SECTION 948
OPTIONAL DRAINAGE PRODUCTS AND LINER REPAIR SYSTEMS

948-1 Polyvinyl-Chloride (PVC) Pipe, or Acrylonitrile-Butadiene-Styrene (ABS) Plastics Pipe.

948-1.1 For Bridge Drains: PVC pipe shall conform to the requirements of ASTM D1785, for Type I, Grade 1, Schedule 80 PVC pipe with a minimum polymer cell classification of 12454 per ASTM D1784 and a minimum of 1.5% by weight of titanium dioxide for UV protection.

948-1.2 Pressure Pipe: Pressure pipe for direct burial under pavement shall conform to the requirements of ASTM D1785, for Type I, Grade I, Schedule 40, for sizes up to and including 2-1/2 inches, and Schedule 80 for sizes up to 4 inches. Pressure pipe 4 inches in diameter and larger shall conform to the requirements of AWWA C900-75, DR18, and ASTM D1785, Type I, Grade I or other types as may be specifically called for in the Plans or Special Provisions.

948-1.3 Pipe Marking: All PVC pipe shall be marked as required by Article 8 of ASTM D1785, and acceptance of the pipe may be based on this data.

948-1.4 Nonpressure Pipe: PVC pipe and ABS pipe intended for direct-burial or concrete encasement, shall meet the following requirements:

1. PVC Pipe: ASTM D3034, SDR-35, or ASTM F949, profile wall without perforations.
2. ABS Pipe: ASTM D2680.

The manufacturer of the PVC or ABS pipe shall submit to the Engineer the mill analysis covering chemical and physical test results.

948-1.5 Underdrain: PVC pipe for use as underdrain shall conform to the requirements of ASTM F758 or ASTM F949. Also, PVC underdrain manufactured from PVC pipe meeting ASTM D3034, perforated in accordance with the perforation requirements given in AASHTO M36 or AASHTO M196 will be permitted.

948-1.6 Edgedrain: PVC pipe for use as edgedrain shall conform to the requirements of ASTM F758, ASTM F949 or ASTM D3034 pipe shall be perforated in accordance with the perforation requirements given in AASHTO M36 or AASHTO M196. Additional perforations will be required as indicated in the Design Standards, Index No. 286 for pipes designated under ASTM F758 and ASTM D3034. PVC pipe intended for direct burial in asphalt shall meet the following requirements:

1. ASTM D3034, SDR-35, or ASTM F949
2. NEMA TC-2 (pipe material and compounds) and NEMA TC-3 (pipe fittings) for PVC (90ºC electrical conduit pipe) NEMA ECP-40 and NEMA ECP-80. Underwriter Laboratory Specifications referenced under NEMA specifications for electrical conductivity are not required.
3. Pipe shall withstand asphalt placement temperatures specified without permanent deformation.
4. Perforations shall be in accordance with AASHTO M36 or AASHTO M196.

948-1.7 PVC Pipe (12 Inches to 48 Inches): PVC pipe for side drain, cross drain, storm drain and other specified applications shall conform to AASHTO M278 for smooth wall PVC

pipe or ASTM F949 for PVC ribbed pipe. Resin shall contain a minimum of 1.5% by weight of titanium dioxide for UV protection. Mitered end sections are not to be constructed of PVC.

PVC pipe shall be installed within two years from the date of manufacture.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-2 Corrugated Polyethylene Tubing and Pipe.

948-2.1 General: For underdrain, corrugated polyethylene tubing and fittings shall meet the requirements of AASHTO M252. For edgedrain, corrugated polyethylene tubing and fittings shall meet the requirements of AASHTO M252, except as modified in 948-2.2. For storm drain side drain, french drain and cross drain corrugated polyethylene pipe shall meet the requirements of AASHTO M-294 and 948-2.3.

The tubing or pipe shall not be left exposed to sunlight for periods exceeding the manufacturer's recommendation.

948-2.2 Edgedrain (4 Inches to 10 Inches): The requirements for edgedrain as specified in AASHTO Mp-252 are modified as follows:

1. Coiling of tubing 6 inches in diameter or greater is not permitted. Tubing shall have a minimum pipe stiffness of 46 psi at 5% deflection.

