

Construction Specification 97—Flexible Membrane Liner

1. Scope

The work consists of furnishing and installing a flexible membrane liner, including appurtenances, cover soil, and concrete pads.

2. Material

The liner, welding rod, vent covers, pipe boots, gaskets, metal battens, clamps, bolts, embed channel, adhesive, and sealant shall conform to the requirements of Material Specification 594, the applicable provisions in this specification, and details as shown on the drawings.

3. Shipping and storage

Liner material shall be delivered, handled, and stored according to the manufacturer's recommendations. Liner material shall be stored and protected from puncture, dirt, grease, excessive heat, exposure to ultraviolet radiation, or other damage.

Damaged liner material shall be repaired or replaced. Liner material that cannot be satisfactorily repaired to comply with the requirements of Material Specification 594 shall be removed from the job site.

4. Subgrade preparation

Subgrade soils shall be compacted to provide a smooth, firm, and unyielding foundation. All subgrade surfaces shall be free of organic material, rocks larger than 3/8 inch, angular rocks, or other sharp objects. Surface deformations shall not exceed 1 inch. Standing water, mud, and snow shall be removed prior to liner placement.

The liner shall not be placed until the subgrade has been approved by the engineer.

5. Anchor trench

The anchor trench provides permanent anchoring for the liner and shall be constructed in accordance with the drawings. The trench corners shall be slightly rounded to prevent sharp bends in the liner.

If sloughing of the trench occurs, the sloughed soils shall be removed and necessary repairs shall be made to provide a smooth trench wall. Standing water, mud, and snow shall be removed prior to liner placement and trench backfill.

Soil material used for backfilling the trench shall meet the requirements specified in section 4 of this specification. The trench shall be backfilled in two equal lifts and compacted by rolling with rubber-tired equipment or manually directed compaction equipment.

6. Liner placement

The liner shall be installed with a minimum of handling by using a spreader bar assembly attached to a front-end loader, track-hoe bucket, or by other methods recommended by the liner manufacturer. The liner shall be placed parallel to the direction of maximum slope. During installation, the liner shall be secured with sandbags to protect it from wind uplift forces. The liner shall be seamed and secured by the end of each workday.

Construction equipment shall not be allowed to operate directly on the liner except for all terrain vehicles that produce ground pressure less than 5 pounds per square inch.

The liner shall not be placed during foggy conditions, precipitation events, or in the presence of excessive winds. High-Density Polyethylene (HDPE) and Linear Low-Density Polyethylene (LLDPE) liners shall not be placed when the temperature is less than 50 degrees Fahrenheit. Polypropylene (PP) liners shall not be placed when the temperature is less than 40 degrees Fahrenheit. Polyvinyl Chloride (PVC) liners shall not be placed when the temperature is less than 40 degrees Fahrenheit or greater than 105 degrees Fahrenheit. Ethylene Propylene Diene Monomer (EPDM) liners shall not be placed when the temperature is less than zero degrees Fahrenheit or greater than 120 degrees Fahrenheit.

The liner shall be loosely laid over the subgrade with sufficient slack to accommodate thermal expansion and contraction. Each panel shall be laid out and positioned to minimize the number and length of liner seams and in accordance with the manufacturer's recommendations. The methods used to place panels shall minimize wrinkles especially along field seams. Wrinkles shall not exceed 6 inches in height or "fold over" during soil cover placement or other load application. When specified in section 16 of this specification or recommended by the manufacturer, a geosynthetic rub sheet shall be used under the liner when dragging or moving the panels.

Seam overlap—Liner panels shall have a minimum seam overlap of 4 inches for hot wedge welding, hot air welding, chemical fusion welding, adhesive seams, in-seam tape, and cover strip seams. A minimum seam overlap of 3 inches shall be used for extrusion-welded seams. Upslope panels shall overlap downslope panels to produce a shingle effect for drainage.

7. Seaming methods

HDPE, LLDPE, PP—The primary method of seaming shall be hot wedge fusion welding. Fillet extrusion welding shall be used for repairs, T-seams, and detail work. Hot air fusion or chemical fusion welding may be used for PP. Seaming shall not be performed when the ambient sheet temperature is below 45 degrees Fahrenheit or above 90 degrees Fahrenheit.

