



GEOGARD™ EPDM GEOMEMBRANE
DESIGN AND INSTALLATION GUIDE
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I. DESIGN CONSIDERATIONS

A. General

This manual contains information on lining systems using Firestone EPDM Geomembrane. Apart from general recommendations on the use of the sheet, it also gives general information on site, design, and excavation considerations.

As a product manufacturer, Firestone does not perform geotechnical or other design functions. The following information is provided as general guidelines and design considerations only.

Generally, for simple projects, the design may be carried out by the owner or the contractor. However, in the case of larger ponds, canals, water features and commercial installations the problems are often considerably more complex. In these installations, it is recommended that a licensed engineer, geologist, or architect be consulted to ensure that the project is designed in accordance with applicable standards and performs as desired.

1. Application Suitability

- a) The Firestone EPDM geomembrane System is appropriate for any of the following installations:
 - (1) Irrigation and water containment
 - (a) Canals
 - (b) Raw water reservoirs
 - (c) Potable water reservoirs
 - (d) Dam facings
 - (2) Waste containment – municipal or agricultural
 - (a) Animal waste lagoons
 - (b) Municipal landfill covers
 - (3) Aquaculture
 - (a) Pond liners
 - (b) Fish hatcheries
 - (c) Tank liners
 - (d) Raceways
- b) The Firestone EPDM Geomembrane System is not appropriate where any of the following conditions exist:
 - (1) Any containment structure where conditions exist that the substrate will not provide continuous and uniform support for the Firestone EPDM Geomembrane.
 - (2) Any containment for hydrocarbons or chemicals that are known to damage Firestone EPDM Geomembrane.

- c) The Firestone EPDM Geomembrane System is not applicable without special consideration from the Firestone Building Products Technical Department, where any of the following conditions exist:
 - (1) The Firestone EPDM Geomembrane will be subjected to chemical discharge.
 - (2) Where the side slopes exceed 2H:1V
 - (3) Projects where the water table may reach the elevation of the liner
 - (4) Projects that contain erodible or collapsing soils or karst terrain
 - (5) Any project where subterranean gases will be generated or exist
 - (6) Any project where the contained liquid exceeds 80° C (180° F)

B. Protection and Precautions

1. Additional precautions and/or protection may be required in the following situations:

- a) Wind
 - (1) Ballast at the bottom, on slopes at the top of slopes
 - (2) Correct section of anchor trench depending on pullout calculation
- b) Waves
 - (1) Mechanical protection of the embankments depending on slope (rock, precast blocks, cast-in-place concrete)
- c) Floating objects (dead wood and debris)
 - (a) Small ponds: cleaning
 - (b) Large ponds: protection of side slopes
- d) Ice – Mechanical protection of side slopes
- e) Animals
 - (1) Escape ladders or access ramps for large animals such as deer
 - (2) Enclosure fence around reservoir
 - (3) Geotextile under the Firestone EPDM Geomembrane on slopes
 - (4) Soil cover in high traffic areas
- f) Vandalism
 - (1) Enclosure fence around reservoir
 - (2) Mechanical protection of embankments
- g) Operating vehicles
 - (1) Protection of the Firestone EPDM Geomembrane with a soil layer minimum 18" (450 mm) in depth
 - (2) Access ramp designed for equipment travel
- h)- Local turbulence [with water velocity exceeding 1.2 m/sec (4.0 ft/sec) (internal agitator or canals)]
 - (1) Protection with designed cover system or ballast

C. Site and Substrate Considerations

- ##### 1. Site Selection – When selecting the construction site, there are numerous design elements that must be considered to ensure long-term performance of the system and to avoid future problems. Site selection is the responsibility of the design professional.
- a) The nature of the soil substrate and subsurface rock
 - b) The presence of cavities (karst terrain)
 - c) The depth to and the variation of the groundwater level
 - d) The presence of gases in the soil (i.e., peat, organic matter)
 - e) The risk of differential settling (i.e., poorly consolidated soil, recent backfill, landfills)
 - f) The risk of internal erosion (i.e., karst soils, fine silty sands)

2. Site Excavation – The configuration of the impoundment is usually constructed by means of one of the following methods:
 - a) Fully excavating into the natural soil
 - b) Building raised embankments
 - c) Partial excavation with raised embankments
3. Soils
 - a) A thorough geotechnical investigation of the site should be conducted to ensure that the underlying soil will remain stable.
 - b) The type of soil (classification) density, permeability, thickness of the strata, and the depth under the lining system must be known. Table I.1 below outlines some risks based on general soil types.
 - c) The soil supporting the Firestone EPDM Geomembrane system should be compacted to between 90% and 95% of Standard Proctor density, either by construction equipment or by mechanical vibrating roller compacting.

TABLE I-1: SOIL TYPES, RISKS, AND SOLUTIONS

SOIL TYPE	RISK	SOLUTIONS
Compressible (peat, fine sand, saturated clay, loose backfill)	<ul style="list-style-type: none"> • Gas generation • Pressure under Firestone EPDM Geomembrane • Settling • Under-consolidation of backfill materials • Differential settlement and tearing of Firestone EPDM Geomembrane 	<ul style="list-style-type: none"> • Gas Drainage • Slope must be adapted to facilitate gas drainage • Appropriate compaction methods • Soil reinforcement
Soil containing organic matter (old sugar or paper industry ponds, landfill, peat)	<ul style="list-style-type: none"> • Decomposition of organics • Gas generation • Pressure under membrane 	<ul style="list-style-type: none"> • Gas drainage • Slope must be adapted to facilitate gas drainage
Soil with internal erosion potential (backfill material containing waste, limestone-type soil, gypsum chalk)	<ul style="list-style-type: none"> • Dissolution of the soil by liquid due to leaks or groundwater • Slope stability • Collapse caused by eroding water 	<ul style="list-style-type: none"> • Change site or provide a good geological assessment to find cavities, if any • Special reinforcement, double waterproofing, or compaction
Soft clay, silt (CL, SC)	<ul style="list-style-type: none"> • Differential settling and tearing of the Firestone EPDM Geomembrane 	<ul style="list-style-type: none"> • An intermediate layer for drainage and special compacting around penetrations
Coarse substrate soil (GW, GP, GM GC)	<ul style="list-style-type: none"> • Puncture of Firestone EPDM Geomembrane 	<ul style="list-style-type: none"> • Provide geotextile protection

