Rehabilitation of Force Mains Using Cured-In-Place Pipe (CIPP)

PERFORMANCE SPECIFICATION GUIDELINE (PSG)

April 2026

This Performance Specification Guideline is maintained and updated by NASSCO's Pressure Pipe Committee

Disclaimer

This Performance Specification Guideline (PSG) was prepared by a Committee comprised of representatives of NASSCO members and peer-reviewed by industry professionals. This PSG is not specific to any one product, project, or job site, and should be considered a guideline only. Conditions for use may require additions, deletions or amendments to these guidelines to conform to project-specific site conditions and to comply with applicable laws, regulations, and ordinances. NASSCO does not guarantee, certify or assure any result and assumes no liability as to content, use and application of these guidelines.

Foreword

This Performance Specification Guideline (PSG) presents a performance-based specification designed to guide the rehabilitation of force mains (i.e., pressurized sewer pipelines) using cured-in-place pipe (CIPP). The PSG offers a variety of materials and technologies that may be considered for force main rehabilitation using CIPP. Throughout the specification, guidance is provided to aid in customizing and drafting a specification tailored to the specific needs of their project. These guidelines are clearly highlighted in bold print and enclosed within bold borders to ensure easy identification and clarity for the user.

NASSCO recognizes that, for the products and technologies included in this PSG to consistently deliver the performance required, those involved in the rehabilitation process - from assessment to inspection - need access to learning opportunities to understand these rehabilitation technologies. NASSCO has responded to these needs by providing instructional learning and objective technical resources, including the following:

Inspector Training Certification Program (ITCP™) for the Inspection of Cured-In-Place Pipe (CIPP) Installation is a training and certification program that provides field construction professionals (i.e., consulting and municipal engineers and contractors) with resources to understand and inspect CIPP rehabilitation technologies.

Pipeline Assessment Certification Program (PACP™) is the trusted source for proper and consistent assessment condition coding of pipelines. The goal of this program is to help pipeline system owners create comprehensive databases to properly identify, plan, prioritize, manage and renovate their assets based on condition evaluation.

On NASSCO's website at NASSCO.org, you can find educational opportunities, technical resources, and ways to stay informed or get involved in advocacy for the underground infrastructure industry. From published reports to specification guidelines, NASSCO's continually growing library of technical resources is the foundation for setting quality industry standards.

PART 1 - GENERAL

1.1 SUMMARY

This PSG covers the rehabilitation of force mains (i.e., pressurized sewer pipelines) with operating pressures greater than 10 psig with considerations for transient hydraulic conditions through the installation of CIPP. Guidance for rehabilitating force mains with operating pressures at or less than 10 psig, can be found in NASSCO's PSG for Rehabilitation of Gravity Sewer Pipelines Using Cured-In-Place Pipe (CIPP), available at NASSCO.org.

A. This specification includes the minimum requirements for the rehabilitation of force mains, also known as pressurized sewer pipelines or rising mains, by providing the work necessary to furnish and install cured-in-place pipe (CIPP) within the existing pipe, as specified by the Owner.

B. This includes the minimum requirements for the rehabilitation defined herein and as shown on the plans included as part of these contract documents.

C. The Contractor is responsible for the accurate and complete installation and warranty of products installed.

1.2 DESCRIPTION OF WORK AND PRODUCT DELIVERY

Specifications define the scope of work required, including descriptions of the products or materials to be used during installation, as well as specific deliverables expected from the Contractor.

This includes identifying the existing diameter, configuration, and length of the pipeline to be rehabilitated, as well as the locations of appurtenances that need to be replaced or considered as an access location for lining.

A pre-rehabilitation closed-circuit television (CCTV) inspection is mandatory. The purpose of this investigation is to measure the size of the pipe, identify unknown conditions, and confirm the scope of work prior to rehabilitation.

A. The Work covered by this specification consists of work necessary to furnish and install the CIPP rehabilitation solution. The Contractor shall deliver a finished product including materials, labor, equipment, and services necessary for mobilization, traffic control, bypass pumping, temporary service, and/or diversion of sewage flows, cleaning equipment, product installation, site restoration, quality controls and samples for performance of required material tests, final inspection and warranty work, as included in this specification and at the quantities of each component contained in the Bid Proposal.

B. The CIPP product shall be a complete system, including a specific resin and tube combination, appropriate equipment, and installation and curing procedures that have been tested together to verify the system's ability to meet the requirements of this specification.

C. The pipeline rehabilitation solution shall be integrated and compatible with materials, equipment, and installation procedures used to complete the work.

A performance statement should outline the objective(s) that the construction or rehabilitation is intended to achieve. The three primary goals for force main rehabilitation are included in Section 1.2.D. below. When applying these to a particular project, the specifications should be modified in Section 1.2.D. to include one, all, or a combination of these objectives, depending on the project requirements.

D. Installed CIPP shall be inspected and tested to confirm the installation meets the performance criteria specified as required in these specifications, including:

1. Prevent exfiltration of sewage and infiltration of groundwater entering the system through the rehabilitated section.
2. Create a barrier covering the rehabilitated sections that is resistant to corrosive effects of process flows to prevent future corrosion of the rehabilitated components.
3. Repair or rehabilitate deteriorated components to re-establish the structural integrity of those components.

E. The CIPP shall form a continuous, jointless liner from one access point to another. It shall be watertight throughout, including terminations, and free of defects that could compromise the operation or performance of the rehabilitated pipeline.

F. Materials or processes used by the Contractor may include styrene or other chemicals that can result in the release, formation, or introduction of detrimental compounds or by-products to the wastewater treatment plant or receiving waters. The Contractor should notify the Owner and identify the resin system, curing method, emission and containment controls, and waste handling and discharge procedures that will be used during installation, and demonstrate compliance with all applicable regulations. When styrene-based resins are proposed, NASSCO's Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe should be referenced, and the Contractor required to adhere to appropriate measures. Additional references that may be useful include NASSCO's Phase 1 through 3 CIPP Emissions reports and the Phase 4 study by NASSCO on Assessing the Impact of CIPP Cure Water on POTW Biological Treatment. The Contractor shall submit a written disclosure to the Owner identifying the resin system, curing method, emission and containment controls, and waste handling and discharge procedures to be used during installation, and shall demonstrate compliance with applicable regulations.

