CURED-IN-PLACE PIPE (CIPP) INSTALLATION

PERFORMANCE SPECIFICATION GUIDELINE (PSG)

June 2023

2023 Edition
NASSCO Pipe Rehab Committee

(Supersedes all previous editions of this document)

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Disclaimer

These Specifications were prepared by a Committee comprised of representatives of NASSCO members and peer-reviewed by industry professionals. These Specifications are 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 so as 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

EFECTIVE SPECIFICATIONS

Effective specifications should encourage the most innovative, efficient and experienced Contractor to provide the level of quality required by the Owner at the best and lowest competitive price.

The specification should not strive to encourage the Contractor to seek the cheapest approach and product delivery available to provide the lowest price.

Effective specifications include the following, which are critical for project success:

1. Product selection for the best solution.
2. Definition of project goals and requirements, both short and long term.
3. Construction means and methods as defined, in writing, by the Contractor.
4. Product provided and installed as specified by the product manufacturer.
5. Product quality and quantity confirmed through inspection and testing.
6. Product design and service life verified through warranty inspection.

Index

PART 1 GENERAL

This performance specification guideline (PSG) is for the rehabilitation of gravity sewers, either sanitary, combined or storm, by the installation of cured-in-place-pipe (CIPP).

A. This performance specification guideline (PSG) includes the minimum requirements for the rehabilitation of sanitary and storm sewer pipelines by the installation of cured-in-place pipe (CIPP) within the existing, deteriorated pipe as shown on the plans included as part of these contract documents.

B. The rehabilitation of pipelines shall be done by the installation of a resin-impregnated flexible tube which, when cured, shall be continuous and tight-fitting throughout the entire length of the original pipe. The CIPP shall extend the full length of the original pipe and provide a structurally sound, jointless and water-tight new pipe-within-a-pipe. The Contractor is responsible for proper, accurate and complete installation of the CIPP using the system selected by the Contractor meeting the Owner requirements.

C. Neither the CIPP product, system, nor its installation, shall cause adverse effects to any of the Owner's processes or facilities. The installation pressure for the product shall not damage the system in any way, and the use of the product shall not result in the formation or production of detrimental compounds or by-products at the wastewater treatment plant. The Contractor shall notify the Owner and identify by-products produced as a result of the installation operations, test and monitor the levels, and comply with local waste discharge requirements. The Contractor shall clean up, restore existing surface conditions and structures, and repair the CIPP system determined to be defective. The Contractor shall conduct installation operations and schedule cleanup in a manner to cause the least possible obstruction and inconvenience to traffic, pedestrians, businesses and property owners or tenants and to provide an environmentally safe restored jobsite.

D. The prices submitted by the Contractor shall include all costs of permits, labor, equipment and materials for the various bid items necessary for furnishing and installing, complete in place, CIPP in accordance with these specifications. Items of work not specifically mentioned herein which are required, by the Contractor, to make the product perform as intended and deliver the final product as specified herein shall be included in the respective lump sum and unit prices bid.

1.1 DESCRIPTION OF WORK AND PRODUCT DELIVERY

The specifications must include a detailed description of the work required including products that are to be included in the installation, and what is to be delivered by the Contractor.

A. This PSG covers work necessary to furnish and install the CIPP. The Contractor shall provide materials, labor, equipment, and services necessary for traffic control (if required), bypass pumping and/or diversion of flows, cleaning, measurement and television inspection of sewers to be rehabilitated, CIPP installation, reconnection of service connections, quality controls, provide samples for performance of required material tests, final television inspection, testing of the rehabilitated pipe system, warranty work and other work, as specified herein.

B. The product furnished shall be a complete CIPP system including specific materials, applicable equipment and installation procedures. If prequalification is required, the CIPP system manufacturer may submit appropriate data/information to the Owner. Other CIPP systems or multi-component products will be required to meet the submittal requirements as contained herein.

C. The CIPP shall be continuous and jointless from manhole to manhole or access point to access point and shall be free of defects that will affect the long-term life and operation of the pipe.

D. The CIPP shall not leak at the manholes or through the wall of the installed pipe.

If the host pipe is in groundwater, the use of end seals, if specified, shall be included to prevent infiltration tracking between the host pipe and CIPP and leaking into the CIPP at manholes.

E. The CIPP shall be designed for a life of 50 years or greater and an equal service life unless specifically specified otherwise by the Owner.

F. The CIPP may be designed for partially deteriorated conditions to resist external groundwater pressures only or for fully deteriorated conditions for a structural stand-alone pipe.

G. The installed CIPP shall comply with the chemical resistance requirements of the relevant ASTM standard(s) F1216, ~~or~~ ASTM D5813 (Section 6.4.1), ASTM F1743 or ASTM F2019.

H. All existing and confirmed active service connections and any other service laterals to be reinstated, as directed by the Owner, shall be re-opened robotically or by hand in the case of person-entry size piping, to their original shape and to 90% - 95% of their original area. All over-cut or under-cut service connections shall be properly repaired to meet the requirements of these specifications.

I. All materials furnished as part of this contract shall be marked with detailed product information, stored in a manner specified by the manufacturer and tested to the requirements of this contract.

J. Testing and warranty inspections shall be executed by the Owner. Defects found shall

be repaired or replaced by the Contractor.

K. The Contractor shall furnish, from the project installation, samples, marked with chain of custody information such as project name, section, date, diameter and thickness, etc., for product testing at the request of the Owner. 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.

1.2 REFERENCES

> All applicable reference documents should be listed in this section. If a document does not apply, is not pertinent or has unknown content, it should not be included. Specific reference document requirements should be defined in the contract documents or by reference to a specific section of the document. Specific Contractor requirements and/or test procedures contained in the references should be defined in detail in the contract documents.

A. The following documents form a part of this specification to the extent stated herein and shall be the latest editions thereof. Where differences exist between codes and standards, the requirements of these specifications shall apply. References to codes and standards shall be to the latest revised version.

- ASCE MOP 145 – Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes
- ASTM - F1216 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
- ASTM - F1743 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)
- ASTM - D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- ASTM - F2019 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method
- ASTM - D2990 Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

- ASTM - D5813 Standard Specification for Cured-in Place Thermosetting Resin Sewer Pipe
- Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-in-Place Pipe, NASSCO. 2023**.**
- Trenchless Technology Center at Louisiana Tech, 2019. NASSCO CIPP Emissions Phase 2: Evaluation of Air Emissions from Polyester Resin CIPP with Steam Cure
- Trenchless Technology Center at Louisiana Tech, 2023. NASSCO CIPP Emissions Phase 3 "Evaluation of Styrene Emissions Associated with Various CIPP Coatings in Refrigerated Storage" Final Report

1.3 PERFORMANCE WORK STATEMENT (PWS) SUBMITTAL

> In place of the engineer defining the specific method for product installation, the contractor defines the installation means and methods through a written plan called the Performance Work Statement (PWS). During construction the PWS provides valuable information to the inspector so that the inspector can determine if the submitted means and methods are being followed by the contractor. The PWS also outlines the necessary quality checks to be performed and the installation crew qualifications.

A. The Contractor shall submit, to the Owner, a Performance Work Statement (PWS) which clearly defines the CIPP product delivery in conformance with the requirements of these contract documents. Unless otherwise directed by the Owner, the PWS shall, at a minimum, contain the following:

B. Clearly indicate that the CIPP will conform to the project requirements as outlined in the Description of Work and as delineated in these specifications.

