the bottom of the pond and the Geomembrane*
- *Effects of waves*
- *Consequences of rapid drop in water level*
- *Consequences of excessive leakage*
- *Stability of the Geomembrane protection layer, if any*
- *Ease of installation*

If no slope stability study is carried out, the contractor shall provide a minimum slope of 2/1.

If the height of the embankment above the base of the pond is between 5 and 10 m, a slope of 3/1 is recommended.

The values mentioned in the table below may be used as a general guide. These values are given according to the nature of the soil. They should be considered with extreme care for the reasons mentioned above.

Nature of soil	Incline
Clay soil	2,5 H/1 V
Clay and sandy soil	2-3 H/1 V
Sandy gravel	2 H/1 V
Soft rock	1,5 H/1 V

1.4.3 Embankment crest (top of the slope)

The embankment crest must have a minimum width of :

- *1,0 m for installation of anchor trench*
- *3,0 m if machines or vehicles are used during the construction and operation of the water feature*

If such width cannot be obtained, alternative anchoring methods must be used. Also a slight incline of 1% towards the outside of the pond is recommended for drainage.

1.4.4 Maximum length of the pond

Waves created by the wind or by boats cause an impact on the side slopes. The greater the length of the pond in the direction of the prevailing winds and the steeper the slope of the embankment, the stronger the wave action will be.

Wave impact can be reduced by :

- *Building a smaller but deeper pond*
- *Selecting another shape, with a shorter dimension in the direction of the prevailing winds*
- *Building several smaller ponds, instead of one large pond*

According to the specific height of the waves, the nature of the soil and the slope of the embankments, we recommend the following :

- *Protection of the Geomembrane adapted to the incline (concrete, riprap, soil cover)*
- *Adequate anchoring of the Geomembrane*
- *Adequate compacting of the soil*
- *A geotextile protection under the Geomembrane*

1.4.5 Maximum liquid level

The higher the liquid level in the pond, the higher the hydrostatic pressure. The risks of the substrate layer settling and the Geomembrane tearing are also higher. Even considering the considerable elongation at break properties of the Firestone Geomembrane, cavities may be present in the soil that could cause the Geomembrane to be perforated, especially if the soil contains gravel. To avoid this risk, a fine grained intermediate layer of sand or clean soil and/or the installation of a geotextile underlayment is recommended.

1. 5 Soil preparation

1.5.1 Natural soil

The support (the soil layer in immediate contact with the sheet) must be clean, smooth, compacted, free of aggressive angle changes, stones and small cavities. This layer must also be able to compensate for the differential settling of the soil and to facilitate the installation of the drainage system when required.

The support may be realized in various ways :

- *Excavated pond base after removing stones, rocks, vegetation etc., followed by smoothing and compacting*
- *Backfill layers with controlled particle size which are compacted (sand, stable earth,...)*

Vegetation

All plant growth must be removed from the base prior to compaction in order to avoid any gas generation and compression of the base. According to the conditions, the use of a durable weed killer is recommended. The weed killer must not contain any components which might affect the Lining System.

Compaction

The Geomembrane support must be optimally compacted (to a density between 85% and 95% of the normal Proctor Optimum), either by natural or by mechanical compacting. The compaction at the crest of the embankments must be carried out with the utmost care.

(Note : The Proctor Optimum value corresponds to a state of soil equilibrium between consolidation and swelling.)

Geotextile

Installation of a geotextile between the support and the Geomembrane is recommended. It is an absolute necessity on embankments where deposition of an additional support layer is often difficult. Depending upon the nature of the soil, the weight of the geotextile may vary between 200 and 500 g/m^2.

When the geotextile also has a drainage function, it must be checked for sufficient transmissibility. In such cases, draining geotextiles must be used. Consult the manufacturer of geotextiles for advice.

1.5.2 Hard substrates (concrete, treated soils,...)

On hard substrates such as concrete, it is always necessary to install a protection layer, unless the Geomembrane is fully adhered. On a bituminous support (bituminous concrete, bitumen emulsion stabilized soil), a geotextile of at least 300 g/m^2 must be used.

1.5.3 Soil around concrete structures

The Geomembrane fixed to a concrete structure must absorb any stress caused by soil movements. Therefore, compaction of the natural soil around such structures must be performed with particular care, to limit settling as much as possible. Backfill material around the structure must be compacted to 95% of the normal Proctor Optimum.

1.6 Drainage system

The need for a drainage system depends on local site conditions such as the presence of clay in the soil. In all cases where liquid or gas may cause an instability of the soil, the amount of water in the soil must be limited. This can be done by means of a specific drainage system, or eventually a double lining system with a drainage layer between the two Geomembranes.

1.6.1 Application criteria

The application of a drainage system is not required, if the permeability of the supporting layer exceeds 10^{-4} m/s, or if no gas or water pressure is anticipated. However, in many cases, the presence of a drainage layer allows the rapid detection of leaks.

Water/Gas drainage is always required under the following conditions :

- *When water flows are possible under the Geomembrane, namely in soils where erosion can be possible (karst soil, ...)*
- *Soils containing organic matter (gas generation)*
- *Embankments containing clay (stability when emptying,..)*
- *Whenever variations of the groundwater level can be anticipated*
- *Whenever the Geomembrane is not fixed and can move (wind,...)*
- *Pond containing organic matter*

The figure below summarizes the main causes of pressures under a Pond.

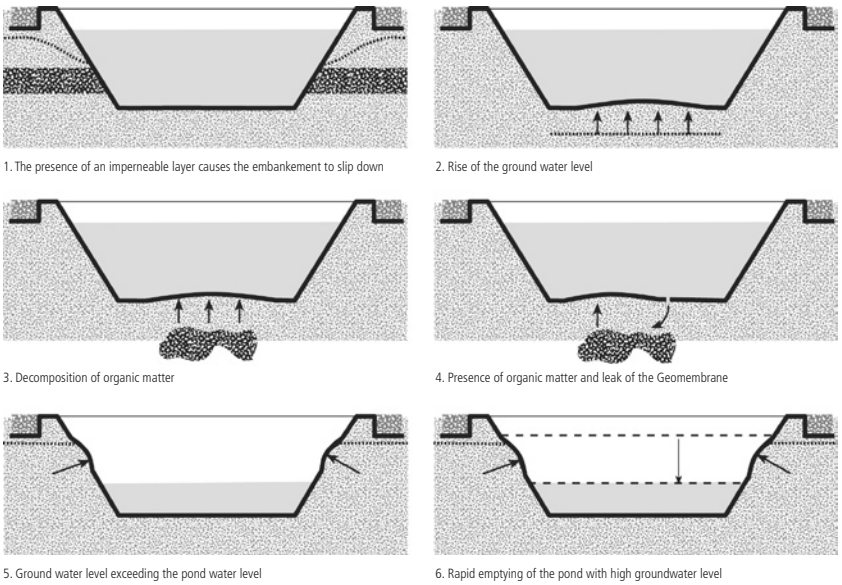

Fig. 3 : Some causes of excessive pressure

1.6.2 Water drainage

Water drainage and gas drainage are often combined. For this reason, a slope of 1 to 2% of the base towards the embankment is recommended.

The water drainage may be implemented by means of one of the following:

- *A layer of permeable material with a minimum thickness of 100 mm*
- *A permeable geosynthetic material*
- *A network of drainage ditches linked to each other covered with a permeable geotextile or a thin layer of permeable material*

In order to prevent the drain blockage, a natural or synthetic filter must be installed between the soil and the drainage layer. Rules for correct filter operation must be complied with. Water must be collected by a network of pipes placed at the lower points of the pond. For larger structures, a compartimentilized drainage network is recommended to facilitate leak detection.

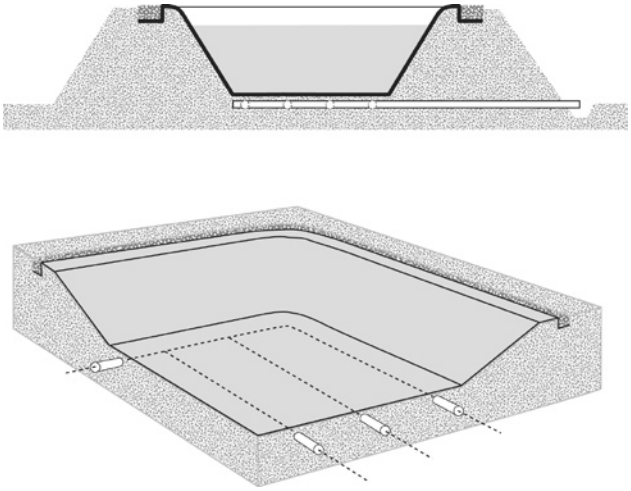

Fig. 4 : Water drainage

Size and gradient of the water drainage system depends on the following factors:

- *Leak flow rate that is acceptable*
- *Flow rate of water coming from outside the pond*
- *Maximum pressures that are acceptable under the Geomembrane*

For smaller projects, the use of perforated drain pipes with a diameter of 60 mm or flat drains is recommended. For larger structures, the size and the density of the network, as well as the compressive strength of the drain pipes must be carefully calculated. Consult the manufacturer for advice.

1.6.3 Gas drainage

The application of perforated pipes is recommended in less permeable soils. A sand bed (or a similar material), a geotextile, or some other permeable geosynthetic material must be placed between the pipes.

A flat synthetic drainage system can be used as an alternative.

Any direct contact between the Geomembrane and abrasive surfaces of the drainage systems must be avoided.

Gas vents are always located at the higher points of the embankment and must be protected by a cap.

Gas drainage must always be designed in such a way that flooding is avoided. All gas drainage systems need to be combined with water drainage.

