

Firestone



Lining for Life™

Technical Specification Guideline

SECTION I- DESIGN CONSIDERATIONS

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SECTION I- DESIGN CONSIDERATIONS

This manual contains information on lining systems using Firestone PondGard™ Rubber Liners. 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.

1.01 Applicability

- A. The PondGard System is appropriate for any of the following installations:
 - 1. Decorative water features
 - a. Waterfalls
 - b. Golf course lakes
 - c. Residential and other small ponds
 - d. Stream features
- B. The PondGard 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 PondGard liner.
 - 2. Any containment for hydrocarbons or chemicals that known to damage PondGard Rubber Liners.
- C. The PondGard System is not applicable without special consideration from Firestone Specialty Products Department, where any of the following conditions exist:
 - 1. The PondGard membrane 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. Any project where subterranean gases are known or suspected to exist.
 - 5. Any project that may contain hot liquids where the temperature of the liquid may exceed 80° C (180° F).

1.02 Protection and Precautions

- A. Additional precautions and/or protection may be required in the following situations:
 - 1. Wind
 - a. Ballast at the bottom, on slopes at the top of slopes
 - b. Correct section of anchor trench depending on pullout calculation
 - 2. Waves

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Mechanical protection of the embankments depending on slope (rock, precast blocks, cast-in-place-concrete)

3. Floating objects (dead wood and debris)
 - a. Small ponds: cleaning
 - b. Large ponds: protection of side slopes
4. Ice - Mechanical protection of embankments
5. Animals
 - a. Geotextile under the PondGard membrane on slopes
 - b. Soil cover in high traffic areas
6. Vandalism
 - a. Enclosure around reservoir
 - b. Mechanical protection of embankments
7. Operating vehicles
 - a. Protection of the PondGard Rubber Liners with a soil layer minimum 457.2 mm (18.0") in depth
 - b. Access ramp protection for embankments
8. Local turbulence (with water velocity exceeding 1.2 m/sec (4.0 ft/sec) (internal agitator or canals))
 - a. Protection with designed cover system or ballast

1.03 Site and Substrate Considerations

- A. 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.
 1. The nature of the soil substrate
 2. The presence of cavities (karst terrain)
 3. The depth to and the variation of the groundwater level
 4. The presence of gases in the soil (i.e. peat, organic matter)
 5. The risk of differential settling (i.e. poorly consolidated soil, recent backfill, landfills)
 6. The risk of internal erosion (i.e. karst soils, fine silty sands)
- B. Site Layout- The layout of the water feature may be executed by means of one of the following methods:
 1. Fully excavating natural soil
 2. Building raised embankments
 3. Partial excavation with raised embankments
- C. Soils
 1. A thorough geotechnical investigation of the site should be conducted to ensure that the underlying soil will remain stable.
 2. The type of soil (classification) density, permeability, thickness of the strata, and the depth under the lining system must be known. The table below outlines some risks based on general soil types.



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3. The soil supporting the PondGard lining system should be compacted to between 90% and 95% of Standard Proctor density, either by construction equipment or by mechanical vibrating roller compacting.

Table 1.1

SOIL TYPE	RISK	SOLUTION
Compressible (peat, fine sand, etc.) (PT, OH, OL,) Loose backfill	<ul style="list-style-type: none"> Gas generation Pressure under PondGard Rubber Liners Settling Under-consolidation of backfill materials Differential settlement and tearing of PondGard Rubber Liners 	<ul style="list-style-type: none"> Gas Drainage Slope must be adapted to facilitate gas drainage Appropriate compaction methods
Soil containing organic matter (old sugar or paper industry ponds, landfill, peat) (PT, OH, OL,)	<ul style="list-style-type: none"> Decomposition/gas generation Pressure under membrane 	<ul style="list-style-type: none"> 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 a leaking lining system 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	<ul style="list-style-type: none"> Differential settling and tearing of the PondGard Rubber Liners 	<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 PondGard Rubber Liners 	<ul style="list-style-type: none"> Provide geotextile protection

D. Slopes - If no slope stability study is carried out, the contractor shall 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' – 30'), a maximum slope of 3H:1V is recommended when a soil cover is to be used. The values in Table 1.2 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.