C. A detailed product installation plan describing preparation work, cleaning operations, pre-CCTV inspections, bypass pumping, traffic control, installation procedure, method of curing, service reconnection, quality control, testing to be performed, final CCTV inspection, warrantees furnished necessary and appropriate for a complete CIPP installation. An installation schedule shall be prepared, submitted and conform to the requirements of this contract.

D. Contractor's description of the proposed CIPP technology, including a plan for identifying active service connections maintaining service, during mainline CIPP installation, to each home connected to the section of pipe being rehabilitated, including temporary service for commercial, industrial and apartment complexes, if required by the contract.

E. A description of the CIPP materials to be furnished for the project. Materials shall be identified in the submittals and conform to these specifications and/or shall conform to the pre-approved product submission.

F. A statement of the Contractors experience. The Contractor shall have a minimum of three (3) years of cumulative experience installing CIPP in pipe of a similar size, length and configuration as contained in this contract. The lead personnel, including the superintendent, the foreman and the lead crew personnel for the CCTV inspection, resin wet-out, the CIPP installation, curing and the robotic service reconnections each

must have a minimum of one (1) year of experience with the CIPP technology proposed for this contract and must have demonstrated competency and experience to perform the scope of work contained in this contract. The name and experience of each lead individual performing work on this contract shall be submitted with the PWS. Personnel replaced by the Contractor, on this contract, shall have similar, verifiable experience as the personnel originally submitted for the project

> If the design calculations include mechanical properties greater than the minimum properties listed in these specifications, the mechanical properties included in the design calculations become the minimum acceptable values when testing field samples.

G. Engineering design calculations, in accordance with the Appendixes of ASTM F1216, or ASTM F2019, ASCE MOP 145, or other design protocol as specified by the owner, for each length of CIPP to be installed including the thickness of each proposed CIPP. It will be acceptable for the Contractor to submit a design for the most severe line condition and apply that design to all the line sections. These calculations shall be performed and certified by a qualified Professional Engineer. All calculations shall include data that conforms to the requirements of these specifications or has been pre-approved by the Owner.

H. Proposed manufacturers' technology data shall be submitted for all CIPP products and all associated technologies to be furnished.

> Reinstating service laterals is a critical operation for completing small diameter CIPP installations. This specialty type equipment is not readily available for rent from local equipment rental companies. Because of this, often redundant robotic cutters are specified for small diameter projects with service laterals.

I. Submittals shall include information on CIPP intended for installation and tools and equipment required for a complete installation. The PWS shall identify which tools and equipment will be redundant on the job site in the event of equipment breakdown. Equipment to be furnished for the project, including proposed back-up equipment, shall be clearly described. The Contractor shall outline the mitigation procedure to be implemented in the event of key equipment failure during the installation process.

> Non-specialty backup equipment should be identified and reserved by the Contractor (on will call) from local rental companies in the event of equipment failure.

J. A description of the Contractor's proposed procedures for removal of existing blockages in the pipeline that may be encountered during the cleaning process.

Proper public notification can prevent many public relations issues during a project. If the residents know that there will be workers and equipment near their homes, that they should not use large volumes of water or that they may smell strange odors, many homeowner concerns and problems can be prevented.

K. A public notification plan shall be prepared and submitted including detailed staged notification to residences affected by the CIPP installation.

CIPP installations commonly include the use of resins which contain a styrene component. These resins can emit a distinctive odor from the styrene component. To minimize this nuisance odor the contractor should devise an odor control plan that will mitigate the nuisance effect to the general public and residents at the project site during the CIPP installation.

L. An odor control plan shall be submitted by the Contractor that will ensure that project specific odors will be minimized at the project site and surrounding area. Part of the plan will include methods for removing odors from residents' homes, if required.

M. Compensation for work required for the submittal of the PWS shall be included in the various pipelining items contained in the Proposal.

1.4 PRODUCT SUBMITTALS

Product submittals require the contractor to submit the materials to be incorporated in the installation. This also allows the contractor to submit alternative materials that may be equal or better than those specified. The engineer must be prepared to evaluate alternative materials through evaluation, certifications and third-party testing to validate alternative materials meet the specified requirements of the contract.

This section includes a list of significant CIPP products and procedures that should be included in the submittal package. These include the two principal products, the tube and the resin, in addition to handling and storing these items from the manufacturing plant to the wet-out facility. Also included are detailed procedures for wet-out, installation and curing.

A. Tube – including the manufacturer and description of product components (i.e., felt, fiberglass and other reinforcing materials) and applicable tube mechanical properties.

B. Flexible membrane – including materials (i.e., coating, foil) specific to the proposed curing method and recommended repair (patching) procedure if applicable.

C. Resin - including the manufacturer and description of product components including

the spectroscopic wavelength diagram for the resin being furnished as well as mechanical properties, corrosion data and creep data.

D. Manufacturers' shipping, storage and handling recommendations for all components of the CIPP system.

E. Safety Data Sheets (SDS) for all materials to be furnished for the project.

F. Tube wet-out and cure method including:

1. A description of the wet-out procedure for the proposed technology. In the case of tubes wet-out by a third party, the wet-out information from the third-party source.

2. The Manufacturer's recommended cure method for each diameter and thickness of CIPP to be installed. The PWS shall contain a detailed curing procedure outlining the curing medium, the method of application and how the curing process will be monitored (e.g., temperatures, pressure, output of light, rate of travel of light train assembly).

G. Compensation for all work required for the submittal of product data shall be included in the Lump Sum price contained in the Proposal for Mobilization.

Worker safety should be the number one priority on a job site. No work should start until the Contractor submits a safety plan, and all work should be conducted in accordance with the safety plan. The plan should be sufficiently detailed to describe daily safety meeting requirements, procedures and documentation. Emergency procedures and location of medical facilities should be identified

1.5 SAFETY

A. The Contractor shall conform to work safety requirements of pertinent regulatory agencies and shall secure the site for the working conditions in compliance with the same. The Contractor shall erect signs and other devices as are necessary for the safety of the work site.

B. The Contractor shall perform the Work in accordance with applicable OSHA standards. Emphasis shall be placed upon the requirements for entering confined spaces and with the equipment being utilized for pipe renewal.

C. The Contractor shall submit a proposed Safety Plan to the Owner prior to beginning any work, identifying all competent persons. The plan shall include a description of a daily safety program for the job site and all emergency procedures to be implemented in the event of a safety incident. The Safety Plan shall include safety recommendations for mitigating styrene emissions on heat-cure CIPP job sites that have a potential to

pose health risks to workers. Refer to TTC's Emissions Phase 2 and Phase 3 Reports and NASSCO's Styrene Guideline (See 1.2 REFERENCES). Work shall be conducted in accordance with the Contractor's submitted Safety Plan.

D. Compensation for work required for the submittal of the Safety Plan shall be included in the pipelining items contained in the Proposal.

1.6 QUALITY CONTROL PLAN (QCP)

A Quality Control Plan (QCP) should be submitted by the Contractor. The QCP should include a discussion of the proposed quality controls to be performed by the Contractor, including material protection and handling, equipment operation and documentation requirements. The Contractor personnel, including names and cell phone numbers for those that are responsible for assuring that all quality requirements are met, should be identified and submitted.

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

1. A discussion of the proposed quality controls to be performed by the Contractor.

2. Defined responsibilities, of the Contractor's personnel, for assuring that quality requirements for this contract are met. These shall be assigned by the Contractor to specific personnel.

