

Approved List 38 **New** Product Application Criteria, Individual Project Design Requirements, and
Associated Construction Requirements to Ensure Valid Designs

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IIM-LD-244.1 and Special Provision for Pipe Culvert Rehabilitation have 5 Methods A-E for rehab/replacement. **Approved List 38 pertains only to Method D.**

Approval for Methods A, B, C, E is based on the following:

- Method A is Jacked pipe installation and this approval is visual in the field.
- Method B is Open trench pipe installation and this approval is based on approved pipes in the VDOT R&B Specs and approved by VDOT Materials Division QA Plans (Approved List 25 for corrugated metal pipe, Approved List 26 for concrete pipe, via NTPEP for corrugated HDPE, compliance with MP21-11 for PP) and backfill standards and allowable cover heights in VDOT R&B Standards PB-1 and PC-1. Also, provisionally Snap-Tite solid wall HDPE pipe to be installed same as corrugated plastic pipe in the standards. PP pipe at this time has its quality accepted as per Section 12 of AASHTO MP-21.
- Method C is Corrugated steel pipe liner and approval is based on those products in the VDOT R&B Specs and in the VDOT Materials Division QA program (Approved List 25 for corrugated metal pipe).
- Method E is Smooth wall steel pipe liner and is approved based on certification, or mill test reports per the VDOT Road and Bridge Specifications.

New Product Application Requirements for All Method D Rehab Systems (Categories A, B, C, D, and E):

- Must list host pipe diameter ranges for which the product is applicable.
- Must list any moisture limitations (e.g. installation in the dry, humidity restrictions, etc.).
- Must list environmental controls to prevent discharge/impact to soils and water.
- Must indicate corrosion potential/acid reaction potential.
- Must require manufacturer's/supplier's representative on-site during installation or use certified contractor if certification exists.
- Must show VDOT interest , and at 5-year resubmittal periods, must show use by VDOT in last 5 years. Otherwise, product will be removed from list. Product may also be removed from list for documented failure to perform properly in the field; or as a result of changes in materials or manufacture or installation processes unless a revised New Product Application is made. (VDOT interest is typically indicated by providing, on the New Product Application, the name of the VDOT person or office or project who is expressing a desire to try the product.)
- Must describe training/certification for installers.
- Must provide hydraulic data (initial surface roughness) of liners in place.

New Product Application Requirements for Method D

Category A – Cured in Place Pipe (CIPP)

- New Product Application requirements:
 - Must provide MSDS sheets.
 - Must list all chemical constituents including proprietary chemicals including CAS Registry Number as available.
 - Must list liner material type.
 - Must provide description of minimum environmental protection requirements
 - Must list cure method (e.g., UV, steam, hot water, etc.).
 - Must list typical, minimum, maximum application thicknesses.
 - Must prove durability of 50 years or 75 years for the applicable roadway functional classification as per VDOT Road & Bridge Standard PC-1.
 - Must give proof of long term modulus.
 - Must provide proof of initial Manning's Number (n value for roughness in open channel flow) of product.
 - Must meet ASTM Specification D5813 or equivalent.
 - Must include specification or standard practice for installation (ASTM F1216 or F1743 or F2019 or F2599 for example).
 - Temperature cure profile
 - Installation ambient temperature range.
- Given design criteria to use for project-specific structural design computations:
 - Must meet IIM-LD-244.1 Table A Flexible Liner Type Selection Guide.
 - Must follow ASTM F1216 Appendix X1.2.2 Fully Deteriorated Gravity Pipe Condition exactly.
 - GW table at crown of pipe.
 - Traffic loading is HL-93, ignored after 8 ft of cover except for multiple barrel rehabs continue indefinitely.
 - Total wet unit weight of soil is 120 pcf, 135 pcf saturated.
 - Modulus of soil reaction (based on VDOT pipe installation standards):
 - 0-5 ft of cover = 1.8 ksi
 - >5-10 ft of cover = 2 ksi
 - >10-30 ft of cover = 2.2 ksi
 - >30-60 ft of cover = 2.6 ksi
 - >60 ft of cover = 2.8 ksi
 - Factor of safety N = 2.0.
- Construction:
 - Any voids around exterior of host pipe must be filled for design assumptions to be valid.

