Quality Assurance/Quality Control Program

I. Summary

FerraTex has established and refined a strict Quality Control Program to ensure that all material and workmanship exceed the minimum standards and guarantee the finished product/facility performs according to design. This Program has been successfully implemented on past projects and is used on all current and future projects. The Program provides a rigid framework but is easily modified to incorporate specific requirements of the Owner.

A. Measurements made to verify the length and cross-section dimensions of the original sewer pipe prior to ordering materials and the liner thickness to be provided for each segment will be submitted.

B. Initial flexural stress will meet or exceed 4500 psi, initial flexural modulus will meet or exceed 300,000 psi and tensile strength is not applicable with gravity pipe.

C. Any liner showing a split or tear, which cannot be repaired, shall be marked as rejected and immediately removed from the job site.

D. The cured-in-place pipe lining system has a minimum design service life of fifty (50) years.

E. The CIPP liner, when cured, will form a continuous, tight fitting, hard, impermeable liner that is resistant to chemicals found in domestic sewage and trace amounts of gasoline and other oil products commonly found in municipal sewage and soils adjacent to the pipe to be lined.

F. The CIPP liners will be fabricated to a size that when reformed will tightly fit the internal surface and the length of the pipe being rehabilitated. Confirm that allowances for circumferential and longitudinal expansion will be taken into account.

G. All dimensions shall be field verified prior to fabricating the liner and that the fabricator shall confirm all dimensions and installation parameters with the field superintendents prior to fabricating the tube. The tube fabricator shall certify that the tube has been fabricated to tightly fit the internal circumference of the original sewer based on the data provided.

H. To ensure that the material and workmanship involved in installing a FerraTex CIPP liner is of the highest quality, open communication pathways are maintained between the Superintendent (field operations), the QC Supervisor (project management), and the material Supplier. These communication pathways are depicted in the flow chart in Appendix A.

II. Liner Production QA/QC

This section details the QA/QC procedures involved in production of the FerraTex Liner CIPP.

- Liner requirements are collected by way of the job order from the superintendent, and are confirmed by the plant manager.
- Once all requirements are known, a liner is designed which will fulfill all the requirements.
- The design is detailed to the production department and then entered into the production schedule.
- The control and test of the liner properties are detailed in Table 1.
- From each liner produced, a sample is cut from one end for QC inspection and test. This sample is destructively tested to ensure that all of the liner properties are within the manufacturing criteria.

Table 1-Control & Testing During Production

Property	Control	Test
Circumference of Liner	Monitored at each production stage against manufacturing criteria.	Destructive test of sample. All layers are measured.
Length of Liner	Monitored at each production stage against manufacturing criteria.	Inspection procedure includes measurement of a sample of liners against manufacturing criteria.
Felt Weld Strength	All welding equipment operates at set parameters.	Each weld is visually inspected during production.
Sealing Tape Weld Strengths	All welding equipment operates at set parameters.	Each weld is visually inspected for air inclusion

1 Liner Components

The history of FerraTex's operation dates back to 1989. Our Cured-In-Place Pipe Liners are made of flat stock polyester felt material and Isophthalic polyester resin and are manufactured to comply with requirements of ASTM F1216. The FerraTex Liner CIPP is manufactured at our facility in McKenney, VA. The dry or wet-out tube (depending on the installation) is folded and shipped to the job site according to the installation schedule. The following table lists the components that make up the FerraTex Liner CIPP.

Table 2 – FerraTex Liner CIPP Components

	Material	Type	Product Name	Manufacturer
FERRATEX LINER (CIPP)	Raw Felt (Flat stock)	Polyethylene Terephthalate	Polyester Needled Felt	Non Woven or Applied Felts Inc.
	Polyurethane Membrane	Polypropylene or Thermoplastic Polyurethane Polymer	Polypropylene or Polyurethane Coated Liner	Applied Felts Inc. OR Haartz
	Resin	Polyester Vinyl Ester Styrene Free-Vinyl Ester	COR series L7 Series	Interplastics Corp. AOC
	Catalyst (Initiator)	Peroxide	TRIGNOX® C	Akzo Nobel
		Peroxide	TRIGNOX® K-90	Akzo Nobel
		Peroxide	TRIGNOX® 121 BB75	Akzo Nobel
		Peroxide	PERKADOX® 16	Akzo Nobel

* Resin System may be either polyester, vinyl ester or styrene free vinyl ester type systems, depending on the application

2 Pipe Lining System

The product description is taken from observation during the installation process. This process changes from application to application. The following notes are not intended to be complete and exhaustive descriptions, but are a brief description of the proposed construction system.