3. Proposed procedures for quality control, product sampling and testing shall be defined and submitted as part of the plan.

4. Proposed methods for product performance controls, including method of and frequency of product sampling and testing both in raw material form and cured product form.

5. Scheduled performance and product test result reviews between the Contractor and the Owner at a regularly scheduled job meeting.

6. 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.

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

1.7 CIPP REPAIR/REPLACEMENT

As part of the PWS, the Contractor should submit repair and replacement procedures for common CIPP defects. Defects should be categorized as those that need no repair, those that can be repaired and those that must be removed and replaced. Defects that affect the operation and/or longevity of the CIPP should be repaired or replaced.

A. Occasionally installations will result in the need to repair or replace a defective CIPP. The Contractor shall outline specific repair or replacement procedures for potential defects that may occur in the installed CIPP. Repair/replacement procedures shall be as recommended by the CIPP system manufacturer and shall be submitted as part of the PWS.

B. Defects in the installed CIPP that will not affect the operation and long-term life of the product shall be identified and defined.

C. Repairable defects that may occur in the installed CIPP shall be specifically defined by the Contractor based on manufacturer's recommendations, including a step-by-step repair procedure, resulting in a finished product meeting the requirements of these contract specifications.

D. Unrepairable defects that may occur to the CIPP shall be clearly defined by the Contractor based on the manufacturer's recommendations, including a recommended procedure for the removal and replacement of the CIPP.

1.8 AS-BUILT DRAWINGS/RECORDS

As-Built drawings/records include the identification of the work completed by the Contractor and should include the pre- and post-inspection documentation. As-Built drawings /records should be kept current and should be available on the project site at all times. As-Built drawings/records can be in the form of actual drawings, either paper or electronic, spreadsheets or Word documents.

A. As-Built drawings/records, pre and post inspection videotapes, CDs or other electronic media shall be submitted to the Owner, by the Contractor, within 2 weeks of final

acceptance of said work or as specified by the Owner. As-Built drawings/records will include the identification of the work completed by the Contractor and shall be prepared on one set of Contract Drawings/Records provided to the Contractor at the onset of the project.

B. As-Built drawings/records shall be kept on the project site at all times, shall include all necessary information as outlined in the PWS or as agreed to by the Owner and the Contractor at the start of the Contract, shall be updated as the work is being completed and shall be clearly legible.

C. Compensation for work required for the submittal and approval of As-Built drawings/records shall be included in the various pipelining items contained in the Proposal.

1.9 WARRANTY

The Contractor should warrant the CIPP material and installation for a period as specified. If required by the Owner, the Contractor should warrant defective work that has been repaired for an extended period as agreed. After completion of the work but before the warranty period has expired, the owner should inspect a portion of the rehabilitated system. Initial warranty inspection should include up to 15% of the completed work. The warranty inspection should be based on the recommendations documented by the project inspector during the execution of the project. Defects found should be remedied in accordance with the repair/replacement plan submitted in the PWS. Depending on the frequency of defects found, the Owner may inspect more installations, as necessary.

A. The materials used for the project shall be certified by the manufacturer for the specified purpose. The Contractor shall warrant the CIPP material and installation for a period of one (1) year. During the Contractor warranty period, any defect which may materially affect the integrity, strength, function and/or operation of the pipe, shall be repaired at the Contractor's expense in accordance with procedures included in Section 1.7 CIPP Repair/Replacement and as recommended by the manufacturer.

B. For work completed by the Contractor that is defective and/or has been repaired, the Contractor shall warrant this work for (1) year in addition to the warranty required by the contract.

C. After a pipe section has been rehabilitated and for a period of time up to one (1) year following completion of the project, the Owner may inspect all or portions of the rehabilitated system. The specific locations will be selected at random by the Owner's inspector and should include all sizes of CIPP from this project. If it is found that any of the CIPP has developed abnormalities since the time of "Post Construction Television Inspection," the abnormalities shall be repaired and/or replaced as defined in Section 1.7 CIPP Repair/Replacement and as recommended by the manufacturer.

If, after inspection of a portion of the rehabilitated system under the contract, problems are found, the Owner may televise all the CIPP installed on the contract. All verified defects shall be repaired and/or replaced by the Contractor and shall be performed in accordance with Section 1.7 CIPP Repair/Replacement and per the original specifications, all at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 MATERIALS

The cured CIPP product must meet the chemical resistance requirements specified as referenced in the relative ASTM standard(s) F1216, ASTM F1743, ASTM D5813 (Section 6.4.1), or ASTM F2019. The tested product should be the same type of tube and resin used on the project. Chemical resistance testing is a qualification test that is typically completed by the resin manufacturer who then certifies that the product meets the specified requirement. This certification, which can be accompanied by the test report, is submitted by the contractor prior to the start of the project.

A. The CIPP System must meet the chemical resistance requirements of these contract documents.

B. Materials shipped to the project site shall be accompanied by test reports certifying that the material conforms to the appropriate ASTM standards listed herein. Materials shall be shipped, stored, and handled in a manner consistent with written recommendations of the CIPP system manufacturer to avoid damage. Damage includes, but is not limited to, gouging, abrasion, flattening, cutting, puncturing or ultra- violet (UV) degradation. On-site storage locations shall be approved by the Owner. Damaged materials shall be promptly removed from the project site at the Contractor's expense and disposed of in accordance with all current applicable agency regulations.

2.2 TUBE

The tube is the vehicle that carries the resin into the pipeline and holds the resin in place prior to and during cure. 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 finished CIPP thickness.

A. The tube shall consist of one or more layers of absorbent non-woven felt fabric, felt/fiberglass, felt/carbon fiber, carbon fiber or fiberglass and meet the material requirements of ASTM F1216, ASTM F1743, or ASTM F2019 and ASTM D5813 as applicable The tube shall be capable of absorbing and carrying resins, constructed to withstand installation pressures and curing temperatures and have sufficient strength to bridge missing pipe segments and stretch to fit irregular pipe sections. The

Contractor shall submit certified information from the tube manufacturer on the nominal void volume in the felt fabric that will be filled with resin or the recommended saturation rates using the proposed resin.

B. The wet-out tube ("liner") shall have a uniform thickness and excess resin distribution that when compressed at installation pressures will meet or exceed the design thickness after cure.

C. The tube shall be manufactured to a size and length that when installed will tightly fit the internal circumference of the original pipe. Allowance shall be made for circumferential stretching during installation. The tube shall be properly sized to the diameter of the existing pipe and the length to be rehabilitated and be able to tolerate circumferential changes to fit irregular pipe sections and negotiate bends. The Contractor shall determine the minimum tube length necessary to effectively span the designated run between manholes. The Contractor shall verify the lengths in the field prior to ordering and prior to impregnation of the tube with resin to ensure that the tube will have sufficient length to extend the entire length of the run. The Contractor shall also measure the inside diameter of the existing pipelines in the field prior to ordering tube so that the CIPP can be installed in a tight-fitting condition.

D. The outside and/or inside layer of the tube (before inversion/pull-in, as applicable) shall be coated or covered with an impermeable, flexible membrane that will contain the resin and facilitate, if applicable, vacuum impregnation and monitoring of the resin saturation during the resin impregnation (wet-out) procedure.

E. No material shall be included in the tube that may cause delamination in the cured CIPP. No dry or unsaturated layers shall be acceptable upon visual inspection as evident by color contrast between the tube and the activated resin containing a colorant, if a colorant is utilized.

F. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be made. The color contrast shall be sufficient to distinguish between the fully resin saturated tube and dry or resin lean areas.

G. Seams in the tube, if applicable, shall meet the requirements of section 7.1 of ASTM F1743.

H. The outside of the tube shall be marked at a maximum of every 5 feet with the name of the manufacturer or CIPP system, manufacturing lot and production footage.

I. The minimum length of the tube shall be that deemed necessary by the installer to effectively span the distance from the starting manhole to the terminating manhole or access point, plus that amount required to run-in and run-out for the installation process.

J. The nominal tube wall thickness shall be constructed, as a minimum, to a sufficient thickness that exceeds the required design thickness for that section of installed CIPP. Wall thickness transitions may be fabricated into the tube between installation entrance and exit access points. The volume of resin used in the impregnation shall be sufficient to fully saturate the tube.

2.3 RESIN

In felt tube CIPP, the resin is the structural pipe. In reinforced tube CIPP, the resin is important in providing the structural matrix so that the reinforcing fibers can significantly increase the CIPP's mechanical properties. Thus, it is important that the applicable resin for the pipe's flow characteristics is specified and delivered to the wet-out facility. The project representative should verify that the resin specified or substituted by the Contractor meets the contract specified requirements. The inspector should verify that the specified or approved resin is supplied by the Contractor and correct amount of resin is added to the tube at the wet-out facility. This information can be verified from the spectroscopic wavelength diagram of the resin, the tube wet-out report and standard resin saturation charts furnished from the suppliers of the resin and tube.

A. The resin shall be a corrosion resistant polyester or vinyl ester resin and catalyst system or epoxy resin and hardener system that, when properly cured within the tube composite, meets the requirements of ASTM F1216, ASTM F1743 or ASTM F2019, the mechanical properties herein, and those which are to be utilized in the design of the CIPP for this project. The resin, specified for the specific application defined in the contract documents, shall produce CIPP which will comply with or exceed the structural and chemical resistance requirements of this specification.

B. The resin to tube ratio, by volume, shall be furnished as recommended by the CIPP tube manufacturer.

2.4 STRUCTURAL REQUIREMENTS

The calculated design thickness typically determines the minimum installed CIPP thickness. However, in small diameter CIPP, such as 8", the calculated thickness may be quite small depending upon the design loads. The minimum installed CIPP thickness in these cases should consider the minimum thickness required for maintenance activities such as pressure jetting and abrasion and damage from materials and objects in the pipe flow. Also, the risk of leakage through the CIPP wall increases as the wall becomes thinner. Under these circumstances, a minimum wall thickness greater than the calculated design thickness may be prudent. The type of CIPP product, for example felt or glass tube, should be considered.

A. The mechanical properties and physical characteristics of the finished CIPP will vary

considerably, depending on the types and mixing proportions of the materials used and the degree of cure executed. It shall be the responsibility of the Contractor to control these variables and to provide a CIPP system which meets or exceeds the minimum properties specified herein or as submitted in the PWS.

B. The CIPP shall be designed as per ASTM F1216 Appendix X1, ASTM F2019 Appendix X1, or ASCE MOP 145. The CIPP design shall assume no bonding to the original pipe wall.

C. The design engineer shall set the long-term (50 year extrapolated) Creep Retention Factor at 50% of the initial design flexural modulus as determined by ASTM D790 test method. This value shall be used unless the Contractor submits long-term test data (ASTM D2990) to substantiate a higher retention factor.

D. The cured pipe material ("CIPP") shall, at a minimum, meet or exceed the mechanical properties, as listed below or as submitted in the PWS.

2.5 MINIMUM MECHANICAL PROPERTIES

Property	Test Method	Cured Composite Per ASTM F1216 or F1743	Cured Composite Per ASTM F2019	Cured Composite Per Design
Flexural Modulus of Elasticity	ASTM D790	250,000 psi	Declared Value but not less than 725,000 psi	Contractor Value
Flexural Strength	ASTM D790	4,500 psi	Declared Value but not less than 15,000 psi	Contractor Value

A. The required CIPP wall thickness shall be based, as a minimum, on the mechanical properties of the cured composite and per the design of the Professional Engineer (see section 1.3.G) and in accordance with the design equations contained in Appendix X1 of ASTM F1216, Appendix X1 of ASTM F2019, or ASCE MOP 145 and the following design parameters:

Design Safety Factor	2.0 (1.5 for pipes 36" or larger, if applicable)
Creep Retention Factor	50% or otherwise verified by test data
Ovality	2% or as measured by field inspection
Constrained Soil Modulus	Per AASHTO LRFD Section 12 and AWWA Manual M45
Groundwater Depth	As specified or indicated on the Plans
Soil Depth (above the crown)	As specified or indicated on the Plans
Live Load	Highway, railroad, airport or permanent structures as applicable
Soil Load (assumed)	120 lb./cu. ft. or as specified

ASCE MOP 145 does not use a safety factor and includes three Design States [I, II, or III]. MOP 145 design is based on LRFD (load and resistance design factors), and the appropriate parameters depend on the Design State used and are defined in the MOP.

B. The Contractor shall submit, prior to installation of the lining materials, certification of compliance with these specifications and/or the requirements of the pre-approved CIPP system. Certified material test results shall be included that confirm that materials conform to these specifications and/or the pre-approved system. Materials not complying with these requirements will be rejected.

C. The design soil modulus may be adjusted based on data, determined from project soil testing results, as provided by the Owner in the contract documents.

PART 3 INSTALLATION

3.1 CONSTRUCTION REQUIREMNTS

The construction requirements cover on-site activities needed for proper installation of the CIPP product. Construction activities (cleaning, inspection, measurement, bypass, etc.) should have been explained in the PWS submitted by the Contractor. Inspection and testing requirements, during construction, should be defined for the Contractor and the inspector. The Contractor shall keep wet-out and curing logs for inspection by the Owner or Owner's project representative.

A. The liner shall be constructed of materials and methods that, when installed, shall

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provide a continuous structurally sound CIPP able to withstand all imposed static and dynamic loads on a long-term basis as required in the specifications.

B. The Contractor may, under the direction of the Owner, utilize existing manholes in the project area as installation access points. If a street must be closed to traffic because of the location of the sewer, the Contractor shall furnish a detailed traffic control plan with necessary labor and equipment. The plan shall be in conformance with the requirements of the local agency having jurisdiction over traffic control.

C. Cleaning of Pipelines – Before ordering tube materials for the project, the Contractor shall remove debris from inside the pipeline that will interfere with the installation and the final product delivery of the CIPP, as required in these specifications, and accurately measure and document the diameter and length of the existing pipeline to be rehabilitated. Solid debris and deposits shall be removed from the system and disposed of properly by the Contractor. Moving material from manhole section to manhole section shall not be allowed. As applicable, the Contractor shall either plug or install a flow bypass pumping system to properly clean the pipelines. Precaution shall be taken by the Contractor in the use of cleaning equipment to avoid damage to the existing pipe. The repair of any damage, caused by the cleaning equipment, shall be the responsibility of the Contractor. The Owner will designate a site for the disposal of debris removed from the Owner's sewer system as a result of the cleaning operation. Unless otherwise specified by the Owner, the Contractor shall dispose of debris at no charge. Should dumping fees apply, the Contractor shall be compensated at the respective unit price bid in the Proposal for cleaning.