PVC—Seams shall be joined using hot wedge fusion welding, hot air fusion welding, chemical fusion welding, or an adhesive. Special precautions, as recommended by the manufacturer, shall be taken for seam joining if the ambient sheet temperature is above 105 degrees Fahrenheit. Seam joining shall not be performed when the ambient sheet temperature is below 40 degrees Fahrenheit or above 140 degrees Fahrenheit.

EPDM—Seams shall be joined using double-faced in-seam tape or a cover strip recommended by the manufacturer. Seaming shall not be performed when the ambient sheet temperature is below zero degrees Fahrenheit or above 120 degrees Fahrenheit.

8. Seaming procedures

Seaming shall extend to the outside edge of the liner to be placed in the anchor trenches. Seaming shall not be conducted in the presence of moisture, dust, dirt, standing water, or soft subgrade. Seaming procedures shall be in accordance with the liner manufacturer's recommendations.

Hot wedge welding—Hot wedge welding shall be accomplished by a double-wedge fusion welder that produces a double track weld. Welding equipment and accessories shall be in accordance with the liner manufacturer's recommendations. The welder shall be calibrated at least once per day at the beginning of each seaming period.

Fillet extrusion welding—Extrusion welding equipment and accessories shall be in accordance with the liner manufacturer's recommendations. The extrusion welder shall be calibrated at least once per day at the beginning of each seaming period. To ensure proper bonding of the extrusion weld, edges of the patch material and the adjacent liner shall be properly abraded by a light grinding. This operation shall be done no more than 15 minutes before the welding operation. The abrasion process shall remove no more than 10 percent of the material thickness.

Hot air welding—Hot air welding shall be accomplished by a single- or double-tracked fusion welder. Welding equipment and accessories shall be in accordance with the liner manufacturer's recommendations. The welder shall be calibrated at least once per day at the beginning of each seaming period.

Chemical fusion welding—The chemical fusion agent shall be applied to both panels by a squeeze bottle or paintbrush. The width of application shall be a minimum of 2 inches. Pressure shall be applied to the seam in accordance with the liner manufacturer's recommendations to provide adequate contact between the panels. Excess agent extruded from the seam shall be immediately removed.

Adhesive—Adhesive shall be approved by the manufacturer and consist of material with a life expectancy similar to that of the liner material. The adhesive shall be applied to both panels by a paintbrush or other approved method. The adhesive shall cover the entire seam overlap. Pressure shall be applied to the seam in accordance with the liner manufacturer's recommendations to provide adequate contact between the panels. Excess adhesive extruded from the seam shall be immediately removed.

Inseam tape—A primer shall be applied to both panels by a scrub pad or other approved method recommended by the manufacturer. The primer shall cover the entire seam overlap. As soon as the primer has flashed, install the tape on the bottom sheet, remove tape backing, lap the top sheet over the tape, and roll with sufficient pressure to provide adequate contact between the panels.

Cover strip—A primer shall be applied to both panels by a scrub pad or other approved method recommended by the manufacturer. The top sheet shall be lapped over the bottom sheet and rolled to provide contact between the panels. Additional primer shall be applied to cover the entire seam overlap. As soon as the primer has flashed, install the cover strip and roll it with sufficient pressure to provide adequate contact between the cover strip and the panels.

9. Seam testing

Field seams shall be nondestructively tested over their full length. Seam testing shall be performed as the work progresses.

Nondestructive seam testing—Air pressure tests shall be performed in accordance with ASTM D 5820 on all double-track fusion seams. The air pressure test equipment and procedures shall conform to this specification and the liner manufacturer's recommendations. Pressurize the air channel to 25 to 30 pounds per square inch for HDPE, LLDPE, and PP liners, 15 to 25 pounds per square inch for 30 mil PVC liners, and 20 to 30 pounds per square inch for 40 mil PVC liners.

Monitor any pressure drops for 5 minutes. A loss of pressure in excess of 4 pounds per square inch for HDPE, LLDPE, and PP liners, 5 pounds per square inch for 30 mil PVC liners, 4 pounds per square inch for 40 mil PVC liners, or a continuous loss of pressure is an indication of a leak. The location of all defective seams shall be marked and repaired.

Vacuum box tests shall be performed in accordance with ASTM D 5641 on all seams and repairs made by extrusion welds and may be used on PP chemical fusion welds. Vacuum box tests shall not be used on PVC liner seams. The location of all defective seams shall be marked and repaired.

