



Illinois Department of Transportation

Memorandum

To: ALL BRIDGE DESIGNERS 22.2

From: Jayme F. Schiff

Subject: Pipe Liners

Date: March 31, 2022

A handwritten signature in blue ink that reads "Jayme F. Schiff".

When pipe culverts and storm sewers become deteriorated, one option to prolong their service life is the addition of an interior pipe liner. These pipe liners are designed to withstand all loads that the host pipe withstands, essentially being a fully designed pipe independent of the host pipe. This memorandum contains an overview of the Illinois Department of Transportation's (IDOT) pipe liner policy and introduces three new Guide Bridge Special Provisions.

IDOT does not prefer one type of pipe liner over another; however, the parameters for each liner type may make one type preferable over another for a particular project. The intent of this memorandum is to increase awareness of different types of pipe liners available for use on IDOT projects and their applicability, design requirements, and Contract requirements.

IDOT currently utilizes four different technologies for pipe liners. They are as follows:

- Insertion Liner
- Folded/Formed PVC Liner
- Cured-In-Place Pipe Liner
- Spray-Applied Pipe Liner

A brief description, applicability parameters and required contract documents are given below for each of these four types of pipe liners.

Insertion Liner

Description: Insertion lining consists of a new smaller pipe, inserted into a deteriorated larger host pipe, with the annular space between the two pipes grouted. Specifications for insertion liner are found in Section 543 of the Standard Specifications for Road and Bridge Construction.

Insertion liner also may be used to line box culvert or pipe arch sections, given that the following requirements are met.

Allowable Diameters: The restrictions on diameter for an insertion liner are the same as those for a new pipe and are dependent upon pipe type and fill depth. Designers should consult the applicable design tables in Section 542 or Section 550 of the Standard Specifications for Road and Bridge Construction when determining applicable pipe diameters for a specific project.

Hydraulic Opening: As per Article 543.02 of the Standard Specifications for Road and Bridge Construction, the minimum hydraulic opening of insertion liner pipe shall be as follows:

Diameter of Existing Pipe/Culvert	Percent of the Cross-Sectional Opening of the Existing Pipe/Culvert
< 5 ft	72 %
5 ft - 10 ft	82 %
> 10 ft	90 %

Designers should consider these reductions in hydraulic opening when determining pipe liner type and diameter. If the resulting reduction in hydraulic opening does not meet the hydraulic requirements of the culvert, designers should consider use of a different liner type.

Unlike other liner types, which become difficult to design for pipes that have “ovalled” due to deterioration, there is no limit on the amount of host pipe deflection that would preclude the use of insertion liner pipe.

Segment Length: There is no restriction on total length of pipe to be lined with insertion liners, as individual segments are spliced together to create one continuous liner. As per Section 543 of the Standard Specifications, no more than three joints are allowed per 50 ft. Segment length will depend on the amount of area provided for jacking operations.

Liners cannot easily accommodate bends; insertion liner should be used for straight segments of pipe only.

Site Conditions: Insertion liner may be installed in wet or dry conditions. Water diversion is not required.

Insertion liners require a jacking pit adjacent to the existing culvert to be lined. The jacking pit should be able to accommodate a segment length of 20 ft, plus extra length for jacking equipment. Designers should evaluate the width of right-of-way available when determining pipe liner type, as small widths of right-of-way may preclude the use of insertion liner.

Structural Design: Pipe design charts are found in Section 542 of the Standard Specifications for Road and Bridge Construction. Storm sewer design charts are found in Section 550 of the Standard Specifications for Road and Bridge Construction. When these charts are used, there are no further design calculations, and there is not a requirement for an Illinois Licensed Structural Engineer.

Required Contract Documents: Plan and Profile sheets should show all information that would be required for a new pipe culvert or storm sewer. In order for the contractor to properly order an insertion liner, host pipe information such as diameter, fill, etc. are required to be placed in the contract documents. Section 543 of the Standard Specifications for Road and Bridge Construction contains all required specifications for the contract. There are no additional special provisions required.

Folded/Formed PVC Liner

Description: Folded/Formed Poly-Vinyl Chloride (PVC) liners consist of a flexible PVC pipe that appears on the jobsite “folded,” or in a flattened shape, with the appearance of a deflated balloon. It is then pulled through the host pipe with a winch, inflated until it conforms with the shape of the host pipe (i.e., “formed”). It is then steam cured and hardened. The final result is a PVC liner that conforms to the contours of the existing pipe.

