



**CONSTRUCTION SPECIFICATION FOR THE
REHABILITATION OF GRAVITY PIPE BY
THERMOFORMED FORM AND FOLD LINER**

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465.01 SCOPE

This specification covers the requirements for the rehabilitation of an existing pipe culvert or stormsewer using thermoformed PVC Alloy or PE Pipe Liner through fold and form liner trenchless technology technique.

465.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 409	Closed-Circuit Television (CCTV) Inspection of Pipelines
OPSS 411	Construction Specification for the Cleaning and Flushing of Culverts, Pipe Sewers, Catchbasins, Maintenance Holes, Ditch Inlets, and Oil-Grit Separators
OPSS 490	Construction Specification for Site Preparation
OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 510	Construction Specification for Removal
OPSS 517	Construction Specification for Dewatering
OPSS 539	Construction Specification for Temporary Protection Systems

Ontario Provincial Standard Specifications, Material

- OPSS 1840 Material Specification for Non-Pressure Polyethylene (PE) Plastic Pipe Products
 OPSS 1841 Material Specification for Non-Pressure Polyvinyl Chloride (PVC) Pipe Products

ASTM International

- D638-22 Test Method for Tensile Properties of Plastics
 D790-17 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 D1784-20 Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds
 D2412-21 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
 D2444-21 Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
 D2657-05(2015) Practice for Heat Fusion of Joining Polyolefin, Pipe and Fittings
 D2990-17 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
 D3350-21 Specification for Polyethylene (PE) Plastics Pipe and Fitting Materials
 F585-16(2021) Guide for Insertion of Flexible Polyethylene (PE) Pipe Into Existing Sewers
 F810-12(2018) Specification for Smoothwall Polyethylene (PE) Pipe for Use in Drainage and Waste Disposal Absorption Fields
 F1504-21e1 Specification for Folded Poly Vinyl Chloride (PVC) Pipe for Existing Sewer and Conduit Rehabilitation
 F1533-20 Specification for Deformed Polyethylene (PE) Folded Pipe
 F1606-19 Practice for Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner
 F1867-22 Specification for Installation of Folded/Formed Poly Vinyl Chloride (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation
 F1947-21a Practice for Installation of Folded Poly Vinyl Chloride (PVC) Pipe into Existing Sewers and Conduits

465.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Design Engineer means the Engineer retained by the Contractor who produces the design and Working Drawings and other engineering documents required of the Contractor.

Fold and Form Liner means a method of pipeline rehabilitation in which a Polyvinyl Chloride (PVC) or Polyethylene (PE) pipe is folded to reduce its size before insertion and reversion to its original shape by thermoforming i.e. the application of heat and/or pressure. The reformed plastic pipe fits snugly to and takes the shape of the inner diameter (ID) of the host pipe. [North American Society for Trenchless Technology (NASTT)]. Depending on the size, the PVC Alloy or PE Pipe Liner shall be coiled either in a flat shape and folded during insertion for smaller sizes, whereas the larger PVC Alloy or PE Pipe Liner shall be coiled in an "H" or "U" shape.

Host Pipe means existing original pipe culvert or sewer to be internally rehabilitated by installation of the PVC Alloy or PE Pipe Liner.

Non-Destructive Testing means a testing and analysis technique used by the industry to evaluate the properties of a material, component, structure or system without damaging or destroying the object being tested.

Thermoform means to give final shape to a material with the aid of heat and/or pressure.

465.04 DESIGN AND SUBMISSION REQUIREMENTS

465.04.01 Design Requirements

465.04.01.01 Fold and Form Liner

The fold and form liner shall be manufactured with a diameter substantially smaller than the inside diameter of the host pipe. The pipe liner shall be manufactured with sufficient excess wall thickness to allow it to meet or exceed the manufacturer's dimension ratio (DR) requirements after being thermoformed.

The fold and form liner shall be designed to meet the following installation performance requirements:

- a) Capable of expanding to a full pipe size larger than the nominal diameter without splitting, or rupturing;
- b) Precisely conform to the configuration of the host pipe after thermoforming, and if required, with a concave dimple typically appearing at each lateral connection;
- c) Impact resistance cell classification of no less than the required ASTM standard, to resist splitting during remote controlled connection reinstatement;
- d) Processing of the fold and form liner shall cause no degradation of the pipe liner physical properties;
- e) The material shall be NSF approved as an indication of its lack of impact on the environment and human health;
- f) No styrene based liners shall be utilized anywhere in the work.

