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Technical Information: Standard Inverted and Pull-In CIPP

1. The CIPP Technical Envelope

	Water Inversion	Steam Inversion	Pull-In
Diameter Range	6 in. - 124 in.	6 in. - 72 in.	6 in. - 12in.
Thickness Limit	50 mm.	Varies	4.5 mm. - 9.0 mm.
pH Range (Polyester Resin Only)	0.5-10.5	0.5-10.5	0.5-10.5
Effluent Temperature (Vinylester resin for 120-140 F)	Up to 140° F	Up to 140° F	Up to 140° F
Structural	Yes	Yes	Yes
Bends	Case by Case Basis	Case by Case Basis	No
Offset Joints	Yes	Yes	Minimal
Diameter Changes	Yes	No	No
Thickness Changes	Yes	No	No
Shot Length (Diameter Dependent)	Up to 2500 ft.	Up to 800 ft.	Up to 800 ft.
Host Pipe Shape	All Shapes	Most Shapes	Round
Host Pipe Material	All Materials	All Materials	All excluding plastic or asbestos cement pipe
Resin	Polyester or Vinylester	Polyester or Vinylester	Polyester or Vinylester

2. Raw Materials

Suppliers are given specifications that must be met for each material.

Part of Tube	Raw Materials Used
Felt	Polyester Fiber
Coating	Polypropylene Blend Polyethylene Blend
Thread	Polyester Thread (Standard Inverted) Cotton Sheathed Polyester Thread (Pull-In) Aramid Fiber Thread (Standard Inverted and Pull-In)

The following characteristics of the Raw Materials are evaluated for Quality Assurance:

Raw Material	Characteristic	Evaluation Method
Fiber	Denier	Visual Reference: Material Tag
Fiber	Crimps per inch	Certificate of Analysis
Fiber	% Finish	Certificate of Analysis
Fiber	Staple Length	Certificate of Analysis
Fiber	Tenacity	Certificate of Analysis
Fiber	Elongation %	Certificate of Analysis
PE Pellets	Melt Index	Certificate of Analysis
PE Pellets	Density	Certificate of Analysis
PE Pellets	Gel Count	Certificate of Analysis
PP Pellets	Melt Flow	Certificate of Analysis
Thread	Strength	Certificate of Analysis
Thread	Elongation	Certificate of Analysis
Thread	Lube	Certificate of Analysis

3. Manufacturing Process

Tubes are manufactured in Batesville, Mississippi, United States and meet all relevant specifications for a cured-in-place pipe product: ASTM D5813, ASTM F1216, and ASTM F1743.

The finished tube is manufactured using multiple layers of felt, with one layer coated with polypropylene or polyethylene plastic. The layers are cut/slit to the desired width and sewn concentrically. The coated layer is also sealed at the seam using an extrusion or taping process to form the final tube. The tube is then inspected and packaged for shipment. All manufacturing processes operate under a quality system that is certified to the ISO9001: 2008 standard.

Step One: Felting

Felt production is achieved by a non-woven process (needle punch) using polyester fiber. The finished felt rolls undergo tests to ensure weight, thickness, density, and elongation meet documented specifications. Multiple samples are taken across the full width of each roll of material produced to ensure fabric consistency. Multiple samples are taken in the machine and cross-machine direction of the fabric to test the fabric stretch at varying loads and the tensile strength. 100% of all felt produced is tested for thickness under a specified load. Tensile strength testing is in accordance with ASTM Standard D5813. For test results, see Appendix A.

The following characteristics are evaluated throughout the Felting process for Quality Assurance:

Characteristic	Evaluation Method
Weight	Scale
Thickness	Compression Testing Machine
Elongation	Tensile Testing Machine
Tensile Strength	Tensile Testing Machine

Step Two: Coating

Felt tubes are coated with a permanently-bonded, continuous layer of polypropylene or polyethylene. The coating is firmly attached to the felt and is resistant to hydrolysis and chemical attack. Because of this, polypropylene and polyethylene coatings have a greater longevity than polyurethane coatings. Polypropylene and polyethylene coatings have also been tested and proven to be more resilient to styrene based resins. Polyurethane coatings tend to swell and blister under prolonged styrene exposure which can adversely affect the final cured product.