948-2.3 Corrugated High Density Polyethylene Pipe (HDPE) (12 Inches to 60 Inches):

948-2.3.1 General: Class I (50 year) corrugated polyethylene pipe used for side drain, storm and cross drain or french drain shall meet the requirements of AASHTO M294 and plant certification from the National Transportation Product Evaluation Program (NTPEP). Corrugations shall be annular. Pipe resin shall conform to ASTM D3350 with a minimum cell classification 435400C and between 2% to 4% carbon black. Mitered end sections are not to be constructed of polyethylene.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-2.3.2 Additional Requirements for Class II HDPE (100 Year), Type S Polyethylene Pipe: Class II HDPE (100 year) polyethylene pipe shall meet the requirements in Table 948-1below in addition to those in 948-2.3. Perforations will not be allowed. Manufacturers may only use ground Class II polyethylene pipe for reworked plastic.

Table 948-1

Stress Crack Resistance of Pipes

Pipe Location	Test Method	Test Conditions	Requirement
Pipe Liner	FM 5-572, Procedure A	10% Igepal solution at 122°F and 600 psi applied stress, 5 replicates	Average failure time of the pipe liner shall be ≥18.0 hours, no single value shall be less than 13.0 hours.
Pipe Corrugation[(1)], (molded plaque)	ASTM F2136	10% Igepal solution at 122°F and 600 psi applied stress, 5 replicates	Average failure time shall be ≥24.0 hours, no single value shall be less than 17.0 hours.

Table 948-1			
Junction	FM 5-572, Procedure B and FM 5-573	Full Test[2][3] Test at 3 temperature/stress combinations: 176°F at 650 psi 176°F at 450 psi 158°F at 650 psi; 5 replicates at each test condition	Determine failure time at 500 psi at 73.4°F ≥ 100 years (95% lower confidence) using 15 failure time values[4] The tests for each condition can be terminated at duration equal to or greater than the following criteria: 110.0 hr at 176°F 650 psi 430.0 hr at 176°F 450 psi 500.0 hr at 158°F 650 psi
		Single Test[5]: Test temperature 176°F and applied stress of 650 psi.; 5 replicates	The average failure time must be equal to or greater than 110.0 hr
Longitudinal Profiles[6]	FM 5-572, Procedure C, and FM 5-573	Full Test[2][3]: Test at 3 temperature/stress combinations: 176°F at 650 psi 176°F at 450 psi 158°F at 650 psi; 5 replicates at each test condition	Determine failure time at 500psi at 73.4°F ≥ 100 years (95% lower confidence) using 15 failure time values[4]. The tests for each condition can be terminated at duration equal to or greater than the following criteria: 110.0 hr at 176°F 650 psi 430.0 hr at 176°F 450 psi 500.0 hr at 158°F 650 psi
		Single Test[5]: Test temperature 176°F and applied stress of 650 psi.; 5 replicates	The average failure time must be equal to or greater than 110.0 hr (no value shall be less than 55.0 hours)
Oxidation Resistance of Pipes			
Pipe Location	Test Method	Test Conditions	Requirement
Liner and/or Crown[7]	OIT Test (ASTM D3895)	2 replicates (to determine initial OIT value) on the as manufactured (not incubated) pipe.	25.0 minutes, minimum
Liner and/or Crown[7]	Incubation test FM 5-574 and OIT test (ASTM D3895)	Three samples for incubation of 265 days at 176°F[8] and applied stress of 250 psi. One OIT test per each sample	Average of 3.0 minutes[9] (no values shall be less than 2.0 minutes)
Liner and/or Crown[7]	MI test (ASTM D1238 at 190°C/2.16Kg)	2 replicates on the as manufactured (not incubated) pipe.	< 0.4 g/10 minutes

Table 948-1			
Liner and/or Crown[7]	Incubation test FM 5-574 and MI test (ASTM D1238 at 190°C/2.16Kg)	2 replicates on the three aged sampled after incubation of 265 days at 176°F[8] and applied stress of 250 psi	MI Retained Value[9][10] shall be greater than 80% and less than 120%.