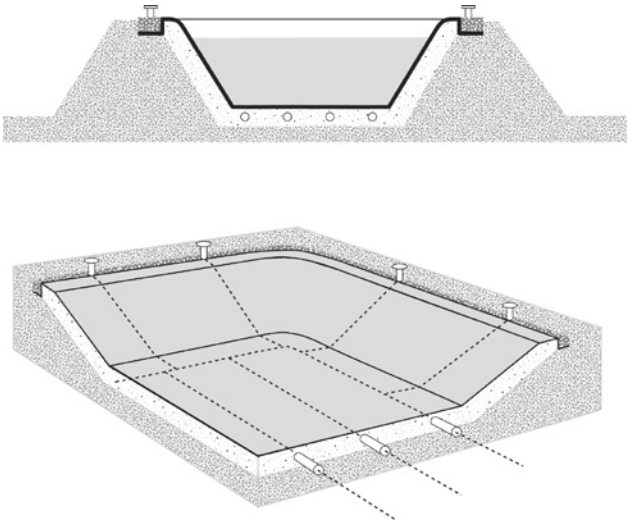

Fig. 5 : Gas drainage

2 • Installation

2.1 Earthwork

2.1.1 Site layout

The site layout may be executed by means of:

- *Excavating natural soil*
- *Building raised embankments*
- *Partial excavation with raised embankments*

The table below shows the advantages and disadvantages of the three systems.

System	Advantages	Disadvantages
Fully excavated	• little soil movement (naturally consolidated) • lowest cost	• removing the excavated earth • water drainage problems
Raised embankments	• easier drainage • the work is above the water level	• higher cost • compacting required • risk of unstable embankment
Partial excavation	• compromise of both systems	• moderate cost

2.1.2 Preparation of the support

All soils supporting Firestone Geomembranes must be compacted between 85% and 95% of the Proctor Optimum value. The compaction is achieved by either natural compaction or by mechanical methods. In the latter case, the material is deposited in layers of 200 to 500 mm maximum and the settling is completed with a vibrating machine or road roller. The compaction operation can be followed by a weed killer treatment.

The supporting surface must not contain any loose stone with a diameter exceeding 5 mm. If the base of the pond consists of soft materials, such as sand or clay, the Geomembrane can be laid directly onto such surface. In most cases however, a geotextile of at least 300 g/m^2 must be installed.

2.1.3 Inspection of excavation work

The contractor must visit the project site to check whether the excavation works have been correctly performed. The surface condition must be controlled and any harmful element removed or adapted. Any correction must be made prior to the start of the waterproofing works.

2.2 Firestone Geomembrane installation

2.2.1 Transport and storage

Care should be taken not to damage the Geomembrane during transport, loading and unloading. The rolls must be stacked on a flat and clean surface, free of sharp protrusions.

Firestone Geomembranes do not require any special protection against weather conditions. However, all accessories need to be stored in a dry and cool place (between 10°C and 25°C), protected against the weather conditions.

2.2.2 Panel layout

If particular site conditions demand so, the contractor must establish a sheet layout. This plan must be made on the basis of the specification and detail plans, and indicate the position of the sheet splices. The on-site layout of the panels must be done according to this plan.

2.2.3 Placing the Firestone Geomembrane

The rolls are unwound and unfolded according to the layout plan. Installation commences with the covering of the embankments. The Geomembrane panels are unrolled from the trench towards the embankment and the Geomembrane is temporarily fixed to avoid it slipping down. Ensure that no pebbles or sharp objects are entrapped under the Geomembrane, whilst the sheets are being unrolled.

While installing the sheets, severe folds in the geotextile and damage of the supporting surface must be avoided to enable the Geomembrane to be manoeuvred correctly. The Geomembrane must be lifted/fluttered at the perimeter allowing air to play underneath, thus moving the membrane on an air cushion.

Excess membrane must be left at the foot of the embankment for connecting with adjoining panels. Horizontal splices on the embankments must be avoided as much as possible.

All Firestone Geomembranes must relax at least 30-45 minutes before splicing the seams or executing details.

2.2.4 Anchoring of the Firestone Geomembrane

The Geomembrane must be kept in place to prevent it slipping down the embankment and/or it being lifted by the wind. Depending upon the situation, the Geomembrane can be anchored in various ways:

- *At the top of the embankment*
- *At an intermediate platform*
- *At the bottom*

Top anchoring

The anchoring must be realized by burying the Geomembrane in a trench or by holding it in place through ballasting. The dimensions of the trench depend on the expected stress. The minimum section should be 0,40 m x 0,40 m in cohesive soil. Moreover, this section depends on the length of the Geomembrane between two anchor points, the distance between a clamping point and the water level, the wind speed, etc.

The Firestone Geomembrane must extend at the bottom of the trench over at least 300 mm.

If considerable soil movements are expected after filling the pond, temporary clamping must be provided at the crest, so that the Firestone Geomembrane can move without being subjected to excessive tension. Partial ballasting in the ditch is immediately provided and final anchoring is done at a later stage.

The pond must be filled prior to filling and compacting the anchoring trench. Filling and compacting the anchoring trench must be performed without subjecting the Geomembrane to stress or being punctured.

In order to avoid movement and lifting of the Geomembrane during installation, a temporary ballast must be used. Such ballasting also facilitates the splicing operations. The ballast can consist of sand bags, tyres or wooden planks.

The table below shows a few practical values for the section in compacted clay soil.

Length of embankment (m)	Section of trench (m^2)	
	Low or medium wind speed (< 100 km/hr)	High wind speed (> 100 km/hr)
< 3	0,16	0,16
3 - 5	0,16	0,16
5 - 15	0,16	0,25
15 - 40	0,25	0,36
> 40	0,36	0,49

An alternative using ballast is possible if necessary measures are taken for the ballast not to erode over time.

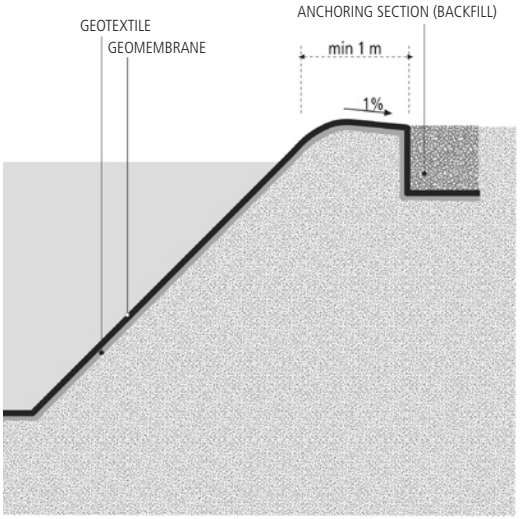

Fig. 6 : Top anchoring in trench

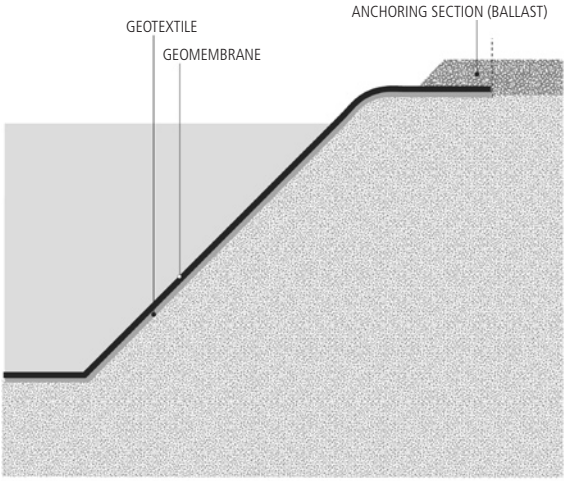

Fig. 7 : Top anchoring with ballast

Intermediate anchoring

If the embankment is high, it can be necessary to provide an intermediate clamping to accommodate the Geomembrane movements. Such clamping can be carried out using ballast or anchor trench. A platform can be added to the incline, in order not to endanger the stability of the embankment.

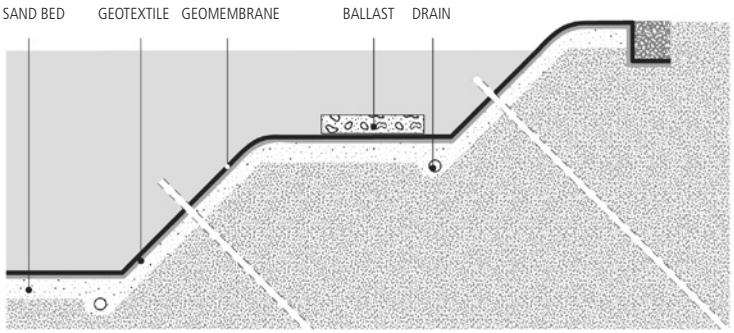

Fig. 8 : Intermediate anchoring

Base anchoring

If the natural soil of the pond base is sufficiently low in permeability (clay, waterproof geological layer,...) anchoring at the base of the pond with ballast is sufficient to provide adequate water-proofing (see fig. 9).

Another practical solution is to provide a 1 m deep ditch at the base of the embankment. When the waterproof layer is situated at a great depth, it is indeed possible to extend enough Geomembrane at the base of the pond to keep the pond losses within acceptable limits (see fig. 10).

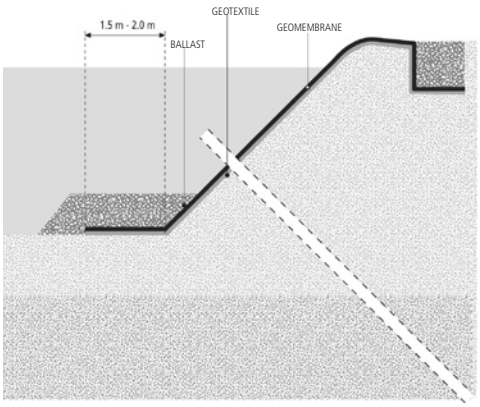

Fig. 9 : Base anchoring with ballast

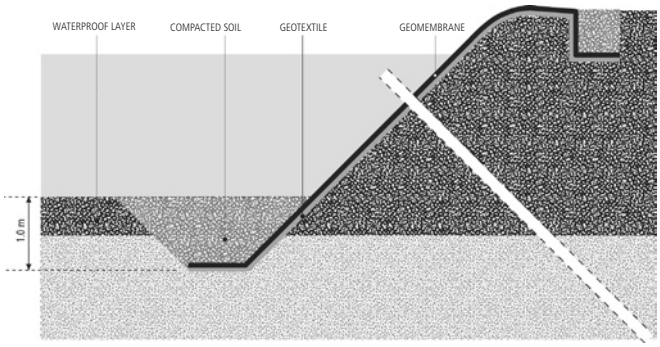

Fig. 10 : Base anchoring with trench

2.2.5 Seaming adjoining Firestone Geomembrane panels

The splicing of adjoining panels should be performed immediately after the relaxation of the Firestone Geomembrane.

All panels must be installed without tension and without major wrinkles, overlapping by at least 150 mm. All seams on slopes must be run up and down the slope with no horizontal seams allowed.