Allowable Diameters: Standard Folded/Formed PVC Liner diameters of 4 in., 6 in., 9 in., 12 in., 18 in., 24 in., and 30 in. are found in ASTM F1504. A second ASTM standard, F1871, has diameters of 4 in., 6 in., 8 in., 9 in., 10 in., 12 in., 15 in., and 18 in. Either standard may be used. As stated in the Guide Bridge Special Provision “Folded/Formed PVC Liner,” host pipes not meeting these exact diameters may also be used, given that the supplier certifies that the diameter used meets the requirements of ASTM F1504 or ASTM F1871. Host pipes with diameters exceeding 30 in. shall not be lined with Folded/Formed PVC Liner.

Host pipes that have ovalled more than 12.5% (e.g., 3.75 in. of deflection on a 30 in. diameter pipe) may require additional structural calculations due to the applicability of the design formulas in the applicable ASTM documents. If this level of deterioration is found, the designer should consider a different liner type that is capable of accommodating this level of deterioration, or complete replacement of the existing pipe.

Hydraulic Opening: Diameter of lined pipe is typically between 0.5 in. and 1.5 in. smaller than that of host pipe diameter.

Segment Length: Folded/Formed PVC Liner segment length is dependent upon host pipe diameter. Host pipes with diameters 15 in. or less may have Folded/Formed PVC Liner segment lengths exceeding 900 ft. Host pipes with diameters of 30 in. have a Folded/Formed PVC Liner segment length limit of 325 ft. Exact segment length limits may be obtained from supplier literature.

Folded/Formed PVC Liners can accommodate bends in host pipes.

Site Conditions: Dry conditions and water diversion are required. Water diversion may be removed after PVC is cured, which is typically on the same day as installation.

Folded/Formed PVC Liners are inserted, formed, and cured from truck-mounted equipment. Jacking pits and additional right-of-way are not required. Temporary lane closures may be required to facilitate the truck-mounted equipment; relevant traffic control standards shall be included in the plans.

Structural Design: Folded/Formed PVC liners are designed using the procedure in ASTM F1867, Appendix X1. Design calculations shall be sealed by an Illinois Licensed Structural Engineer.

Required Contract Documents: Plan and profile sheets should show host pipe diameter and fill height. For pipes that have ovalled due to deterioration, both the maximum and minimum diameters of the pipe should be shown. This information

may be difficult to obtain due to pipe location and diameter, and therefore may be omitted from the plans. Soil class around pipe should be provided; however, due to unknown backfill used in the initial pipe installation, this information may not be attainable. In the event of omitted diameter or soil type data, the structural engineer will make conservative assumptions based on the data provided. Host pipes that have ovalled more than 10% may require a higher level of analysis than the prescribed procedure in the applicable ASTM standard.

Guide Bridge Special Provision Folded/Formed PVC Liner shall be included in the contract documents.

Cured-In-Place Pipe Liner

Description: Cured-In-Place Pipe Liner consists of a flexible resin-impregnated polypropylene. This material appears on the jobsite in a deflated shape. It is then inserted into a deteriorated pipe, inflated until it conforms with the shape of the host pipe, and the resin is then cured using heated water, steam, or UV light. When cured, the resin hardens, creating a liner for the existing pipe.

Allowable Diameters: There are no restrictions on maximum or minimum host pipe diameter, but Cured-in-Place Pipe Liners may become prohibitively expensive when used to line pipes of larger diameters. The preferred maximum diameter to ensure cost-effectiveness is 36 in.

Host pipes that have ovalled more than 10% (e.g., 3 in. of deflection on a 30 in. diameter pipe) may require additional structural calculations due to the applicability of the design formulas in the applicable ASTM documents. If this level of deterioration is found, the designer should consider a different liner type that is capable of accommodating this level of deterioration, or complete replacement of the existing pipe.

Hydraulic Opening: Diameter of lined pipe is typically less than 1 in. smaller than that of host pipe diameter.

Segment Length: Cured-In-Place Pipe Liner segment lengths between 300 ft. and 500 ft. are typical. Segment lengths exceeding 1000 ft. are possible, but may be difficult to install.

Cured-In-Place Pipe Liners can accommodate bends in host pipes.

Site Conditions: Dry conditions and water diversion are required. Water diversion may be removed after Cured-In-Place Pipe Liner is cured, which is typically on the same day as installation.