465.04.02 Submission Requirements

465.04.02.01 Product Data

A minimum of 2 weeks or as specified in the Contract Documents, the manufacturer's product data with samples of the proposed fold and form liner and installation instructions including handling and storage requirements shall be submitted to the Contract Administrator.

465.04.02.02 Certifications

Installation shall be preformed by a licensed installer of the fold and form liner. The following shall be submitted to the Contract Administrator:

- a) A letter of certification from the manufacturer that the product meets or exceeds all technical and packaging requirements.
- b) Manufacturer's certifications that materials have been approved for the installation conditions shown on the Contract Drawings and as specified herein.
- c) Manufacturer's materials warranty certificate.
- d) Installer's job history, reference certificates, and a certified statement from the manufacturer that the installer performing the work has been trained and approved in the handling and installing of the product to be used. Certification letter shall be dated within 6 months of the bid date.
- e) Proof of any necessary federal, provincial, or local permits or licenses necessary for the project.

465.04.02.03 Working Drawings and Technical Information

A minimum of 2 weeks or as per the Contract Documents, prior to commencement of the fold and form liner installation three copies of written procedures and Working Drawings showing the design calculations and entire work plan for the fold and form liner rehabilitation of the host pipe shall be submitted to the Contract Administrator. Prior to making a submission, the seal and signature of a design Engineer shall be affixed on the written procedures and Working Drawings verifying the drawings are consistent with the Contract Documents.

The written procedures and Working Drawings shall include the following:

- a) The Working Area layout;
- b) A work plan outlining the materials, procedures, methods and schedule to be used to execute the work;
- c) A traffic control plan;
- d) A work plan including all materials and methods for any repairs necessary to the host pipe prior to the pipe insert line application;
- e) A safety plan including the company safety manual and emergency procedures;
- f) The fold and form liner size shall be the maximum allowable internal diameter size that will fit the host pipe as per the manufacture's specifications;
- g) Demonstrate, in conjunction with the manufacturer's specifications, that the heat and pressure resistance of the host pipe material is sufficient to tolerate, without damage, the heat and pressure exerted during the fold and form liner installation;
- h) Pipe culvert or sewer flow by-pass plan, when specified in the Contract Documents;
- i) A containment and contingency plan in conformance with the Contract Documents for the following potential conditions:
 - i) Improper placement of the fold and form liner.
 - ii) Damage to the host pipe.
 - iii) The product's failure to achieve the intended use.
 - iv) Potential environmental impacts and emergency containment and clean-up procedures.

465.05 MATERIALS

465.05.02 Delivery of Materials

When the delivered quality of certified fold and form liner product is deemed to be unacceptable by the Contract Administrator, the product shall be rejected.

465.05.03 Transporting, Unloading, Storing, and Handling Materials

Manufacturer's recommendations for transporting, unloading, storing, and handling of materials shall be followed.

465.07 CONSTRUCTION

465.07.01 General

The Contract Administrator shall be notified, minimum of 48 hours, in advance of starting the work. The exact size and length of all existing pipes and culverts to be rehabilitated shall be confirmed prior to installation. All required equipment shall be on-site and in satisfactory working order prior to commencing the installation of a lining section.

Appropriate heating procedures shall be adopted during the liner installation phase to reduce the risk of compromising the structural integrity of the liner pipe and liner flotation.

Any joints shall be as per the manufacturer's recommendations, shall be watertight, interlocking, and shall not increase or decrease the inside or outside diameter of the pipe insert liner.

The product shall be protected from damage during the pullback operation.

465.07.02 Site Preparation

Site preparation shall be according to OPSS 490.

465.07.03 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

465.07.04 Dewatering

When required, flow diversion, unwatering/dewatering, shall be installed to fulfill the Contract requirements. Dewatering when required shall be according to OPSS 517.

The Environment Canada weather forecast shall be monitored prior to commencement of lining operations. Where the anticipated weather conditions are such that anticipated host pipe/box culvert flows may exceed the installed bypass pumping capacity or may cause potential site flooding, commencement of construction shall be delayed until favourable weather is forecast.

465.07.05 Temporary Protection Systems

The construction of all protection systems shall be according to OPSS 539.

465.07.06 Cleaning of Host Pipe

The host pipe cleaning shall be according to OPSS 411.