G. The Contractor will conduct installation operations and schedule cleanup in a manner to restore the site to existing conditions while minimizing disruption to traffic, pedestrians, businesses, property owners or occupants in accordance with local regulations.

H. Materials furnished shall be marked with product information, stored in a manner as specified by the manufacturer, and tested to the requirements of this contract.

I. Prior to rehabilitation, the Contractor shall provide a sampling plan intended to secure samples for testing at the request of the Owner. The samples shall be marked to delineate the specific location that the sample was retrieved from, the time and date that the sample was secured, supplementary marking requirements identified by the Owner, and, when applicable, the axial and hoop directions of fiber reinforcement. The Owner shall take possession of the samples for testing and shall maintain the chain of custody, deliver the samples to an approved laboratory, and pay for material and product testing performed under this contract.

J. For each rehabilitation, a record of materials installed shall be prepared by the Contractor. The record shall include, but not limited to, the date, location, length, and diameter of the CIPP installed.

K. Quality assurance documentation and test reports for CIPP installations shall be prepared and submitted post-rehabilitation by the Contractor as required herein.

L. Testing and warranty inspections shall be executed by the Owner. Defects shall be repaired or replaced by the Contractor as required in the contract documents.

1.3 PRICES

A. The Contractor shall deliver a finished product including materials, labor, equipment, and services necessary for traffic control, bypass pumping and/or diversion of sewage, use and payment for potable water, cleaning equipment, product installation, site restoration, quality controls and samples for performance of required material tests, final inspection and warranty work, as specified in the Description of Work and at the quantities of each component contained in the Bid Items.

Measurement and Payment are defined in Part 4.

1.4 REFERENCES

References are included in specifications to provide guidelines for applicable standards that typically govern the product performance and/or installation standards. If a reference document does not apply, or is not pertinent or has unknown content, then it should not be included. Specific reference document requirements should be defined in the project's specifications or by reference to a specific section of the reference document. Specific Contractor requirements and test procedures contained in the references should be defined in the project's specifications.

A. ASTM and other applicable reference standards are made a part of these specifications by reference to the extent stated herein and shall be the latest edition thereof. Where there are differences between codes, standards, and these specifications, these specifications shall govern.

B. ASCE MOP 145 - Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

C. ASTM Standards

1. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
2. ASTM D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
3. ASTM D2290 - Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe
4. ASTM D2990 - Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
5. ASTM D3039 - Standard Test Method of Tensile Properties of Polymer Matrix Composite Materials
6. ASTM D5813 - Standard Specification for Cured-in-Place Thermosetting Resin Sewer Pipe
7. ASTM F1216 – Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
8. ASTM F1743 – Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

D. AWWA/ANSI C623 - Cured-in-Place Pipe (CIPP) Rehabilitation of Pressurized Potable Water Pipelines, 4 in. (100 mm) and Larger

E. AWWA Committee Report - Structural Classifications of Pressure Pipe Linings: Suggested Protocol for Product Classification

F. ISO 11297-4 - Plastics piping systems for renovation of underground drainage and sewerage networks under pressure - Part 4: Lining with cured-in-place pipes

G. NASSCO Guidelines and Practices

1. NASSCO's Pipeline Assessment Certification Program (PACP™)
2. NASSCO's Sewer Pipe Cleaning Guideline
3. NASSCO's Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe

1.5 PERFORMANCE WORK STATEMENT

In place of the project specifications defining the specific method for CIPP installation, options may be allowed by the Owner for the contractor to either submit prior to bidding a prequalification package for approval of the proposed product and installation method, or at the time of bid submission provide a Performance Work Statement (PWS) detailing the proposed installation means and methods.

These documents, once approved, serve as the basis for inspection during construction to verify compliance with the approved approach. These submittals should include recommended quality assurance procedures and documentation of crew qualifications.

If elected by the Owner, a prequalification process may be implemented, allowing the Owner to review the Contractor's qualifications and the submitted product before the bid submission. This prequalification process enables the Owner to evaluate and approve contractors and products in advance, thereby limiting bid submissions to only those prequalified. The following section may be modified and used to specify the requirements for submission of a prequalification package versus submittal of PWS.

A. The Contractor shall submit, to the Owner, a Performance Work Statement (PWS) that defines the proposed method for rehabilitation using CIPP and demonstrates conformance with the requirements of the contract documents. At a minimum, the PWS should include the following:

   1. Documentation that the CIPP will conform to the project requirements as outlined in these specifications.
   2. A CIPP installation plan describing the preparation work, cleaning operations, pre-inspections, bypass or flow maintenance, traffic control, installation procedure, method of curing, quality control, testing to be performed, final inspection, and that necessary and appropriate for a complete CIPP installation.
   3. An installation schedule that meets the requirements of this contract.
   4. A description of the CIPP, or materials that comprise the CIPP, to be furnished for the project. Material descriptions shall be sufficient to verify conformance to project specifications and/or shall conform to the pre-approved CIPP submission.
   5. A statement of the Contractor's PACP-certified personnel, including names and experience, that will conduct CCTV inspections to the requirements of this contract. [Optional: Certifications equivalent to NASSCO's CCTV inspection standards are permitted when alternative inspection methods are approved by the Owner.]
   6. A statement of the Contractor’s experience installing CIPP in a pressurized pipeline of similar size as contained in this Contract shall be submitted within the Bid Proposal, including the names and experience of lead personnel assigned to the project. If personnel are substituted, they shall have similar, verifiable experience as the personnel originally submitted for the project.

Specific qualification requirements can vary by project typically based upon scope and size of the project as well as availability of contractors qualified to provide specialized services.

7. Current documentation from the CIPP manufacturer demonstrating that the Contractor possesses the required equipment and training to comply with the manufacturer's Quality Assurance requirements for installation. Contractor's personnel possessing current required training shall be listed individually.

Public notification can prevent many public relations issues during a project. If those who will be impacted by construction are aware that workers and equipment will be near their location, that residents in homes should not use large volumes of water, or that they may experience strange odors, many concerns and problems can be prevented.