For soft subsoils, a wooden board, a piece of insulation, or a laminated panel must be used under the Geomembrane, in the area of the splice. The panel is moved by means of a rope as the splicing process progresses.

Seaming procedure

Two overlapping Firestone Geomembrane panels are assembled by means of a self-adhesive tape. Below are the various steps required for proper splicing.

Step 1 : Position the Geomembrane

- Both Geomembrane panels must be positioned with sufficient overlap (± 200 mm).
- The Geomembranes must lay flat and without any tension.
- Use a marker to indicate on the lower sheet the exact location where the tape is to be installed.
- The mark must be situated between 10 and 20 mm from the edge of overlapping sheets, and is repeated every metre.

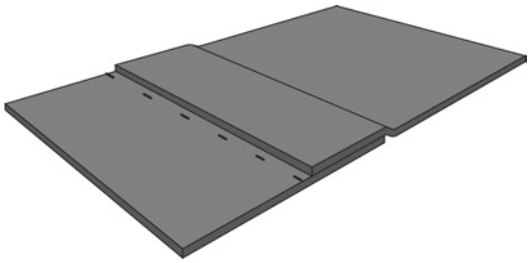

Fig. 11

Step 2 : Tack-back the overlap

- The upper Geomembrane panel is folded back 250 mm, the fold is glued down every metre with QuickPrime.
- In case the Geomembrane is covered with mud or very dirty, we recommend to pre-clean the overlap area, using a cloth soaked in Splice Wash. Soil should not be allowed to contaminate the Geomembrane in the splicing area.

Step 3 : Apply the QuickPrimer

- Stir the QuickPrime before and during use and transfer a small quantity (1,5 l) to a bucket. The Primer is applied with a scrubbing pad.
- Immerse the scrubbing pad in the QuickPrime, keeping the pad horizontally and let excess of QuickPrime drip off.
- Apply the QuickPrime uniformly along the length of the splicing area, with long back and forth strokes, both to the lower face of the top sheet and the upper face of the lower sheet, until the surfaces become a dark grey in colour. Avoid traces and wet spots. Each pad immersed in QuickPrime will cover a splice of about 1,00 m, over a width of 100 mm (one side).
- Change scrubbing pads each 60 m or when the primer has dried on the pad. Used pads are to be discarded at the end of the working day.
- Additional priming is required at factory seams, at the intersection of two splices and to areas covered with adhesive.
- Both sides to be spliced are treated simultaneously, so as to obtain an identical drying time.
- Test QuickPrime for readiness. Allow the primer to flash off. The primer needs to dry completely (± 10 minutes) before installing the tape. Check its dryness by touching the primed surface with a clean and dry finger to make sure that the primer does not string. When touching the primer, push forward on the primed surface at an angle to ensure that the primer is dry throughout its thickness. If either motion exposes a stringy primer when the finger is lifted, then the splice is not ready for installing the tape. Flash off time will vary depending on ambient air conditions (relative humidity, wind,....).

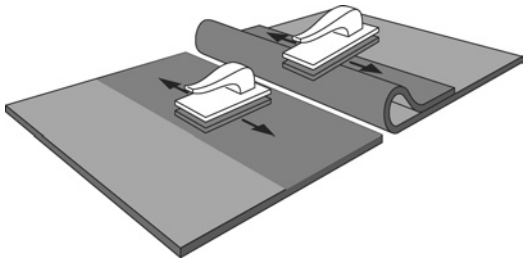

Fig. 12

Step 4 : Install the tape

- Apply the QuickSeam Splice Tape (with release paper intact) on the bottom sheet, aligning the edge of the release paper with the markings.
- Immediately roll the splice with a 100 mm wide silicone sleeved hand roller.

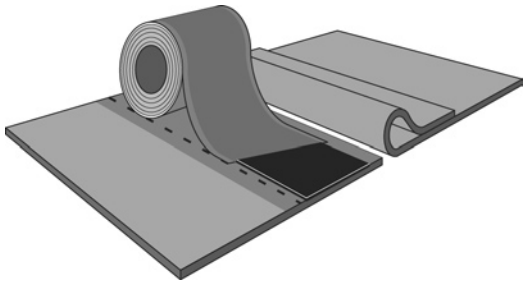

Fig. 13

Step 5 : Check the Splice Tape alignment

- The upper Geomembrane is released and the splice is closed with the hand. To avoid wrinkling, close the splice gently with a movement perpendicular to the splice. The upper sheet must fall without wrinkling or tension onto the lower sheet. Allow the top sheet to rest on top of the tape's paper backing.
- Trim the top sheet as necessary to assure that 10 to 15 mm of the QuickSeam Splice Tape will be exposed on the finished splice.

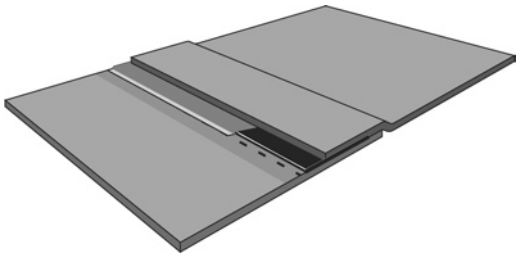

Fig. 14

Step 6 : Remove paper backing

- To remove the paper backing from the tape, first roll back the Geomembrane sheet. Peel the paper backing off the QuickSeam Splice Tape by pulling against the weight of the bottom sheet at approximately a 45 degree angle to the tape and parallel with the roof surface.
- Allow the top sheet to fall freely onto the exposed QuickSeam Splice Tape. Mate the entire length of the splice as the release paper is being removed.

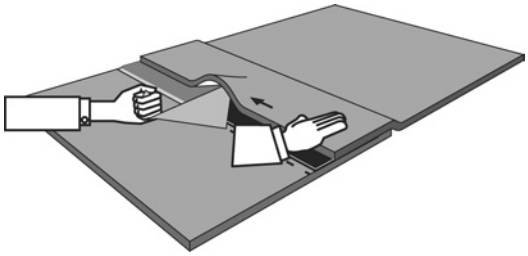

Fig. 15

Step 7 : Roll the splice

- Finally, roll the splice by means of a silicone rubber roller, first across the splice and then along the entire length of the splice.

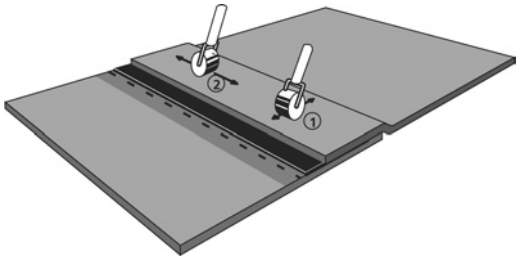

Fig. 16

- The completed splice will eventually look as follows:

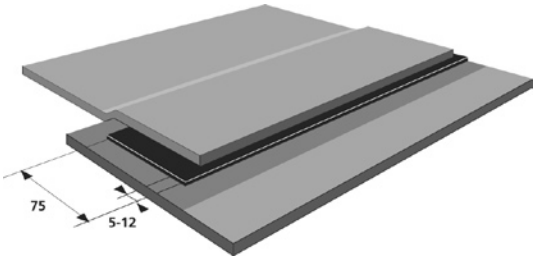

Fig. 17

Special considerations are required (End laps, T joints, etc...) :

- When the seam is greater in length than the tape, the overlap between two adjoining tapes should be at least 25 mm. Apply a FormFlash reinforcement (225 x 200 mm) over this joint area.
- When several Geomembrane panels meet at a common point, only three panels may overlap each other. Apply a FormFlash reinforcement (200 x 200 mm) over this joint area.
- Apply a FormFlash reinforcement (200 x 200 mm) over the area where a field splice runs from the horizontal area into any slope of the embankment as illustrated below:

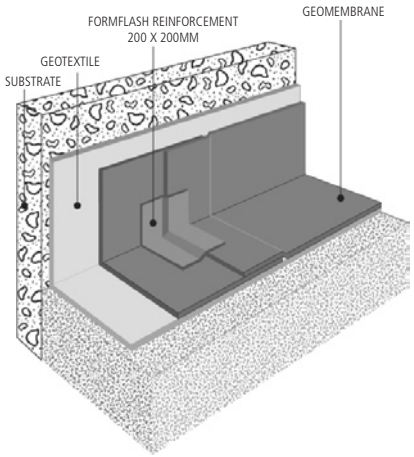

Fig. 18 : Vertical Splice Reinforcement

- Clean the seam area with Splice Wash before applying the QuickPrime if it is contaminated (mud, etc.).
- Stop the application of the QuickSeam when the atmospheric conditions are unfavourable (humidity, condensations on the QuickPrime, rain).
- Movement of the Firestone Geomembrane during application of the Splice Tape and during the first few minutes after application should be avoided.
- Positioning of a larger number of panels than can be spliced in one day is not allowed.
- Field seams on side slopes must run parallel with the slope i.e. up and down the slope. Horizontal field seams on slopes are not allowed.

2.2.6 Protection of the Firestone Geomembrane

Under most conditions, protection of the Firestone Geomembrane will be required. In the table below you will find some recommendations for the protection against potential damage.