D. Bypassing Existing Flows - The Contractor shall provide for the flow of existing mainline and service connection effluent, if applicable, around the section or sections of pipe designated for CIPP installation. With most small diameter pipelines, particularly on terminal sewers, plugging will be adequate but must be monitored on a regular basis to prevent backup of sewage into adjacent homes. Service connection effluent may be plugged, if required, only after proper notification to the affected residence and may not remain plugged overnight. Installation of the CIPP shall not begin until the Contractor has installed the required plugs, or a sewage bypass system, and all pumping facilities have been installed and tested under full operating conditions including the bypass of mainline and side sewer flows, if required. Once the installation has begun, existing flows shall be maintained, until the CIPP is fully cured, cooled down, fully televised and the CIPP ends finished. The Contractor shall coordinate sewer bypass and flow interruptions with the Owner at least 7 days in advance. The pump and bypass lines shall be of adequate capacity and size to handle peak flows. The Contractor shall submit a detail of the bypass plan and design to the Owner before proceeding with any CIPP installation. Compensation for bypass pumping and all associated plans and approvals shall be at the price bid in the Proposal.

E. Contractor shall perform post-cleaning video inspections of the pipelines. Only PACP certified personnel trained in locating defects, obstacles and service connections by

closed circuit television shall perform the inspection. The Contractor shall provide the Owner a copy of the pre-cleaning and post-cleaning video and suitable log, and/or in digital format, for review prior to installation of the CIPP and for later reference by the Owner.

F. Line Obstructions - It shall be the responsibility of the Contractor to clear the line of obstructions that will interfere with the installation and long-term performance of the CIPP. If pre-installation inspection reveals an obstruction, misalignment, broken or collapsed section or sag that was not identified as part of the original scope of work and will prohibit proper installation of the CIPP, the Contractor may be directed by the Owner to correct the problem(s) prior to installation by utilizing open cut repair methods. The Contractor shall be compensated for this work under a contingency pay item designated for open cut point repairs. Removal of previously unknown obstructions shall be considered as a changed condition. The cost of removal of obstructions that appeared on pre-bid video documentation and made available to the Contractor, prior to the bid opening, shall be compensated for on a unit price basis in accordance with the contract documents.

G. The Contractor shall be responsible for confirming the locations of all branch service connections prior to installing the CIPP. If required in the contract documents, each connection will be dye tested to determine whether or not the connection is live or abandoned. Other approved methods to confirm live connections are acceptable. The cost for dye testing of existing service connections shall be compensated at the unit price bid in the Proposal for Dye Testing of Existing Service Connections. In the event the status of a service connection cannot be adequately defined, the Owner will make the final decision, prior to installation of the CIPP, as to the status. Typically, only service connections deemed “active” shall be reopened by the Contractor.

H. The Contractor shall be allowed use water from an owner-approved fire hydrant in the project vicinity. Use of an approved double check backflow assembly shall be required. Contractor shall provide his own approved assembly. Contractor shall pay current market price for all water usage.

3.2 INSTALLATION OF CIPP

It is important that the CIPP be installed in accordance with the manufacturer’s recommendations. These procedures should have been outlined in the PWS submitted by the Contractor. Recommended procedures that should be monitored include: Installation speed and pressure, the cure schedule and curing temperature monitoring must be maintained and documented, as recommended by the manufacturer. Chemical grouting should be utilized, or a pre-liner should be installed, where the infiltration into the pipeline is excessive and may affect the cure and/or the final structure of the CIPP unless the tube has an outer coating or film.

A. The CIPP shall be installed and cured in the host pipe per the manufacturer's specifications as described and submitted in the PWS.

B. CIPP installation shall be in accordance with the applicable ASTM standards as modified in this Section 3.2.

C. If significant groundwater infiltration is present in the existing sewer, such as PACP defects coded "infiltration gusher" or multiple "runners", the Contractor shall install a preliner or perform chemical grouting to control resin loss and contamination, maintain CIPP thickness, prevent mechanical property reduction and prevent inadequate curing of the CIPP resulting from water or other contamination of the resin during installation. The preliner shall be a plastic tube to fit the existing pipeline and shall be continuous from manhole (access) to manhole (access). Preliners are not required in this situation when using pulled-in liners with exterior coatings or in the case of light cured liners (i.e., UV or LED) that contain an outer membrane.

D. The liner shall be positioned in the pipeline using the method specified by the manufacturer. Care should be exercised not to damage the liner during installation. The liner should be pulled-in or inverted through an existing manhole or approved access point and fully extend to the next designated manhole or termination point in accordance with ASTM F1216, ASTM F1743, or ASTM F2019, and the manufacturer's recommendations.

E. When Using Hot Water or Steam Cure: Prior to installation and as recommended by the manufacturer, remote temperature gauges or sensors shall be placed inside the host pipe to monitor the temperatures during the cure cycle. CIPP and/or host pipe interface temperature shall be monitored and logged during cure.

To monitor the temperature of the CIPP wall and to verify correct curing, where specified by the contract documents, temperature monitors can be placed between the host pipe and the CIPP in the bottom of the host pipe (invert) at manholes or access points and/or throughout its entire length (continuous) to monitor the temperature on the outside of the CIPP during the curing process.

Curing shall be accomplished by utilizing the appropriate medium in accordance with the manufacturer's recommended cure procedure and/or schedule. The curing source or in and output temperatures shall be monitored and logged during the cure cycles, if applicable. The manufacturer's recommended cure method and schedule shall be used for each line segment installed, and the CIPP wall thickness and the existing ground conditions with regard to temperature, moisture level, and thermal conductivity of soil shall be taken into account by the Contractor.

If any temperature sensor or continuous sensor location does not reach the temperature as specified by the manufacturer to achieve proper curing or cooling, the installer can make necessary adjustments to comply with the manufacturer's recommendations. For continuous temperature monitoring, the system computer should have an output report that specifically identifies stations along the length of pipe, indicates the maximum temperature achieved and the sustained temperature time at the stations. 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.

> When using hot water or steam cure methods, monitoring cure temperatures is important for verifying the correct cure of the resin. 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 prior to CIPP installation. Continuous monitoring systems are computer controlled with a real-time screen display and can be monitored by any smart device. This is especially useful for critical sewers and medium to large diameter sewers. As a minimum, standard thermocouples, which measure temperatures at one point, should be used, typically at the pipe invert in the termination manhole. Often thermocouples are used in addition to continuous monitoring systems to verify proper cure of the CIPP.

F. When Using Photoinitiated Reaction (i.e., UV or LED light cure): A protocol shall be defined by the manufacturer and recorded during the cure process and maintained as documentation to verify cure. Data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the liner and the power output of the light assembly along the entire length of the installed CIPP. The cure procedure shall be in accordance with ASTM F1216, ASTM F1743, or ASTM F2019 and the manufacturer's recommendation as included in the PWS submission by the Contractor.

3.3 COOL DOWN

> Proper cool down of CIPP is important to help minimize CIPP shrinkage and cracking. The temperature profile and times required should be provided as a part of the cure schedule. Short cuts that reduce the cool down time should not be allowed.

A. The Contractor shall cool the CIPP in accordance with the approved CIPP manufacturer's recommendations as described and outlined in the PWS.

B. 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.

3.4 FINISH

Any defect which could affect the structural integrity or longevity of the CIPP should be repaired. Sealing the ends of the CIPP at manholes and at service connection openings, if specified, is important in cases where the sewer is below the groundwater surface elevation. Leaks through the wall of the CIPP are considered a defect.