8. CIPP installations may utilize resins that contain a styrene component. The resins can emit a distinctive odor from the styrene component. To minimize this nuisance odor and mitigate the potential impacts on the public and building occupants, the Contractor should develop an odor control plan. NASSCO developed a community outreach flyer and door hanger that can be used to educate the public on the value of CIPP, the steps they can take to prevent the odor from entering buildings, and answer questions about safety. The plan author should use NASSCO's "Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe" as a resource when developing their plan. A public notification plan shall be prepared and submitted including staged notification to building occupants affected by the CIPP installation.
9. A project-specific odor control plan shall be submitted by the Contractor that demonstrates how odors from the installation process will be minimized at the project site and surrounding area. A component of the plan must include methods for removing odors from homes or buildings, if required by the Owner.

1.6 PRODUCT SUBMITTALS

Product submittals require the Contractor to submit the complete CIPP system intended for use in the installation. The submittal should identify the specific combination of tube and resin materials, the designated curing method, and all associated components, including end seals and any other materials required for a complete CIPP rehabilitation installation. If allowed by the contract documents, the Contractor may propose alternative CIPP systems that are equal to or better than those specified. The submitted information should be sufficient for the Owner to assess the alternative CIPP system's ability to meet the contract's specified requirements.

Test results should reflect the CIPP constructed with the specific resin and tube intended for use on the project.

A. Product data submittals are required for the CIPP system, defined as the specific combination of tube and resin materials and the designated curing method, and other materials proposed for use in the rehabilitation.

1. Technical data sheet(s) including manufacturer, product material type, intended use, resin saturation charts, reference standards for materials or design, and mechanical properties of the CIPP product.
2. Copies of third-party test results for chemical resistance, and physical and mechanical properties that demonstrate that the proposed CIPP product meets these specifications and the submitted design.
3. Design calculations for both the internal and external loading parameters specified in Section 1.7.D. shall be submitted for review and approval. The Owner shall further designate design conditions of the subject pressure pipeline(s) as AWWA Class III or Class IV as defined in the *AWWA Committee Report - Structural Classifications of Pressure Pipe Linings - Suggested Protocol for Product Classification*. The design submittal shall identify the physical and mechanical properties used for design that shall be the basis for acceptance of the final product. The design shall be certified by a registered Professional Engineer.
4. Manufacturer's shipping, handling and storage guidelines for materials to be furnished for the project.
5. Safety Data Sheets (SDS) for materials to be furnished for the project.
6. Manufacturer's installation requirements for the CIPP system proposed, including cleaning and preparation of the existing pipeline, flow diversion, resin impregnation (i.e., wet-out), insertion, cure, and sealing processes, and the equipment required for delivery of a quality product.
7. Manufacturer's quality assurance guidelines for inspection and testing throughout the installation process including acceptance protocol.

Equipment used for the installation and curing of the CIPP is critical. This specialized equipment is not readily available from local equipment rental companies. As a result, provisions for the availability of redundant equipment or a plan for managing delays and damage may be specified.

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8. Information on the proposed CIPP system, including the tools and equipment required for a complete installation. The Contractor shall identify which equipment will be redundant on the job site in the event of equipment breakdown and outline the mitigation procedures to be followed if key equipment fails during the installation process.

1.7 DESIGN

Typically, the design calculations determine the minimum required wall thickness based on the mechanical properties of the proposed CIPP product and specific conditions of the existing pipeline. The mechanical properties and characteristics of CIPP can vary depending on the tube and resin materials used and the degree of cure achieved. The Contractor is responsible for controlling these variables and providing a CIPP system that meets or exceeds the mechanical properties used in the submitted design and performance required in the contract documents.

Design guidance is found in the *AWWA Committee Report - Structural Classifications of Pressure Pipe Linings - Suggested Protocol for Product Classification*, including design considerations and future design development using CIPP as an example in Appendix A (non-mandatory; for information and discussion purposes only). Design submittals must be supported by third-party testing and documentation specific to the CIPP system being proposed.

The design should account not only for internal pressure loads, but also for external hydrostatic pressures that may occur when the host pipe is depressurized. Additionally, the CIPP system should be evaluated for its ability to withstand transient pressure surges, cyclic loading, and vacuum conditions. Some CIPP systems are designed to carry external loads independently, while others rely on composite action with the host pipe to achieve hoop strength. The inherent resistance of the CIPP to external buckling typically increases with greater pipe wall stiffness. In a Class IV design, if the internal operating pressure exceeds the total external loads, additional Class IV external design may not be necessary. However, guidance is found in ASTM F1216 and/or ASCE MOP 145 when design is required for applications where the CIPP must resist total external loads during depressurized or low-pressure conditions. Short-term Class III external load design for groundwater and vacuum conditions is required. Structural performance requirements—both internal and external—must be defined in the design criteria to ensure appropriate system selection and validation. De-rating should be considered for any geometric anomaly or joint gap, including bends, where non-uniform stress or material stretching is anticipated within a CIPP installation.

A. The CIPP design as a Class III or Class IV lining shall be in accordance with the defined project requirements using the *AWWA Committee Report - Structural Classifications of Pressure Pipe Linings - Suggested Protocol for Product Classification* for guidance. Design calculations for each segment of CIPP shall be performed and certified by a registered Professional Engineer. Submitted calculations shall include data that meets the requirements of these specifications or as approved by the Owner.

B. For external loading design, the flexural modulus of elasticity shall be determined by applying the creep reduction factor, as determined by the ASTM D2990 test results on the CIPP system submitted for use on the project. The reduction factor shall be based on the estimated duration of the non-pressurized condition.

C. The cured CIPP shall, at a minimum, meet or exceed the mechanical properties used within the design calculations as submitted.