465.07.07 Preparation and Pre-Lining Repairs

Prior to liner installation, the host pipe shall be inspected using visual observations or when specified, CCTV/zoom camera, especially where personnel entry is impracticable. CCTV inspection shall be according to OPSS 409.

Any open joints and voids shall be sealed with approved material prior to the lining of the host pipe. If required, non-destructive testing (e.g. InSight™ Lite, Backscatter Computed Tomography, endoscope camera inspections, or other testing methods approved by the Contract Administrator) shall be performed to confirm that all identified voids and low density soil areas have been successfully filled with the approved material.

If additional repair procedures are required to restore the host pipe for lining, for example invert reconstruction, a repair plan shall be submitted to the Contract Administrator prior to proceeding.

All active infiltration shall be sealed prior to application of the fold and form liner material and ensure that the host pipe is sufficiently dewatered as per the manufacturer's instructions.

Additional materials including quick setting mortars, chemical grouts and hydraulic cements necessary to stop infiltration and create a surface for the fold and form liner to be applied to may be necessary and shall be in accordance with the relevant standards. All products used to stop active infiltration shall be approved by the Contract Administrator and used in accordance with the manufacturer's recommendations.

The diameter, profile, length and all other dimensions of all host pipes or box culvert to be rehabilitated shall be accurately measure for planning all construction activities and choosing appropriate equipment.

The Contract Administrator shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

465.07.08 Construction and Operational Constraints

All activities shall be confined to the designated Working Areas.

The length of the fold and form liner shall be that which is deemed necessary to effectively carry out the liner insertion and to seal the fold and form liner at the inlet and outlet ends. Any necessary excavation shall be approved in writing by the Contract Administrator prior to commencement of such excavation.

The thermoformed fold and form liner shall be positioned to enable it to naturally curve and directly insert into the host pipe. The fold and form liner shall be pulled into the host pipe by means of a winch cable extending the length of the host pipe. The fold and form liner shall be uncoiled at approximately the same speed that it is being pulled as evidenced by slack in the pipe liner as it uncoils. In order to limit insertion stresses, speed should be adjusted according to the fold and form liner temperature, the required pulling force, and the risk of abrasion. The liner's ends shall be equipped with flow-through plugs or fittings to allow for the controlled introduction and release of steam and pressure.

If required, the host pipe ends shall be removed and reinstated or replaced to facilitate the installation of the new fold and form liner. Removals shall be according to OPSS 510.

During the installation process, the maximum axial/compression forces and bending moments shall not exceed tolerable limits of the host pipe in order to avoid damaging the host pipe and/or joints.

A rounding device or a "squeegee" type apparatus shall not be used in an attempt to unfold or to expand the fold and form liner. It shall only be accomplished by using steam and pressure as per the manufacturer's recommendations.

The fold and form liner, once thoroughly heated to permit proper expansion, shall be expanded with sufficient air and steam pressure to form tightly against the inner wall of host pipe. Temperatures and pressures shall be monitored to ensure that the minimums and maximums recommended within the technology supplier's installation guidelines are not exceeded. After the fold and form liner is thermoformed tightly to conform to the host pipe, the pipe liner shall be cooled to a temperature as directed by the technology supplier's installation guidelines before relieving the pressure required to hold the fold and form liner tightly against the host pipe. In no case shall this temperature be in excess of 38 °C/100 °F.

During cooling of the fold and form liner, the plugs shall remain properly pressurized throughout the cooling process. After the fold and form liner has cooled, the plugs shall be removed and the pipe liner ends shall be trimmed, leaving a minimum of 75 mm and a maximum of 150 mm protruding beyond the host pipe in order to maintain the tight fit created by the flaring of the fold and form liner.

Lateral connections, as may be visible in the pre-lining video inspection, shall be reinstated using remote robotic devices. Only experienced operators shall make robotic connection reinstatements.

465.07.09 Supervision

The Superintendent shall have received adequate training from the technology supplier and shall have a minimum of 3 years demonstrated experience on projects with similar scope and complexity.

465.07.10 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

465.07.11 Site Restoration

Site restoration shall be according to OPSS 492.

465.07.12 Environmental Protection and Contingency

Environmental protection requirements and mitigation measures shall be according to the Contract Documents. Prior to any discharge, it shall be confirmed with the Contract Administrator that the quality of the discharge meets the requirement of the receiver.