Category B – Fold and form flexible liner

- New Product Application requirements:
 - Must provide MSDS sheets.
 - Must list all chemical constituents including proprietary chemicals, including CAS Registry Number as available.
 - Must list liner material type.
 - Must list type of cure if other than steam.
 - Must list typical, minimum, maximum application thicknesses.
 - Must prove durability of 50 years or 75 years for the applicable roadway functional classification as per VDOT Road & Bridge Standard PC-1.
 - Must give proof of long term modulus.
 - Must provide proof of initial Manning's Number (n value for roughness in open channel flow) of product.
 - Must meet ASTM Specifications F1504 or F1871 or D5813 or equivalent.
 - Must include specification or standard practice for installation (ASTM F1606 or F1867 or F1947 for example).
 - Must provide ambient temperature range for installation
- Given design criteria to use for project-specific structural design computations:
 - Must meet IIM-LD-244.1 Table A Flexible Liner Type Selection Guide.
 - Must follow ASTM F1947 Appendix X1.2.2 Fully Deteriorated Design Condition or ASTM F1867 Appendix X1.2.3 Fully Deteriorated Design Condition exactly.
 - GW table at crown of pipe.
 - Traffic loading is HL-93, ignored after 8 ft of cover except for multiple barrel rehabs continue indefinitely.
 - Unit weight of soil is 120 pcf, 135 pcf saturated.
 - Modulus of soil reaction (based on VDOT pipe installation standards):
 - 0-5 ft of cover = 1.8 ksi
 - >5-10 ft of cover = 2 ksi
 - >10-30 ft of cover = 2.2 ksi
 - >30-60 ft of cover = 2.6 ksi
 - >60 ft of cover = 2.8 ksi
 - Factor of safety N = 2.0.
- Construction:
 - Any voids around exterior of host pipe must be filled for design assumptions to be valid.

Category C – Solid wall HDPE or PVC slip-liner

- New Product Application requirements:
 - Must meet AASHTO M326 or ASTM F714 and Sections 7.4, 7.5, and 9.3 of AASHTO M326 (solid wall HDPE), AASHTO M278 for PVC or similar/equivalent for >375mm diameter PVC.
 - Must list minimum cell class for PVC.
 - Must include specification or standard practice for installation (ASTM F585 for example).
 - Joints shall be watertight as per ASTM D3212. Typically, a watertight joint is tested at the manufacturing facility, and a Professional Engineer witnesses the test and submits a report which is kept on file. This report would be submitted as proof of watertightness of joint for future projects, without having to perform the test for each individual project, as long as the joint has not been changed.
- Given design criteria to use for project-specific structural design computations:
 - Must meet IIM-LD-244.1 Table A Flexible Liner Type Selection Guide.
 - Must follow AASHTO LRFD Bridge Design Specifications, Section 12, version in use by VDOT Structure & Bridge Division at time of submittal.
 - Must provide SDR and outside diameter of pipe.
 - GW table at crown of pipe.
 - Traffic loading is HL-93, ignored after 8 ft of cover except for multiple barrel rehabs continue indefinitely.
 - Unit weight of soil is 120 pcf, 135 pcf saturated.
 - Constrained soil modulus (based on VDOT pipe installation standards):
 - 0-5 ft of cover = 1.8 ksi
 - >5-10 ft of cover = 2 ksi
 - >10-30 ft of cover = 2.2 ksi
 - >30-60 ft of cover = 2.6 ksi
 - >60 ft of cover = 2.8 ksi
 - Shape factor shall be 3.0.
 - Long term modulus shall be used for stiffness computation.
 - Live Load Distribution Factor = 1.
 - Deflection Lag Factor = 1.5.
 - Bedding Factor = 0.1.
 - Installation Factor = 1.5.
 - Maximum deflection, deflection needed in any computations, and service long-term tension strain limit shall be 5% for PE, and either 5% or 3.5% for PVC depending on cell class as per AASHTO LRFD Bridge Design Specs Table 12.12.3.3.1.
 - Poisson's ratio of soil shall be 0.3.
 - Earth load modifier shall be 1.05 and live load modifier shall be 1.0.

