

are to be contained, captured, transported offsite and disposed of in accordance with project permits and local, state and federal regulations. The Contractor shall place an impermeable barrier immediately upstream and downstream of the host pipe, prior to any internal repair method, to capture any possible raw product spillage during installation and shall dispose of any materials in accordance with the submitted disposal plan.

It shall be the Contractor's responsibility to report and take appropriate corrective actions to remediate any water quality alteration resulting from internal pipe repair operations in accordance with project permits and applicable local, state and federal regulations.

The cost for creating, implementing and maintaining the Disposal Plan, including any necessary remediation, shall be considered incidental to the project and no additional payment will be allowed

T-15.53 MATERIALS FOR JOINT SEAL, GROUTING AND SPINCAST

The use of high density two-component polyurethane foams and/or resins will be considered and approved on a case by case basis, by the Engineer.

Flexible Polyurethane Resin for Pipe Joint Sealing

The medium used for pipe joint sealing shall be a moisture-activated, hydrophilic polyurethane injection resin that carries an ANSI/NSF 61 Certification approving it for use in potable water applications and meets the following physical properties:

Tensile Strength, ASTM D-3574 450 psi	Shrinkage, ASTM D-1042/ D-756 less than 2%
Tensile Elongation, ASTM D-3574 350%	Tear Resistance, ASTM D-3574 21 lbs/inch
Viscosity @ 73°F - liquid 250-350 centipoise	Solids Content @ 73°F - liquid 88%

The joint filler material that is saturated with the polyurethane material specified above, and placed in the joint, shall be oil-free jute oakum.

Sufficient material to perform the entire pipe sealing operation shall be in proper storage at the site prior to any field preparation so that there shall be no delay in procuring the material for each day's application.

Polyurethane Resin for Pipe and Structure Back-Grouting

The medium used for pipe and structure back-grouting shall be a moisture-activated, hydrophobic polyurethane injection resin that carries an ANSI/NSF 61 Certification approving it for use in potable water applications. This material shall utilize a catalyst

to activate timed expansion as required by the site conditions. The material shall meet the following physical properties:

Tensile Strength, ASTM D-3574 41 psi	Shrinkage, ASTM D-1042/ D-756 None
Tensile Elongation, ASTM D-3574 3.4%	Compressive Strength, ASTM C-39 (with fine sand) 970 psi
Viscosity @ 73°F - liquid 110-130 centipoise	Solids Content @ 73°F - liquid 100%

Sufficient material to perform the entire back-grouting, probe-grouting, or soil stabilization operation shall be in proper storage at the site prior to any field preparation, so that there shall be no delay in procuring the material for each day's application.

Mortar for Spin Casting

The pipe lining / rehabilitation material shall meet all the following typical performance criteria when cured at 70°F (21°C):

1. Compressive Strength, ASTM C 109

1 Day	3,000 psi (20.7 MPa)
7 Days	6,000 psi (41.4 MPa)
28 Days	8,000 psi (55.2 MPa)

2. Bond Strength, ASTM C 882

7 Days	2,000 psi (13.8 MPa)
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3. Flexural Strength, ASTM C 348

28 Days	1,300 psi (9.0MPa)
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4. Modulus of Elasticity, ASTM C 469

28 Days	3.35 x 10 ⁶ psi (23.1 MPa)
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5. Length Change, ASTM C 157

28 Days Wet	+0.05%
28 Days Dry	-0.15%

6. Chloride Ion Permeability, ASTM C 1202

28 Days	Low
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7. Freeze / Thaw Resistance, ASTM C 666A

	90% RDM @ 300 cycles
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8. Working Time

	30 minutes
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T-15.53-A SUBMITTALS AND CERTIFICATIONS

Submittals for all materials, manufacturer's warranty, and a copy of the contractor's confined safety plan as referenced herein shall be provided to the Project Engineer for approval one week prior to work being initiated. The Contractor shall furnish material certifications from the manufacturer that they meet or exceed the specifications as written here in. The reports can be used for material acceptance or the Engineer may perform independent verification testing. The reports shall not be interpreted as a basis for payment.