A. The installed CIPP shall be continuous over the entire length of a sewer line section and be free from visual defects such as foreign inclusions, dry spots, pinholes, major wrinkles and delamination. The CIPP shall be impervious and free of leakage through the CIPP wall.

B. Any defect which will or could affect the structural integrity or strength of the CIPP shall be repaired at the Contractor's expense in accordance with the procedures submitted under Section 1.7 CIPP Repair/Replacement.

C. The beginning and end of the CIPP shall be sealed to the existing host pipe, if specified. The sealing material shall be compatible with the pipe end and shall provide a watertight seal.

D. If any of the service connections leak water between the host pipe and the installed CIPP, the connection mainline interface shall be sealed, if required by these specifications, to provide a leak tight connection.

E. If the wall of the CIPP leaks, it shall be repaired or removed and replaced with a watertight pipe as recommended by the manufacture of the CIPP system.

F. Compensation shall be at the actual length of CIPP installed. The length shall be measured from center of manhole to center of manhole. The unit price per linear foot installed shall include materials, labor, equipment and supplies necessary for the complete CIPP installation. Compensation for service connection sealing and pipe sealing at the manhole/wall interface shall be at the unit price bid in the Proposal.

The long-term structural capability of the existing underground pipeline is defined by the pipe design and the surrounding soil structure. When a CIPP is installed through an existing pipe that represents such defects as soil visible or soil missing, the engineer should consider that the soils be replaced using a flowable fill technique to provide soils support for the newly installed CIPP.

3.5 FLOWABLE FILL OF VOID AREAS

A. Where required by the Owner, the Contractor shall backfill known voids that remain

after installation of CIPP. The material shall be of the flowable fill type and shall be injected into the void while removing all trapped air from the void. The Contractor shall submit the proposed method of placing the flowable fill, including pressures that will not collapse the CIPP and air release method to be employed, to the Owner for review before material is installed. The cost of this work shall be at the unit price bid for flowable fill and include all material, equipment, and labor to complete the filling of the soil void

3.6 MANHOLE CONNECTIONS AND RECONNECTIONS OF EXISTING SERVICES

> The most common method of sealing the CIPP at manholes is to install a hydrophilic rubber seal prior to installing the CIPP. Sealing the CIPP at manholes after the CIPP has been installed is possible but less effective. Side connections should be cut open to at least 90%-95% of the original service connection opening area. In all cases, the invert of the lateral connection shall be cut flush with the invert entering the mainline to eliminate debris build-up.

A. A seal, consisting of a resin mixture or hydrophilic seal compatible with the installed CIPP, shall be applied at manhole/wall interface, if specified, in accordance with the CIPP System manufacturer's recommendations.

B. Existing services shall be internally or externally reconnected unless indicated otherwise in the contract documents

C. Reconnections of existing services shall be made after the CIPP has been installed, fully cured, and cooled down. It is the Contractor's responsibility to make sure that all active service connections are reconnected. If verification of active service connections requires techniques beyond standard mainline CCTV then a separate bid item shall be included.

> Verification of active services can be completed using many options such as dye testing, CCTV via lateral launching from the main, connection records from the Owner or other means. Methods requiring the Contractor to extend resources beyond mainline CCTV should be separate bid items.

D. External reconnections are to be made with a tee fitting or other approved method in accordance with CIPP System manufacturer's recommendations. Saddle connections shall be seated and sealed to the new CIPP using grout or resin compatible with the CIPP.

E. A CCTV camera and remote cutting tool shall be used for internal reconnections. The machined opening shall be at least 90 percent of the service connection opening area and the bottom of both openings must match. The opening shall not be more than 100 percent of the service connection opening. The edges of the opening shall not have

pipe fragments or CIPP fragments which may obstruct flow or snag debris. In all cases the invert of the service connection shall be cut flush with the invert entering the mainline.

F. If service reinstatements result in openings that are greater than 100 percent of the service connection opening, the Contractor shall install a CIPP type repair, sufficiently in size to completely cover the over-cut service connection. No additional compensation will be paid for the repair of over-cut service connections.

G. Coupons or fragments of CIPP material resulting from service tap cutting shall be collected at the next manhole downstream of the pipe rehabilitation operation prior to leaving the site. Coupons may not be allowed to pass through the system.

H. Compensation shall be at the actual number of services reconnected using either internal or external means as contained in the Proposal. The unit price bid per service line reconnected shall be include all materials, labor, equipment and supplies necessary to complete the work as required in these specifications.

3.7 TESTING OF INSTALLED CIPP

CIPP mechanical properties should be verified through field sampling and independent testing. Samples shall be taken from the CIPP section installed and should be properly marked and transmitted to an independent testing laboratory or obtained from the project site by a laboratory representing the Owner. Test results should be transmitted from the laboratory to the Owner's representative. Sampling should be in accordance with ASTM F1216, ASTM F1743, or ASTM F2019 as applicable, and a chain of custody should be strictly maintained. Restrained samples can be used for sewers of 18" diameter or less. Plate samples are used for pipelines larger than 18" diameter. Samples should be acquired as directed and specified by the Owner or the Contract documents.

A. The mechanical properties and thickness of the installed CIPP shall be verified through field sampling and laboratory testing. All materials for testing shall be furnished by the Contractor to the Owner for testing. All materials testing shall be performed at the Owner's expense by an independent third-party laboratory selected by the Owner as recommended by the CIPP manufacturer. All tests shall be in accordance with applicable ASTM test methods to confirm compliance with the requirements specified in these contract documents, or as submitted in the PWS. Tubes constructed of fiberglass and cured by light (i.e., photoinitiated reaction) shall be tested in accordance with Appendix X2 of ASTM F2019.

B. The Contractor shall provide samples for testing to the Owner from the actual installed CIPP. Samples shall be provided from each section of CIPP installed or as required by the Owner. The sample shall be cut from a section of cured CIPP that has been inverted or pulled through a like diameter pipe which has been held in place by a

suitable heat sink, such as sandbags. All curing, cutting and identification of samples will be witnessed by the Owner and transmitted by the Owner's representative as specified, and sent to the testing laboratory. Flat plate samples can be taken on pipelines greater than 18 inches in diameter, if specified. Identification on the samples shall include markings indicating the direction of reinforcement when used in tube construction and shall be standard chain of custody markings.

C. The laboratory results shall identify the test sample location as referenced to the nearest manhole and station. Final payment for the project shall be withheld pending receipt and approval of the test results. If properties tested do not meet the minimum mechanical and thickness requirements, the CIPP shall be repaired or replaced by the Contractor unless the actual mechanical properties and the thickness of the sample tested meet the design requirements as required in the contract.

> Chemical resistance is a qualification test where CIPP samples tested should be of the tube and resin proposed for the actual construction. For municipal applications, a certification is typically submitted from the manufacturer verifying that the chemical resistance meets the contract requirements. For industrial installations, the chemical resistance of the resin installed must be tested to meet the corrosion resistance requirements of the pipeline being rehabilitated.

D. Chemical resistance - The CIPP system installed shall meet the chemical resistance requirements of the relevant ASTM standard(s) F1216, ~~or~~ ASTM F1743, ASTM D5813 (section 6.4.1), or ASTM F2019. CIPP samples tested shall be of the tube and the specific resin proposed for actual construction. It is required that CIPP samples without plastic coating meet these chemical testing requirements. A certification may be submitted, by the Contractor, from the manufacturer verifying that the chemical resistance of the CIPP meets the contract requirements.