Protection against	Precautions
Wind	• ballast at the bottom and/or on slopes (in case of temporary emptying) • correct section of the anchor trench
Waves	• mechanical protection of the embankments depending on the slope : rock covering, concrete pavement, cast concrete
Floating objects (dead wood, boats)	• small ponds : cleaning • larger ponds : protection
Ice	• mechanical protection of embankments
Animals (rodents)	• ladders • enclosure around the reservoir • mechanical protection of embankments
Operating vehicles	• protection of the Geomembrane with soil or a sand bed (min. 20 cm) • access ramp
Local turbulence with water speed exceeding 1 m/sec. (internal agitator or canals)	• protection with ballast

Protection of the Firestone Geomembrane can be realized in the following ways :

Base :

- *Sand bed* (minimum thickness : 200 mm) : protection with geotextile not required
- *Gravel* (minimum thickness : 200 mm) : protection with geotextile required
- *Prefabricated materials* (tiles) : protection with geotextile required

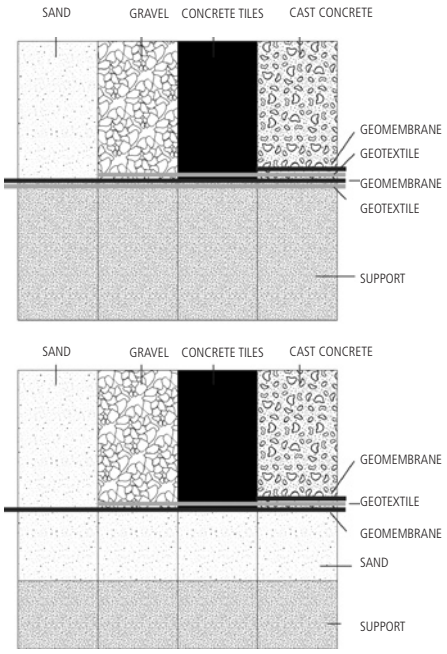

Fig. 19 : Protection of the Geomembrane

Embankments :

- *Rock covering :* This solution is applicable for slopes up to 3/1. A transition layer (geotextile + sand bed) with a minimum thickness of 200 mm is required. Rock covering depends on the level of the impacting forces such as waves.
- *Prefabricated tiles :* Stability measurements of the tiles and installation of a geotextile or extra layer of Firestone Geomembrane at the foot of the embankment are required.
- *Cast concrete :* Stability measurements and installation of a geotextile or extra layer of Firestone Geomembrane are required at the foot of the embankment.

2.3 Details

2.3.1 General

If possible, avoid cutting the Firestone Geomembrane at details. In some cases, however, as with corner details against concrete walls, connections with pipes, a cut in the Geomembrane will simplify the installation. In such cases, FormFlash (unvulcanized rubber sheet) will be used and adhered with Splice Adhesive in order to provide a tight seal of the detail.

2.3.2 Connection to concrete structures

Connections of the Firestone Geomembrane to concrete or masonry structures must comply with the following rules :

- Soil around the concrete must be compacted
- Connection surfaces must be smooth, clean, dry and must not present any sharp protrusion
- Firestone Geomembrane is fully adhered to the walls using Bonding Adhesive. Make sure that the sheet is placed in its final position and fold it back evenly onto itself so as to expose the underside. Wipe any dust or dirt from the backside of the Geomembrane and the wall prior to application of the adhesive. Stir the Bonding Adhesive thoroughly before and during use. Apply Bonding Adhesive at about the same time to the underside of the sheet and the substrate to which it will be adhered to, so as to allow the same drying time. Use a paint roller with solvent resistant short bristles to apply a uniform film thickness. Care must be taken not to apply Bonding Adhesive over an area of Geomembrane which is to be cleaned and spliced to another sheet or flashing. Allow the adhesive to flash off until tacky. Follow the same method to verify as indicated in the splicing section. Starting at the fold, slowly roll the previously coated part of the sheet into the coated substrate, and work evenly so as to minimise wrinkles. Compress the bonded sheet with a stiff broom to ensure full adhesion.
- Firestone Geomembrane is fixed at the top using Termination Bar and Fasteners adapted to concrete (plugs every 200 mm). Water Block is placed between the Geomembrane and the wall, as indicated below. The Termination Bar must be installed above the waterline. Lap Sealant is used at the top of the Termination Bar.

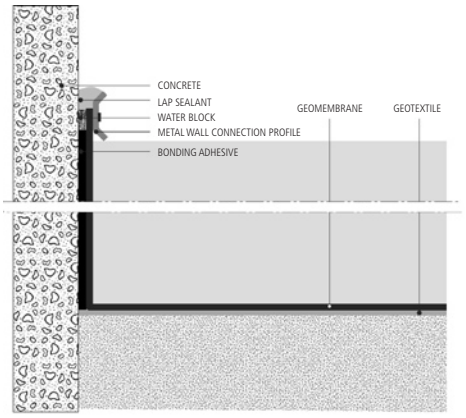

Fig. 20 : Connecting to concrete and masonry

2.3.3 Flashing of round penetrations

Connections to large penetrations must be made by means of unvulcanized rubber sheet, Form-Flash, as follows :

- Pipe needs to be firmly anchored and the pipe temperature may not exceed 80°C
- Make a circular cutout in the Geomembrane panel, measuring approximately 50 % of the pipe diameter
- Pull the Geomembrane over the pipe
- Pipe and Geomembrane are flashed together by means of a piece of FormFlash
- Finally, the assembly is mechanically secured with a clamping collar

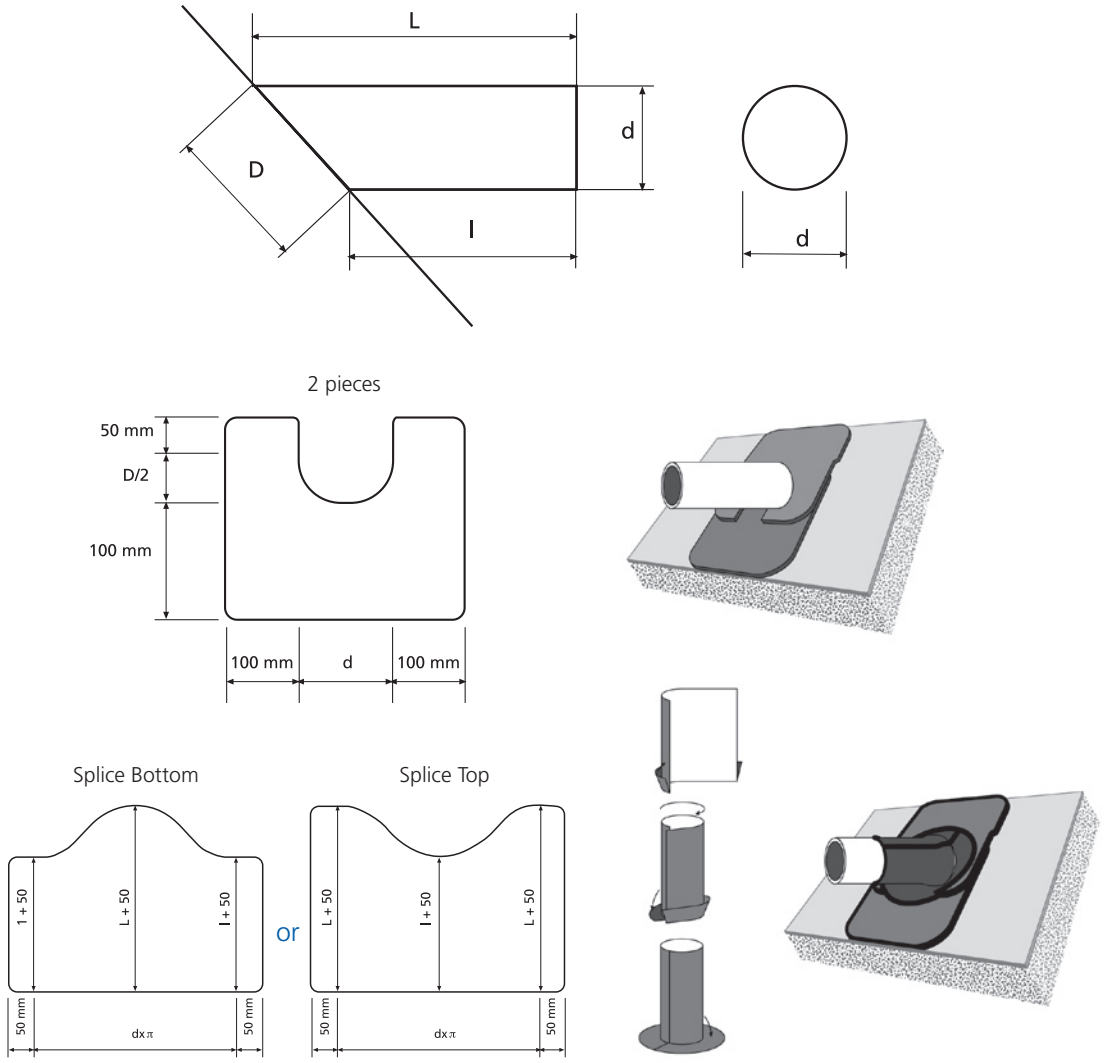

Fig. 21 : Flashing pipe penetration

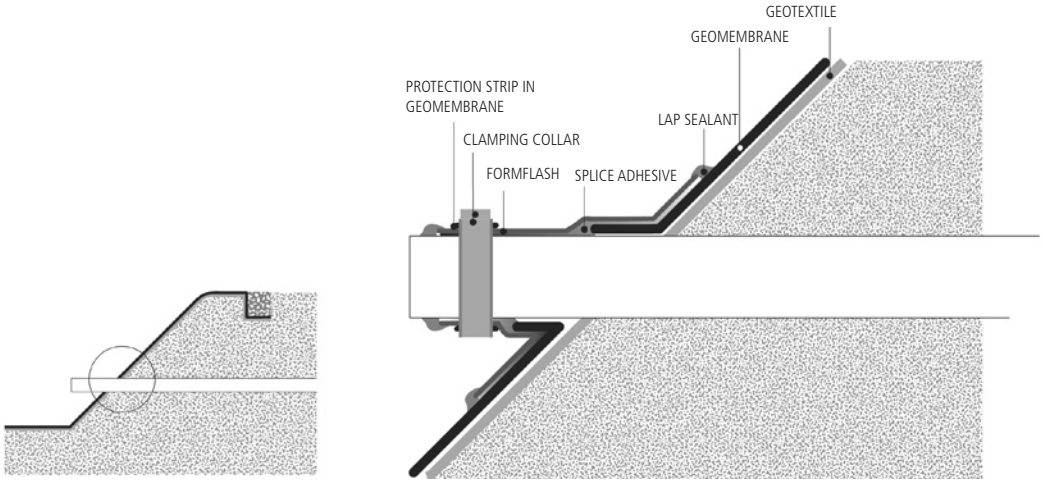

Fig. 22 : Connection around pipe penetration

2.3.4 Drains

We recommend that a concrete base is provided underneath the Geomembrane around discharges. The Geomembrane is then mechanically fastened with a clamping system or an insert piece (rubber, PVC, lead, ...), mechanically fastened to the concrete base. Apply a waterproofing sealant (Water Block) between the Geomembrane and the concrete, as indicated in the details, prior to fixing of the clamping system or insert piece. If an insert piece is required, use FormFlash for flashing this detail.