D. The CIPP shall be designed using the following design parameters:

Pressure pipe design condition	Class III or Class IV as defined by AWWA Committee Report
Maximum allowable operating pressure (MAOP), psi	As specified or indicated on the Plans
Surge pressure, psi	As specified or indicated on the Plans
Vacuum, psi	As specified or indicated on the Plans
Test pressure, psi	As specified or indicated on the Plans
Normal operating temperature, °F	As specified or indicated on the Plans
Design Safety Factor, internal pressure	2.0
Creep Retention Factor, tensile and flexural	Test data
Burial depth (ground surface to top of pipe)	As specified or indicated on the Plans
Groundwater Depth (phreatic surface to top of pipe)	As specified or indicated on the Plans
Live Load	Highway, railroad, airport, or permanent structures, as applicable
Constrained Soil Modulus	Per AASHTO LRFD Section 12 and AWWA Manual M45
Soil Load (assumed)	120 lb./cu. ft. or as specified

E. Prior to installation of the CIPP, the Contractor shall submit certification demonstrating compliance with the project specifications or with the requirements of the pre-approved CIPP system. The submittal shall include certified material test results verifying the materials conform to these specifications or to the pre-approved system. Materials that do not meet these requirements will be rejected.

1. Test results substantiating the mechanical properties used in design calculations for the proposed CIPP product.
2. Test results substantiating the pressure rating of the CIPP system.
3. Chemical resistance test results demonstrating compliance with the requirements of Appendix X2 of ASTM F1216.

1.8 SAFETY

The Owner should provide site specific workplace safety requirements that the Contractor must adhere to. The Contractor is responsible for performing work in compliance with the applicable provisions of their safety program, OSHA standards, confined space entry procedures, trench safety, personal protective equipment (PPE) requirements, handling of hazardous materials, and traffic control measures.

It is notable that requirements for confined space entry and trench safety are found in OSHA Construction Standard 29 CFR 1926, Subpart AA and Subpart P, respectively. For hazardous materials that may be encountered, requirements are found in the OSHA Hazard Communication Standard 29 CFR 1910.1200. Guidance for traffic control can be found in the Manual on Uniform Traffic Control Devices.

A. The Contractor shall comply with applicable work safety requirements set forth by relevant regulatory agencies, including the Occupational Safety and Health Administration (OSHA), and shall ensure that the work site is secured and maintained in accordance with these standards. The Contractor shall erect signs and other devices as necessary for the safety of the work site.

B. The Contractor shall perform Work in accordance with compliance with relevant OSHA standards. Emphasis shall be placed upon the requirements for trenching, entering confined spaces, traffic control, and with the equipment being used.

C. The Contractor shall submit a proposed Safety Plan to the Owner prior to beginning Work. The plan shall include a description of a daily safety program for the job site and emergency procedures to be implemented in the event of a safety incident. Work shall be conducted in accordance with the Contractor’s submitted Safety Plan and relevant OSHA and regulatory guidelines.

D. The plan shall include safety recommendations for mitigating styrene emissions on CIPP sites that have the potential to pose health risks to workers. Refer to NASSCO's Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe and the reports on CIPP Emissions Phase 2 and Phase 3, Trenchless Technology Center at Louisiana Tech.

E. Work shall be conducted in accordance with the Contractor's submitted Safety Plan, as approved by the Owner.

1.9 QUALITY CONTROL PLAN (QCP)

A Quality Control Plan (QCP) should be submitted by the Contractor documenting proposed quality control measures to be implemented. The QCP should address material protection and handling, equipment operation, and documentation requirements. The Contractor personnel, including names and cell phone numbers for those that are responsible for ensuring that quality requirements are met, should be identified and submitted.

A. A Quality Control Plan (QCP) shall be submitted to the Owner that meets the requirements of these specifications. At a minimum the QCP shall include the following:

   1. Proposed quality control measures to be performed by the Contractor.
   2. Proposed procedures for quality controls at each stage of construction including cleaning and preparation, installation and cure, product sampling, and testing.
   3. Proposed methods for product performance controls, including the process and frequency of product sampling and testing, shall be defined and submitted as applicable.
   4. Proposed schedule for the review of performance and product test results between the Contractor and Owner.

Success of CIPP rehabilitation leverages an industry standard of care, performance specification, and an inspector that understands CIPP rehabilitation quality control procedures required on the project and for the CIPP system being furnished. The inspector should be trained and knowledgeable in where the use of CIPP is applicable, technology procedures, material wet-out, installation, curing requirements, acceptability standards, and required testing.

It is recommended that personnel performing and documenting inspections or testing be NASSCO-Certified in the inspection of Cured-In-Place Pipe (CIPP) installation through NASSCO's Inspector Training and Certification Program (ITCP-CIPP), where applicable to the project scope.

B. Inspection forms and guidelines for quality control inspections shall be prepared in accordance with the standards specified in this contract and submitted with the QCP.

Occasionally, installations will result in the need to repair or replace defective CIPP. The specific repair, replacement, or removal procedures should follow the CIPP system manufacturer's recommendations to ensure a finished product that meets the contract requirements.

C. [Optional] A description of defects that may occur in the installed CIPP including a repair or removal and replacement procedure resulting in a finished product meeting the requirements of this contract.

1.10 DELIVERY, STORAGE AND HANDLING

A. Materials shall be shipped, stored, and handled in accordance with the written recommendations of the CIPP system manufacturer to prevent damage. Damage includes, but is not limited to, gouging, abrasion, flattening, cutting, puncturing, or UV-light degradation. Damaged materials shall be promptly removed from the project site at the Contractor's expense and disposed of in accordance with applicable regulations.

B. Materials shall be stored at locations approved by the Owner. The materials are to be kept dry, protected from weather, and stored under cover, following the manufacturer's recommendations.

C. Materials are to be handled in accordance with their safety data sheets (SDS) and manufacturer's recommendations.

1.11 WARRANTY

The Contractor should warrant the CIPP installation for a period as specified by the Owner. One year is the typical industry standard. Documented defects should be remedied in accordance with the repair and replacement procedures required in the contract documents and as recommended by the CIPP manufacturer.

The Owner should perform, at its own cost, warranty inspections with its own personnel or personnel independent of the installation contractor. Inspection should be performed and documented by a qualified inspector knowledgeable of the CIPP system used.

A. The materials used for the project shall be certified by the manufacturer as suitable for the specified purpose. The manufacturer shall warrant the CIPP to be free from defects in raw materials for [X period] after installation or from the date of acceptance by the Owner, whichever is later. The Contractor shall warrant the installation of the rehabilitation components for a period of [X].

B. The Owner shall, at their own cost, conduct warranty inspections of the CIPP.

PART 2 - PRODUCTS

2.1 GENERAL

CIPP products should be commercially available, have a proven history of successful installation in pressurized sanitary sewer pipelines, and be acceptable to the Owner.