Table I-1: Soil Types, Risks, and Solutions

4. Slopes

If no slope stability study is carried out, the contractor should provide a maximum recommended slope of 2H:1V. If the height of the embankment (above the base of the pond) is between 4.6 and 9.2 m (15.0' and 30.0'), a maximum slope of 3H:1V is recommended when a soil cover is to be used. The values in Table I.2 may be used as a general guide for exposed installations. These values are given according to a uniform type of soil. They should be considered as general guidelines only. Slope stability is the responsibility of the design professional.

a) Bottom

(1) A slope of 1 – 2% is recommended for the following:

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

b) Side slopes or embankment inclines

Stability of the impoundment are geotechnical and geosynthetic issues that must be addressed by a professional design engineer. The presence of groundwater and the type of the soil play an important part in the stability of side slopes. The Firestone EPDM Geomembrane system is not a structural component and is not to be used to provide stability of side slopes. The design engineer should investigate the following:

- (1) The stability of the drainage system and of other layers between the bottom of the pond and the Firestone EPDM Geomembrane.
- (2) Effects of waves
- (3) Consequences of rapid drop in water level
- (4) Consequences of excessive leakage
- (5) Stability of the protection layer, (max. slope for soil cover is 3H:1V)
- (6) Ease of installation

TABLE I-2: TYPE OF SUBSTRATE AND MAXIMUM SLOPE

TYPE OF SUBSTRATE	MAXIMUM SLOPE
Clay	2H:1V
Sandy Clay	2.5H:1V
Sand, Sandy Gravel	3H:1V
Soft Fractured Rock	1.5H:1V

Table I-2: Type of Substrate and Maximum Slope

c) Top of slope crest

(1) The crest at the top of the embankment should have a minimum width as follows:

- (a) 1.5 m (5.0') for installation of the anchor trench
- (b) 4.5 m (15.0') if vehicles are used during the construction and operation of the water feature.
- (c) If a minimum width cannot be obtained, adequate anchoring methods (mechanical connection, anchor trench) must be used. Also, a slight incline of 1% towards the outside of the water feature is recommended for drainage.

5. Drainage

The need for a drainage layer beneath the membrane depends on local site conditions. In all cases, where liquid may cause instability of the subsoil, the amount of water in the soil should be minimized. This may be done by means of a drainage system. 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 pressure is anticipated. Water/gas drainage is always required under the following conditions:

- a) When water flows are possible under the Firestone EPDM Geomembrane
- b) Soils containing organic matter (gas generation)
- c) Slopes containing clay or fine sands (stability when emptying...)
- d) Whenever variations of groundwater level can be anticipated
- e) Whenever the Firestone EPDM Geomembrane is not fixed and can move (wind...)
- f) Rise of the groundwater level/gas entrapment
- g) Groundwater level exceeding the pond water level:

If the ground water level is higher than the bottom of the impoundment, the Firestone EPDM Geomembrane lining system will be subject to hydrostatic backpressure (i.e., uplift). Also, air may be entrapped, causing gas pressure from the groundwater as the level rises. The depth of the groundwater table must be known (both the average level and the extreme level). If the groundwater elevation exceeds the lowest elevation of the Firestone EPDM Geomembrane system, the Firestone EPDM Geomembrane risks being lifted, and the function of the gas drainage system (if installed) may be disturbed. In this case, an appropriate drainage system under the Firestone EPDM Geomembrane membrane, including ballast on top of the Firestone EPDM Geomembrane, should be provided. Groundwater issues and design of dewatering systems must be addressed and designed by a professional engineer.

- h) Water drainage and gas drainage are often combined. For this reason, a slope of 1 – 2% of the base toward the side slopes is recommended. The water drainage may be facilitated by means of one or more of the following:
 - (1) A layer of cohesionless soil (sand or fine gravel) with a minimum thickness of 300 mm (12.0").
 - (2) A layer of permeable geosynthetic material (thick non-woven geotextile or drainage geocomposites).
 - (3) To prevent drain blockage, a natural or synthetic filter must be installed between the soil and the drainage layer. Rules for correct filter design should be followed and addressed by a professional design engineer.
 - (4) A double lining system with a drainage layer between the two Firestone EPDM Geomembranes
 - (5) A network of drainage pipes linked to each other covered with permeable geotextile or a layer of permeable material. Water is collected through a designed network of primary and secondary perforated collection pipes directed to a collection sump or low point. This can also be accomplished with a layer of geonet composite. Again, any drainage system must be designed by a professional engineer.

6. Substrate Venting

A substrate venting system may be required. If so, a design professional with experience in design of similar systems should be consulted prior to commencement of any work. The venting system could be composed of perforated pipes, porous mineral layer, geonet composite, or flat drainpipes. In addition to gas drainage under the Firestone EPDM on the bottom and slopes, top of slope gas vents must be installed.

7. Water Impoundment Shape and Length and Wave Action

- a) Waves created by the wind or by boats can 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, the stronger the wave action will be.
- b) Depending on the specific height of the waves, the type of soil and the slope of the embankments, one or a combination of the following is recommended:
 - (1) Firestone EPDM Geomembrane protection adapted to the slope (concrete, concrete block mattress, rip rap, soil cover)
 - (2) Provide adequate anchoring of the Firestone EPDM Geomembrane lining system
 - (3) Provide adequate compaction of the base soil
 - (4) Provide geotextile protection under the Firestone EPDM Geomembrane lining system to prevent soil sloughing on slopes.