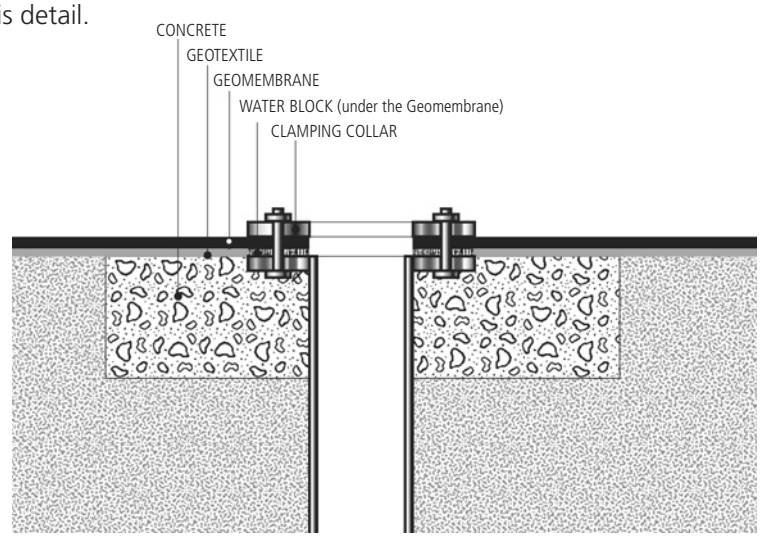

Fig. 23 : Water discharge with clamping collar

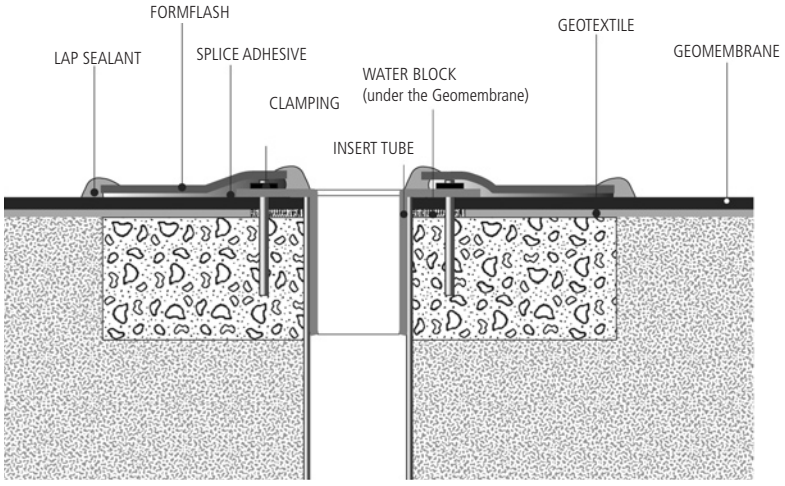

Fig. 24 : Water discharge with insert pipe

2.3.5 Corners

In most cases, the excess Firestone Geomembrane is folded in the corners. However, if one or both walls consist of concrete or masonry, cutting away the excess of membrane may be required to facilitate full adhesion to the wall upstands. In this situation, the corner has to be sealed with FormFlash as illustrated below:

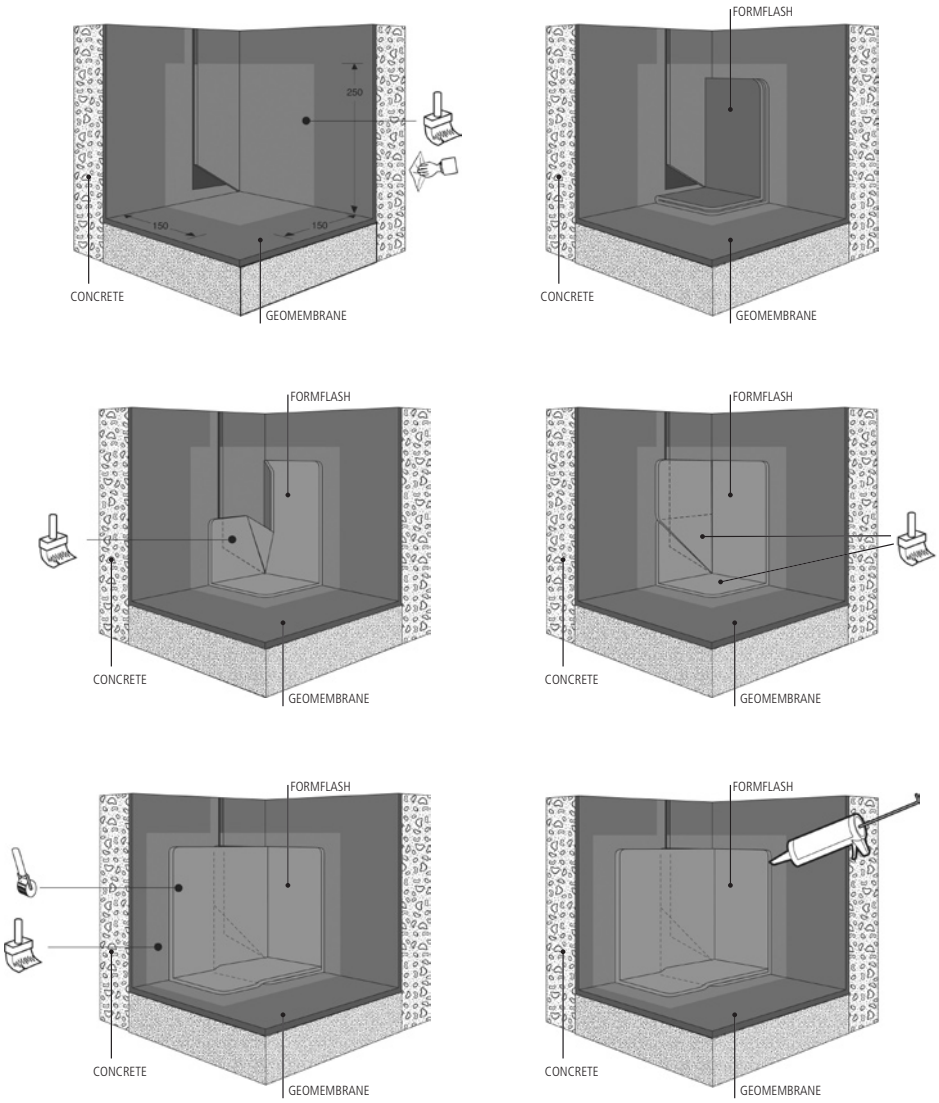

Fig. 25 : Inside corner

Outside corners are sealed using FormFlash as illustrated below :

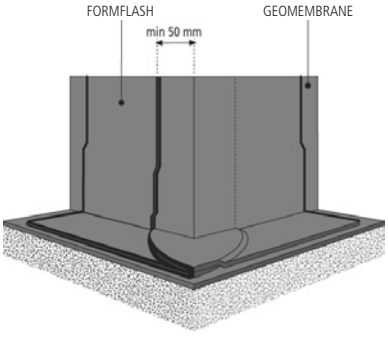

Fig. 26 : Outside corner

2.4 Miscellaneous

2.4.1 Repair procedure

A tear or hole in the Geomembrane can be repaired by means of a piece of FormFlash or Firestone Geomembrane covering the tear in every direction with an overlap of at least 150 mm. The patch must be adhered to the membrane with Splice Adhesive as follows:

- Clean the damaged area by scrubbing it with a cloth soaked with Splice Wash, to remove mud or any contaminant which will effect the splice. Correct cleaning has been achieved when the Geomembrane surface is dark grey in colour with no streaking.
- After drying, apply a coat of Splice Adhesive by means of a brush onto both surfaces (Geomembrane and patch). Mate both surfaces, when the adhesive is dry. Roll the patch by means of a silicone rubber roller.
- Finally, apply Lap Sealant to protect the exposed splice edges, as explained in the splicing section.

2.4.2 Maintenance

An annual inspection of the installation is recommended to detect any problems which may endanger the durability of the system. This inspection process will limit costs if damage has occurred.

Recommendations :

- Visual inspection of the Geomembrane, splices, connections and the anchoring
- Measurement of the leak flow rate and monitoring of water level
- Check all gas drainage vents
- Avoid any overflowing of the pond
- Check the chemical composition and the temperature of the liquids coming into contact with the Geomembrane
- Check the protection of the sheet, if any

2.4.3 Safety

Specific precautions are to be taken to assure safety of people and animals on site, especially when the pond has been installed close to any habitation and tourist areas.

The following precautions should be taken :

- Ladder or climbing rope
- Low gradient of embankment (< 3/1)
- Intermediate platform at location with limited depth of reservoir
- Enclosure around the project

Attachment 1

The Firestone Lining Systems uses a complete range of materials including the Firestone EPDM Geomembrane, adhesives, tape, sealants, cleaning products and prefabricated accessories in order to guarantee the homogeneity of the system.

Membrane

- ***Firestone Geomembrane :*** the main component of the system consists of the Firestone EPDM Geomembrane. The Geomembrane is manufactured by calendering and vulcanising. The sheet has a thickness of 1,02 - 1,14 or 1,52 mm. The 1,02 mm thick sheet is specially designed for application in decorative and landscape ponds.
- ***FormFlash :*** self-vulcanising rubber strips which can be shaped and adapted in a flexible way to irregular shapes such as corners, pipes, etc.

Adhesives and pressure sensitive tape

- ***Splice Adhesive :*** butyl based contact adhesive, used for field splicing of Firestone Geomembrane and FormFlash.
- ***Bonding Adhesive :*** neoprene based contact adhesive used for bonding Geomembrane sheets or FormFlash to non Geomembrane surfaces (wood, metal, concrete and others).
- ***QuickSeam Splice Tape :*** double sided butyl based adhesive tape for splicing Firestone Geomembrane panels.

Cleaning products

- ***Splice Wash :*** cleaning product used during the preparation of a Firestone Geomembrane sheet, before applying the Splice Adhesive. This product may not be used for the application of QuickSeam Splice Tape.
- ***QuickPrime Plus :*** product for treating the Firestone Geomembrane sheet prior to applying the QuickSeam Splice Tape.

Sealants

- ***Lap Sealant :*** rubber based sealant for sealing splice edges, when Splice Adhesive is used.
- ***Water Block Seal :*** butyl based sealant, for making a waterproof seal when executing waterproofing details

Accessories

- ***Termination Bar :*** aluminium profile for terminating the Firestone Geomembrane sheet at the top against an upright wall .