A. The CIPP systems defined herein include those identified as commercially accepted methods for rehabilitation of force mains. Methods or products not defined herein must be pre-approved by the Owner before use on this project under these specifications.

B. Materials used to stop infiltration, repair, and rehabilitate shall be chemically compatible and designed to work together without causing adverse reactions or degradation to ensure the durability and effectiveness of the installed CIPP.

The CIPP product must meet the chemical resistance requirements specified. The tested product should be the same type of tube and resin used on the project. Chemical resistance testing is a qualification test typically conducted by the resin manufacturer to certify that the product meets the specified requirements. This certification, accompanied by the test report, should be included in the Contractor's product submittals.

C. The CIPP system must meet the chemical resistance requirements of these specifications. Test methods and qualification requirements shall be in accordance with ASTM F1216 Appendix X2, or other test methods approved by the Owner, as applicable to the proposed CIPP system.

2.2 MATERIALS

Specific physical and mechanical properties may be included within the specifications; alternatively, these should be provided in the PWS submitted by the Contractor, along with third party test results and/or other documentation supporting the compliance of the submitted CIPP system with the contract requirements.

A. Tube

The tube is the component that carries the resin into the pipeline and holds the resin in place before and during cure. There are two basic tube material types used for CIPP systems in pressurized sewer pipeline applications: a felt-based tube consisting of needle-punched polyester felt that includes reinforcement such as glass-fiber or carbon-fiber; and a glass-fiber based tube consisting of glass fiber and/or glass fabric. The selection of resin and curing method may be influenced by the tube material. The technical envelope of the CIPP system may also vary based on system composition, including the type of tube material, which can introduce differing capabilities or limitations. The thickness of the tube and installation procedures determine the finished thickness of the CIPP. A properly designed and specified tube is critical to achieving the specified wall thickness and ensuring a tight fit with the host pipe. It is recommended that the Contractor physically measure the diameter of the existing pipeline before ordering the tube.

1. The tube shall consist of one or more layers of woven synthetic material, fiber reinforcement, flexible needled felt, or a combination of these materials, and shall meet the applicable requirements of ASTM F1216, ASTM F1743, or otherwise approved by the Owner. The tube shall be capable of absorbing and carrying resins and shall be constructed to withstand installation loads (e.g., inversion pressure, abrasion, tensile-pull load), operational and test pressures, and curing temperatures. It shall also be compatible with the resin system and curing method to be used. The Contractor shall submit the resin saturation rates provided by the CIPP system manufacturer, indicating the volume of resin required to properly saturate each of the tube dimensions to be used on the project.
2. The tube shall be manufactured to have a uniform thickness that, once properly saturated with resin, installed and cured using the manufacturer's recommended methods and pressures, will meet the design requirements.

A tight fit to the host pipe is critical when rehabilitating a pressurized pipeline, making it necessary to physically measure the diameter of the existing pipeline before ordering the tube.

3. The tube shall be manufactured to a size and length that, when installed, will tightly fit the internal circumference of the host pipe. The Contractor shall determine the minimum tube length necessary to span the designated run between access points effectively.

4. The outside and/or inside layer of the tube shall be constructed with an impermeable, flexible membrane that will contain the resin and facilitate, when applicable, vacuum impregnation and monitoring of the resin during the wet-out process. The membrane or coating shall be compatible with the resin and cure method to be used in constructing the CIPP.
5. The wall color of the interior surface of the CIPP after installation shall be a light reflective color so that a clear examination with CCTV inspection equipment may be made.
6. The tube shall be marked with the product name or manufacturer, lot number, and production footage, as required by the Owner and/or to meet local regulations or requirements of the contract documents. The markings shall be visible when inspecting the inside of the installed CIPP.

B. Resin

Resin systems used in CIPP applications for pressurized pipelines must exhibit higher elongation properties than the polyester resins typically used in non-pressure (i.e., gravity) sewer systems. For applications involving force mains with operating and transient pressures exceeding 10 psig, resin systems such as vinyl ester or epoxy - demonstrated through testing to perform reliably within the selected CIPP system (i.e., tube, resin, installation, and curing methods) - may be required.

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1. The resin shall be a thermoset vinyl ester or epoxy resin system that, when properly cured within the tube composite, meets the requirements of ASTM F1216 or ASTM F1743, and the chemical resistance, physical and mechanical properties specified herein, and those used in the design of the CIPP for this project.
2. The method of cure may either be from a manufacturer recommended heat source or by photoinitiated reaction (i.e., light). Method of cure instructions along with a cure log shall be on the project site.
3. The resin to tube ratio, by volume, for impregnation of the selected tube shall be provided by the CIPP system manufacturer.

PART 3 - EXECUTION

Rehabilitation of a force main is typically performed from an excavated access pit located at valves, bends, or at the origin point of the force main (e.g., pump station). Excavated access pits must comply with the Owner's specifications for trenching, excavation, backfilling, and surface remediation. This includes grading, paving, concrete work, and landscape restoration.

Confined space entry, traffic control, and other specific project activities require adherence to safety measures that must be followed.

3.1 GENERAL

The Contractor is typically responsible for cleaning, CCTV inspection, measuring, and lining of the force mains. This includes isolation of the pipeline segment, bypass pumping, notifying the impacted public, and managing the rehabilitation process from start to finish. The Owner should assist with pipeline isolation, traffic control, water access, permitting, and communication with property owners.

The number and location of access pits are determined based on the alignment of the existing pipe, the location of appurtenances, and the required installation lengths of the CIPP. Excavation and trenching must be performed in accordance with the contract documents and applicable federal, state, provincial, and local regulations.

Excavations should be adequately sized and safely configured to meet the requirements of the selected CIPP installation method. Where access pit locations necessitate street closures or deviation from normal traffic patterns, the Contractor should submit a traffic control plan for approval. The plan should be comprehensive and shall comply with the requirements of the local agency having jurisdiction over traffic control.

A. Contractors qualified in accordance with these specifications shall perform the CIPP installation.

B. CCTV inspections shall be carried out by the Contractor using PACP-certified professionals, or equivalent as approved by the Owner.