8. Wind Uplift

- a) In areas of high wind ballasting with sand tubes on slopes may be necessary.
- b) Temporary ballasting may be removed if and when permanent ballast is installed (i.e. water, cover soils, ballast tubes, etc.)

9. Maximum Liquid Level

The higher the liquid level in the pond, the higher the hydrostatic pressure. The risks of the base soil settling and the membrane tearing are also increased. Even when considering the high elongation at break properties (500%) of the Firestone EPDM Geomembrane lining systems, settlement could cause the membrane or seams to be stressed and ruptured or punctured by rock. If settlements are anticipated, the subsoils must be structurally designed with geogrids or geotextiles to limit movement. Stabilization of base soils must be designed by a professional prior to the EPDM installation.

D. Product Considerations

1. Membranes:

- a) The Firestone EPDM Geomembrane is a synthetic rubber membrane. The panels are assembled in the factory prior to vulcanization to widths up to 15.25 m (50') thus limiting on-site field seaming. The panels are folded and rolled on cores 3.30 m (10.8') long.
- b) Refer to product TIS for factory panels sizes.
 - (1) Thickness – 1.14 mm (0.045"), 1.52 mm (0.060") and 2.28 mm (0.090")
 - (2) Scrim reinforced EPDM Geomembrane is also available in 1.14 mm (0.045") and 1.52 mm (0.060").
 - (3) Each roll is labeled with the membrane type, thickness, dimensions, manufacture date, and production lot, and an arrow indicating direction of unroll/unfold.
- c) All elements of the Firestone EPDM Geomembrane lining system shall be Firestone products as described in the Technical Data Sheets or products, which are approved by Firestone.

2. Protection Geotextiles

- a) Firestone can provide a protection geotextile that is acceptable as an underlayment.
- b) Geotextiles or geocomposites may be acceptable but should be verified with the design professional and Firestone prior to installation.

E. Anchorage / Attachment Considerations

1. Perimeter Anchoring

- a) Anchor Trenches – An anchor trench is commonly used as a perimeter termination. The trench is excavated, and the membrane is loose laid in it. The trench is then backfilled and compacted with the excavated material or concrete. The type of trench and any requisite pullout calculations shall be completed by a design professional to determine the dimensions of the anchor trench for any given project. In any event, the top of slope runout length to an anchor trench should be a minimum of 0.91 m (3.0').

2. Intermediate Anchoring

- a) If the embankment is high with long slopes, it may be necessary to provide intermediate anchoring to reduce the potential for membrane movement. In these cases, a bench may be added along the slope to provide stability of the EPDM geomembrane. Ballast applied over the membrane at the bench may provide the desired stability.

3. Toe of Slope / Bottom Ballast

- a) In some cases, especially on large reservoirs, temporary and/or permanent ballast (soil cover) may be required due to operating conditions or wind conditions. Additionally, and especially on embankments or dam facings, a toe of slope anchor trench may be required.

4. Inlet Pipe or Concrete Structure Terminations

- a) Where water enters or exits the lined area special considerations must be made for terminating the membrane to ensure that the termination remains intact. This may include prefabricated pipe boots or mechanical batten bar connections.

5. Mechanical Terminations

- a) Mechanical terminations shall be in accordance Firestone specifications and details as well as the design plans and specifications prepared by the design engineer.

F. Firestone EPDM Geomembrane Field Seaming Procedures

Two overlapping Firestone EPDM Geomembrane panels are seamed by means of a patented splicing tape or cap strip system. [Section II.G](#) of the Installation Guide provides details of the various steps required for correct seam procedures for the Firestone EPDM Geomembrane.

G. Flashings and Penetrations

1. Firestone recommends a minimum clearance of 300 mm (12.0") between penetrations, pipes, conduits, etc.
2. Where possible, provide a minimum design height of at least 200 mm (8.0") for all flashing terminations except pre-molded QuickSeam™ Pipe Flashings.
3. When installing mechanical bolt and batten bar terminations, ensure the surface termination provides a constant seal on the concrete or steel substrate.

H. Cover Soil Consideration and Access Ramps (base only or on side slopes)

1. Cover soil can and is commonly installed over the Firestone EPDM Geomembrane System:
 - a) To provide protection from mechanical damage, but it is not required for UV.
 - b) To provide habitat for fish and plant life.
 - c) To provide additional protection from intense wildlife or equipment traffic.
 - d) To provide a more aesthetically pleasing appearance.
2. Concrete and shotcrete can also be installed over and adjacent to the Firestone EPDM Geomembrane System to provide support pads or access ramps for equipment such as aerators, agitators, or other mechanical equipment.

- I. Quality Assurance (Manufacturer and Contractor Experience)
 - 1. A Firestone trained and approved installer is required to install the Firestone EPDM Geomembrane System for issuance of a Firestone material warranty.
 - 2. Projects with membrane only warranties are not always inspected by Firestone.
 - 3. Consultation:
 - a) Firestone Building Products Technical Department is available for consultation with respect to any deviations from Firestone specifications and details.
 - b) If there is any deviation from Firestone procedures without first obtaining written approval from the Firestone Building Products Technical Department, it may not be possible for Firestone to issue a site-specific warranty.
- J. Job Site Considerations (Cautions and Warnings)
 - 1. Protect the membrane against wind damage by ballasting the bottom and side slopes and designing the perimeter anchorage.
 - 2. Ensure against mechanical damage from floating objects, ice, operating vehicles, equipment, etc.
 - 3. Animals can present significant problems. Provide escape ladders, fence around reservoirs, and use a geotextile under the membrane to prevent damage.
 - 4. Confirm compatibility of the membrane with all materials being stored or retained in conjunction with the membrane.
 - 5. Confirm the suitability of the compacted subgrade to ensure that it will have sufficient structural integrity to fully support the membrane and specify repair as required.
 - 6. Avoid contact with asphalt or petroleum products with components of the Firestone EPDM Geomembrane System.
 - 7. Protect all components of the Firestone EPDM Geomembrane System from discharges or contact with petroleum products, greases, oils (mineral and vegetable), and animal fats. Contact Firestone Building Products Technical Department for suggested methods of protection.
- K. Warranty
 - 1. Upon acceptance of the installed Firestone EPDM Geomembrane System by Firestone, the requested warranty shall be issued. Only Firestone supplied components are covered by the Firestone warranty.
 - 2. See Warranty Section for a listing of available Firestone warranties for Firestone EPDM Geomembrane installations.