The following characteristics are evaluated throughout the Coating process for Quality Assurance:

Characteristic	Evaluation Method
Overall Thickness	Compression Testing Machine
Coating Thickness	Dial Indicator
Weight	Scale
Peel Strength	Tensile Testing Machine
Tensile	Tensile Testing Machine
Elongation	Tensile Testing Machine

Step Three: Slitting

Special cut widths are used depending on whether the tube will be inverted or pulled in, and the width of the fabric ultimately depends on the overall design diameter and thickness of the tube being produced.

The following characteristics are evaluated throughout the Slitting process for Quality Assurance:

Characteristic	Evaluation Method
Width	Tape Measure
Length	Mechanical roll counter
Material Type, Job # & Sequence	Verify roll ticket and roll # to cut requisition
Surface Contaminants	Visual
Holes / Cuts / Tears	Visual

Step Four: Sewing

Tubes are sewn together using a butt sewn seam and are tested to ensure the seam is as strong as or stronger than the fabric. The butt sewn seam eliminates the need for overlapped seams. To create uniform thickness around the full circumference of the tube, Insituform developed and patented a method for sewing together the butted ends of our fabric. Our experience has shown that the strongest tubes with the fewest wrinkles are made with butt-sewn seams because overlapped seams have shown to create uneven thickness, resin lean areas, and surface wrinkles.

The following characteristics are evaluated throughout the Coating process for Quality Assurance:

Characteristic	Evaluation Method
Material Type/ Coating / Sequence	Verify roll ticket and roll # to sew order
Width	Tape Measure
Flamebond Attachment	Pull at Flamebond area
Flamebond Tensile Strength	Tensile Testing Machine
Flamebond Peel Strength	Tensile Testing Machine
Flamebond Machine Settings	Record Settings
Stitches per inch	Tape Measure
Seam Structure	Visual Inspection
Surface Contaminants	Visual
Coating Voids	Visual
Holes / Cuts / Tears	Visual
Dropped Stitches	Visual
Starter Rope Location	Tape Measure

Step Five: Extrusion/Taping

An extrusion or taping process is used to bond the coated layer at the seam.

The following characteristics are evaluated throughout the extrusion process for Quality Assurance:

Characteristic	Evaluation Method
Coating / Material Type	Verify to Order
Thickness	Bulk Test with scale
Adhesion	Peel Testing
Adhesion	Verify Correct Extruder Settings
Adhesion	Verify Correct Extruder Settings
Correct Extrusion Material	Verify with order ticket
Extrusion Location	Automated Camera System
Extrusion Location	Visual
Extrusion Voids	Visual
Excessive / Uneven Extrusion	Visual
Heat/Pressure (Taping System)	Visual

Step Six: Inspection

The tubes go through a 100% inspection process to ensure we are shipping the highest quality product. This includes a dye bath on the standard inverted product that highlights any pinholes that might be present in the coated layer. All repairs are made prior to the tubes being shipped.

The following characteristics are evaluated throughout the Inspection process for Quality Assurance:

Characteristic	Evaluation Method
Watertight Outer Tube	Vacuum Test (Inverted Tube Only)
Watertight Outer tube	Dye Bath (Inverted Tube Only)
Seam Structure	Visual
Extrusion / Tape Location	Visual
Extrusion / Tape Voids	Visual
Excessive / Uneven Extrusion / Tape	Visual
Surface Contaminants	Visual
Coating Voids	Visual / Dye Bath (Inverted Tube Only)
Holes / Cuts / Tears	Visual / Dye Bath (Inverted Tube Only)

Appendix A:

The following material test records are samples of actual test data results for non-woven fabrics (felt) used in the manufacturing of Insituform tubes. The testing criteria for these materials meet the following standards:

- ASTM D-5199 – Standard Test Method for Thickness of Geotextile/Geomembranes
- ASTM D-5035 – Standard Test Method for Breaking Force & Elongation of Textile Fabrics

Additionally, per ASTM D-5813 – Standard Specification for Cured-In-Place Thermosetting Resin Sewer Pipe, all supplied materials meet or exceed the 750 psi “Fabric Tube Strength” requirement as defined by paragraph 6.1 of the specification. The porosity of our fibers is approximately 85%.