Materials from other manufacturers, including fasteners, drain insert pieces, metal profiles, etc. , which are not described in these technical guidelines, can be used when approved by Firestone.

Technical Data Sheets

- Firestone Geomembrane
- FormFlash
- QuickSeam FormFlash
- Splice Adhesive
- Bonding Adhesive
- QuickSeam Splice Tape
- Splice Wash
- QuickPrime Plus
- Lap Sealant HS
- Water Block Seal
- Termination Bar

Firestone Geomembrane

1. Description

The Firestone Geomembrane is a cured single-ply synthetic rubber membrane made of ethylene-propylene-diene terpolymer (EPDM). It is available in a variety of thicknesses and panel sizes. Depending on the dimensions of the liner, the waterproofing surface may be seamless. In other situations, seams can be made using a self-adhesive tape.

The 1,02 mm thick Firestone EPDM Geomembrane is specifically designed for decorative pond applications. It is commercialized under the trade name "**Firestone Pond Liner™**". Because of its specific formulation and production process, **only the Firestone Pond Liner™ membrane is guaranteed to be compatible with aquatic life** in accordance with testing reports published by the Water Research Centre in the UK.

2. Preparation

Product : Allow the membrane to relax for approximately 30 minutes before splicing.
Substrate : The substrate needs to be smooth, dry and free of sharp objects, oil, grease and other materials that may damage the Geomembrane.

3. Application

Install the Firestone Geomembrane in accordance with current specifications and details.

4. Coverage

The dimensions of the Geomembrane are calculated to cover the base of the reservoir, slopes and anchor trenches, including seam overlaps.

5. Characteristics

The Firestone Geomembrane is a rubber material with the following properties :

Physical	• Elastomeric membrane with a good combination of high elasticity and tensile strength • Water-resistant • Temperature stable from -45°C to 130°C • Retains its elasticity at low temperature and resists to temperature shocks up to 250°C. • Excellent resistance to alkali rains, less resistant to oil products. Contact with some kind of oils, petroleum products, hot bitumen and grease must be avoided • Excellent resistance to U.V. radiation and ozone concentration	
Technical	• Base	rubber
	• Colour	black
	• Solvents	none
	• Solids (%)	100
	• State	cured
	• Storage	Store the membrane in a dry place until use

6. Technical Specifications

1. Physical Properties	Method	Result	Unit
• Specific weight	direct measurement	1150	kg/m^3
• Shore A durometer	ASTM-D-2240	65 ± 10	-
• Tensile strength	UEAtc		
- unaged		≥ 8,0	N/mm^2
- heat aged *		≥ 8,0	N/mm^2
• Elongation	UEAtc		
- unaged		≥ 300	%
- heat aged *		≥ 300	%
• Tear resistance	UEAtc	11,7	N/mm
• Dimensional stability** (free)	UEAtc	≤ 0,5	%
• Low temperature flexibility	DIN 53361	crack free at -30	°C
• Ozone resistance	DIN 7864	crack free	-
• U.V. resistance	ASTM G 53-84	crack free	-
• Static indentation	UEAtc		
- concrete		L_4	
• Peel resistance	UEAtc		
- concrete		27,8	N

* 84 days at 80° C. - ** 24 hours at 100° C.

2. Packaging Thickness (in)	Thickness (mm)	Width (m)	Length (m)	Weight (kg/m^2)
.040"	1,02	6,10-7,62-9,15-12,20-15,25	30,50-45,75-61	1,25
.045"	1,14	3,05-6,10-7,62-9,15-12,20-15,25	30,50-45,75-61	1,41
.060"	1,52	3,05-6,10	30,50	1,95

Note: Special panel sizes are available upon request.

7. Precautions

Take care when moving, transporting or handling to avoid sources of punctures and physical damage. Isolate waste products, such as petroleum products, greases, oils (mineral and vegetable) and animal fats from the Geomembrane.

FormFlash

1. Description

Firestone FormFlash is a self-curing rubber strip, adaptable to irregular shapes and designed to flash the system details in accordance with Firestone specifications.

2. Preparation

Product : During cold weather (< 15°C) the FormFlash may be installed using a heat gun to improve its workability.

Substrate : Must be clean, dry, smooth, free of sharp edges, loose or foreign materials, oil, grease and chemical products that could affect the material.

3. Application

Refer to Firestone installation instructions for flashing. The FormFlash material is to be adhered using Splice Adhesive. The edge of each splice has to be protected with Lap Sealant.

4. Characteristics

Physical

- easily adaptable to irregular shapes and surfaces
- superior weathering characteristics
- self-curing rubber material, with similar characteristics as the Firestone Geomembrane after 12 months

Technical

- Base: rubber
- Colour: black
- Solvents: none
- Solids (%): 100
- State: uncured
- Thickness (mm): 1,40
- Packaging:

Width (cm)	Length (m)	Packaged	Weight (kg)
15 - 30	30,5	2 rolls/ctn	± 8-16
45 - 60	30,5	1 roll/ctn	± 24-32

- Storage/Shelf Life: 12 months, if stored in original unopened carton at temperatures between 15°C and 25°C

5. Precautions

Keep away from heat sources during storage and installation. Do not expose to the sunlight when stored.

QuickSeam FormFlash

1. Description

QuickSeam FormFlash consists of a 229 mm (9") or 305 mm (12") uncured FormFlash factory laminated to QuickSeam Tape. The strip is designed to flash inside and outside corners, pipes, penetrations and other applications as specified in the Firestone specifications as an alternative to details with FormFlash. Please contact Firestone Technical Department for further information about the use of this product.

2. Preparation

The Geomembrane surfaces and/or mating surfaces must be prepared with QuickPrime Plus, using a QuickScrubber tool. Use of other products is not allowed. Restore the product to room temperature prior to use if exposed to temperatures below 15°C for prolonged periods.

3. Application

On cloudy days with ambient temperature below 15°C, the use of a heat gun is recommended to warm the QuickSeam FormFlash and to ensure good formability. On sunny days, pre-heating of the product is usually not necessary. QuickSeam FormFlash is to be applied as per the Firestone specifications and details.

4. Coverage

In accordance with length of detail.

5. Characteristics

Technical	*EPDM Flashing*	*QuickSeam Tape*
• Base	EPDM	Rubber polymers
• Colour	Black	Black
• Solvents	None	None
• Solids (%)	100	100
• State	Uncured	Cured
• Thickness (mm)	1,6	0,6
• Width (mm)	229 - 305	235 - 311
• Packaging	15.2 m (50') rolls 2 rolls per carton (9") - 1 roll per carton (12")	
	Note: QuickScrubber pads and handles are included in each carton. Quantities vary depending on the QuickSeam product.	
• Storage	Store in original unopened carton at temperatures between 15°C and 25°C. Keep the material out of direct sunlight until ready for application.	
• Shelf life	12 months, when stored in above-mentioned conditions. Verify production date on each roll. Shelf life will be reduced if exposed to higher temperatures.	

Splice Adhesive (SA-1065)

1. Description

Firestone Splice Adhesive is a butyl based contact adhesive designed for field splicing of Firestone Geomembrane panels and FormFlash to Firestone Geomembrane.

2. Preparation

Product : Stir the adhesive before and during use. Restore the adhesive to room temperature prior to use, if exposed to temperatures lower than 15°C.

Substrate : The adhered surfaces must be cleaned with Splice Wash using cotton cloths.

3. Application

Apply in a thick, even, smooth coat on both surfaces with a 75 to 100 mm wide solvent resistant paint brush. Do not use circular motions for applying Splice Adhesive (no paint rollers) and allow the adhesive to flash off prior to mating the surfaces. In cold weather, moisture contamination of the adhesive can occur when condensation/frost forms on the adhesive while the solvents flash off. For further instructions refer to the splicing section.

4. Coverage

A uniform application is required to avoid mixed results. Thinning of the adhesive is not allowed. A coverage rate of 15 lin.m/gal, for a 300 mm wide splice area, on both sides, is recommended.

5. Characteristics

Physical

- excellent moisture resistance
- excellent resistance to heat and cold
- excellent green tack

Technical

Base	synthetic polymers
Colour	black
Solvents	hexane, toluene, xylene
Solids (%)	26 (min)
Viscosity (cp)	2.900-3.700
Weight/gallon (kg)	3,33
Specific gravity	0,876
Flash Point (°C)	-17,7
Packaging	1 gallon (3,78 l)
Storage/Shelf life	9 months if stored in original sealed container at temperatures between 15°C and 25°C. Once opened, use the adhesive within 48 hours

6. Precautions

Flammable. Keep away from sources of ignition. Do not smoke when using. Store and use the material in well ventilated areas. May cause sensitivity by inhalation. Avoid contact with skin and eyes.

Bonding Adhesive (BA-2004)

1. Description

Firestone Bonding Adhesive is a neoprene-based adhesive designed for bonding Firestone Geomembrane to wood, metal, masonry and other acceptable non rubber substrates.

2. Preparation

Product : Stir the adhesive. Restore the adhesive to room temperature prior to use if exposed to cold temperatures (< 15°C.).

Substrate : Surfaces to which Bonding Adhesive is to be applied must be clean, smooth, dry and free of sharp edges, loose materials, oil, grease and other contaminants. The mating surface of the Geomembrane shall be cleaned with a brush or clean rag.

3. Application

Apply the adhesive in an even, smooth coat on both surfaces with a solvent-resistant paint roller and avoid globs and puddles. Allow adhesive to flash off until tacky (15 to 45 minutes). Test the adhesive for its dryness, using the push-touch test procedure. If the adhesive is ready, mate both surfaces and press with a brush.

4. Coverage

The adhesive must be applied at a uniform rate to both the back of the Geomembrane and the substrate. If the applicator can place a finger or hand directly on the adhesive without feeling some degree of tackiness, the application is too thin and the adhesive should be re-applied. Thinning of the adhesive is not allowed. The normal coverage rate is 5 tot 6 m^2 both sides, per gallon.

5. Characteristics

Physical

- excellent resistance to ageing
- excellent adhesive strength to different applications
- good resistance to heat, cold and water

Technical

Base	polychloroprene
Colour	amber
Solvents	toluene, acetone, hexane
Solids (%)	23 (min)
Viscosity (cp)	2.300-3.000
Weight/Gallon (kg)	3,2
Specific gravity	0,84
Flash Point (°C)	< -17,7
Packaging	5 gallon pail
Storage/Shelf life	12 months if stored in original sealed container at temperatures between 15° and 25°C. Once opened, use the adhesive within 48 hours.