II. INSTALLATION GUIDELINES

Furnish and completely install the Firestone EPDM Geomembrane System in accordance with Firestone's published Installation Procedures, specifications, and details as well as project design requirements.

A. Submittals

1. Panel Layout

- a) The installation contractor shall provide a panel layout drawing or plan.
- b) The panel layout drawing shall be based on the specification and design details and will show the position and size of each panel and location of field seams.
- c) The placement of the panels will proceed according to this plan unless changes must be made due to unforeseen site conditions.

2. Installation Details

The installation contractor shall provide copies of any special detail terminations that may be required.

B. Job Site Considerations (Cautions and Warnings)

1. Ignition Sources

Keep all adhesives, sealants, and cleaning materials (e.g., gas, heptane, etc.) away from ALL ignition sources (i.e., torches, flames, fire, sparks, etc.).

2. Safety Instructions

Consult container labels and Safety Data Sheets (SDS) for specific safety instructions.

3. Storage

Store Firestone EPDM Geomembrane in the original undisturbed plastic wrap in such a manner as to protect it from site damage, equipment and standing water.

4. Membrane Contamination

Do not use oil-based or bituminous-based materials with Firestone EPDM Geomembrane.

5. Miscellaneous Contamination

All bonding, splicing, and sealing surfaces must be free of dirt, moisture, and any other contaminants.

6. Temperature

When the outside temperature is below 4.4° C (40° F), certain combinations of temperature and humidity may cause condensation on the surface of solvent-based adhesives and primers. If this condition occurs, discontinue the application. When the ambient air conditions no longer cause condensation on the adhesive surfaces, reapply additional adhesive or primer and proceed.

- a) The consistency of sealants, adhesives and primers will begin to thicken as the temperature drops. To minimize this, the following is recommended:

- (1) Start work with sealants, adhesives and primers that have been stored between 15.5 °C and 26.7 °C (60 °F and 80 °F). Insulated and/or heated boxes may be helpful.
- (2) Complete test areas to determine if conditions will cause problems such as condensation with the application of the material.
- (3) Stop the operation or change to another warm container when material becomes too thick to properly dry.

- b) Do not use heat guns or open flames to dry adhesives and primers.

7. Cautions

- a) Do not thin or modify any Firestone material.
- b) Deliver materials to job site in their original containers as labeled by the manufacturer.
- c) Follow manufacturer's directions for protection of materials prior to and during installation. Do not use materials, which have been damaged to the point that they will not perform as specified.
- d) Care should be taken not to damage the Firestone EPDM Geomembrane during transport, loading, and unloading. The rolls must be stacked on a flat, clean surface, free of sharp protrusions that could damage the geomembrane.
- e) Firestone EPDM Geomembrane does 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 (50° F and 77° F), protected against extreme weather conditions.

C. Subgrade Inspection and Preparation

1. Inspection of Support Surface

- a) As part of Construction Quality Control (CQC) and before installing the Firestone EPDM Geomembrane, quality of the soil subgrade and the surface condition should be examined to determine compliance with design requirements and Firestone minimum requirements for placement and seaming of the EPDM geomembrane panels.

2. Soil Preparation

- a) The subgrade soils in intimate contact with the Firestone EPDM Geomembrane shall be smooth, compacted, and free of aggressive angle changes, ruts, loose stones, and angular stones in excess of 12.0 mm (0.5"). The subsoil should be roller compacted to minimum 95% of Standard Proctor Density and designed to resist any differential settling of the soil and facilitate the installation of a drainage system, if required. Adequate support can be provided in the following ways dependent on design requirements:
- b) Excavate the unsuitable subgrade base soil, remove rock, vegetation, saturated soils etc., followed by smoothing and compacting of the base.
- c) Backfill with layers of select fill material which are then compacted to the desired density and grade.

3. Vegetation

All plant growth should be removed from the base soil prior to grading and compaction to avoid any gas generation and compressible areas. Depending on the conditions, the use of water-based herbicide is recommended. The herbicide must not contain any chemicals, known to affect the Firestone EPDM Geomembrane lining system.

4. Compaction

- a) All soils supporting the Firestone EPDM Geomembrane System must be roller-compacted smooth to between 90% and 95% of Standard Proctor Density and in accordance with methods and specifications provided by the Design Engineer.
- b) The supporting surface should not contain any loose angular stones exceeding 12.0 mm (0.5") in diameter. The final surface should be smooth and uniform with no abrupt changes in elevation.
- c) If site conditions and soils are not acceptable, a protection layer of minimum 10 oz/yd² (340 gm/m²) non-woven geotextile should be provided.

d) Soil around concrete structures

The Firestone EPDM Geomembrane liner fixed to a concrete structure must be on firm soil subgrade. Compaction of backfill around such structures must be performed with particular care and shall be compacted to minimum 95% of Standard Proctor Density and must comply with Design Engineer requirements.

D. Underlayment Installation

1. Hard Substrates (concrete, treated soils, etc.)

On hard substrates such as concrete, it is always necessary to install a protection layer, unless the Firestone EPDM Geomembrane is fully adhered. On a bituminous support (bituminous concrete, bitumen emulsion stabilized soil), a geotextile of at least 270 g/m² (8.0 oz/yd²) or more should be used.