1. Bottom

- a. A slope of 1% to 2% is recommended for the following:
- 1) Correct operation of the drainage system
 - 2) Easy maintenance of the pond (if unprotected)
 - 3) Positive gas movement



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2. Side Slopes or Embankment Inclines

Stability of the impoundment are geotechnical and geosynthetic issues. The presence of groundwater and the nature of the soil play an important part in the stability of the side slopes. The PondGard system is not to be used to provide stability of the side slopes. The minimum stability study shall deal with the following:

- a. The stability of the drainage system and of other layers between the bottom of the pond and the PondGard membrane.
- b. Effects of waves
- c. Consequences of rapid drop in water level
- d. Consequences of excessive leakage
- e. Stability of the protection layer, (max. slope for soil cover is 3H:1V)
- f. Ease of installation

Table 1.2

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

3. Top of slope crest

- a. The crest shall have a minimum width as follows:
 - 1) 1.5 m (5.0') for installation of the anchor trench
 - 2) 4.5 m (15.0') if vehicles are used during the construction and operation of the water feature.
- b. If a minimum width cannot be obtained, adequate anchoring methods (like an anchor trench) must be used. Also, a slight incline of 1% towards the outside of the water feature is recommended for drainage.

E. 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:

1. When water flows are possible under the PondGard membrane, in soils where erosion may be possible (karst soil,...)
2. Soils containing organic matter (gas generation)
3. Slopes containing clay (stability when emptying...)
4. Whenever variations of groundwater level can be anticipated
5. Whenever the PondGard membrane is not fixed and can move (wind...)

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6. Rise of the groundwater level/gas entrapment
7. Groundwater level exceeding the pond water level:
If the ground water level is higher than the bottom of the water feature, the PondGard 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 PondGard system, the PondGard membrane 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 PondGard membrane, including ballast on top of the PondGard membrane, should be provided. Groundwater drainage systems must be designed by a design professional.
 - a. Rapid emptying (draw down) of the pond with high groundwater level.
8. Water drainage and gas drainage are often combined. For this reason, a slope of 1 to 2% of the base toward the side slopes is recommended. The water drainage may be facilitated by means of one of the following:
 - a. A layer of cohesionless soil (sand or fine gravel) with a minimum thickness of 304.8 mm (12.0").
 - b. A layer of permeable geosynthetic material (thick non-woven geotextile or drainage geocomposites).
 - c. In order 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.
 - d. A double lining system with a drainage layer between the two PondGard membranes, or by covering the embankment crest with PondGard membrane in order to avoid infiltration in back of the lining system.
 - e. A network of drainage pipes linked to each other covered with permeable geotextile or a layer of permeable material.
 - 1) Water can be collected by a network of primary and secondary collection pipes placed at the lower points of the pond or a layer of geonet composite placed over the entire pond bottom. For larger structures a compartmentalized drainage network is recommended to facilitate leak detection.
 - 2) Size and gradient of water drainage system depends on the following factors:
 - a) Leak flow rate that is acceptable.
 - b) Flow rate of water coming from outside of the pond.
 - c) Maximum pressures acceptable under the membrane.
 - 3) For smaller projects the use of perforated drainpipes with a minimum diameter of 63.5 mm (2.5") is recommended. For larger structures, the size and the density of the network, as well as the compressive strength of the drainpipes, must be carefully designed. All drainage systems must be designed by a professional engineer.

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F. 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.

1. The application of perforated pipes is recommended for less permeable soils.
2. It is recommended that the layout of the any system be done by a design professional.
3. A porous sand layer, geotextile or other permeable geosynthetic (geonet composites) should be placed between pipes.
4. A flat synthetic drainage system may be used as an alternative (geonet composites).
5. Any direct contact between the PondGard membrane and an abrasive surface of the drainage system must be avoided. Protection using a geotextile underlayment is required.
6. Gas vents are required at the high points of the slopes and should be protected by a vent cap.

G. Water Feature Length and Wave Action

1. 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, the stronger the wave action will be.
2. 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:
 - a. PondGard liner protection adapted to the slope (concrete, concrete block mattress, rip rap, soil cover)
 - b. Provide adequate anchoring of the PondGard lining system
 - c. Provide adequate compaction of the base soil
 - d. Provide geotextile protection under the PondGard lining system
 - e. Building a smaller but deeper water feature.
 - f. Selecting another shape, with a shorter dimension in the direction of the prevailing winds.
 - g. Building several smaller water features instead of one large water feature.

H. Wind Uplift

1. In areas of high wind ballasting with sand bags may be necessary.
2. Ballasting may be removed if and when permanent ballast is installed (i.e. water, cover layer, etc.)

I. 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 PondGard lining systems, cavities may be present in the soil that could cause the membrane to be punctured, especially if the soil contains rock. To avoid this risk, a fine grained intermediate layer of sand or clean soil and/or the installation of a geotextile underlayment is recommended.