E. Hydraulic Capacity - The installed CIPP shall, at a minimum, be equal to the full flow capacity of the original pipe before rehabilitation. Calculated capacities may be derived using a commonly accepted roughness coefficient for the existing pipe material taking into consideration its age and condition.

F. The installed CIPP thickness shall be measured for each line section installed as per the ASTM requirements specified. If the CIPP thickness does not meet that specified in the contract and submitted as the approved design by the Contractor, then the CIPP shall be repaired or removed unless the tested mechanical properties and the thickness of the sample tested meet the design requirements as required in the contract. The CIPP thickness shall have tolerance of minus 5%. In worker-entry size piping, where sampling is by flat plate, a quality-based approach using the approved quality plan will be used to accept installed thickness (see discussion in following text box). If the plate sample does not meet the required mechanical property values, or if quality checks are deficient, it may be necessary for the Contractor to remove a 2-inch core from the CIPP 12 o'clock position to check thickness. The openings produced from core samples shall be repaired in accordance with manufacturer's recommended

procedures.

For small diameter CIPP of 18" inch diameter or less, the restrained sample can be measured for thickness. In sewers larger than 18-inch diameter the flat plate sample can be tested for thickness, but a flat plate can be constructed in any thickness. The thickness can be measured in a manhole once the CIPP ends are cut, but this may result in a low measurement due to resin loss and thinning. A quality-based approach can be used where it is determined that if all the quality checks are met, the likelihood of the CIPP installed thickness meeting the required minimum installed thickness is good. For example, if 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, the installed thickness should meet the design minimum thickness. If the plate sample does not meet the required physical property values, or if any quality checks are deficient, it may be necessary to remove a core sample from the CIPP at the 12:00 o'clock position to check thickness. The core hole shall be repaired as recommended by the manufacturer.

G. All costs to the Contractor associated with providing cured CIPP samples for testing shall be included in the Lump Sum price bid for Mobilization. Payment for all testing by a laboratory will be paid for by the Owner directly to the laboratory under the lump sum Reserve for Testing item in the Bid Proposal.

3.8 FINAL ACCEPTANCE

Sample testing and repairs to the CIPP should be completed. Test results must have been received from the independent laboratory and meet the contract specified requirements prior to final acceptance of the installed CIPP.

A. CIPP sample testing and repairs to the installed CIPP, as applicable, shall be completed before final acceptance, meeting the requirements of these specifications, and documented in written form.

Prior to conducting the final CCTV, the Contractor should thoroughly clean the newly installed CIPP. Sewage flow in the line should be minimized, and standing water in sags should be cleared. The CCTV visual quality of the final inspection shall be as specified in the contract. If the quality does not meet the specified requirements, the Contractor shall re-CCTV those section that are unacceptable.

B. The Contractor shall perform a closed-circuit television inspection in the presence of the Owner after installation of the CIPP and reconnection of the side sewers per PACP requirements. Conventional pan-and-tilt TV camera or sidewall scanning technology, as approved by Owner, shall be used. The finished CIPP shall be continuous over the entire length of the installation and shall be free of significant visual defects, damage, lifts, holes, leaks and other defects that are not a reflection of the existing pipe condition. Unedited digital documentation of the inspection shall be provided to the

Owner within ten (10) working days of the CIPP installation. The data shall note the inspection date, location of all reconnected side sewers, debris, as well as defects in the CIPP, including, but not limited to, gouges, cracks, bumps, or bulges. If post installation inspection documentation is not submitted within ten (10) working days of the CIPP installation, the Owner may, at its discretion, suspend further installation of CIPP until the post-installation documentation is submitted. As a result of this suspension, no additional working days will be added to the contract, nor will adjustment be made for increase in cost. Immediately prior to conducting the CCTV inspection, the Contractor shall clean the newly installed CIPP removing debris and build-up that may have accumulated at no additional cost to the Owner.

Final CCTV inspection should be performed using water jets to eliminate standing water in sags and bellies while the line is being televised.

If required by the Owner in the specifications, leakage can be determined through visual inspection (water or air installations), hydrostatic testing (water installations), air testing (air installations) or infiltration testing (water or air installations). For small diameter sewers installed with air pressure (light cure or steam cure), it does not make sense to do hydrostatic (exfiltration) testing for leakage. This leaves visual inspection or air testing as viable alternatives.

For large diameter sewers, visual inspection for leakage is the most common method. Air and hydrostatic testing should not be performed for sewers greater than 36" diameter because of worker safety. Any unacceptable leakage through the CIPP wall should be repaired as required in the contract documents or agreed to by the owner.

C. If required by the Owner in the specifications, and if the pipe diameter is less than or equal to 36", the CIPP shall be tested for leakage using the water exfiltration test (ASTM F1216 8.2) or a low pressure air test (refer to Appendix A). Testing is limited to pipe lengths with no reinstated service laterals and could delay service lateral reinstatement. Water exfiltration or air testing is not recommended in pipe diameters exceeding 36" diameter. In these cases, a visual inspection for leakage shall be performed, if specified.

Any unacceptable leakage through the CIPP wall should be repaired as required in the specifications or agreed to by the owner.

Not all CIPP line segments can be air tested because of end configurations in the manhole, shape of the CIPP and CIPP irregularities. It is recommended that only a set percentage of the line segments in any one project be tested in lieu of testing each line segment.

Low pressure air testing can be a dangerous operation. It is imperative that all safety protocols for plug operation & maintenance and air testing be followed, including proper blocking/bracing of plugs during the air test and limiting air tests to a maximum diameter of 36 inches.

D. Bypass pumping or plugging from the upstream manhole shall be utilized to minimize sewage from entering the line during the inspection. In the case of bellies in the line, the pipe shall be cleared of standing water to provide continuous visibility during the inspection.

3.9 TYPICAL BID ITEMS

Additional items such as pre-liner and flowable backfill can be added to specific contracts requiring these items.

A. Mobilization – Lump Sum - Includes all PWS information, submittals, safety plan, as-built drawings, testing samples, mobilization/demobilization of labor, equipment and materials to the project site. Generally limited to 5% of the total amount bid for the project.

B. Pre-Installation CCTV Inspection – Per linear foot - Includes pre-cleaning and post cleaning CCTV for Owner review. Does not include CCTV inspection just prior to CIPP installation. All inspections will be performed by PACP trained and certified personnel.

C. Dye Testing of Service Connections – Per each - Includes dye testing and documentation of existing service connection on each pipe length to be lined.

D. Point Repairs – Per each or by Lump Sum Contingency - Includes excavation and restoration of a section or sections of pipe that are beyond rehabilitation using CIPP. Note: Point repair items shall be categorized by pipe size, a minimum length of excavation and depth category of excavation to be paid for in the Proposal. If point repairs are not identified in the contract documents, payment shall be on a contingency basis.

E. Standard Pipe cleaning – Per linear foot for each pipe size category – including all labor, equipment, materials and cost of material disposal.

F. Heavy Pipe Cleaning – Per linear foot for each pipe category – including all labor, equipment, materials and cost of material disposal.

G. Preliner Installation – per linear foot installed by size category. Includes all labor, equipment and materials required.

H. CIPP Installation – Per linear foot for each pipe size category - Includes all labor,

equipment and materials required for the complete installation of a CIPP.

