

APPENDIX A – SPECIAL CONTRACT REQUIREMENTS

The following is a guide specification to be used for polyurethane resin injection (PUR) projects and should be modified, as necessary, to meet the specifics of each individual project. The Section and Subsection numbers shown below refer to FLH’s Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-03.

Section XXX. – POLYURETHANE RESIN INJECTION (PUR)

Description

XXX.01 This work consists of furnishing and injecting polyurethane resin (PUR) for the purpose of stabilizing, consolidating, and strengthening fractured and jointed rock masses and masoned and placed-stone earth retaining structures.

Material

XXX.02 Conform to the following Subsection:

Polyurethane Resin (PUR)	725.XX
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Construction Requirements

XXX.03 Qualifications. Submit the following at least 30 days before the start of PUR injection operations:

- (a) Submit Contractor or subcontractor references citing satisfactory completion of at least 3 PUR injection projects of similar scope and complexity within the last 3 years. Submit a brief description of each project including the owning agency's name, a contact at the owning agency, and current telephone number.
- (b) Provide an on-site supervisor and drill operators with at least 2 years experience with injecting PUR products on projects of similar scope and complexity. Identify on-site supervisors and drill operators assigned to the project and submit a summary of each individual's experience.

XXX.04 Submittals. Submit the following at least 30 days before the start of PUR injection operations:

(a) Product information.

- (1) Product description; including whether the PUR product is a single- or two-component system, what the components are and their exact mix ratios, and whether the injected PUR product is a non- to mildly-foaming hydrophobic product or a highly-foaming hydrophilic product (with approximate expansion ratios in the presence of water). Provide product information sheets and Material Safety Data Sheets (MSDS) for PUR components.

- (2) Initial and final set times.
- (3) Water absorption.
- (4) Average cured density (under dry injection conditions).
- (5) Maximum percent volume expansion in presence of water.
- (6) Compressive strength.
- (7) Tensile strength.
- (8) Shear strength.
- (9) Viscosity.
- (10) Elongation.
- (11) Flash point.
- (12) Manufacturer's recommended air and rock mass injection temperature range.
- (13) Toxicity rating when cured.

(b) Product samples. Provide cured samples of product to be injected. The CO will determine at the pre-construction meeting if sampling and testing during progression of PUR injection are necessary.

(c) Drilling and site access equipment. Provide a description of the drilling equipment to be used, including power and operating requirements, approximate dimensions of the drill rig, and range of hole sizes and depths to be drilled. Provide a description of ancillary equipment to be used to access the site, including lifts and cranes. Describe temporary ground support measures that may be required during drilling, initial PUR injection, or both.

(d) Injection equipment. Provide a description of the pumping system, power requirements, operating pressure ranges, PUR component conveyance system, PUR quantity and injection pressure measurement systems, component mixing system, and injection nozzle/packer assemblies and installation.

(e) Injection plan. Provide the approximate number, spacing and depths of holes to be drilled, and describe the general progression of work. Provide an estimate of the quantity of PUR take for each hole. Provide a description of rock mass monitoring methods and procedures to be used during PUR injection.

(f) Traffic control. Provide a proposed traffic control plan, per Section 635 Temporary Traffic Control, for both drilling and PUR injection operations. Include provisions for minimizing PUR drips onto vehicles and nearby structures.

(g) Site cleanup. Describe the methods and equipment to be used to remove PUR overruns from rock surfaces, including the estimated time interval between injection and when cleanup is to be initiated. Describe the expected degree or percent to which overruns can be successfully removed with these methods. Describe waste disposal requirements.

XXX.05 Storing and Handling. Handle and store PUR according to the manufacturer's recommendations to avoid extreme temperature variations, reduce the potential for spillage,

mitigate vapors and fumes in confined transportation vehicles or enclosures, and protect against fire hazards. Provide required cleanup equipment and resources to quickly respond to PUR component spills.

XXX.06 Injection Operations. Inject PUR according to the accepted injection plan and manufacturer's recommendations. The Contractor's means, methods and experience may suggest deviations from the general procedures presented here. Such deviations will be reviewed and approved by the CO.

Drill injection holes either in a pre-determined pattern, as shown on the plans, and/or at spot locations selected as work progresses to effectively grout the designated rock mass and confine and manage PUR volumes. Drill injection holes using dry-drilling techniques only.

Systematically inject PUR into the holes at depths, locations, and rates determined by the Contractor to optimize PUR take within the ground mass while mitigating the potential for displacing rock or creating instability within the rock mass. Begin resin injection in the lowermost holes, progressively working upward through the rock or structure mass unless conditions dictate optimal grout take through other approaches. Estimate maximum injection pressures, PUR quantities, and injection rates based on a visual site review and communicate with the CO prior to injection operations; adjust and communicate with the CO during installation as conditions warrant. The Contractor may choose to temporarily plug the exterior traces of openings and fractures to prevent premature loss of PUR prior to initial set.

Maintain a daily record of hole diameter and depths, injection packer placement depths, average and maximum injection pressures, drilling and injection times per hole, quantities injected in each hole, and any occurrences of excessive overruns, ground deformations or failures, or unplanned formation of cracks.

Clean up and dispose of PUR overruns. Continue cleanup until product overruns have been sufficiently removed to no longer be acutely visible by normal pedestrian traffic. Seal drillholes with colored grout matching the surrounding rock mass

Conduct daily safety and work coordination meetings with project and traffic control personnel. Ensure that only trained and experienced Contractor PUR injection personnel are in the immediate work zone during drilling or PUR injection activities. Determine when it is safe for project personnel and the public to travel within the work zone. Suspend vehicle and personnel travel, when necessary, within the work zone during drilling and injection activities and until sufficient PUR set has been obtained such that there is no risk of drips or airborne strands damaging vehicle finishes.

XXX.07 Acceptance. Injection of polyurethane resin will be evaluated under Subsections 106.02 and 106.04. At the discretion of the CO, the Contractor may be required to demonstrate and test their proposed means and methods through a sacrificial injection hole.

Measurement

XXX.08 Measure the Section XXX items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure total injected weight of the PUR product. Drilling, temporary support measures, ground monitoring, site access and cleanup/waste disposal will not be measured for payment, and are considered incidental to PUR injection.

Payment

XXX.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 725. – MISCELLANEOUS MATERIAL

725.XX Polyurethane Resin (PUR). Use hydrophobic to mildly hydrophilic polyurethane resin conforming to the following:

(a) Initial set time at 60°F	1 to 5 minutes
(b) Final cure time at 60°F	24 to 48 hours
(c) Max. cured density (under dry injection conditions), ASTM D 3800 / D1622	60 to 80 pounds per cubic ft
(d) Min. cured density (under damp/wet injection conditions), ASTM D 3800 / D 1622	5 to 20 pounds per cubic ft, min.
(e) Compressive strength, ASTM D 695 / D1621	6,000 pounds per square in, min.
(f) Tensile strength, ASTM D 638 / D 1623	2,000 pounds per square in, min.
(g) Viscosity at 75°F, ASTM D 1638	100-200 centipoise
(h) Min./max. air and rock mass injection temperature range	50 °F - 95 °F