6. Precautions

Flammable. Keep away from sources of ignition. Do not smoke when using. Store and use the material in well ventilated areas. May cause sensitivity by inhalation. Avoid contact with skin and eyes.

QuickSeam 3" (76 mm) Splice Tape

1. Description

Firestone QuickSeam Splice Tape is designed for field splicing of Firestone Geomembrane panels.

2. Preparation

Product : Restore the tape to room temperature prior to use if exposed to temperatures below 15°C for prolonged periods.

Substrates : The Geomembrane surfaces must be prepared with QuickPrime using the QuickScrubber tool.

3. Application

Refer to splicing section for specific installation instructions. Use of Firestone QuickPrime and Quick-Scrubber is required.

4. Characteristics

Physical

- excellent moisture resistance
- excellent resistance to heat and cold
- excellent green tack

Technical

• Base	rubber polymers
• Colour	black
• Solvents	none
• Solid (%)	100
• Specific gravity	0,98 ± 0,02
• Cure state	cured
• Thickness	0,76 mm +/- 0,127 mm
• Packaging	Length : 30,48 m per roll - 6 rolls/per box Width : 76 mm
• Storage/Shelf life	12 months when stored at temperatures between 15 °C and 25 °C in original unopened carton Storage period is shortened at high temperatures Keep in box on site and out of the sun

Splice Wash (SW-100)

1. Description

Firestone Splice Wash is designed to clean and prepare the Firestone Geomembrane in areas to receive Splice Adhesive. It is not designed to prepare the Geomembrane prior to the installation of QuickSeam Splice Tape.

2. Preparation

Substrate : Remove excess accumulations of dirt with a brush (and water) prior to application.

3. Application

Apply Splice Wash to the splicing area using clean cotton rags in a scrubbing motion until the splicing surface is dull black in colour. Take extra care at factory seams and allow the cleaned surfaces to dry.

4. Coverage

Coverage rate for 300 mm one side, is 60 lin.m. per gallon.

5. Characteristics

Physical

- Flammable liquid

Technical

• Colour	Clear
• Solvents	Aliphatic Hydrocarbon
• Viscosity	Very thin, free flowing
• Weight/gallon (kg)	2,676
• Specific gravity	0,75
• Flash Point (°C)	12,8
• Boiling Point (°C)	119
• Packaging	5 gallon (13,4 kg)
• Storage/Shelf life	12 months if stored in original unopened container at temperatures between 15° and 25°C Keep the material out of direct sunlight until ready for immediate use

6. Precautions

Flammable. Keep away from sources of ignition. Do not smoke when using. Store and use the material in a well ventilated place. Do not empty into drains.

QuickPrime Plus

1. Description

Firestone QuickPrime Plus is designed to clean and prime the Geomembrane in seaming areas, before application of the QuickSeam Splice Tape. The Primer activates the Geomembrane surface and ameliorates the seam quality.

Firestone QuickPrime Plus must be applied with a QuickScrubber. It may also be used to clean the Firestone Geomembrane prior to the application of the Firestone Splice Adhesive.

2. Preparation

Product : Stir thoroughly before and during use.

Substrate : Surfaces to be primed must be clean, dry, free of foreign materials, talc and dirt. Clean with broom if required.

3. Application

Apply QuickPrime Plus to the Firestone Geomembrane surfaces with the QuickScrubber tool using long back and forth strokes with moderate to heavy pressure along the length of the area until surfaces become dark grey in colour with no streaking or puddling. Allow the primed surfaces to dry completely (usually less than 10 minutes) before applying QuickSeam Splice Tape or Splice Adhesive.

4. Coverage

Coverage rate of ± 10 m^2, both sides, or ± 60 lin.m. of standard 3" seam per gallon. Thinning is not allowed.

5. Characteristics

Physical

- excellent resistance to ageing
- excellent resistance to heat and cold
- translucent when dry which allows guide marks to show through after application.

Technical

Base	synthetic rubber polymers
Colour	Translucent grey
Solvents	Heptane, toluene , methyl alcohol
Solids (%)	16-18
Viscosity	Very thin, free flowing
Weight/gallon (kg)	3
Specific gravity	0,793
Flash Point (°C)	-17,77
Packaging	1 gallon (3,8 l) and 3 gallon (11,4 l) pails
Storage/Shelf life	12 months if stored in original unopened container at temperatures between 15 °C and 25 °C

6. Precautions

Flammable. Keep away from sources of ignition. Do not smoke when using. Store and use the product in well ventilated areas. Avoid contact with skin and eyes. Do not empty into drains.

Lap Sealant HS

1. Description

Firestone Lap Sealant is designed to seal and mechanically protect the exposed edge of all field fabricated seams made with Splice Adhesive.

2. Preparation

Product : Restore to room temperature prior to use if exposed to temperatures < 15 °C for a prolonged period.

Substrate : Surfaces on which Lap Sealant is to be applied must be clean, dry, free from loose and foreign materials, oil and grease and primed with Splice Adhesive. Wait minimum 4 hours between splicing and application of Lap Sealant. Under bad weather conditions Lap Sealant must be applied before end of the working day.

3. Application

Apply with a mastic gun a bead of Lap Sealant along the properly cleaned, exposed Geomembrane lap edge. A preformed tool shall be used to feather the bead of sealant. Feathering must take place immediately after the Lap Sealant is applied.

4. Coverage

7 lin.m. per cartridge. Thinning is not allowed.

5. Characteristics

Physical

- excellent resistance to ozone, ultra violet and general weathering
- excellent resistance to heat, cold and water
- good adhesion to Firestone Geomembrane sheet, metals, wood and concrete
- good slump resistance

Technical

Base	rubber polymers
Colour	black
Solvents	light aliphatic solvent
Solids (%)	min. 80
Weight/gallon (kg)	4,24
Specific gravity	1,34-1,46
Flash Point (°C)	11
Packaging	25 tubes/carton
Storage/Shelf life	12 months when stored in original sealed containers at temperatures between 15° and 25°C.

6. Precautions

Flammable. Keep away from sources of ignition. Do not smoke when using. Use in a well ventilated place.

Water Block Seal (S-20)

1. Description

Firestone Water Block Seal is designed to provide a watertight seal as indicated in the details.

2. Preparation

Product : Restore to room temperature prior to use if exposed to temperatures < 15 °C for a prolonged period.

Substrate : Surfaces onto which Water Block Seal is to be applied shall be free from loose parts of concrete, stone, mortar, foreign materials, and other contaminants.

3. Application

Apply a bead onto the substrate surface. Roll or press the flashing membrane firmly against the seal and substrate avoiding wrinkles to assure a complete seal. Install the appropriate Firestone detail as per Firestone's current specification.

4. Coverage

3 lin.m. per tube or 4 drains per tube

5. Characteristics

Physical

- excellent resistance to ageing
- good resistance to heat, cold and water
- non drying, adheres well to Firestone Geomembrane sheets, metals, wood and concrete
- good slump resistance

Technical

Base	butyl rubber
Colour	grey
Solvents	heptane
Solids	86 %
Viscosity (27°C) (cp)	1.600.000 ± 300.000
Weight/Gallon (kg)	5,0
Specific Gravity	1,33
Flash Point (°C)	-10,0
Packaging	25 tubes/carton
Storage/Shelf life	12 months if stored in original sealed container at temperatures between 15° and 25 °C

6. Precautions

Flammable. Keep away from sources of ignition. Do not smoke when using. Use in well ventilated place and do not breathe fumes.

Termination Bar

1. Description

Firestone Termination Bar is designed for attaching and sealing flashing terminations as per Firestone's current specifications.

2. Preparation

Product : When field cutting is necessary, remove any burrs from the bar and clean up shavings that may result from cutting.

Substrate : Must be free from dust, dirt, oil, water and other contaminants prior to installation and needs to provide the required pull-out resistance.

3. Application

Install Water Block Seal behind flashing. Anchor the bar through pre-punched holes at a rate to maintain a tight compression to the wall against Water Block Seal. Remove excess flashing material above and install Lap Sealant into the upper channel. Keep each piece (3.05 m) of Termination Bar separated from adjoining bar by 6 mm and cut the bar at inside and outside corners.

4. Characteristics

• Material	Corrosion-resistant aluminium
• Length (m)	3,05
• Width (mm)	27,4
• Thickness (mm)	2,2
• Holes (mm)	7,1 x 9,9 slotted holes - 100 mm on centre
• Packaging	50 pieces of 3,05 lin.m. per carton (152,4 m)
• Storage	in a dry place

Attachment 2

Installation Tools

1. Job preparation

- tape measures (50 m and 5 m)
- chalk line
- scissors
- claw hammer
- stiff bristle brooms
- squeegee

2. Cleaning the Firestone Geomembrane

- clean cotton rags
- cleaning agent - Splice Wash (in petrol can)

3. Mechanical fixation

- drilling machine with key
- drill bits (masonry and steel)
- hack-saw with blades
- screw-driver
- caulking gun
- tin snip

4. Field seams

- QuickScrubber tool (pad + handle)
- small plastic bucket
- marker (white)
- roller - 50 mm width (silicon rubber)

5. Adhesion of the Firestone Geomembrane

- brushes (solvent resistant, short hair, 100 mm width)
- paint rollers (solvent resistant, short hair, 225 mm width)
- hot air gun
- roller - 50 mm width (silicon rubber)

6. Additional

- electrical leads
- rubber gloves

Attachment 3

Firestone Geomembrane Chemical Resistance Chart

Firestone Geomembrane exposure to these chemicals causes no swelling, softening or surface deterioration of the membrane.