I. Flowable Fill – per cu. yd. of material installed and documented including all labor, equipment and materials required for the complete backfilling of soil voids.

J. Traffic Control – Lump Sum – Includes all labor, equipment and materials required to implement a traffic control plan for the entire project and shall include all costs associated with sub-contracted traffic control specialists.

K. Sewage Bypass – Lump Sum – Includes all labor, equipment and materials required to implement a flow bypass plan for the entire project, including the cost of all sub-contracted flow bypass specialists.

L. Service Reconnections – Per each – Includes reconnecting existing live sewer service connections to the installed CIPP. Owner shall review and verify those connections that are not live and will be left unopened.

M. Service connection sealing – Per each – Includes sealing the interface between the installed CIPP and the host pipe at the location of the service connection.

N. Manhole/Wall Interface Sealing – Per each – Includes sealing the interface between the installed CIPP and the manhole wall.

O. Post Construction CCTV Inspection - Per linear foot - Includes post lining CCTV for submission to the Owner. All inspections will be performed by PACP trained and certified personnel.

P. Reserve for Testing – Lump Sum Reserve – 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)

END OF SECTION

Appendix A: Air Testing of CIPP

Pressure gauges used for this test shall have a minimum division of 0.1 psi and an accuracy of 0.0625 psi.

Test Procedure:

1. The tested pipe may be wet or dry.
2. The minimum test pressure should equal 3.5 psi plus 0.433 psi for each foot of average water or groundwater depth over the crown of the pipe. The maximum test pressure shall be 6 psi.
3. Slowly add air to the section of pipe being tested until the internal air pressure is raised to 4 psi greater than the average back pressure due to water or groundwater. The maximum air pressure shall be 6 psi.
4. Once the test pressure is reached, allow a period of time for the air temperature to stabilize. The stabilization period can vary from a few minutes to an hour or more dependent upon the temperature of the air and CIPP under test. Add air to maintain pressure.
5. After the temperature stabilization period, disconnect the air supply.
6. Record the time in seconds required for the air pressure to drop from 3.5 to 2.5 psi greater than the average back pressure due to water or groundwater.

Acceptance Criteria:

The tested section is acceptable if the time recorded is not less than the time in seconds (T):

$$T = K/C$$

Where:

K = the sum of the computations ($0.011d^2L$) for each size of CIPP and its length in the section
C = the sum of the computations (0.0003882 dL) for each size of CIPP and its length in the section; the minimum value for C = 1
d = inside diameter of CIPP in inches
L = length of CIPP in feet

If the tested section fails the air test (time recorded is less than T), check all connections of the test apparatus with soapy water for leaks. Complete another stabilization period (# 4 above) and retest. If the tested section fails again but the results are better (time recorded is still less than T but closer), the problem may be temperature stabilization or re-rounding or expansion of the CIPP. Repeat the stabilization/test cycle if results continue to improve until the section passes. If after repeated test/stabilization cycles the results are not improving, there is most likely a leak in the CIPP or the test apparatus.

If it is determined that there is a leak in the CIPP test section, then a visual test will be performed to locate the leak and repair it, if possible. Repairs will be in accordance with manufacturer's recommendations. Once repaired, the section should be retested.

Not all CIPP line segments can be air tested because of end configurations in the manhole, shape of the CIPP and CIPP irregularities such as wrinkles. It is recommended that only a set percentage (typically 10%) of the line segments in any one project be tested in lieu of testing each line segment.

Low pressure air testing can be a dangerous operation. It is imperative that all safety protocols for plug operation & maintenance and air testing be followed, including proper blocking/bracing of plugs during the air test and limiting air tests to a maximum diameter of 36 inches.

Table 1: Example Air Test Chart for Gravity Sewers

*Adapted from “Oregon Standard Specifications for Construction, 2015, Section 00445.72 Pipe Testing, pp. 330-331”

Table 1: Example Air Test Chart for Gravity Sewers

Example Air Test Chart for Gravity Sewers

Minimum Acceptance Time for Pressure Drop from 3.5 to 2.5 psi

Adapted from "Oregon Standard Specifications for Construction" (2015)

Diameter	6-inch			8-inch			10-inch			12-inch			18-inch			24-inch		
Length (ft.)	C	K	Minimum Time	C	K	Minimum Time	C	K	Minimum Time	C	K	Minimum Time	C	K	Minimum Time	C	K	Minimum Time
			Min.-Sec.			Min.-Sec.			Min.-Sec.			Min.-Sec.			Min.-Sec.			Min.-Sec.
100	1.00	35	0'-35"	1.00	64	1'-02"	1.00	100	1'-40"	1.00	146	2'-26"	1.00	329	5'-29"	1.00	585	9'-45"
150	1.00	53	0'-53"	1.00	93	1'-33"	1.00	150	2'-30"	1.00	219	3'-39"	1.01	493	8'-10"	1.34	877	10'-53"
200	1.00	70	1'-10"	1.00	125	2'-05"	1.00	200	3'-20"	1.00	292	4'-52"	1.34	658	8'-10"	1.79	1169	10'-53"
250	1.00	88	1'-28"	1.00	156	2'-36"	1.00	250	4'-10"	1.12	365	5'-27"	1.68	822	8'-10"	2.24	1462	10'-53"
300	1.00	105	1'-45"	1.00	187	3'-07"	1.11	300	4'-30"	1.34	439	5'-27"	2.01	987	8'-10"	2.68	1754	10'-53"
350	1.00	123	2'-03"	1.02	218	3'-33"	1.29	349	4'-30"	1.57	512	5'-27"	2.35	1151	8'-10"	3.13	2046	10'-53"
400	1.00	140	2'-20"	1.17	249	3'-33"	1.48	399	4'-30"	1.79	585	5'-27"	2.68	1316	8'-10"	3.58	2339	10'-53"
450	1.00	158	2'-38"	1.31	280	3'-33"	1.66	449	4'-30"	2.01	658	5'-27"	3.02	1480	8'-10"	4.03	2631	10'-53"
500	1.10	175	2'-40"	1.46	312	3'-33"	1.85	499	4'-30"	2.24	731	5'-27"	3.36	1644	8'-10"	4.47	2923	10'-53"
550	1.21	193	2'-40"	1.61	343	3'-33"	2.03	549	4'-30"	2.46	804	5'-27"	3.69	1809	8'-10"	4.92	3216	10'-53"
600	1.31	210	2'-40"	1.75	374	3'-33"	2.22	599	4'-30"	2.68	877	5'-27"	4.03	1973	8'-10"	5.37	3508	10'-53"
650	1.42	228	2'-40"	1.90	405	3'-33"	2.40	649	4'-30"	2.91	950	5'-27"	4.36	2138	8'-10"	5.82	3801	10'-53"
700	1.53	245	2'-40"	2.05	436	3'-33"	2.59	699	4'-30"	3.13	1023	5'-27"	4.70	2302	8'-10"	6.26	4093	10'-53"

Notes:		
	1. C = (0.0003882)dL	4. If C is less than 1 use C =1
	2. K = (0.011)d^2L	5. For project calculated minimum times, use actual inside diameter of CIPP
	3. $T_{(Sec.)}$ = (K/C)	6. Calculations shown are for 4.5 mm CIPP for 6", 6 mm for 8", 10" & 12", 9 mm for 18" and 12 mm for 24"
	7. If C > 1, $T_{(Sec.)}$ = 28.34d	