- Manning's $n = 0.011$ for PVC, 0.12 for HDPE. (For hydraulic design.)
- Construction:
 - Any voids around exterior of host pipe must be filled for design assumptions to be valid.
 - The annular space between host pipe and liner pipe must be fully grouted for design assumptions to be valid.

Category D – Corrugated or profile wall HDPE, PVC, or polypropylene slip-liner (includes spiral-wound liners, assuming they are ribbed/profiled)

- New Product Application requirements:
 - Must meet AASHTO M294 (HDPE), ASTM F894 (profile PE) or equivalent, M304 (PVC) , MP21-11 (PP), ASTM F1735 (PVC profile strip) or equivalent, ASTM F1697 (PVC spiral-wound) or equivalent.
 - Must list minimum cell class for PVC.
 - Must include specification or standard practice for installation (ASTM F585 or F1698 or F1741 for example).
 - Joints shall be watertight as per ASTM D3212. Typically, a watertight joint is tested at the manufacturing facility, and a Professional Engineer witnesses the test and submits a report which is kept on file. This report would be submitted as proof of watertightness of joint for future projects, without having to perform the test for each individual project, as long as the joint has not been changed.
- Given design criteria to use for project-specific structural design computations:
 - Must meet IIM-LD-244.1 Table A Flexible Liner Type Selection Guide.
 - Must follow AASHTO LRFD Bridge Design Specifications, Section 12, version in use by VDOT Structure & Bridge Division at time of submittal.
 - Must provide outside diameter, inside diameter, diameter to centroid of wall, moment of inertia, gross and effective areas of wall.
 - GW table at crown of pipe.
 - Traffic loading is HL-93, ignored after 8 ft of cover except for multiple barrel rehabs continue indefinitely.
 - Unit weight of soil is 120 pcf, 135 pcf saturated.
 - Constrained soil modulus (based on VDOT pipe installation standards):
 - 0-5 ft of cover = 1.8 ksi
 - >5-10 ft of cover = 2 ksi
 - >10-30 ft of cover = 2.2 ksi
 - >30-60 ft of cover = 2.6 ksi
 - >60 ft of cover = 2.8 ksi
 - Shape factor shall be 3.0.
 - Long term modulus shall be used for stiffness computation.
 - Live Load Distribution Factor = 1.
 - Deflection Lag Factor = 1.5.
 - Bedding Factor = 0.1.

- Installation Factor = 1.5.
- Maximum deflection, deflection needed in any computations, , and service long-term tension strain limit shall be 5% for PE, and either 5% or 3.5% for PVC depending on cell class as per AASHTO LRFD Bridge Design Specs Table 12.12.3.3.1, and 3.5% for PP.
- Poisson's ratio of soil shall be 0.3.
- Earth load modifier shall be 1.05 and live load modifier shall be 1.0.
- Manning's n = 0.011 for smooth interior PVC and 0.012 for smooth interior HDPE and PP. (For hydraulic design.)
- Construction:
 - Any voids around exterior of host pipe must be filled for design assumptions to be valid.
 - The annular space between host pipe and liner pipe must be fully grouted for design assumptions to be valid.

Category E – Spray-on liners

- New Product Application requirements:
 - Must provide MSDS sheets.
 - Must list all chemical constituents including proprietary chemicals, including CAS Registry Number as available
 - Must provide description of minimum environmental protection requirements.
 - Must list liner material type.
 - Must list typical, minimum, maximum application thicknesses.
 - Must prove durability of 50 years or 75 years for the applicable roadway functional classification as per VDOT Road & Bridge Standard PC-1.
 - Must give proof of long term and short term modulus, long term and short term strength.
 - Must provide proof of initial Manning's n of product.
 - Must include specification or standard practice for installation.
- Given design criteria to use for project-specific structural design computations (typically in the past spray-on liners have been used to prevent further corrosion/deterioration, not for structural rehabilitation):
 - Must meet IIM-LD-244.1 Table A Flexible Liner Type Selection Guide.
 - Because of the variety of spray-on liners available, several design options may be used. For cementitious liners, design shall be guided similarly to nonreinforced concrete pipe or alternately similar to fiberglass pipe (high modulus material). For other liners, polyurea for example, design shall be guided similarly to fiberglass pipe (high modulus material) or simply as plastic pipe if flexural modulus or ring bending strain results are not satisfactory.
 - Cementitious liner treated similarly as nonreinforced pipe:
 - Follow wall thickness and 3-edge bearing strengths per Table 1 of ASTM C14. 3-edge bearing test results must be supplied. Assume a Type 4

