

**SPECIFICATIONS
FOR
INTERNAL REPAIR OF PIPES USING
PIPEMEDIC™**

FIBER REINFORCED POLYMER (FRP) COMPOSITE LAMINATES

1. INTENT

It is the intent of this specification to provide for the renovation of gravity or pressure pipelines by the installation of the innovative, patent-pending PipeMedic™, a fiber reinforced polymer (FRP) laminate to the inside surface of the pipe. A FRP composite laminate lining is formed by the insertion of single rings or a continuous spiral, of significantly strong PipeMedic™ sheets inside the pipe. A pressure vessel is constructed inside the pipe with the application of these laminates into the existing pipe capable of handling all axial and longitudinal internal forces. The finished product is a joint-less pipe lining that is formed to the profile of the existing pipe. PipeMedic™ is designed as a Class IV full structural repair capable of handling all internal pressure forces, to span and seal pinholes, eliminate leakage through joints, and prevent internal corrosion in the host pipe.

2. REFERENCED DOCUMENTS

The following references are incorporated into these specifications. The ACI and ICRI references are not specifically developed for concrete or corrugated metal pipe and are applicable only to the extent referenced. These written specifications take precedence over incorporated references. The references used shall be the latest available version of:

ACI 440.2R – Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures

ACI 440.3R – Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures

ACI 503R – Use of Epoxy Compounds with Concrete

ASTM D2247 – Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity

ASTM D3039 – Test Method for Tensile Properties of Polymer Matrix Composite Materials

ASTM D3410 – Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading

ASTM D7290 – Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications

ASTM E2092 – Standard Test Method for Distortion Temperature in Three-Point Bending by Thermomechanical Analysis

ICRI Guideline No. 03732 – Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

ICRI Guideline No. 03733 – Guide for Selecting and Specifying Materials for Repairs of Concrete Surfaces

3. PREQUALIFICATION

- 3.1 The Manufacturer/Supplier must support a training program to instruct system installers in the installation of the products specified in these specifications.
- 3.2 The Contractor's field representatives shall have completed the training program supported by the Manufacturer/Supplier on the installation of FRP laminated systems specified in these specifications and shall have experience in confined spaces. Any change of Contractor's representatives is subject to the same qualifications.
- 3.3 The Contractor shall be qualified and certified by OSHA for confined space training (if required by the project conditions), and have proper and proven equipment, supervisory personnel, and installation execution proposal. The Contractor shall have on site calibrated gas testers for all phases of work at all times.
- 3.4 References: Installation references of projects that are similar in size and scope to this project shall be submitted. The submittal shall include, at a minimum, the client contact name, phone number, and the diameter and footage of pipe(s) rehabilitated.

4. MATERIALS

The FRP composite system shall be a system consisting of all associated fiber reinforcement and polymer adhesives/resins. All components of the FRP composite system including primer, thickened epoxy, fiber reinforcement, impregnating resin, and top coat resin shall be compatible and provided by the same Manufacturer/Supplier. The laminates shall be manufactured in a ISO 9000 compliant manufacturing facility.

With PipeMedic™, the carbon fabrics of any design (up to a width of 60 inches) are saturated with the resin and run through a special press; the result is a solid laminate with a thickness that can be set from 0.02 to 0.08 inches. The high-quality ISO 9000 approved plant-manufactured laminates offer consistent and uniform mechanical properties and are packaged in approximately 12-inch coils for convenient shipment.

As the coil is carefully opened inside of the pipe, its elastic memory will cause the laminate to push itself against the inner surface of the pipe -- like a loaded spring!. A thin layer of epoxy (tack coat) is applied to the back side of PipeMedic™ to provide bonding to the pipe. In single rings or a continuous spiral, a significantly strong carbon FRP pressure vessel is constructed inside of the pipe with the application of these laminates.

- 4.1 Packaging: Standard rolls are 24 in. X 450 feet (610 mm X 135 m). PipeMedic™ laminates can be custom manufactured in widths up to 60 inches.
- 4.2 Manufacturer's/Supplier's Material Safety Data Sheets (MSDS) for all materials to be used shall be provided.

4.3 Application instructions, delivery, storage and handling instructions, and general recommendations regarding each material to be used will be provided by Manufacturer/Supplier.

5. DESIGN PARAMETERS

5.1 The structural properties of the FRP laminate sheets shall be determined according to the proper ASTM standard. The minimum design values for the FRP will be determined by the engineer based on the project needs.