This is conformation that all materials supplied by Insituform Technologies, Inc. are tested for product quality and fitness for use per the aforementioned ASTM guidelines with all test records maintained and made available at the customer’s request.

3mm Coated Felt

Roll	Line	Material	Work Order	Date	Thickness (ASTM D5199)	CD Tensile (ASTM 5035)	MD Tensile (ASTM 5035)
8433	3	3100183	369023	12/20/2011	3.4	1240	1292
8434	3	3100183	369023	12/20/2011	3.3	1290	1380
8436	3	3100183	369023	12/21/2011	3.2	1247	1324
8437	3	3100183	369023	12/21/2011	3.3	1263	1344
8438	3	3100183	369023	12/21/2011	3.2	1259	1347
8439	3	3100183	369023	12/21/2011	3.4	1155	1315
8440	3	3100183	369023	12/21/2011	3.3	1244	1247
8441	3	3100183	369023	12/21/2011	3.4	1213	1264
8442	3	3100183	369023	12/21/2011	3.2	1272	1339
8443	3	3100183	369023	12/21/2011	3.2	1245	1279

16oz Material - 3mm Plain Felt

Roll	Line	Material	Work Order	Date	Thickness (ASTM D5199)	CD Tensile (ASTM 5035)	MD Tensile (ASTM 5035)
6771	2	3000003	365316	11/30/2011	3.2	1121	1135
6772	2	3000003	365316	11/30/2011	3.2	1186	1121
6773	2	3000003	365316	12/1/2011	3.1	1217	1087
6774	2	3000003	365316	12/1/2011	3.4	1183	1173
6775	2	3000003	365316	12/1/2011	3.1	1134	1073
6776	2	3000003	365316	12/1/2011	3.3	1128	1143
6777	2	3000003	365316	12/1/2011	3.2	1251	1074
6778	2	3000003	365316	12/1/2011	3.3	1167	1122
6779	2	3000003	365316	12/1/2011	3.3	1235	1136
6780	2	3000003	365316	12/1/2011	3.2	1226	1114

24oz Material - 4.5mm Plain Felt

Roll	Line	Material	Work Order	Date	Thickness (ASTM D5199)	CD Tensile (ASTM 5035)	MD Tensile (ASTM 5035)
7849	1	3000064	369019	12/13/2011	4.9	1137	1063
7850	1	3000064	369019	12/13/2011	4.8	1071	1012
7851	1	3000064	369019	12/13/2011	4.8	1050	1068
7852	1	3000064	369019	12/13/2011	4.7	1057	1060
7853	1	3000064	369019	12/13/2011	4.7	1116	1005
7854	1	3000064	369019	12/13/2011	4.7	1074	1047
7855	1	3000064	369019	12/13/2011	4.8	1167	1027
7856	1	3000064	369019	12/13/2011	5.1	1218	1132
7857	1	3000064	369019	12/13/2011	5	1190	1059
7858	1	3000064	369019	12/13/2011	4.9	1084	1051

30oz Material - 6mm Plain Felt

Roll	Line	Material	Work Order	Date	Thickness (ASTM D5199)	CD Tensile (ASTM 5035)	MD Tensile (ASTM 5035)
8124	1	3000069	369020	12/21/2011	6.5	1121	1059
8125	1	3000069	369020	12/21/2011	6.5	1126	1122
8126	1	3000069	369020	12/21/2011	6.4	1092	1039
8127	1	3000069	369020	12/21/2011	6.5	1045	1044
8128	1	3000069	369020	12/21/2011	6.5	1109	1076
8129	1	3000069	369020	12/21/2011	6.3	1069	1065
8130	1	3000069	369020	12/21/2011	6.3	1071	1132
8131	1	3000069	369020	12/21/2011	6.6	1096	1100
8132	1	3000069	369020	12/21/2011	6.4	1155	1083
8133	1	3000069	369020	12/21/2011	6.5	1050	1090