bedding. Correlate the strength and bedding type to an allowable cover fill. (Methodology yet to be determined.)

- In order to provide 3-edge bearing results, it is recognized for a spray-on product, this would require special formwork at a fabrication facility to obtain specimens to test. Similarly as is done for watertight joint testing, these tests may be done and witnessed by a PE and a report submitted, which may then be used as proof of strength without having to perform the test for each future project, as long as materials and processes have not changed. Application thicknesses not tested may be interpolated by a satisfactory method. Extrapolation beyond thicknesses tested will not be permitted on the thin side, and will only be permitted for thicker applications by satisfactory statistical data.
- Cementitious liner treated similarly as fiberglass pipe (this method is based on the proposed AASHTO LRFD Bridge Design Specifications for fiberglass pipe):
 - Articles referenced below are from AASHTO LRFD Bridge Design Specifications, Section 12, version in use by VDOT Structure & Bridge Division at time of submittal.
 - The flexibility factor for fiberglass pipe shall be determined in accordance with Article 12.12.3.6, but with the modulus replaced by flexural modulus, and the flexibility factor shall be limited as specified in Article 12.5.6.3.
 - Follow Section 12.12.2.2 for deflection, except replace modulus with flexural modulus (ksi) and drop the “ $e_{sc}D$ ” term.
 - Factored long term strain due to flexure shall be less than or equal to $0.9*S_b$ (S_b is ring bending strain).
 - Factored buckling strain demand shall be less than or equal to $0.7*$ nominal strain capacity for buckling demand, computed per Eqn. 12.12.3.10.1e-2, except replace modulus with flexural modulus and soil resistance factor shall be 1.0. Factored buckling strain shall be:
 - $[[13.65*Height\ of\ soil\ over\ crown\ (in\ feet) + 1.75*P_L] * radius\ of\ liner\ to\ centroid\ of\ wall\ in\ in.]/(flexural\ modulus\ in\ ksi * X-S\ area\ of\ liner\ in\ in^2/in)$, where P_L is determined from Eqn. 12.12.3.9-1.
 - Flexural modulus shall be determined from pipe stiffness tests and per Appendix 2 of ASTM D2412, and shall be at least 1,200 ksi.
 - Long term ring bending strain, S_b , shall be determined in accordance with ASTM D5365 and results extrapolated to both 50 years and 75 years, and shall be at least 0.006.
 - It is recognized that for a spray-on product, obtaining specimens for flexural modulus and ring bending strain tests would require

special formwork at a fabrication facility. Similarly as is done for watertight joint testing, these tests may be done and witnessed by a PE and a report submitted, which may then be used as proof of results without having to perform the tests for each future project, as long as materials and processes have not changed. Application thicknesses not tested may be interpolated by a satisfactory method. Extrapolation beyond thicknesses tested will not be permitted on the thin side, and will only be permitted for thicker applications by satisfactory statistical data.