2. Installation of a geotextile between the subgrade soil and the Firestone EPDM Geomembrane is generally recommended. It is an absolute necessity on slopes where deposition of an additional support layer is often difficult. Depending on the type of soil and roughness of the surface, the mass of the geotextile may vary between 270 and 540 g/m² (8 and 16 oz/yd²). The typical geotextile is a non-woven, needle punched fabric. There are other types of geosynthetics, such as geonets, and geonet composites that can provide gas and water drainage as well as protection and may be required dependent on the design.

3. Protection geotextiles are usually thermally welded at an overlap of 100.0 mm (4.0"). To avoid any wind uplift, the geotextile should be temporarily ballasted with sandbags.

E. Firestone EPDM Geomembrane Installation

1. The panels are unrolled and/or unfolded into the position indicated on the layout plan.

2. Generally, side slope panels are placed and temporarily ballasted (sandbags) first, followed by the bottom panels.

3. The Firestone EPDM Geomembrane panels are unrolled from the anchor trench down the side slopes and the geomembrane is temporarily anchored to avoid movement down slope.

4. No rocks or sharp objects are allowed under the geomembrane during placement. Damage to the supporting soil or geotextile underlayment must be avoided and must be repaired.

5. The side slope panels should extend a minimum of 1.65 m (5.0') out onto the pond bottom for connecting with adjoining panels.

6. All Firestone EPDM Geomembrane panels must be allowed to relax at least 30 – 45 minutes prior to seaming or attachment to structures.

7. To avoid movement and wind uplift of the Firestone EPDM Geomembrane during installation, a temporary ballast (sandbags) is recommended. Such ballasting also facilitates the seaming operations.

F. Firestone EPDM Geomembrane Lap Seaming

1. The seaming of adjacent panels should be performed immediately after the relaxation of the Firestone EPDM Geomembrane.

2. All panels must be installed without tension and without wrinkles overlapping by at least 100 mm (4.0"). All seams on side slopes must be parallel with the slope (i.e., up and down the slope). Horizontal field seams on slopes are not allowed.

3. For soft or rough subsoils, a board or piece of conveyor belt is used under the Firestone EPDM Geomembrane in the area of the seam. The seaming board is moved by means of a rope as the seaming process progresses.

4. Seams should not be made under the following conditions:
 - a) Moisture
 - b) Soft subgrade soil
 - c) Condensation on the primer or on the geomembrane
 - d) Rainfall
 - e) Ponded water
 - f) Excessive wind/dusty conditions
 - g) Other contaminants
 5. Moisture in the seam will cause failure of the seam.
 6. Use only Firestone-approved products. Non-Firestone products cannot be approved to make seams and will void any warranties.
 7. Clean the seam area with water and dry before applying the QuickPrime™ Plus, if it is contaminated (mud, etc.).
 8. Stop the application of the QuickSeam™ Tape and FormFlash™ when the atmospheric conditions are unfavorable (humidity, condensation on the QuickPrime Plus or rain).
 9. Movement of the Firestone EPDM Geomembrane during application of the QuickSeam Splice Tape and during the first few minutes after application should be avoided.
 10. Positioning of a large number of panels than cannot be seamed together in one day is not allowed.
- G. Firestone EPDM Geomembrane Seaming Procedures
- a) 150 mm (6.0") wide cover strip tape seaming system:
 - (1) Position the Firestone EPDM Geomembranes
 - (2) Both adjacent panels are positioned with sufficient overlap 100 mm (4.0").
 - (3) The panels should lay flat and without any tension.
 - b) Clean the Overlap

If there is dirt in the overlap area, clean the overlap area using a broom, air blower or clean cotton cloth. Soil should not be allowed to contaminate the Firestone EPDM Geomembrane in the splicing area.
 - c) Apply the QuickPrime
 - (1) Stir the QuickPrime Plus before and during use and transfer a small quantity 1.5 L (0.4 gal) to a bucket. The Primer is applied with a scrubbing pad.
 - (2) Immerse the scrubbing pad in the QuickPrime Plus, keeping the pad horizontal and
 - (3) let excess of QuickPrime Plus drip off the pad.
 - (4) Each pad immersed in QuickPrime Plus will cover an area of about 0.92 m (3.0') in length, over a width 100 mm (4.0") one side.
 - (5) Change scrubbing pads every 61.0 m (200.0') or when the primer has dried on the pad. Used pads are to be discarded at the end of the working day.
 - (6) Additional priming is required at factory seams, at the intersection of two seams and to areas covered with adhesive.
 - (7) Both sides to be seamed are treated simultaneously to obtain an identical drying time.
 - (8) Prime a minimum of 76.0 mm (3.0") on either side of the overlap edge.

- d) Test QuickPrime Plus for Readiness (use the touch-push method)
Allow the primer to flash off. The primer needs to dry completely (5 – 10 minutes) before installing the tape. Check its dryness by touching the primed surface with a clean and dry finger to be certain 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...).
- e) Install the QuickSeam Cover Strip
- (1) Place the roll of QuickSeam Cover Strip on the ground a few feet ahead of the overlap starting point, positioned so that it unrolls from the top of the roll (release paper will be on top).
 - (2) Starting a minimum of 76.0 mm (3.0") ahead of the edge of the panel, center the QuickSeam Cover Strip roll on the overlap edge and unroll onto the clean and primed surface.
 - (3) Advance the roll keeping the cover strip centered over the overlap edge. Peel the release paper as you apply the cover strip.
 - (4) When it is necessary to cover a longer overlap edge than the length of one roll of cover strip, it is required to overlap the next roll a minimum of 25.0 mm (1.0") onto the installed roll before continuing to unroll the second roll. When the end of the overlap is reached, extend the cover strip 76.0 mm (3.0") before cutting.
- f) Roll the QuickSeam Cover Strip
Apply pressure along the entire length of the cover strip by hand to completely mate the two surfaces. Using a 38.0 mm (1.5") wide silicone rubber roller, roll the QuickSeam Cover Strip with positive pressure towards the outside edge then along the entire length of the cover strip.
- g) Install Cover Strip at the End of Seaming Runs or T-Joints
- (1) At the 25.0 mm (1.0") laps of the cover strip it is required to install a 300 mm (12.0") long section of cover strip parallel with the lap edge and centered over it. Before installing the cover strip, the area to be covered must be cleaned and primed in the normal fashion.
 - (2) When cover strips intersect at any point, a 300 mm (12.0") long section of cover strip shall be installed centered over each T-joint area.
 - (3) Round the corners on the 300 mm (12.0") section and then install it onto the dry primed area. Roll with the silicone rubber roller in the same manner as done to the cover strip.
- h) Special Considerations – End Laps, T-Joints, etc.
- (1) End Laps:
When the splice is greater in length than the QuickSeam Cover Strip, the adjoining 150 mm (6.0") QuickSeam Cover strip must be overlapped a minimum of 25 mm (1.0")
 - (2) T-Joints:
Apply a section of Firestone QuickSeam Flashing or QuickSeam Joint Cover over the T-Joint area.

