Designation: F2994 – 13

Standard Practice for Utilization of Mobile, Automated Cured-In-Place Pipe (CIPP) Impregnation Systems[1]

This standard is issued under the fixed designation F2994; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes the procedures for the impregnation of 4 to 48 in (100 to 1200 mm) diameter cured-in-place pipe utilizing mobile, automated systems. Temporary impregnation facilities set up at the jobsite ("over-the-hole" wet outs) are not covered under this standard. Once resin saturation is complete, the wet out liner is then used to rehabilitate existing gravity flow or pressure pipelines, process piping, electrical conduits or ventilation systems.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1600 Terminology for Abbreviated Terms Relating to Plastics

D5813 Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems

F412 Terminology Relating to Plastic Piping Systems

F1216 Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *certificate of analysis (COA), n*—Documented evidence of the quality control testing performed on the resin and catalyst formulations. As a minimum, the COA shall include the product name; batch number; date of manufacture; name, address and phone number of manufacturer; test methods; test limits and actual results.

3.2.2 *CIPP automation, n*—The use of PLCs and HMIs to control the operation of a mobile impregnation unit. As a minimum, the following functions shall be controlled and monitored by the CIPP automation process: Operating speed and pressure of resin and catalyst pumps; resin and catalyst temperature, mixing ratio, tank levels, utilization, recirculation and dispense; vacuum pump operation; calibration roller speed, direction and gap setting. Data from all installations shall be electronically stored on an internal memory device integrated into the HMI and shall be downloadable to an external storage device for project quality assurance recordkeeping. The data stored shall at a minimum include: project name, identification number and location; date and time of processing wet out; CIPP liner diameter, thickness and length; and resin and catalyst temperatures and volumes utilized. Additional data recorded may include the calibration roller distance, gap setting and roller speed.

3.2.3 *cured-in-place pipe (CIPP), n*—a hollow cylinder containing a nonwoven or a woven material, or a combination of nonwoven and woven material surrounded by a cured thermosetting resin. Plastic coatings may be included. This pipe is formed within an existing pipe. Therefore, it takes the shape of and fits tightly to the existing pipe.

3.2.4 *electric calibration roller, n*—Electrically driven or variable speed hydraulic drive device used to assist with the impregnation process. Resin saturated liners shall pass through the rollers at a set speed and gap setting. The gap setting shall be adjustable and measurable via a mechanical scale or the electronic display of the HMI. The linear rate of the CIPP liner processed through the roller shall be adjustable via a variable speed drive or the electronic display of the HMI.

3.2.5 *impregnation module, n*—fully contained, insulated system used in the production of CIPP on a mobile impregnation unit.

3.2.5.1 *Discussion*—The module shall operate through CIPP

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

automation and as a minimum shall include the following components: precision pumps and metering devices, bulk resin and catalyst storage tanks with temperature control system, roller bed, work table, external connections for resin and catalyst filling, compatible piping, hoses, directional flow control valves, vacuum system, hoses and connections and resin mixing chamber including static mixer. The vacuum pump may be installed inside or outside the insulated module.

3.2.6 *mobile impregnation unit, n*—a mobile system, usually permanently mounted on a trailer or truck, used to manufacture CIPP at or nearby the point of installation using CIPP automation.

3.3 *Acronyms:*

3.3.1 *PLC, n*—programmable logic controller

3.3.2 *HMI, n*—human machine interface (touch screen)

4. Significance and Use

4.1 This practice is for use by installers who are involved in the rehabilitation of conduits through the use of a mobile, automated CIPP impregnation system to manufacture resin impregnated tube installed through an existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 All materials shall be handled, packaged, marked and transported in accordance with local, state and federal regulations and requirements.

5.2 *Liner tube*—The liner tube shall consist of one or more layers of flexible needled felt or fiberglass, or both, an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials or fiberglass, or a combination thereof, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube shall be compatible with the resin system used. The outside layer of the tube shall be coated or protected with a material that is compatible with the resin system used. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit.

5.3 *Resin*—A formulated resin and catalyst that is compatible with the automation process and end use application shall be used. The resin shall have an initiation temperature for cure that is less than 180°F (82.2°C).