Acetamide
Acryimide (to 60°C)
Acetaldehyde (to 38°C)
Acetophenone (to 60°C)
Acetylene gas (to 93°C)
Alum (to 60°C)
Aluminum acetate
Aluminum chloride
Aluminum nitrate
Aluminum sulfate (to 60°C)
Ammonia
Ammonia gas (cold)
Ammonia gas (hot) (to 60°C)
Ammonia hydroxide (to 10%)
Ammonia hydroxide (concentrated)
Ammonium carbonate
Ammonium chloride
Ammonium nitrate
Ammonium phosphate
Ammonium sulfate
Amyl alcohol
Arsenic acid (to 60°C)
Adipic acid (to 60°C)

Barium chloride (to 80°C)
Barium hydroxide
Barium sulfide
Benzaldehyde (to 93°C)
Benzyl alcohol
Boric acid (to 60°C)
Borium sulfate (to 21°C)

Calcium acetate
Calcium chloride (to 80°C)
Calcium hydrochlodte (to 20%, to 21°C)
Calcium hydroxide (to 80°C)
Calcium nitrate (to 80°C)
Calcium silicate (to 21°C)
Calcium sulfide (to 80°C)
Caustic soda (to 50%, to 80°C)
Chloroacetone (to 21°C)
Citric acid (to 93°C)
Copper II chloride (to 80°C)
Copper cyanide (to 60°C)
Copper nitrate (to 80°C)
Copper sulfate (to 21°C)
Copper sulfide (to 21°C)

Diiron sulfide
Diisopropyl ketone (to 21°C)
Dimethyl holmiamide
Dibutyl cellosolve adipote (to 93°C)
Dextrose (to 80°C)
Disodium phosphate (to 21°C)
Dioctyl amine (to 49°C)

Ethyl chloride (to 60°C)
Ethyl silicate (to 21°C)
Ethylene glycol (to 100°C)
Ethlendiamine (to 49°C)
Ethyl alcohol (to 93°C)
Ethyl sulfate (to 93°C)

Flurobodc acid (to 60°C)
Formaldehyde (to 40%, to 21°C)
Freon 142B (to 21°C)
Floromethane (to 21°C)

Gelatin
Glucose
Glue (to 80°C)

Hydrochloric acid (to 20%, to 21°C)
Hydrogen peroxide (to 0.5%, to 21°C)
Hydrobromic acid (to 20%, to 93°C)
Hydrogen (to 60°C)
Hydrogen sulfide (to 60°C)
Hydroxybutane (to 21°C)

Iron sulfate (to 21°C)
Iron II chloride (to 80°C)
Iron II nitrate (to 80°C)
Isobutyl alcohol (to 71°C)
Isopropyl acetate (to 71°C)
Isopropyl alcohol (to 71°C)

Lead sulfate (to 80°C)
Lactic acid (to 100%, to 60°C)
Lead acetate (to 93°C)
Lead nitrate (to 80°C)
Lead sulfamate (to 60°C)
Lead chloride (to 80°C)
Lime, soda (to 21°C)

Magnesium chloride (to 100%, to 80°C)
Magnesium hydroxide (to 80°C)
Magnesium sulfate (to 80°C)
Mercury (to 60°C)
Mercury II chloride (to 60°C)
Methyl alcohol (to 80°C)
Mirabilite (to 21°C)
Magnesium acetate (to 20%, to 49°C)

Nickel acetate (to 21°C)
Nickel chloride (to 80°C)
Nickel sulfate (to 21°C)
Nitric acid (to 25%, to 21°C)
Nitrogen, gas (to 21°C)

Octyl alcohol (to 71°C)
Oxalic acid (to 100%, to 121°C)
Oxygen, cold (to 21°C)
zone, [O3] (to 21°C)
Orthoboric acid (to 21°C)

Phosphoric acid (to 85%, to 93°C)
Potassium bichromate (to 60°C)
Potassium bisulfite (to 80°C)
Potassium carbonate (to 80°C)
Potassium hydroxide (to 100%, to 93°C)
Potassium nitrate (to 100%, to 80°C)
Potassium phosphate (to 21°C)
Potassium sulfate (to 60°C)
Propyl alcohol (to 80°C)
Propylene glycol (to 21°C)

Salicylic acid (to 93°C)
Salt solution (to 100%, to 80°C)
Silicone greases (to 60°C)
Silicone oil (to 60°C)
Silver nitrate (to 80°C)
Soap solution (to 100°C)
Sodium bicarbonate (to 100%, to 100°C)
Sodium bisulfate (to 80°C)
Sodium bisulfite (to 100°C)
Sodium borate (to 60°C)
Sodium carbonate (to 100%, to 80°C)
Sodium chloride (to 100%, to 80°C)
Sodium hydroxide (to 100%, to 21°C)
Sodium nitrate (to 80°C)
Sodium perborate (to 100%, to 60°C)
Sodium phosphate (to 100%, to 80°C)
Sodium silicate (to 100%, to 80°C)
Sodium sulfite (to 100%, to 60°C)
Sodium sulfate (to 100%, to 60°C)
Sodium thiosulfate (to 60°C)
Sulfuric acid (to 25%, to 60°C)
Sulfurous acid (to 20%, to 100°C)
Sucrose solution (to 121°C)

Tannic acid (to 100%, to 60°C)
Triethanol amine (to 71°C)

Vinegar (to 60°C)

Zeolite
Zinc acetate (to 60°C)
Zinc chloride (to 100%, to 80°C)

Firestone Geomembrane exposed to these chemicals can cause some discoloration, swelling and up to a 30% loss of tensile strength. Limited duration exposure is recommended.

Acetic acid (to 10%, to 21°C)
Acetic anhydride
Acetone
Anhydrofluoric acid
Aniline (to 93°C)
Aniline dye
Animal fats (10%, to 60°C)

Butyl acetate (to 60°C)
Butyl alcohol (to 121°C)

Carbinol (to 21°C)
Carbonic acid (to 85°C)
Carbonic acid gas (to 85°C)
Caster oil (to 60°C)
Chromic acid (to 25%, to 21°C)
Cottonseed oil (to 80°C)
Cyclohexanone (to 21°C)

Dibutylphtalate (to 121°C)
Dibenziether (to 21°C)
Diethlylene glycol (to 60°C)
Dioctylphthalate (at 60°C)
Dioxane (to 71°C)

Epichlorohydrin (to 21°C)
Ethanolamine (to 21°C)
Ethyl acetate (to 70°C)
Ethyl acrylate (to 21°C)
Ethyl cellulose (to 21°C)

Freon 12 (to 21°C)
Furfural (to 71°C)

Glycerin (to 93°C)

Hydrochloric acid (to 25%, to 80°C)
Hydrofluoric acid
Hydrogen peroxide (to 100%, to 21°C)
Hypochlorous acid (at 50% to 60°C)

Linseed oil (at 21°C)

Methyl acetate (to 71°C)
Methyl ethyl ketone (to 93°C)
Mono ethanol amine (to 60°C)
Methyl cellosolve (to 93°C)

Nitric acid (to 35%, to 21°C)
Nitrobenzene (to 60°C)
Nitro ethane (to 21°C)
Nitromethane (to 49°C)

Olive oil (to 21°C)

Palmitic acid diluted (to 50%, to 21°C)
Picric acid (to 21°C)
Propyl acetate (to 21°C)
Pyridine (to 71°C)

Stearic acid concentrated (to 60°C)
Sodium hypochlorite (to 5%, to 21°C)
Sulfuric acid (to 25%, to 60°C)
Sulfuric acid gas (to 50%, to 100°C)
Sulfurous acid (to 20%, to 100°C)
Sulfurous acid gas (to 21°C)

Triethanol amine (to 71°C)

Urea (to 93°C)

Vegetable oil (to 93°C)

Firestone Geomembrane exposure to these chemicals is expected to cause deterioration of the membrane. EXPOSURE TO THESE CHEMICALS IS NOT RECOMMENDED.

Acrylonitrile
Aciyonitrile
Amyl acetate
Amyl naphthalene
Animal fats (concentrated)
Aqua regia
ASTM oil no. 1
ASTM oil no. 2
ASTM oil no. 3
ASTM fuel oil A
ASTM fuel oil B
ASTM fuel oil C
Acetyl chloride

Benzene
Benzyl chloride
Benzine
Butane
Butyl acrylate
Butyl acetate (above 60°C)
Butyl stearate (21°C or higher)

Biphenyl

Carbolic acid
Carbon disulfide
Carbon tetrachloride
Chlorine gas (wet)
Chloro benzene
Chloro naphthalene
Chloro sulfonic acid
Chloroform
Chlorotolehe
Chromic acid (to 25%, above 21°C)
Cresol(s)
Creosote oil
Cyclohexanol
Corn oil
Cyclohexane
Cyclohexanone

Dibutylether
Diclorobenzene
Diethylether
Dipentene
Diisopropyl ether
Dibutylamine
Dextron

Ethyl benzene
Ethylene oxide
Ethylenedichloride
Ethyl bromide
Ethyl butyrate

Freon 11
Freon 21
Freon 113
Fuel oil
Furan
Furfural (at 100°C)

Gasoline
Glacial acetic acid

Hexane
Hexyl alcohol
Hexylene
Hydrochloric acid (above 20%, above 21°C)
Hydrofluoric acid (at 25% or above at 100°C, 100% conc. at 60°C)
Hypochlorous acid (at 75% or above at 21°C or higher)
η-Heptane
Hydrogen peroxide (to 100%, above 21°C)

Itexylene
Isooctane
Isopropyl ether
Isoamyl chloride
Isoamyl ether
Isoamyl phthalate
Isobutylnamide

Jet Fuel
J.P. fuel oil

Lacquer
Lard oil
Linolenic acid
Liquid petronium gas

Malic acid
Mercaptan
Methyl isobutyl ketone
Methyl methacrylate
Methylene dichloride
Mineral oil

Monochlorbenzene
Mineral Naphtha

Naptha
Napthalene
Natural gas
Nitric acid (above 30%, at 21°C or higher
Nitric acid (above 60%)

Oxygen (above 21°C)
Oleic acid
Octane

Pyridine
Perchloroethylene
Petrol (gasoline)
Petroleum, hydraulic fluid
Pinene
Pine oil
Piperidine
Propane
Propylene
Palm oil (at 21°C)
Phenol (at 21°C)
Pyrole

Solene
Styrene
Sulfuric acid (concentrated)
Sulfur monochloride
Sulfur dichloride
Sulfur trioxide

Terpene
Tetraln
Trachloroethane
Toluene
Trichloroethylene
Turpentine oil
Tall oil
Tartaric acid
Tetrahydrofuron [THF] (at 21°C)
Trichloromethane
Tung oil (at 77°C)

Xylene

Varnish
Vinyl benzene

Wood tar

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