FerraTex Liner CIPP consists of polyester felt, polyester resin, and polyurethane (PU) or polypropylene PP coating. The polyester felt is overlaid on one side with a PU or PP barrier and formed into a tube with a diameter to match the pipe, and a thickness as required for

strength. The polyester felt tube is impregnated with polyester resin and the tube is inverted in place and cured.

2.1 Cured Resin Properties

The cured resin can attain physical properties as high as the following values:

Table 3 – Cured Resin Properties

Description	Value	Test Method
Initial Flexural Strength (psi)	>4,500 (Typically ≥ 6,000)	ASTM D-790
Initial Flexural Modulus (psi)	> 300,000 (Typically ≥ 400,000)	ASTM D-790
Tensile elongation (%)	< 2	ASTM D-638
Compressive Strength (psi)	15,000	ASTM D-695
Hardness (Barcol)	50 – 55	ASTM D-785

2.2 Lining System Materials & Processes

2.2.1 Material Inspection & Receiving Report

The shipping documents received at the plant in McKenney, VA or at the site with each individual load will include: (a) the shipper; (b) shipping point; (c) consignee; (d) contract and item number; (e) product identification; (f) gallons or dimensions; (g) (if shop wetout).

2.2.2 Housekeeping & Cleanliness During Manufacturing

Cleanliness is essential during the resin mixing process. Resins must not be in direct sunlight during mixing, transportation or inversion.

2.2.2.1 Resin Storage

Improper storage of the resin will cause premature exotherm. Resins are perishable materials that have a shelf and pot life. Resin storage is as recommended by the manufacturer. The tests for deterioration of resin include visual observation, gel time and/or viscosity.

2.2.2.2 Catalyst & Promoters

Catalyst and promoters are stored separately and away from other flammable material. The stock is rotated so the maximum storage time is as recommended by the manufacturer.

2.2.2.3 Solvents

Solvents are used in the tube manufacturing process for patching the coating and taping the seams. The most commonly used solvent is Tetrahydofuran (THF), which is highly flammable; only a small quantity of this solvent is needed to bond the tube coating..

2.2.3 Tube Fabrication

Liner fabrication starts with a field report of the actual length of the line to be rehabilitated. This initial record includes the diameter of the pipe, depth of each manhole structures on either side of the reach and the height of the water inversion tower. The liner length is indicated by making tic marcs, with the actual length value in 5-foot intervals, on the liner itself using a permanent ink. The thickness of the liner is made with one or many layers of felt with the outer layer coated with polyurethane.

2.2.3.1 Heat Bonding

Plain felt is jointed by heat bonding. This process will be performed at the factory plant only. Only in rare cases of a liner being too long to ship, it may become necessary to field splice two or more sections together. Heated air is passed quickly between the felt layers so that only the extreme outer fibers of each felt layer are melted.

2.2.3.2 Thickness Varying

A particular liner maybe designed and constructed with varying thicknesses over a certain length, particularly if that liner is being installed through multiple pipe segments. The amount of overlying ground and water pressure loading typically varies over the length of a pipe segment and more so with multiple pipe segments. With that in mind when a liner is designed it may be beneficial to design the liner with varying thicknesses over the length of the liner. The minimum thickness of the liner is calculated (according to ASTM F1216-07b) based on the maximum ground and water pressure loading over the particular pipe length. The liner is then constructed according to the liner design with the thickness always equal to or greater than the minimum design thickness. For quality assurance the transition from one thickness to another is carried out so that the thicker of the two liner sections extends 10ft in the direction of decreasing thickness to assure that the thickness of the installed liner is never less than the minimum design thickness.

2.2.3.3 Diameter Varying

A particular liner maybe designed and constructed with varying diameter over a certain length. This is done when producing a liner that is to be installed through multiple pipe segments that do not have the same diameter sizes. Using the information from the field reports of the measured host pipe a liner maybe constructed so that it is tapered to transition from one diameter to another.

2.2.3.4 Inspections & Reporting During Tube Fabrication.

All relevant facts about the dry tube fabrication is recorded by direct observation. Measurements of the liner in its 'lay-flat' configuration along with length numbering, bag end installation and rope installation information are indicated on the quality control report completed for each liner produced (see sample report in Appendix B). A certificate of compliance is also generated for each liner certifying its dimensions and build information (see Appendix C). Cutting and assembling of the materials is done in a well-ventilated and well lighted area.