2. Overlapped Inseam Double Faced Tape System (alternative to 150 mm (6.0") wide cover strip tape seaming system) **NOTE:** This is an optional method only as the Cover Strip Seam is the method most commonly used in geomembrane applications.
 - a) Position the Firestone EPDM Geomembrane
 - (1) Both adjacent panels are positioned with a minimum overlap of 100 mm (4.0").
 - (2) The panels should lay flat and without any tension.
 - (3) A marker is used to indicate on the lower sheet the exact location where the splice tape is to be installed.
 - (4) The mark shall be situated between 10 and 20 mm (0.4" and 0.8") from the edge of overlapping sheets and is repeated every 0.91 m (3.0') of seam length.
 - b) Tack-back the Overlap
 - (1) The upper Firestone EPDM Geomembrane panel edge is folded back 254.0 mm (10.0") and the fold is tacked down every 0.91 m (3.0') with QuickPrime Plus.
 - (2) If there is dirt in the overlap area, clean the overlap area using a clean cotton cloth soaked in QuickPrime Plus. Soil should not be allowed to contaminate the Firestone EPDM Geomembrane in the splicing area.
 - c) Apply the QuickPrime
 - (1) Stir the QuickPrime Plus before and during use and transfer a small quantity 1.5 L (0.4 gal) to a bucket. The Primer is applied with a scrubbing pad.
 - (2) Immerse the scrubbing pad in the QuickPrime Plus, keeping the pad horizontal and let excess of QuickPrime Plus drip off the pad.
 - (3) Apply the QuickPrime Plus uniformly along the length of the overlap seam 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 gray in color. Avoid traces and wet spots. Each pad immersed in QuickPrime Plus will cover an area of about 0.91 m (3.0') in length, over a width of 100 mm (4.0") one side.
 - (4) Change scrubbing pads every 61.0 m (200.0') or when the primer has dried on the pad. Used pads are to be discarded at the end of the working day.
 - (5) Additional priming is required at factory seams and at the intersection of two seams.
 - (6) Both sides to be seamed are treated simultaneously so as to obtain a similar drying time.
 - (7) Test QuickPrime Plus for readiness. Allow the primer to flash off. The primer needs to dry completely (5 – 10 minutes) before installing the tape. Check its dryness by touching the primed surface with a clean dry finger to be certain 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...).
 - d) Install the QuickSeam Splice Tape
 - (1) Apply the QuickSeam Splice Tape (with release paper intact) on the bottom sheet, aligning the edge of the release paper with the markings.
 - (2) Immediately roll the splice with a 100 mm (4.0"), wide silicone sleeved hand roller or other methods to achieve 100% bond area.
 - (3) When it is necessary to start a new roll of tape to continue seaming, it is required to overlap the installed tape by 25 mm (1.0") minimum before unrolling the second roll.
 - e) Check the QuickSeam Splice Tape Alignment
 - (1) The Firestone EPDM Geomembrane is released, and the seam is closed by 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.

- (2) Trim the top sheet as necessary to assure that 10 – 15 mm (0.4" – 0.6") of the QuickSeam Splice Tape will be exposed on the finished splice.
- f) Remove the Paper Backing
 - (1) To remove the paper backing from the tape, first roll back the upper Firestone EPDM Geomembrane panel over the installed QuickSeam Splice Tape. Peel the paper backing off the QuickSeam Splice Tape by pulling against the weight of the bottom sheet at a 45° angle to the tape.
 - (2) Allow the top sheet to fall freely onto the exposed QuickSeam Splice Tape. Mate the entire length of the seam as the release paper is being removed.
- g) Roll the Overlap Seam
 - (1) Finally, roll the seam area by means of a 38 mm (1.0") silicone rubber roller, first across the splice and then along the entire length of the splice.
 - (2) For uneven or soft subgrades, a seaming board is required directly under the seam area. The seaming board is moved as the seam is completed.
- h) Install QuickSeam Joint Covers or QuickSeam Cover Strip at the End of Seaming Runs and T-Joints
 - (1) Install a 146 mm (5.75") QuickSeam Joint Cover over end laps or T-joints. Before installing the Joint Cover, the area to be covered must be cleaned and primed in the normal fashion. Roll the Joint Cover with the roller in the same manner as the overlap seam.
 - (2) At 25 mm (1.0") laps in the seam tape it is required to install a 150 mm x 150 mm (6.0" x 6.0") section of cover strip centered over the seam edge and over the lap. Before installing the cover strip, the area to be covered must be cleaned and primed in normal fashion.
 - (3) Trim seam so that the edge of seam tape and the edge of the geomembrane are flush beneath the T-joint area. Apply a 228 mm (9.0") long section of cover strip centered over the seam step-off.
 - (4) Round the corners of the cover strip section and then install it onto the dry-primed area. Be sure to center the cover strip so that it extends 76 mm (3.0") in each direction from the center of the overlap and the edge of the seam. Roll with the roller in the same manner as done with the overlap seam.
- i) Special Considerations – End Laps, T-Joints
 - (1) End Laps:

When the splice is greater in length than the QuickSeam Cover Strip, the adjoining 150 mm (6.0") QuickSeam Cover strip must be overlapped a minimum of 25 mm (1.0").
 - (2) T-Joints:
 - (a) Apply a section of Firestone QuickSeam Flashing or QuickSeam Joint Cover over the T-Joint area.
 - (b) After the primer has dried, apply a continuous bead of Lap Sealant 0.52 mm x 6.35 mm (0.375 x 0.25") around the cover strip section edge. Using the supplied Lap Sealant tool, feather the Lap Sealant immediately, taking care to leave a mound of sealant directly over the cover strip section edge.