- GW table at crown of pipe.
- Traffic loading is HL-93, ignored after 8 ft of cover except for multiple barrel rehabs continue indefinitely.
- Unit weight of soil is 120 pcf, 135 pcf saturated.
- Modulus of soil reaction (based on VDOT pipe installation standards):
 - 0-5 ft of cover = 1.8 ksi
 - >5-10 ft of cover = 2 ksi
 - >10-30 ft of cover = 2.2 ksi
 - >30-60 ft of cover = 2.6 ksi
 - >60 ft of cover = 2.8 ksi
- Shape factor shall be 3.0.
- Live Load Distribution Factor = 1.
- Deflection Lag Factor = 1.5.
- Bedding Factor = 0.1.
- Installation Factor = 1.5.
- Maximum deflection and deflections needed in any computations shall be 5%.
- Poisson's ratio of soil shall be 0.3.
- Earth load modifier shall be 1.05 and live load modifier shall be 1.0.
- Other liner types treated similarly as fiberglass pipe:
 - Same as for cementitious liner treated similarly as fiberglass pipe above.
- Other liner types treated same as plastic pipe:
 - Follow AASHTO LRFD Bridge Design Specifications, Section 12, for thermoplastic pipe, version in use by VDOT Structure & Bridge Division at time of submittal.
 - GW table at crown of pipe.
 - Traffic loading is HL-93, ignored after 8 ft of cover except for multiple barrel rehabs continue indefinitely.
 - Unit weight of soil is 120 pcf, 135 pcf saturated.
 - Modulus of soil reaction (based on VDOT pipe installation standards):
 - 0-5 ft of cover = 1.8 ksi

- >5-10 ft of cover = 2 ksi
 - >10-30 ft of cover = 2.2 ksi
 - >30-60 ft of cover = 2.6 ksi
 - >60 ft of cover = 2.8 ksi
- Shape factor shall be 3.0.
- Live Load Distribution Factor = 1.
- Deflection Lag Factor = 1.5.
- Bedding Factor = 0.1.
- Installation Factor = 1.5.
- Maximum deflection and deflections needed in any computations shall be 5%.
- Poisson's ratio of soil shall be 0.3.
- Earth load modifier shall be 1.05 and live load modifier shall be 1.0.
- Construction:
 - Any voids around exterior of host pipe must be filled for design assumptions to be valid.
- ASTM C14 – Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
- ASTM D2412 – Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
- ASTM D5365 – Standard Test Method for Long-Term Ring-Bending Strain of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
- ASTM D5813 – Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
- ASTM F585 – Standard Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers
- ASTM F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
- ASTM F1216 – Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
- ASTM F1504 – Standard Specification for Folded Poly(Vinyl Chloride) (PVC) Pipe for Existing Sewer and Conduit Rehabilitation
- ASTM F1606 – Standard Practice for Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner
- ASTM F1697 – Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Strip for Machine Spiral-Wound Liner Pipe Rehabilitation of Existing Sewers and Conduit
- ASTM F1698 – Standard Practice for Installation of Poly(Vinyl Chloride)(PVC) Profile Strip Liner and Cementitious Grout for Rehabilitation of Existing Man-Entry Sewers and Conduits
- ASTM F1735 – Standard Specification for Poly (Vinyl Chloride)(PVC) Profile Strip for PVC Liners for Rehabilitation of Existing Man-Entry Sewers and Conduits

- ASTM F1741 – Standard Practice for Installation of Machine Spiral Wound Poly (Vinyl Chloride) (PVC) Liner Pipe for Rehabilitation of Existing Sewers and Conduits
 - ASTM F1743 – Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)
 - ASTM F1867 – Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation
 - ASTM F1871 – Standard Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation
 - ASTM F1947 – Standard Practice for Installation of Folded Poly (Vinyl Chloride) (PVC) Pipe into Existing Sewers and Conduits
 - ASTM F2019 – Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)
 - ASTM F2599 – Standard Practice for The Sectional Repair of Damaged Pipe By Means of An Inverted Cured-In-Place Liner
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- AASHTO M294 – Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter
 - AASHTO M304 – Poly(Vinyl Chloride) (PVC) Profile Wall Drain Pipe and Fittings Based on Controlled Inside Diameter
 - AASHTO M326 – Polyethylene (PE) Liner Pipe, 300- to 1600-mm Diameter, Based on Controlled Outside Diameter
 - AASHTO MP21-11 – Polypropylene Pipe, 300- to 500-mm (12- to 60-in.)
 - AASHTO PP63-09 – Pipe Joint Selection for Highway Culvert and Storm Drains