C. CIPP installation shall be carried out by the Contractor in accordance with these specifications, using equipment and methods as recommended and approved by the CIPP manufacturer.

D. Contractor shall measure the internal diameter of the existing pipelines and the length of each designated run to confirm the required tube dimensions and length prior to ordering, assembly, and wet-out of the tube.

E. The Contractor shall verify the operational status of adjacent pipes and confirm that the section of the force main has been isolated, depressurized, and secured before

commencing work. The Contractor shall excavate access pits following applicable safety regulations. The existing force main shall be accessed by exposing the pipe and removing designated sections, including associated valves, fittings, and appurtenances, as required to facilitate the work.

F. The Contractor shall provide the Owner with the requirements for flow diversion or stoppage to be maintained for each pipeline segment throughout the rehabilitation process. Installation shall not begin until the required diversion or bypass, along with necessary pumping facilities, has been completed and tested under full operating conditions. Pumps and bypass lines shall be of adequate capacity and size to convey stipulated flow conditions.

3.2 PREPARATION

It is the responsibility of the Contractor to clear the connection and pipeline of obstructions that could interfere with the installation and long-term performance of the CIPP. If pre-installation inspection reveals an obstruction, misalignment, or other defect that was not identified as part of the original scope of work and will prevent proper installation of the liner, the Contractor may be directed by the Owner to correct the issue(s) prior to lining, using open cut or other repair methods. This work may be considered a changed condition, or, if there is an existing bid item for this work, the Contractor would be compensated under the designated pay item for open cut point repairs.

Before ordering tube materials, the Contractor should clean the host pipe to remove internal debris that could interfere with liner installation or performance of the CIPP, as specified in the contract documents. The Contractor should then measure and document the internal diameter and length of each pipeline segment to be rehabilitated. The inside of the prepared pipe must be free of sharp edges, deposits, debris, and protrusions that could cause point loading on the installed CIPP, or unforeseen obstructions such as reducers, line valves, and protruding connections that will prevent proper installation of the liner. Previously applied coatings and linings must be removed unless they are tightly bonded and the CIPP manufacturer and the Owner determine that the residual material will not compromise the performance or integrity of the CIPP.

The Contractor is also responsible for identifying or confirming the locations of appurtenances or branch connections within the pipeline to be rehabilitated prior to installation of the liner.

A. The Contractor shall be permitted to use water from an Owner-approved fire hydrant in the project vicinity. Use of an approved double-check backflow assembly is required, unless an open gap exists in the Contractor's equipment. The Contractor shall provide the approved assembly and pay the current market price for water usage, unless otherwise specified by the Owner.

B. The interior surfaces of the pipeline shall be prepared for lining by cleaning to remove debris, deposits, sediment, corrosion products, existing coatings or linings, and other obstructions, protrusions, or foreign matter that could interfere with the proper installation or performance of the CIPP. Care shall be taken to avoid damage to the existing pipe during cleaning. Cleaning methods shall comply with the CIPP manufacturer's guidelines and be approved by the Owner. The pipe shall be cleaned as many times as necessary to meet the surface preparation requirements. The Contractor shall dispose of debris removed from the Owner's system, at no cost, at the disposal site designated by the Owner. Guidance on cleaning is available in NASSCO's Sewer Pipe Cleaning Guideline.

C. Pre-Installation Inspection – Upon completion of the cleaning, the Contractor shall conduct an inspection of the pipeline to be rehabilitated using CCTV equipment, just prior to insertion of the resin impregnated tube (i.e., liner).

D. The Contractor shall perform post-cleaning video inspections of the pipelines using PACP-certified technicians. The Contractor shall provide the Owner with a copy of the pre-cleaning and pre-installation video recordings and suitable log for review prior to installation of the liner, as required by the Owner.

3.3 INSTALLATION

Although various methods are described in the ASTM installation standards, the manufacturer's installation requirements should be followed. While AWWA/ANSI C623 is specifically intended for the rehabilitation of pressurized potable water pipelines, it includes information that may also be valuable when specifying the rehabilitation of non-potable applications.

The manufacturer's recommended installation guidelines should be followed. This includes the recommended minimum and maximum pressure for installing the liner using the inversion method, the specified pulling force when installing the liner using the pull-in-place method, and the recommended pressure and maximum allowable pressure required to expand the liner and hold it securely against the pipe throughout the curing process for both the pull-in place and inversion methods. Care shall be taken during the curing process to avoid overstressing the liner.

Manufacturers of CIPP systems offer components optimized to function together, including specialized installation equipment and resins designed to cure using UV light. Compliance with the manufacturer's installation instructions should be required for the specific CIPP product approved or specified for installation.

A. Resin impregnation, or wet-out, shall be completed according to the manufacturer's recommendations to achieve full and consistent resin distribution. The manufacturer shall specify the process to be used, the volume of resin required, the quality control provisions to be used, and other applicable parameters.

B. Before installation begins, the Contractor shall submit the manufacturer's installation guidelines, including the recommended pulling force when using a winch for installation, the minimum pressure required to install and hold the liner tight against the host pipe wall, and the maximum allowable pressure to avoid damage to either the liner or the host pipe. Once installation has started, pressure shall be maintained between the minimum and maximum values and documented throughout the installation, including curing and cool down.

C. The liner shall be cured in accordance with the manufacturer's recommendations and procedures required for the materials used, which shall comply with the applicable installation procedures in ASTM F1216 or ASTM F1743.

CIPP can be cured using hot water circulation, controlled steam, or photoinitiated reaction (i.e., UV light). The CIPP wall thickness and the existing ground conditions, including temperature, moisture level, and thermal conductivity of soil, should be considered by the Contractor to adjust cure time and temperature as needed.

When using hot water or steam cure methods, monitoring cure temperatures is used to verify the cure of the resin. As a minimum, standard thermocouples should be used, which measure temperature at the point they are positioned, typically at the pipe invert in the termination manhole. Temperatures can be monitored continuously in time and location throughout the pipeline being rehabilitated by using a fiber optic cable sensing system installed in the pipe invert before liner installation. For continuous temperature monitoring, the system should have an output report that specifically identifies stations along the length of the pipe, indicates the maximum temperature achieved, and the sustained temperature time at each station. At each station along the length of the pipe, the computer should record both the maximum temperature and the minimum cool down temperature and comply with the manufacturer's recommendations. This is especially useful for critical sewers and those with medium to large diameters. Thermocouples are often used in conjunction with continuous monitoring systems to verify the proper cure of the CIPP.