H. Geomembrane Termination

The Firestone EPDM Geomembrane must be restrained in place to prevent movement down the slope and/or by wind. Depending on the design requirements, the Firestone EPDM Geomembrane may be anchored at various locations (i.e., top of embankment, toe of slope, or at an intermediate bench).

1. Top Anchoring the Firestone EPDM Geomembrane

- a) The top of the slope should be rounded to provide a smooth transition for the liner to reduce stress. An anchor trench must be excavated around the entire perimeter of the impoundment. The excavated soil material can be placed next to the trench for backfilling after Firestone EPDM Geomembrane placement. The anchor trench should be a minimum of 0.91 m (3.0') back from the top of slope. The edge of the trench should be rounded and free of protrusions to reduce stress and damage on the Firestone EPDM Geomembrane.
- b) If considerable soil movements are expected during the filling of the pond, temporary anchoring should be provided at the crest so that the Firestone EPDM Geomembrane underlayment can move without being subjected to excessive tension. Partial ballasting in the anchor trench is immediately provided and final backfill is done at a later stage. To avoid movement and wind uplift of the Firestone EPDM Geomembrane during installation, temporary ballast (sandbags) is recommended. Such ballasting also facilitates the seaming operations.
- c) The Firestone EPDM Geomembrane must be kept in place to prevent down slope movement and/or wind uplift. Depending on the design requirements and potential for movement, the Firestone EPDM Geomembrane may be anchored at the top of the embankment (anchor trench), at the bottom, or at an intermediate bench.
- d) The top of slope anchor is commonly accomplished by burying the Firestone EPDM Geomembrane in a trench or by holding it in place through soil backfilling or ballasting. The dimensions of the trench depend on the expected stress and pullout calculations that are provided by the design engineer and are reflected in the design drawings.
- e) The Firestone EPDM Geomembrane should extend down the front (inside) of the trench wall and fully extend across the bottom of the trench.

2. Intermediate Anchors

- a) If the embankment is high and slopes are relatively long, it may be necessary to provide an intermediate bench at mid slope to accommodate the potential for Firestone EPDM Geomembrane movement. A bench may be added by the design engineer to provide slope stability of the embankment in addition to restricting downslope movement and allowing soil cover stability.
- b) The Firestone EPDM Geomembrane should be held in place by prefabricated ballast, anchor trench in the bench, or cover soil.

3. Toe of Slope / Bottom Ballast

In some cases, especially on large reservoirs, temporary and/or permanent ballast (soil cover) may be required due to operating conditions or wind conditions. Additionally, and especially on embankments or dam facings, toe of slope anchor trenches may be required as part of the design.

4. Inflow Terminations

Dependent on the design requirements, especially on reservoirs and canals, the point where the water enters the lined area must have proper termination as well as protection of the lining system. The area of inflow must be anchored against uplift and turbulence and must be protected by concrete or riprap as required in the design documents.

I. Terminations

a) Flashing Walls

- (1) Connections of the Firestone EPDM Geomembrane to concrete/masonry structures shall comply with the following:
 - (a) Soil around the concrete/masonry shall be compacted to 95% standard Proctor density.
 - (b) Connection surfaces shall be smooth, clean and free of any sharp protrusions.
 - (c) Firestone EPDM Geomembrane shall be fully adhered to the walls using bonding adhesive or splice adhesive as required.
 - (d) Corners are installed with QuickSeam Corner Flashings or by using QuickSeam FormFlash.
 - (e) The detail of the Firestone EPDM Geomembrane connection with the wall shall not permit any leakage.
 - (f) Firestone EPDM Geomembrane is fastened at the ends or top using termination bars and fasteners adapted to concrete/masonry. Firestone Water Block sealant can be placed between the Firestone EPDM Geomembrane and the wall as shown in Firestone details. Alternatively, the design specifications and details may require specific mechanical attachment and sealing.

J. Flashing Penetrations

1. To avoid any differential settling, the backfill around the structures should be placed in successive layers, each compacted to 95% standard Proctor density.
2. If possible, avoid cutting the Firestone EPDM Geomembrane at details. In some cases, however, as with corner details against concrete/masonry walls, pipe connections, etc., a cut in the Firestone EPDM Geomembrane liner will simplify the installation. In such cases, QuickSeam FormFlash (unvulcanized EPDM sheet) will be used to provide a tight connection when properly installed according to the manufacturer's instructions.
3. For larger diameter pipes, connections to pipes shall be made by means of unvulcanized EPDM sheet, QuickSeam FormFlash, as follows:
 - a) Pipe must be firmly anchored, and the pipe wall temperature must not exceed 80° C (175° F) during service
 - b) Make a circular cut-out in the Firestone EPDM Geomembrane, measuring approximately 80% of the pipe diameter.
 - c) Pull the Firestone EPDM Geomembrane over the pipe.
 - d) Pipe and Firestone EPDM Geomembrane are sealed by means of a piece of QuickSeam FormFlash.
 - e) Mechanically secure the connection with double stainless-steel clamping collar or as shown in the design details for the project.
4. Bottom Drains
 - a) The Firestone EPDM Geomembrane shall be mechanically fastened at the location of concrete structures designed for water discharge.