465.07.13 Electrical Equipment, Fixtures and Systems

Electrical equipment shall be suitably insulated for noise reduction. Noise produced by electrical equipment must comply with local municipal noise by-laws.

465.07.14 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

465.08 QUALITY ASSURANCE

465.08.01 Fold and Form Liner Material

The fold and form liner shall be continuous and joint-less, free of all visual and material defects except those resulting from pre-lined conditions. Such conditions shall be brought to the attention of the Contract Administrator prior to the fold and form liner installation. In the event that the fold and form liner requires repair, materials used in the repair shall not contain styrene and the thickness of the repair shall not exceed the thickness of one fold and form liner.

Appropriate inflation and cooling procedures must be adhered to during the installation phase to reduce the risk of compromising the structural integrity of the fold and form liner.

465.08.01.01 Sampling

All QA sampling and testing of the installed fold and form liner shall be in accordance with the requirements of the Liner manufacturer's specifications & design recommendations, and applicable standards. A sample shall be taken from the obvert of the installed fold and form liner, sufficient in size to meet the requirements for testing of ASTM D790 and ASTM D638 for flexural strength, flexural modulus, and tensile strength as per ASTM F1867, ASTM F1871, or ASTM F1533, to confirm compliance with the requirements specified in the Contract Documents.

The Contractor shall provide a truly representative sample of each installed liner. The field sample shall be a restrained sample made by extending the liner installation through a cylindrical form (e.g. PVC pipe) that closely matches the inside diameter of the installation. The form shall not expand or otherwise distort during sample forming or processing. The sample shall be taken from each installed fold and form liner extended at an access point or from Liner that extends into an access point of the section.

In areas with limited access, the sample shall be fabricated from material taken from the precursor pipe tube and formed with sandbags in a restrained manner that simulates the heat sink present during the actual installation. The environmental conditions under which the field sample is made shall result in a cured sample that has properties representative of the cured fold and form liner.

The length and size of any sample shall be sufficient to obtain at least five test specimens for ASTM D790 testing (or at least 200 mm).

The Contract Administrator or designated representative shall witness the sampling and administer as specified in the Contract Documents, except that delivery shall be to the qualified independent testing laboratory retained by the Contract Administrator. Samples shall be delivered to the laboratory within 24 hours of sampling.

In the case of stormsewer, as per the Contract Documents, the fold and form liner's ends at the maintenance hole walls, shall be trimmed as close as practical to the maintenance hole walls with allowance for thermal contraction to produce a slight outward flare on the liner ends. The space behind the liner flare and the sewer pipe or the maintenance hole wall shall be sealed with epoxy and/or non-styrene resin material that can withstand differential expansion/contraction of the liner.

465.08.01.02 Testing

The testing of the samples shall be done by an independent testing laboratory retained by the Contract Administrator. Subject to the approval of the Contract Administrator, an independent testing laboratory certified by the Standards Council of Canada can perform all the tests as required per the ASTM standards. The

Contractor shall provide the testing laboratory with the design parameters for the Liner corresponding with the field samples. The testing laboratory report shall reference these values as the specified values.

The testing laboratory technician shall cut the required test/specimen samples and complete the specified testing.

Reports detailing test results shall be issued within 10 Working Days of delivery of the sample to the testing laboratory.

465.08.02 Inspection of Materials

The fold and form liner materials shall be subject to rejection by the Contract Administrator at any time on account of failure to meet any of the requirements in the Contract Documents, even though samples may have been accepted as satisfactory at the place of manufacture. Materials rejected after delivery shall be marked for identification and shall be removed from the job site at once.

465.08.03 Closed-Circuit Television (CCTV) Inspection

Lined host pipe with fold and form liner shall be inspected using visual observations or specified CCTV/zoom camera where personnel entry is impracticable. CCTV inspection shall be according to OPSS 409.

In the case of repairs required to restore the host pipe for lining, such as joints sealing, invert reconstruction, or additional repairs etc., a post preparation CCTV inspection shall be completed for each host pipe, when specified in the Contract Documents.

465.09 MEASUREMENT FOR PAYMENT

465.09.01 Actual Measurement

465.09.01.01 Fold and Form Liner

Measurement for payment shall be the length in meters of the concrete canvas liner installed, as measured along the centerline of the invert of the host pipe.

465.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clause under Actual Measurement.

465.10 BASIS OF PAYMENT

465.10.01 Fold and Form Liner - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.