When curing using UV light, the protocol defined by the manufacturer and recorded during the cure process should be maintained as documentation to verify cure. Data collected may include time, rate of travel of the light assembly for dynamic curing processes, pressures, temperature in the liner and the power output of the light assembly along the entire length of the liner segment being cured.

D. The Contractor shall monitor and document installation and curing activities, in written or electronic format, in accordance with the CIPP system manufacturer's recommendations. The log shall include, at a minimum: the date, time, and location of wet out; the time of liner insertion into the host pipe; the pressures applied during insertion, curing, and cool down phases; curing information including method, temperature, duration, and cool down rate; and additional parameters required by the specified installation or curing method or as recommended by the CIPP system manufacturer.

E. The liner shall be positioned in the pipeline using the method specified by the manufacturer. Care should be taken to avoid damaging the liner during installation. The liner should be pulled in or inverted through an existing or approved access point and fully extend to the termination point in accordance with ASTM F1216 or ASTM F1743, and the manufacturer's recommendations.

F. The liner shall be cured using the appropriate medium following the manufacturer's recommended cure procedures and schedule, as well as the applicable standard referenced in the PWS by the Contractor. The Contractor shall consider the wall thickness of the liner and site-specific conditions, such as temperature, moisture level, and thermal conductivity of the surrounding soil, and make necessary modifications to ensure proper cure.

Proper cool down is a critical step in the curing process to minimize shrinkage and prevent cracking of the CIPP. The temperature profile and duration of the cool down period should follow the CIPP system manufacturer's recommendations, and the cure schedule submitted by the Contractor in the PWS. Reduction or omission of the cool down process should not be permitted.

G. Temperatures and curing data shall be monitored and recorded by the Contractor throughout the installation process to ensure that each phase of the process is achieved as approved in accordance with the CIPP system manufacturer's recommendations.

H. The Contractor shall cool down the CIPP in accordance with the CIPP system manufacturer's guidelines as outlined in the PWS and approved by the Owner. Reduction or omission of the cool down process shall not be permitted.

CIPP terminations should be sealed to meet the hydrostatic and leakage requirements of the pipeline system. Mechanical end seals or other materials proposed for use should comply with the CIPP system manufacturer's specifications and installation instructions.

I. Terminating ends of the CIPP shall be sealed to meet the hydrostatic and leakage requirements of the force main being rehabilitated. The sealing process shall utilize materials and methods compatible with the selected CIPP system, as outlined in the PWS, and must be approved by the Owner.

3.4 FINISH

Defects that could affect the structural integrity, operational performance, or longevity of the CIPP should be repaired. Leaks coming through the wall of the CIPP itself are considered a defect. Observed leakage at the CIPP terminations should be identified and effectively sealed.

A. The finished CIPP shall be continuous over the entire length of the pipeline section and be free from visual defects such as foreign inclusions, lifts, dry spots, pinholes, delamination, bumps, fiber reinforcement material defects, sags, tears, prominent wrinkles, bubbles, blisters, and out-of-roundness.

B. No leakage shall be observed through the CIPP itself or at the terminating ends of the CIPP.

C. Defects that will or could affect the structural integrity or strength of the CIPP shall be repaired at the Contractor's expense in accordance with the manufacturer's recommendations and approved by the Owner.

3.5 TESTING

The mechanical properties of the CIPP may be verified through field sampling and testing. The samples should be cut from a section of cured CIPP that has been installed through a like-diameter section of pipe or other tubular restraint at an access pit where the liner is being installed, or plate samples as described in ASTM F1216. Plate samples should be cured under conditions that simulate the installation parameters being used, such as installation/inflation pressure, temperature of heat when applied and cure time, or power output of the light assembly, and the temperature of the environment of the pipeline being lined (i.e., temperature at the bottom of the access pit). Completed samples should be marked to sufficiently document how and when the sample was made and marked to identify the axial and hoop directions of the reinforcement or other reinforcement features where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the mechanical properties. It is recommended that the samples be sent, following a chain of custody, to the Owner or specified laboratory for testing.

For CIPP 18 inches in diameter or less, the thickness may be verified using restrained samples. In CIPP installed in pipelines larger than 18 inches in diameter, flat plate samples may be used for thickness testing. However, it should be noted that flat plates can be fabricated to any thickness and may not reliably represent in situ conditions. Thickness measurements may also be taken from the CIPP inside the pipe after the ends of the CIPP are cut, but this method may produce low readings due to resin loss or wall thinning near the termination.

A. The flexural and tensile properties of the installed CIPP shall be verified through field sampling and laboratory testing performed at the Owner's expense by an independent third-party. Samples shall be collected in accordance with the methods in ASTM F1216, or specific sampling requirements identified or approved by the Owner. For anisotropic materials, tensile and flexural properties shall be obtained in the hoop and axial directions to confirm overall behavior of the CIPP. When suitable samples for testing in both hoop and axial directions cannot be obtained, mechanical properties shall be obtained in the hoop direction at a minimum.
    1. Flexural modulus and flexural strength tests shall be performed in accordance with ASTM D790.
    2. Tensile strength tests shall be performed in accordance with ASTM D638 using Type 1 specimens when the CIPP includes a fiber reinforcement, ASTM D3039, or ASTM D2290 using Procedure A when the CIPP includes a fiber reinforcement.
B. Samples shall be prepared following collection methods described in Section 8 of ASTM F1216, and must be fabricated from material taken from the resin-impregnated tube and cured in a manner that simulates the installation conditions relevant to the lining technology being used (e.g., pressure, temperature, cure time, radiation intensity) and the environmental conditions of the pipeline being lined (e.g., temperature at the bottom of an access pit). Light cured samples shall be handled and packaged in a manner that protects them from exposure to light beyond that used during the curing process. Samples must remain shielded from ambient or incidental light during transport and delivery to the laboratory to ensure controlled testing conditions.
C. Samples shall be marked with standard identification, including markings to indicate the direction of reinforcement when applicable to the tube construction. Properly marked completed samples shall be submitted to the Owner or the specified testing laboratory, in accordance with the Owner's requirements, to maintain the chain of custody.