K. Firestone EPDM Geomembrane Repair and Maintenance Procedures

1. A small tear or hole in the Firestone EPDM Geomembrane may be repaired by placing a piece of the 150 mm (6.0") cover strip over the area to be repaired with 75.0 mm (3.0") extending all

- directions beyond the repair. The patch must be round, oval, or contain rounded corners.
2. 150 mm (6.0") Diameter QuickSeam Joint Cover patches
 - a) Small holes may be repaired using the QuickSeam Cover Patch.
 - b) Clean the damaged area by scrubbing with a cloth soaked in QuickPrime Plus. The surface should be dark gray in color with no streaking. Allow the area to dry.
 - c) Repair the larger tears or holes by cutting a piece of Firestone EPDM Geomembrane that extends beyond the tear or hole by a minimum of 100 mm (4.0") extending all directions beyond the repair. Tape all edge seams as per [Section II.G](#) using the cover strip seaming tape system.
 3. Annual maintenance inspection of the EPDM installation is recommended to detect any problems or potential problems. This inspection process will limit costs if damage has occurred. As a minimum, the following items should be included:
 - a) Visual inspection of the Firestone EPDM Geomembrane, seams, and terminations.
 - b) Measurement of any leakage rate at collection sump and monitoring of water level.
 - c) Inspect all gas drainage vents for proper operation.
 - d) Inspect for any historical or current overflowing of the pond, canal, or water feature.
 - e) Inspect and sample the chemical composition and the temperature of the liquids coming into contact with the Firestone EPDM Geomembrane.
 - f) Inspect any cover materials for stability and movement that could damage the EPDM.
- L. Seam Test Procedures
1. Test Seam or Trial Seam – Destructive Mechanical Testing
 - a) At the start of a shift and every 4 hours, the seaming crew should complete a trial seam of 3.0 m (10.0') in length.
 - b) From the trial seam, 25 mm (1.0") wide strips are cut for testing on a field tensiometer – 3.0" peel and 3.0" – shear. Shear and peel tests are carried out in general accordance with ASTM D413 and D7272 with the strain rate of 500 mm/min (20 in/min) for both peel and shear due to the elastomeric properties of Firestone EPDM Geomembranes. Trial seam test strips and destructive samples should be allowed 24 hours of cure time prior to testing.
 - c) The minimum requirements are as follows:
 - (1) Shear: 6.15 kN/m (35 lb/in) at 200% strain.
 - (2) Peel: 2.11 kN/m (12 lb/in) in cohesive bond mode.
 - d) The same minimum requirements can be expected for specimens taken from a destructive field seam cut out when required.
 2. Non-Destructive Test (NDT) Procedure
 - a) Air Lance Test (ASTM D4437)
 - (1) Inspect all field seams for unbonded areas using an air nozzle directed on the upper seam edge and surface to detect loose edges, ruffles indicating unbonded areas within the seam, or other undesirable seam conditions.
 - (2) Check all bonded seams using a minimum 345 kPa (50 lb/in²) air supply directed through a 4.8 mm (0.18") nozzle, held not more than 50 mm (2.0") from the seam edge and directed along the seam edge.
- M. Protection of the Firestone EPDM Geomembrane During Service
1. Under all operating conditions, protection of the Firestone EPDM Geomembrane will be required and should be designed by a professional engineer. Table II.1 below illustrates some recommendations for the protection of exposed EPDM geomembrane against possible damage.

2. Protection of the geomembrane may be realized in the following ways and must be designed by a professional engineer:
 - a) Base
 - (1) Sand cover (minimum thickness: 300 mm (12.0") – protection with geotextile usually not required.
 - (2) Gravel (minimum thickness 300 mm (12.0") – protection with geotextile required.
 - (3) Prefabricated blocks – protection with geotextile required.
 - b) Slopes
 - (1) Rock covering (riprap) – This solution is applicable for slopes less than 3:1. A transition layer (geotextile plus sand cover) with a minimum thickness of 300 mm (12.0") is required. Rock size depends on the level of the impacting forces, such as wave height.
 - (2) Prefabricated blocks – Stability investigations of prefabricated blocks and installation of a redundant layer of EPDM may be required.
 - (3) Cast-in-place concrete – Stability investigations and installation of a redundant layer of EPDM may be required.
 - (4) Shotcrete – installation of a geotextile may be required on steep slopes (>2H:1V). Additionally, wire reinforcement may be required. (If wire reinforcement is used contact Firestone Building Products Technical Department for additional protection requirements.)

TABLE II-1: PROTECTION RECOMMENDATIONS

PROTECTION AGAINST	RECOMMENDATION
Wind	<ul style="list-style-type: none"> • Ballast at the bottom or on slopes • Correct section of anchor trench depending on pullout calculations
Waves	<ul style="list-style-type: none"> • Mechanical protection of the embankments depending on slope (rock covering, concrete pavement, cast-in-place concrete)
Floating objects (dead wood, debris)	<ul style="list-style-type: none"> • Small ponds: cleaning • Large ponds: protection of side slopes
Ice	<ul style="list-style-type: none"> • Mechanical protection of embankments
Animals	<ul style="list-style-type: none"> • Ladders • Fence around reservoir • Geotextile under the Firestone EPDM Geomembrane on slopes
Vandalism	<ul style="list-style-type: none"> • Enclosure around reservoir • Mechanical protection of embankments
Operating vehicles	<ul style="list-style-type: none"> • Protection of the Firestone EPDM Geomembrane with soil or a sand bed [min. 18" (450mm)] • Access ramp protection of embankments
Local turbulence with water velocity exceeding 4 ft/sec (1.2 m/sec) (internal agitator or canals)	<ul style="list-style-type: none"> • Protection with designed cover system or ballast

Table II-1: Protection Recommendations

N. Warranty

1. Upon inspection and acceptance of the installed Firestone EPDM Geomembrane System, the requested warranty shall be issued. Only Firestone supplied components are covered by the Firestone warranty.