Air lance tests shall be performed in accordance with ASTM D 4437 on single-track fusion welds, chemical fusion welds, and on adhesive PVC seams and EPDM seams, and may be used on PP chemical fusion seams. The location of all defective seams shall be marked and repaired.

Destructive seam testing—If specified in section 16 of this specification, seam samples shall be cut at no more than one sample per 500 feet of weld for destructive seam testing. All destructive seam samples shall be tested in shear and peel modes in accordance with ASTM D 6392 to verify seams meet the requirements of Material Specification 594.

10. Repairs

All defective liner areas and failed seams shall be repaired and retested.

Tears, punctures, material defects—All tears, punctures, and material defects in the liner shall be repaired by installing a patch over the defective area. Surfaces of the liner to be patched shall be cleaned before the repair. All patches shall be of the same liner material and extend a minimum of 6 inches beyond the edges of the defect area. All patches shall have rounded corners and shall be seamed to the liner. Holes that are less than 0.25 inch in diameter on HDPE, LLDPE, and PP liners shall be repaired by a bead of extrudent.

Seam repair—Failed seams shall be repaired by installing a cap strip over the entire length of failed seam. The cap strip shall be of the same liner material and shall extend beyond the failed seam a minimum of 6 inches in all directions. Alternatively, the upper flap may be extrusion welded to the liner along the entire length of the failed seam.

11. Appurtenances

The liner shall be mechanically attached to pipe, concrete, or steel structures as shown in the drawings and according to liner the manufacturer's recommendations.

Pipe boots—Factory fabricated pipe boots shall be used as specified in section 16 of this specification. Pipe boots fabricated in the field shall be from the same material as the liner. The boots shall be welded and clamped to pipes of the same material as the liner. They shall be clamped to other types of pipe as shown in the drawings, or as recommended by the manufacturer, to provide a leak-free attachment.

Metal battens—Metal battens shall meet the requirements of Material Specification 594 and shall be installed according to the drawings and the liner manufacturer's recommendations. The battens shall be bolted to concrete by bolts on 6-inch intervals to create a leak-free connection under submerged conditions. Bolt spacing may be increased to 12 inches for connections above the fluid level.

Embed channel—Embed channel shall meet the requirements of Material Specification 594 and be installed according to drawings and the liner manufacturer's recommendations. The embed channel shall be prefabricated to the dimensions shown on the drawings. All sections of the channel shall be continuously welded to subsequent sections before installation in the concrete forms. All corners shall be miter cut and welded on all sides.

12. Gas vents and drainage

Gas vent flaps vent pipes, and drainage systems shall be installed as specified in section 16 of this specification and as shown on the drawings.

13. Cover soil

If specified in section 16 of this specification, cover soil and placement method shall be in accordance to the drawings and shall conform to this specification and the liner manufacturer's recommendations. Cover soils shall meet the same requirements as specified for subgrade soils in section 4 of this specification. Cover soil placement shall be performed by a loader or bulldozer with ground pressure of less than 8 pounds per square inch. Cover soil shall not be dropped onto the liner from a height of more than 3 feet. Following construction of an access ramp, the soil shall be placed from the bottom of the slope upward. Construction equipment or machinery shall not operate directly on the liner. Cover soil shall be placed during the coolest part of the day.

14. Placement of concrete

Concrete placement for ramps and other appurtenances shall be in accordance with the drawings and as specified in section 16 of this specification. All reinforcing steel shall be placed on flat-footed plastic rebar chairs. All rebar splices shall be fully tied. On slopes, concrete shall be placed from the bottom of the slope to the top and have a slump as specified in section 16 of this specification. Internal vibrators shall be used to consolidate concrete. Metal shovels and rodding shall not be used to consolidate or place the concrete. Concrete forms shall be held in place by methods that avoid damaging the liner.

15. Measurement and payment

For work for which specific unit prices are established in this contract, the quantity of liner installed shall be determined to the nearest square foot by measurement of the covered surfaces only, disregarding that for anchorage, seams, and overlaps. Payment for items listed separately in the contract bid schedule shall be made at the contract price for those items. Such payment shall constitute full compensation for furnishing, shipping, and installing the liner including all pipe boots or shirts, mechanical attachments to pipes and structures, and other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 16 of this specification.

16. Items of work and construction details