The Spin Cast mortar thickness shall be determined by a structural engineer, and be based upon the depth of the pipe. The contractor shall submit structural calculations supporting the proposed mortar thickness. No work shall be performed without express written approval by the Engineer/Owner. The Spin Cast liner system supplied by the contractor shall conform to the following requirements as supported by submitted design calculations;

- Shall list host pipe diameter ranges for which the product is applicable.
- Shall indicate corrosion potential/acid reaction potential.
- Shall provide hydraulic calculations comparing existing culvert to proposal culvert liner.
- Shall provide structural calculations.
- Shall list typical, minimum, maximum application thicknesses.
- Shall provide proof of initial Manning's Number (n value for roughness in open channel) of product.
- Shall list liner material type.
- Shall include documentation of specification or standard practice for installation.
- Shall give proof of long term and short term modulus, long term and short term strength.
- The line pipe must carry one hundred (100) percent of the design load without taking into account the strength of the host pipe.
- Host pipe grouting is assumed to have no greater load bearing capacity than surrounding soil.
- Traffic loading is HS-20. Neglect after 8 feet of cover on single barrel culverts if span length is 8 feet or less. For multiple span culverts, the effects may be neglected where the depth of fill exceeds the distance between inside faces of end walls. See AASHTO LRFD Bridge Design Specifications for additional information.

- Minimum thickness for cementitious or geopolymer liner material is listed below (clear of corrugations and/or bolt heads).

Pipe Diameter	Minimum Spin Cast Mortar Thickness
36"	0.75"
42"- 48"	1.0"
54"and Greater	1.5"

Contractor shall provide approved applicator certification from manufacturers of all materials, as described herein. No work shall be performed without express written approval by the Engineer/Owner.

The Engineer, at his option, may take concrete mix samples for testing. If the material does not achieve the specified properties listed in the Materials section, the pipe liner may be rejected. Contractor shall submit a new work plan for the placement of material before replacing the rejected pipe.

- If there are visible defects in the pipe liner, submit a work plan for repairing the defects. Measure the length of the defect along the centerline of the culvert.
- If the length of the defect is 60 inches long or less, patch defects using the same cementitious material used in the work. Hand methods may be used.
- If the length is greater than 60 inches long, replace the defective length of the pipe liner for the full diameter of the pipe liner. Replace the defective length using machine methods.

Quality Control for other liner material will be determined per manufacture recommendations

The finish liner may be rejected if not continuous over its entire length and free from visual defects such as foreign inclusions, joint separations, cracks, insufficient liner thickness, material loss, roughness, deformation, dry spots, pin holes, insufficient bonding to host pipe, delamination, or other material or installation deficiencies as described herein.

Remedies for rejection of liner – In the event the post installation inspection reveals defects in localized areas of the liner pipe (comprising less than 20 percent of the pipe length) the localized defects shall be repaired as specified by the manufacturer. Where defects occur on 20 percent or more of the pipe length the defects shall be repaired, however, the Contractor will not be allowed to continue with his methodology of installation and/or the liner system used until he/she can demonstrate to the Engineer that he/she has remedied his/her operations to a sufficient level of quality as determined by the Engineer. All such remedial efforts shall be at the Contractor's expense. Further failure(s) to perform a proper installation may result in the disallowance of the use of that liner system and an adjustment in the cost or non-payment of the failed installations depending on the severity of the failure.

The Contractor shall notify the Engineer upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers for inspection by the Engineer. Material shall not be loaded into the equipment until inspected by the Engineer.

T-15.53-B INSTALLATION

Equipment

The Contractor shall furnish all equipment and hardware necessary for the performance of the work in accordance with these specifications. All machines, tools and equipment used in the performance of work required by these specifications will be subject to the approval of the Engineer and maintained in a safe and satisfactory working condition at all times. Standard mortar mixers, compressors and pumps are required. A spin cast applicator is required.

Drills - Pneumatic drill/driver or an electric drill which shall be capable of drilling holes up to 1" in diameter or driving ½" diameter steel probes.

Pumping Unit - Portable pumping unit capable of injecting the polyurethane formulation behind pipe or into subsurface soils through steel probes. This pumping unit will be capable of controlling the delivery of polyurethane and have a maximum output capable of injecting material up to 3300 psi and a minimum of 2/gpm behind the structure or into the subsurface soils as required.

T-15.53-C Construction Methods

Cleaning and Preparation

The Contractor shall determine size of structure pipe joints, areas to be back grouted, spin cast or depth of soils that may require treatment. All areas to be treated shall be approved by the Engineer. For structure sealing, the Contractor's personnel shall be properly trained to perform the work in accordance with OSHA confined entry requirements. Sanitary sewer manholes will be pressured washed prior to entering. All joints shall be wetted down with water prior to insertion of joint material. For back grouting structures, a series of 3/8" holes shall be drilled through the structure wall at each joint to be treated, in a circumferential spacing approved by the Engineer. Ports shall be placed in drilled holes to facilitate back grouting. For probe-grouting, ½" diameter steel pipes shall be driven in a grid pattern or at a spacing and a depth as approved by the Engineer.

Divert water flow and then flush all material from pipe. Culvert inverts will be cleaned using high-pressure power washer and hand-brooming. Protruding areas in the invert caused by corrosion such as severe pitting or perforations will be either cut away and disposed of at the contractor's expense or hammered out so area no longer protrudes into pipe interior. Plug active leaks and fill voids as outlined below.