Cured-In-Place Pipe Liners are inserted, formed, and cured from truck-mounted equipment. Jacking pits and additional right-of-way are not required. Temporary lane or road closures may be required to facilitate the truck-mounted equipment; include relevant traffic control standards in the plans.

Structural Design: Cured-In-Place Pipe Liners shall be designed using the procedure in ASTM F1216, F1743, or F2019, depending upon Cured-In-Place Pipe

Liner type. Design calculations shall be sealed by an Illinois Licensed Structural Engineer. Host pipes that have ovalled more than 10% may require a higher level of analysis than the prescribed procedure in the applicable ASTM standard.

Required Contract Documents: Plan and Profile sheets should show host pipe diameter and fill height. For pipes that have ovalled due to deterioration, both the maximum and minimum diameters of the pipe should be shown. This information may be difficult to obtain due to pipe location and diameter, and therefore may be omitted from the plans. Soil class around pipe should be provided; however, due to unknown backfill used in the initial pipe installation, this information may not be attainable. In the event of omitted diameter or soil type data, the structural engineer will make conservative assumptions based on the data provided.

The Guide Bridge Special Provision Cured-In-Place Pipe Liner shall be included in the contract documents.

Spray-Applied Pipe Liner

Description: Spray-Applied Pipe Liners consist of a geopolymer concrete that is sprayed onto the inside surface of the host pipe, creating a liner similar to shotcrete. The application is performed via a machine that is pulled through the host pipe. This machine has a spinning nozzle that sprays the geopolymer concrete. Larger pipes may be installed with trained technicians using a hand nozzle applicator.

Allowable Diameters: Due to the possibility that manual application may be required for areas of application, host pipes of diameters 36 in. and larger are preferred. Host pipes of 30 in. diameter are allowed, but installation of the Spray-Applied Pipe Liner may be difficult due to the size of the equipment, and possibility of a manual operator, required for installation.

Host pipes that have ovalled more than 12% (e.g., 3.6 in. of deflection on a 30 in. diameter pipe) may require additional structural calculations due to the applicability of the design formulas in the design methodology document. If this level of deterioration is found, the designer should consider a different liner type that is capable of accommodating this level of deterioration, or complete replacement of the existing pipe.

Hydraulic Opening: Diameter of lined pipe is typically between 1 in. and 4 in. smaller than that of host pipe diameter.

Segment Length: Spray-Applied Pipe Liners may be applied continuously, with no limitations on segment length. When multiple days of application are required, segment lengths are spliced together, creating one continuous liner.

Tight bends in host pipes may be accommodated, but will require manual application at the bend location.

Site Conditions: Dry conditions and water diversion are required. Water diversion may be removed after Spray-Applied Pipe Liner is cured, which is typically the same day as installation.

Structural Design: Spray-Applied Pipe Liners may be designed using methodology in industry literature such as the document Testing and Modeling Analysis of

Geopolymer Pipe-lining Technology for Sewer & Stormwater Rehabilitation (approved by Water Resources Council). The methodology in this document was based on experiments on pipes with a maximum ovality of 12%. Design calculations shall be sealed by an Illinois Licensed Structural Engineer.

Required Contract Documents: Plan and Profile sheets shall show host pipe diameter and fill height. For pipes that have ovalled due to deterioration, both the maximum and minimum diameters of the pipe should be shown. This information may be difficult to obtain due to pipe location and diameter, and therefore may be omitted from the plans. Soil class around pipe should be provided; however, due to unknown backfill used in the initial pipe installation, this information may not be attainable. In the event of omitted data, the structural engineer will make conservative assumptions based on the data provided.

The Guide Bridge Special Provision Spray-Applied Pipe Liner shall be included in the contract documents.

Implementation

Three new Guide Bridge Special Provisions (GBSPs) have been released for use of pipe liners: Folded/Formed PVC Liner (#97), Cured-In-Place Pipe Liner (#98), and Spray-Applied Pipe Liner (#99). The GBSP for Folded/Formed PVC Liner replaces Recurring Special Provision #16. These GBSPs may be found on the IDOT website at [Guide Bridge Special Provisions](#).

Please direct questions to Mark Shaffer, Policies, Standards and Final Plan Control Unit Chief, by telephone at (217) 785-2914 or email at mark.shaffer@illinois.gov.

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