Note: FM = Florida Method of Test.
(1) Required only when the resin used in the corrugation is different than that of the liner.
(2) A higher test temperature (194°F) may be used if supporting test data acceptable to the State Materials Engineer is submitted and approved in writing.
(3) Full test shall be performed on alternative pipe diameter of pipe based on wall profile design, raw material cell classification, and manufacturing process. Full test must be performed on maximum and minimum pipe diameters within a manufacturing process.
(4) Computer program to predict the 100 year SCR with 95% lower confidence can be obtained from FDOT.
(5) Single test for the junction and longitudinal profile may be used on alternating pipe sizes within a manufacturing process. Single point tests may not be used on maximum and minimum pipe sizes within a manufacturing process except by approval of the Engineer. Single point tests may be used for quality assurance testing purposes.
(6) Longitudinal profiles include vent holes and molded lines.
(7) OIT and MI tests on the crown are required when resin used in the corrugation is different than that of the liner.
(8) The incubation temperature and duration can also be 196 days at 185°F.
(9) The tests for incubated and "as-manufactured" pipe samples shall be performed by the same lab, same operator, the same testing device, and in the same day.
(10) The MI retained value is determined using the average MI value of incubated sample divided by the average MI value of as-manufactured pipe sample.

948-2.3.3 Certification: Submit to the Engineer signed certification from the manufacturer for each pipe diameter LOT to be incorporated into the project that the pipe meets the requirements of these Specifications.

948-2.3.4 Laboratory Accreditation: Manufacturers seeking evaluation of a product in accordance with Departmental procedures must submit test reports conducted by a laboratory qualified by the Geosynthetic Accreditation Institute-Laboratory Accreditation Program (GAI-LAP) or qualified by ISO 17025 accreditation agency using personnel with actual experience running the test methods for Class II HDPE pipe. Submit the test reports to the State Materials Office.

948-2.4 Steel Reinforced Polyethylene Ribbed Pipe:

948-2.4.1 General: Steel reinforced polyethylene ribbed pipe used for side drain, storm and cross drain or french drain shall meet the requirements of AASHTO MP20-13 or ASTM F-2562 and the testing requirements for stress crack and oxidation resistance in Table 1. Pipe resin shall conform to ASTM D3350 with a minimum cell classification 435400C and between 2% to 4% carbon black. Mitered end sections are not to be constructed of steel reinforced polyethylene ribbed pipe.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-2.4.2 Certification: Meet the requirements of 948-2.3.3.

948-2.4.3 Laboratory Accreditation: Meet the requirements of 948-2.3.4 except use personnel with actual experience running the test methods for steel reinforced polyethylene ribbed pipe.

948-3 Fiberglass Reinforced Polymer Pipe.

948-3.1 For Bridge Drains: Fiberglass pipe shall conform to the requirements of ASTM D3262, ASTM D2996 or ASTM D2310, for Type I, Grade 2, Class E, using polyvinyl ester as the only resin. The minimum hoop stress designation shall be A. The resin shall contain UV stabilizers or a two-part 100% solids polyurethane coating.

948-4 Ductile Iron Pipe.

948-4.1 For Bridge Drains: Ductile iron pipe shall conform to the requirements of AWWA C151.

948-5 Hot Dip Galvanized Steel Pipe.

948-5.1 For Bridge Drains: Hot dip galvanized steel pipe shall conform to the requirements of ASTM A53.

948-6 Flexible Transition Couplings and Pipe.

948-6.1 For Bridge Drains: Flexible transition couplers and pipe shall conform to the requirements of ASTM C1173.

948-7 Profile Wall Polypropylene (PP) Pipe (12 Inches to 60 Inches).

948-7.1 Class I PP: Class I (50 year) PP pipe used for side drain, cross drain, storm drain, and french drain shall meet the requirements of AASHTO M330 and plant certification from the NTPEP. Corrugations shall be annular. Polypropylene compound shall conform to the requirements of ASTM F2881. Mitered end sections are not to be constructed of polypropylene.

Obtain pipe from a production facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion shall meet the requirements of Section 105.

948-7.2 Additional Requirements for Class II (100 Year) PP: Class II (100 year) PP shall meet the requirements in Table 948-2 in addition to those in 948-7.1. Manufacturers may only use ground Class II PP for reworked plastic.