5.2 The design of the pipe lining shall be based on the following parameters, unless otherwise specified by the Owner:

Diameter _____ inches
 Internal Operating Pressure _____ psi
 Total Operating Pressure _____ psi
 Minimum Operating Temperature _____ °F
 Internal Vacuum, if applicable _____ psi
 Design Life 50 Years

5.3 The physical properties used in the design submittal shall be clearly identified. These physical properties shall be the basis for the acceptance of the final product. At a minimum, the pipe lining shall have the following physical properties:

	ASTM TEST METHOD	MINIMUM PROPERTY VALUE
Glass Laminate:		
Glass Laminate Initial Tensile Strength	D638	60,000 psi
Glass Laminate Initial Tensile Modulus	D638	3,500,000 psi
Uniaxial Carbon Laminate:		
Carbon Fiber Laminate Initial Tensile Strength	D638	150,000 psi
Carbon Fiber Laminate Initial Tensile Modulus	D638	13,500,000 psi

*Values are for design conditions at 75°F (25°C)

5.4 The pipe lining shall be designed to span over any small holes that exist in the pipeline under the normal internal pressure design conditions. For the hole spanning condition, the design shall be based on factor of safety of 2.0 and a flexural strength, reduced to account for long-term effects, equal to 1/3 of the initial design flexural strength.

5.5 The pipe lining shall be capable of withstanding the thermal stresses induced at the minimum operating temperature specified in Section 5.2.

6. SUBMITTAL

6.1 Design: Detailed design calculations for both the internal and external loading parameters specified in Section 5 shall be submitted for review and approval. The design submittal shall follow the requirements specified in Section 5. The design

submittal shall also clearly identify the physical properties used for design. These physical properties shall be the basis for acceptance of the final product.

- 6.2 Product data sheets for all materials to be used in the FRP laminate system including all material property data listed.
- 6.3 Working drawings detailing the type, locations, dimensions, number of layers, and orientations of all FRP materials to be installed.
- 6.4 Tensile test results for the FRP system reported by an independent testing agency.
- 6.5 Material Safety Data Sheets for all materials to be used.
- 6.6 Chemical Resistance: The Contractor shall submit test results which indicate that the pipe lining system proposed meets the chemical resistance requirements of the owner.
- 6.7 Hydraulic Capacity: The Contractor shall submit calculations which show that the pipe lining, at a minimum, achieves 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.
- 6.8 Field Samples: The Owner may request physical property tests from samples of laminates furnished for this project. These test results must verify that the physical properties used in the design submittal have been achieved.
- 6.9 Delivery, storage, handling, and application instructions and general recommendations for each material to be used.
- 6.10 Reinstatements: The Contractor shall submit details of how existing tees, air relief valves, blow-off valves, threaded taps, etc., will be reinstated. Reinstatements shall provide a sufficient seal to prevent water tracking between the pipe lining and the host pipe.
- 6.11 Access Points: The number and location of access points required for installation of the pipe lining shall be provided.

7. INSTALLATION

7.1 Access, Cleaning and Inspection

7.1.1 Prior to entering access areas (such as manholes) and performing inspection or cleaning operations, the Contractor shall make an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen and detection measures shall be undertaken in accordance with local, state, or federal safety regulations.

7.1.2 The Owner shall provide rights of access to the pipeline. The Contractor or Owner, as specified in the contract documents, shall provide the excavation, pipe work, reconnection and restoration for installation access points.

7.1.3 The Contractor shall remove all internal debris out of the pipeline that will interfere with the pipe liner installation. Pipes shall be cleaned by the Contractor, as

needed, with high-velocity jet cleaners, mechanically powered equipment, cable-attached devices or fluid-propelled devices (e.g., pipe pigs). Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. The Owner shall provide a dump site for all debris removed from the pipe during the cleaning operation. Unless specified otherwise, this site shall be at or near the project site. Any hazardous waste material encountered during this project shall be considered as a changed condition.

7.1.4 Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, etc., by closed-circuit television or man entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of PipeMedic™, and it shall be noted so that these conditions can be corrected. If unseen obstructions are encountered that will prevent proper installation, the Contractor shall remove such obstructions on written order from the Owner.

7.2 Bypassing - the Owner shall be responsible for bypassing the flow during the renovation process.

7.3 Installation

7.3.1 The existing pipeline shall be dewatered and free of incoming water.

7.3.2 Wipe PipeMedic™ with appropriate cleaner (e.g. acetone or MEK) using clean cloth.

7.3.3 Apply QuakeBond™ J201TC onto the substrate or the back side of PipeMedic™ with a trowel or spatula to a nominal thickness of 40 mil (1.0 mm). A notched trowel may be used for this application.

7.3.3 Apply the epoxy coated face against the surface of the pipe or tank and press firmly with hand pressure to ensure uniform contact between PipeMedic™ and the substrate surface.

7.3.4 Provide adequate overlaps in the hoop and longitudinal direction.

7.3.5 The bonded PipeMedic™ laminates should not be disturbed for 24 hours.

7.3.6 Laminates can be cut to appropriate length using commercial quality heavy duty shears. Care must be taken to support both sides of the laminate to avoid splintering. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

7.3.7 PipeMedic™ PC4 is non-reactive and fully cured. It does not require a Material safety Data Sheet (MSDS). However, caution must be used when handling since a fine carbon dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Care must also be taken when cutting the laminates to protect against airborne carbon dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

7.4 Storage

7.4.1 Contractor will store materials in areas where temperatures conform to Manufacturer/Supplier's written recommendations and instructions.