A quality-based approach may be employed to assess conformance with the required minimum installed thickness. This approach assumes that if the quality control parameters are met, such as the dry tube is the correct thickness, the correct type and amount of resin is added during wet-out, and the correct pressures, temperatures and procedures are used during installation and cure, then the installed CIPP is likely to meet the design minimum thickness. If the plate samples fail to meet the required mechanical property values, or if quality control checks are deficient, then the Owner may require the Contractor to obtain a core sample from the installed CIPP at the 12:00 o'clock position to verify wall thickness. CIPP core holes should be repaired in accordance with the manufacturer's recommended procedures.

D. The installed CIPP wall thickness shall be measured for each line section in a manner consistent with Section 8.1.2 of ASTM D5813. The average thickness shall meet or exceed the minimum specified design thickness. The minimum thickness at any point shall not be less than 87.5 percent of the specified design thickness.

E. Costs to the Contractor associated with providing cured CIPP samples for testing shall be included in the Lump Sum unit price bid for Mobilization. Final payment for the project shall be withheld pending receipt and approval of the test results.

F. If required by the Owner in the contract documents, a hydrostatic pressure and leakage test shall be performed in accordance with Section 8.3 of ASTM F1216. Testing shall be conducted on a rehabilitated pipeline section after placement of end seals, but before reinstatement of connections or reconnection to appurtenances. The CIPP shall be cooled down to the ambient ground temperature that existed before the CIPP installation. The test shall be conducted at the lesser of two times the specified operating pressure, exclusive of short-term overpressure, or at the specified operating pressure plus 50 psi.

G. If test results do not meet the design requirements or the contract documents stipulated values, then a design reconciliation shall be carried out by a party acceptable to the Owner to assess whether the design objectives for the installation have been met. Where the post-construction design reconciliation cannot resolve the deficiencies, the Contractor shall remediate the CIPP in a manner acceptable to the Owner or as specifically identified for remedy in the contract documents.

3.6 FINAL ACCEPTANCE

Some CIPP systems inherently have folds or result in wrinkling at bends and/or at irregularities in the existing pipeline. Folding has potential impacts on both hydraulic and structural performance of CIPP designed for pressure applications. Under no conditions shall the folds reduce the structural capacity of the CIPP to less than the design objectives. For hydraulic performance, the CIPP should not introduce surface irregularities, in addition to those of the existing pipeline, which exceed the greater of 2 percent of the nominal diameter or 0.25 in. (6 mm) as referenced in ISO 11297-4. This requirement can be changed when noted in the contract documents and/or where the CIPP rehabilitated pipe will meet hydraulic performance requirements.

CIPP may occasionally require repair or replacement. When necessary, the CIPP manufacturer should be consulted to determine the appropriate repair or replacement procedures to ensure compliance with the project specifications. Sample testing and repairs should be completed with test results received and reconciled before final acceptance of the rehabilitation.

A. CIPP sample testing and repairs to the CIPP shall be completed prior to final acceptance, complying with these specifications and documented in writing.

B. After the CIPP installation is completed, the Contractor, using PACP-certified technicians, shall perform and record a CCTV inspection in the presence of the Owner to document the full diameter and axial length of each CIPP segment installed, with sufficient resolution and lighting to assess the fit and finish of the installation.

C. The CIPP shall be continuous over the entire length of the pipeline section, exhibit a close fit with the host pipe, be properly connected at appurtenances or connections, and be free of visual defects, damage, lifts, holes, leaks, disbonding, delamination, or other defects that are not a reflection of the existing pipe condition.

D. Wrinkles in the CIPP may occur, particularly at bends or changes in the geometry of the existing pipeline. Under no conditions shall wrinkles reduce the structural capacity of the CIPP to less than the design objectives.

E. Issues that occur in the CIPP shall be repaired or replaced based on manufacturer's recommendations to meet the requirements of the contract documents.

PART 4 - MEASUREMENT AND PAYMENT

4.1 BID ITEMS

The bid item(s) for the rehabilitation process may include items such as pipeline isolation and bypass, mobilization, traffic control, access pits, pre-inspection of pipeline to confirm/identify existing conditions, cleaning, and installation of the product. These items may be listed individually or combined with other work to be performed. Units of measurement should be relevant to the item(s) included and may be listed as Lump Sum. The following examples (4.1.A. - H.) of bid items are for informational purposes only and may or may not be applicable to a specific project.

A. Lump Sum - Mobilization – Includes PWS information, submittals, safety plan, as-built drawings, testing samples, mobilization/demobilization of labor, equipment and materials to the project site.

B. Lump Sum - Bypass Pumping - Includes labor, equipment and materials required to implement a flow bypass plan for the project, including the cost of sub-contracted flow bypass specialists.

C. Unit Price (Per Each) - Pit Excavation

D. Unit Price (Per Foot / Meter) - Pre-Installation CCTV Inspection – Includes pre-cleaning and post-cleaning CCTV for Owner review. Does not include CCTV inspection just prior to CIPP installation.

E. Unit Price (Per Foot / Meter) for [XX]-in./mm diameter - Standard Pipe Cleaning – Includes labor, equipment, materials and cost of material disposal.

F. Unit Price (Per Foot / Meter) for [XX]-in./mm diameter - Heavy Pipe Cleaning – Includes labor, equipment, materials and cost of material disposal.

G. Unit Price (Per Foot / Meter) for [XX]-in./mm diameter CIPP Installation - Includes labor, equipment and materials required for the complete installation, and post-lining CCTV for submission to the Owner.

H. Lump Sum - Reserve for Testing – For Owners' use to include testing required as directed by the Owner, under this contract, by an independent laboratory. (The amount will be set by the Owner in the Bid Proposal)

4.2 MEASUREMENT AND PAYMENT

A. Measurements for each item furnished and installed to the satisfaction of the Owner shall be based on the units of measure specified in the Bid Proposal.

B. Payment for each item and CIPP installed, as specified in the contract documents and approved by the Owner, shall be made at the unit or lump sum prices specified in the Bid Proposal.

END OF SECTION