Table 948-2

Stress Crack Resistance			
Pipe Location	Test Method	Test Conditions	Requirement
Pipe Liner	FM 5-572, Procedure A	10% Igepal solution at 50°C and 600 psi applied stress, 5 replicates	Average failure time of the pipe liner shall be ≥100 hours, no single value shall be less than 71 hours.(1)
Oxidation Resistance			
Pipe Location	Test Method	Test Conditions	Requirement
Pipe Liner and/or Crown(2)	OIT Test (ASTM D3895)	2 replicates (to determine initial OIT value) on the as manufactured (not incubated) pipe.	25.0 minutes, minimum
Pipe Liner and/or Crown(2)	Incubation test FM 5-574 and OIT test (ASTM D3895)	Three samples for incubation of 264 days at 85°C(3). One OIT test per each sample	Average of 3.0 minutes(4) (no values shall be less than 2.0 minutes)

Table 948-2			
Pipe Liner and/or Crown[2]	MI test (ASTM D1238 at 230ºC/2.16Kg)	2 replicates on the as manufactured (not incubated) pipe.	< 1.5 g/10 minutes
Pipe Liner and/or Crown[2]	Incubation test FM 5-574 and MI test (ASTM D1238 at 230°C/2.16Kg)	2 replicates on the three aged sampled after incubation of 264 days at 85°C[3]	MI Retained Value[4][5][6] shall be greater than 80% and less than 120%.

Note: FM = Florida Method of Test.

(1) If due to sample size this test cannot be completed on the liner then testing shall be conducted on a molded plaque sample. Samples can be removed if test time exceeds 100 hours without failure.
(2) OIT and MI tests on the crown are required when resin used in the corrugation is different than that of the liner.
(3) The incubation temperature and duration can also be 192 days at 90°C or 140 days at 95°C.
(4) The tests for incubated and "as-manufactured" pipe samples shall be performed by the same lab, same operator, the same testing device, and in the same day.
(5) Within each replicate set of tests, the discrepancy range shall be within 9%. If an out-of-range discrepancy occurs, repeat the two MI tests on the same pipe sample. If insufficient material is available, a repeat of one test is acceptable.
(6) The MI retained value is determined using the average MI value of incubated sample divided by the average MI value of as-manufactured pipe sample.

948-7-2 Certification: Meet the requirements of 948-2.3.3.

948-7.4 Laboratory Accreditation: Meet the requirements of 948-2.3.4 except use personnel with actual experience running the test methods for profile wall polypropylene pipe.

948-8 Filter Fabric Sock for Use with Underdrain.

For Type I underdrain specified in the Design Standards, Index No. 286, filter sock shall be an approved strong rough porous, polyester or other approved knitted fabric which completely covers and is secured to the perforated plastic tubing underdrain in such a way as to prevent infiltration of trench backfill material.

The knitted fabric sock shall be a continuous one piece material that fits over the tubing like a sleeve. It shall be knitted of continuous 150 denier yarn and shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.

The knitted fabric sock shall comply with the following physical properties:

Weight, applied (oz/sq. yd.)	3.5 min	ASTM D3887
Grab tensile strength (lbs.)	50 min.*	ASTM D5034
Equivalent opening size (EOS No.)	25 min.**	Corps of Engineers CW-02215-77
Burst strength (psi)	100 min.**	ASTM D3887

*Tested wet.
**Manufacturer's certification to meet test requirement.

The knitted fabric sock shall be applied to the tubing in the shop so as to maintain a uniform applied weight. The tubing with knitted fabric sock shall be delivered to the job site in such manner as to facilitate handling and incorporation into the work without damage. The knitted fabric sock shall be stored in UV resistant bags until just prior to installation. Torn or punctured knitted fabric sock shall not be used.

948-9 Liner Repair Systems for Rehabilitation of Pipe and Other Drainage Structures.

948-9.1 General: Liner systems shall have at least the minimum stiffness required for the intended application in accordance with the AASHTO LRFD Bridge Design Specifications.

948-9.2 Folded Liner: Folded liner shall be manufactured in an out of form state, usually collapsed circumferentially, and folded on the long axis. After installation in a host structure, the liner is formed by means of heat and pressure to fit the host structure. When installed, folded liner shall extend from one structure to the next in one continuous length with no intermediate joints.

948-9.2.1 Polyethylene: Folded polyethylene liner shall meet the requirements of ASTM 2718 or ASTM F714 with a minimum cell classification of 335420 and between 2% to 4% carbon black.

948-9.2.2 PVC: Folded PVC liner shall meet the requirements of ASTM F1504 (meet all the requirements for cell classification 12334 or 13223) or ASTM F1871 (meet all the requirements for cell classification 12111).