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1.04 Product Considerations

A. Membranes:

1. The Firestone PondGard membrane is a fish friendly synthetic rubber membrane. The panels are assembled in the factory prior to vulcanization in order to limit on-site field seaming. The panels are folded and rolled on cores 3.30 m (10.8') long.
2. Refer to product TIS for factory panels sizes.
 - a. Thickness - 1.02 mm (0.04")
 - b. Each roll is labeled with the membrane type, thickness, dimensions, manufacture date, and production lot, and an arrow indicating direction of unrolling. Firestone also offers a reinforced liner in 3.05 m (10.0') wide panels and the lengths shown above.
3. All elements of the PondGard lining system shall be Firestone products as described in the Technical Data Sheets or products, which are approved by Firestone.

B. Underlayments

1. Firestone can provide a geotextile that is acceptable as an underlayment.
2. Other geotextiles may be acceptable, but should be verified with the design professional and Firestone prior to installation.

1.05 Fastening Considerations

A. Perimeter Anchoring

1. Anchor Trenches – An anchor trench in the shape of a "U" or "V" can be 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. 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. Top Run-outs – The top of the bank is scraped smooth back a specified distance. The membrane is loose laid and after the pond is filled then the edge is covered with ballast of a sufficient amount to ensure perimeter securement.

B. Intermediate Anchoring

If the embankment is high and/or long, 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 incline in order to provide slope stability of the embankment. Ballast applied over the membrane at the bench may provide the desired stability.

C. Toe of Slope / Bottom Ballast

In some cases, temporary and/or permanent ballast (soil cover) may be required due to operating conditions or wind conditions.

D. Head Water Terminations

Where water enters the lined area special considerations must be made for terminating the membrane to ensure that the termination remains intact and does not erode due to the flow into the lined area.



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E. Mechanical Terminations

Mechanical terminations shall be done in accordance Firestone specifications and details.

1.06 PondGard Rubber Liner Field Seaming Procedures

Two overlapping PondGard panels are seamed by means of a patented splicing tape or cap strip system. Section 2.08 of the Installation Guide provides details of the various steps required for correct seam procedures for the PondGard membrane.

1.07 Flashings and Penetrations

- A. Firestone recommends a minimum clearance of 304.8 mm (12.0") between penetrations, pipes, conduits, etc.
- B. Where possible, provide a minimum design height of at least 203.2 mm (8.0") for all flashing terminations except Pre-molded QuickSeam™ Pipe Flashings.
- C. When using a surface mounted termination (i.e. termination bar) ensure the surface termination provides a constant seal on the substrate.

1.08 Cover Soil Consideration (base only or on side slopes)

- A. Cover soil can and is commonly installed over the PondGard System:
 - 1. It provides protection from mechanical damage (i.e. equipment, vandalism, etc.) but it is not required for UV.
 - 2. Cover soil is installed to provide habitat for fish and plant life.
 - 3. Cover soil is installed for additional protection from intense wildlife traffic.
 - 4. Cover soil maybe used to provide a more aesthetically pleasing appearance.
- B. Concrete and shotcrete can be installed over and adjacent to the PondGard System:
 - 1. It provides a durable wear surface for pads and access points for
 - a. Agitators
 - b. Aerators
 - c. Other mechanical equipment

1.09 Quality Assurance (manufacturer and contractor experience)

- A. A Firestone trained installer must install the PondGard System for issuance of a Firestone material warranty.
- B. Projects with membrane only warranties are not always inspected by Firestone.
- C. Consultation:
 - 1. Firestone Specialty Products Department is available for consultation with respect to any deviations from Firestone specifications and details.
 - 2. If there is any deviation from these specifications without first obtaining written approval from the Firestone Specialty Products Department, it may not be possible for Firestone to issue the desired warranty.

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1.10 Job Site Considerations (cautions and warnings)

- A. Protect the membrane against wind by ballasting the bottom or side slopes and designing the perimeter attachment properly.
- B. Ensure against mechanical damage from floating objects (i.e. dead wood), ice, operating vehicles, equipment, etc.
- C. Animals can present significant problems. Provide escape ladders, fence around reservoirs and use a geotextile under the membrane to prevent damage.
- D. Confirm compatibility of the membrane with all materials being stored or retained in conjunction with the membrane.
- E. Confirm the suitability of the compacted substrate to ensure that it will have sufficient structural integrity to fully support the membrane and specify repair as required.
- F. Asphalt, coal tar pitch, oil or plastic cements are not to be used in direct contact with components of the PondGard System.
- G. Protect all components of the PondGard System from discharges or contact with petroleum products, greases, oils (mineral and vegetable), and animal fats. Contact Firestone Specialty Department for suggested methods of protection.