7.4.2 Stored FRP laminated sheets and resins must be protected from dust, moisture, and chemical exposure.

7.4.3 Resins must be stored in areas with an ambient temperature between 50°F and 75°F and away from direct sunlight, flame sources, or other hazards. Resin components must be stored separately and in tightly closed containers.

7.4.4 In the event that the work is to be completed during winter or in temperatures below freezing the fiber reinforcement and resins shall not be exposed to freezing temperatures during transport, storage, preparation, installation or curing.

8. INTERNAL END SEALS AND REINSTATEMENTS

8.1 The Contractor shall install end seals at the pipe lining beginning and termination points.

8.2 The end seals shall be a wet layup design per Manufacturer/Supplier recommendation or mechanical, expansion type, constructed of stainless steel and elastomeric seals. The end seals shall be rated by the manufacturer for the operating pressure and shall be compatible with the piped fluid. The pipe at the end of the seal installation points shall be structurally sound and free of any significant pitting or heavy corrosion. This is required to ensure an adequate seal between the pipe lining and the existing pipeline.

8.3 All reinstatements of tees, air relief valves, blow-off valves, threaded taps, etc., shall be completed following the approved procedures identified in the submittal described in Section 6.10 of this specification.

9. INSPECTION AND TESTING

9.1 The installation shall be inspected visually. No infiltration of groundwater shall be observed.

9.2 The finished pipe lining shall be continuous over the entire length of an installation run and be free of dry spots, lifts, and delaminations.

9.3 The pipe lining shall be pressure tested for water tightness following the test protocol described in Section 10.

10. PRESSURE TESTING FOR WATER TIGHTNESS

10.1 This section provides procedures for pressure testing for water tightness of pipe lining used in the renovation of pressure pipelines. Pressure testing for water tightness shall be provided on all pipe lining sections identified by the Owner in the contract documents or purchase order.

10.2 Test Procedure

10.2.1 The test section shall be subjected to a hydrostatic pressure of twice the known internal operating pressure (specified in Section 5.2) or at the internal operating pressure plus 50 psi, whichever is less.

10.2.2 The pressure test shall be conducted after placement of all appurtenances such as end seals, reinstatements of side connections, corporation stops, etc. To avoid the

testing of other associated piping, the side connections, corporation stops, etc., shall be capped or otherwise isolated. When sections of rehabilitated piping are reconnected with new spool pieces, ensure that all flange connections are watertight during the pressure test. Note: The emphasis is that only renovated piping (and its appurtenances) shall be tested. Otherwise, leakage in other side piping could contribute to a leakage rate measured for the pipe lining.

10.2.4 The pipe section to be tested shall be isolated with blind flanges or other appropriate method rated for the required test pressure. Means for air relief and filling the test section with water shall be provided. The line tested shall be configured such that leakage from the ends and branch lines can be monitored.

10.2.5 The ends, termination points, elbows, etc. that are removed shall be properly braced, blocked and supported for the duration of the test. The test pressure shall not exceed the safe pressure on such fittings.

10.2.6 The test shall be one hour in duration.

10.2.7 The test section shall be filled slowly from any available water source. All air shall be expelled from the pipeline during filling. This is a very critical step of the process since trapped air will compress during pressurization giving erroneous leakage measurements. When filling the pipeline with water, all air release valves and the high elevation end of the pipeline shall be opened until a free flow of water is visible, to release all air from the pipeline to be tested.

10.2.8 Once the pipe lining is filled, the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Owner. The test pressure shall be applied in steps at intervals of 50 psi or one-half of the test pressure, whichever is less, until the required test pressure is reached. The pressure shall be held at each step for a minimum of 30 minutes.

10.2.9 Bleed off any air at the ends of the test section prior to beginning the test. As stated previously, the pressure test shall be for a duration of one hour. After the one hour test, the amount of make-up water needed to return to the required pressure shall be quantified.

10.3 Acceptance

The test shall require that the quantified make-up water for the one hour test shall not exceed 20 gallons per inch-diameter, per mile of pipe, per 24 hour day (20 GPDIM). The quantified make-up water for the one hour test shall be extrapolated to the 24 hour rate for comparison purposes. Any visible leakage at termination points shall be eliminated. If not feasible or possible at the time of the test, the termination point leakage shall be kept to a minimum, collected and then deducted from the actual make-up water rate. If the leakage at test pressure exceeds the allowable, the Contractor shall endeavor to locate the source of the leakage and reduce it in a manner acceptable to the Owner. The pressure test for water-tightness shall be deemed acceptable if that actually measured during the one hour test (which has been extrapolated to a 24 hour day rate) is equal to or less than the allowable make-up water rate of 20 GPDIM.

11. CLEAN-UP

11.1 Upon acceptance of the installation, the Contractor shall reinstate, to original conditions, the project area affected by the operations.