948-9.2.3 Cured-In-Place: Folded resin impregnated flexible tubing shall meet the requirements of ASTM F1216 and ASTM D5813.

948-9.3 Prefabricated (Slip) Pipe Liner: When used in slip lining applications, prefabricated liner shall be round, flexible or semi-rigid liner, manufactured in lengths that may be joined in a manhole or access pit before insertion in a host pipe.

948-9.3.1 Polyethylene:

1. Solid wall polyethylene pipe liner shall meet the requirements of ASTM F714 or AASHTO M326 and shall have a minimum cell classification of 345464 and between 2% to 4% carbon black.

2. Profile wall polyethylene pipe liner shall meet the requirements of AASHTO M294 and shall have a minimum cell classification of 435400 and between 2% to 4% carbon black

3. Steel reinforced polyethylene pipe liner shall meet the requirements of AASHTO MP20-13, ASTM F2562 or ASTM F2435 and shall have a minimum cell classification of 334452 and between 2% to 4% carbon black.

948-9.3.2 PVC:

1. Solid wall PVC pipe liner shall meet the requirements of ASTM D2729 and shall have a minimum cell classification of 12454.

2. Profile wall PVC pipe liner shall meet the requirements of ASTM F794, ASTM F949, or AASHTO M304 and shall have a minimum cell classification of 12454.

948-9-3.3 Fiberglass: Prefabricated fiberglass pipe liner shall meet the requirements of ASTM D3262.

948-9.4 Spiral-Wound Liner: Spiral-wound liner shall consist of coils of profile strips or one piece profile strips that are wound directly into a host pipe helically

948-9.4.1 Polyethylene: Polyethylene spiral-wound liner shall meet the requirements of ASTM F1697 or ASTM F1735, except the resin shall conform to ASTM D3350 with a minimum cell classification of 335420 and between 2% to 4% carbon black.

948-9.4.2 PVC: PVC spiral-wound liner shall meet the requirements of ASTM F1697 or ASTM F1735 and shall have a minimum cell classification of 12454.

948-9.4.3 Steel Reinforced: Steel reinforced spiral-wound liner shall meet the requirements of ASTM F1697 or ASTM F1735, except the resin shall conform to ASTM D3350

with a minimum cell classification of 335420 and between 2% to 4% carbon black. The steel reinforcement shall be fully encapsulated to prevent exposure to corrosive elements.

948-9.5 Segmental Panel Liner: Segmental panel liner consists of custom fit flat or curved panels that are formed to the inside wall of a host structure.

948-9.5.1 Polyethylene: Polyethylene segmental panel liner shall meet the requirements of ASTM F1735, except the resin shall conform to ASTM D3350 with a minimum cell classification of 345464 and between 2% to 4% carbon black.

948-9.5.2 PVC: PVC segmental panel liner shall meet the requirements of ASTM F1735 and shall have a minimum cell classification of 12454.

948-9.6 Point Repair Liner: Point repair liner may be used to repair and rehabilitate an isolated portion of an existing structure and may consist of any materials covered by this specification. Materials that shall be used as primary components of point repair apparatus are:

1. Stainless steel, which shall meet the requirements of AASHTO M167M, ASTM A167, or ASTM A240
2. Aluminum, which shall meet the requirements of AASHTO M196
3. Rubber, which shall meet the requirements of ASTM C923.

948-9.7 Coating Liner: Coating liners consist of liquid, slurry, foam or gel that is spread or sprayed over the interior surface of an existing structure to rehabilitate it, with or without fiber reinforcement. Coating liner installers shall submit to the Department proof of experience for on-site supervision and previously completed contracts including the following:

1. Project name and location
2. Names of contracting parties
3. Owner's names
4. A brief description of the work
5. Dates of completion of coating liner work

Materials that may be used for coating are:

1. Hydrophilic urethane-based foams or gels which shall meet the requirements of ASTM F2414.
2. Epoxy resins and unsaturated styrene-based resins which shall meet the resin material requirements of ASTM F1216.
3. Cementitious materials, as recommended by the manufacturer, including:
    a. annular backfill
    b. low density cellular concrete
    c. shotcrete
    d. gunite
    e. centrifugal cast
    f. pre-packaged grout