Joint and Pipe Penetration Sealing

Joint and penetration sealing shall be performed by inserting jute oakum that has been saturated in the hydrophilic polyurethane resin and activated with water into the pipe joint and allowed to cure, sealing the joint completely. The Contractor shall perform the joint sealing in accordance with OSHA confined space entry using properly calibrated air quality meters and harnesses as required. Clean area in joint, removing soil, grease or chemical contaminants with water and scrub brush. Spray joint with water prior to inserting containment dam. Cut the oakum into appropriate lengths and saturate with hydrophilic polyurethane resin. Rubber gloves shall be used while handling activated oakum. Avoid breathing urethane vapors (see Ventilation). Submerge saturated oakum in water per manufacturer's instructions. Force oakum into joint and drive in as deep as possible with screwdriver or pry bar. Allow to cure.

The Contractor shall perform the joint sealing in accordance with OSHA confined space entry using properly calibrated air quality meters and harnesses as required.

The polyurethane material for joint and pipe penetration sealing shall be paid for by the linear feet of joint sealed, which will include furnishing and installing joint material.

Back-grouting Structure/Pipe (Inside Pipe)

Back-grouting structure/pipe shall be performed by pumping the moisture-activated hydrophobic polyurethane resin in through the grout ports, filling voids as material flows out adjacent ports. Material shall be properly mixed with the catalyst to react based on the site conditions and approval of the Engineer.

Drill 3/8" injection port holes at approximately 18" cc around the periphery of each joint. Clean holes by injecting water through a wand that will reach the back of the hole. Insert injection ports, flush water into the port holes, leaving the fittings off.

Mix the appropriate ratio of catalyst to hydrophobic polyurethane resin as the conditions require, following the recommended rates per the manufacturer. Apply first fitting to port in the bottom and pump resin at a pressure of 250 psi minimum or per manufacturer's instructions. When material begins to flow out of next port up, apply fitting and begin pumping in through that port, working around the entire perimeter of the joint.

Soil Stabilization

Soil stabilization shall be performed by pumping the moisture-activated hydrophobic polyurethane resin through the steel pipes and into the underlying soils. Material shall be pumped down to elevations and in quantities as directed by the Engineer.

Spin Casting

Prepare mixer and mortar per manufacturers specifications. Pump and apply immediately after mixing. Position the spin cast applicator within the center of the pipe and commence pumping the mixed mortar into the spin caster. As the mortar begins

to be centrifugally cast evenly around the interior, retrieve the spin cast applicator at the best speed for applying the thickness that has been specified. Thickness may be verified at any point. If additional thickness is desired at any location, place the spin cast applicator at that location, once initial placement is set and sufficiently hard, and recommence pumping and centrifugal casting until proper design thickness is achieved. Keep pump lines cool by spraying with cold water when temperatures are 90°F (32°C) or higher. Transfer mixed mortar from mixer to pump and immediately start next mix. Apply in suitable thickness of ¼ to 1 inch in single pass. Allow material to set and stiffen before applying subsequent pass. Due to the potential corrosion reactivity between cementitious materials and aluminum pipe, all aluminum pipe should be coated with a coal tar type coating (or similar material) prior to application of mortar.

Protection and Cleanup

The Contractor shall be responsible for storage, clean-up, and removal from the work area all debris, waste, residual repair materials, and by-products generated by the preparation and application operations to the satisfaction of the Engineer. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

Basis of Payment

The quantity of material to be paid for shall be the quantity actually used, based on the contract unit price shown on the bid form. Only those items shown on the bid sheet shall be paid for directly. All other labor, tool, equipment, and incidentals necessary for the completion of the project shall be considered incidental to the contract bid items.

T-15.54 CONFINED SPACE ENTRY

The contractor and all laborers shall be certified per OSHA regulations for Confined Space Entry. All laborers shall wear full harnesses, meeting OSHA regulations with sufficient lengths of ½ -inch nylon rope tied off at entry. An outside supervisor shall be stationed at the entry during work inside pipe. Supervisor and crew shall communicate using standard-issue 2-way communication devices. The contractor is responsible for entry using a ladder or other acceptable means. Entry security is to be maintained by the contractor during the project and in coordination with the contracting officer. The contractor is to submit copies of Confined Entry Safety plan to NCDOT engineer prior to commencement of work (see Submittals and Certifications). There will be no separate measurement or payment for any personnel, equipment or materials required to meet these regulations.

T-15.55 VENTILATION

A ventilation fan, stationed outside the pipe manhole entry, shall be utilized to pump clean air into the work area. The fan shall employ sufficient duct to force air into the work zone. Contractor is responsible for operation of fan. Air quality detection