5.4 *Catalyst*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

6. Design Considerations

6.1 *Wall Thickness*—The CIPP wall thickness shall be designed in accordance with Practice F1216, Appendix X1.

6.2 Unless otherwise specified, the CIPP shall meet the requirements of grade 3, Type I, II or III CIPP as described in Specification D5813.

7. Equipment

7.1 *Resin pumps*—Positive displacement pumps specifically designed for the formulated resin and catalyst utilized shall be used. The pumps shall be capable of delivering the required volume of mixed resin to the tube during impregnation in a suitable time frame and shall also be capable of pulling suction for tank filling.

7.2 *Piping, fittings and tanks*—All piping, fittings and tanks used to convey, circulate and store resin and catalyst shall be made of a material suitable for constant contact with the respective material(s). Resin and catalyst tanks shall meet all federal, state and local regulations for material transport.

7.3 *Flow meter*—Precision metering device used to measure resin and catalyst quantities with an accuracy tolerance of ± 1.0% or better by volume.

7.4 *Temperature control system*—A heat exchange system used to regulate resin and catalyst temperatures. Acceptable methods may include utilizing temperature controlled air or water, glycol lines, or heat tracing and insulation.

7.5 *Static mixer*—Plastic or stainless steel device consisting of mixing elements within a carrier tube that is used to thoroughly mix resin and catalyst prior to liner impregnation. The static mixer shall be appropriately designed and sized for the viscosity and flow rate of the mixed resin utilized.

7.6 *Vacuum system*—A device used to remove air from a liner and assist with liner impregnation. The vacuum pump shall have a minimum capacity of 9.4 ft^3/min (16 m^3/hr) for up to 12 in. (300 mm) diameter CIPP and 23.5 ft^3/min (40 m^3 /hr) for CIPP greater than 12 in. (300 mm). The vacuum system shall have an integrated vacuum regulator, vacuum gauge with a range of 0 to -14.5 psi (0 to -1.0 bar), distribution piping/hoses with the necessary connections and service points, and a ball valve and suction cup attached to the terminating end of each vacuum hose. Vacuum hose shall be made of a suitable material, such as clear reinforced PVC, with a minimum inside diameter of 0.375 in (9.5 mm). Suction cups shall be 2.5 Bellows or similar style and capable of accommodating flat, concave or slanted surfaces.

8. System Operation

8.1 The mobile impregnation unit shall be supplied with adequate power and internal memory for data storage, and be equipped with an emergency stop.

8.2 The HMI shall be utilized to input project specific information. This includes customer and jobsite data, CIPP diameter, thickness and length or other applicable data points, or a combination thereof.

8.3 Resin and catalyst tank levels and temperatures shall be checked prior to using the mobile impregnation system. If additional resin is needed, material inventory should be inspected prior to use. Resin and catalyst should be stored indoors in sealed containers within a temperature range recommended by the resin manufacturer. Prior to use, the resin should be tested for reactivity in accordance with manufacturer's recommendations. In lieu of reactivity testing, a COA may be obtained from the resin manufacturer for each batch of resin and catalyst utilized. Resin and catalyst tanks may be filled to desirable levels using external transfer pumps and/or on-board resin and catalyst pumps with gravity assist.

8.4 The mobile impregnation system shall be in resin circulation mode prior to start up. Upon system start up, all functions and components shall be checked and verified to be operational and within the manufacturer's recommended tolerances. Resin and catalyst temperature levels shall also be checked prior to use. The mobile impregnation system shall not be operated if resin and catalyst temperatures fall outside the range recommended by the manufacturer. Resin that is too cold will have a viscosity that is too high, causing excessive pump pressures; resin that is too warm will reduce the pot life of the mixed resin. Work room climate control systems such as roof mounted HVAC, stand heating or refrigeration units may be utilized in conjunction with temperature control systems as described in 7.4 to assist with the material heating or cooling process.

8.5 All liner tube should be stored indoors or protected from moisture and ultraviolet light when not in use. Storage temperature for all liner tube shall be within acceptable limits as established by the manufacturer. The tube(s) proposed to be used for the next installation(s) may be transported in bulk to the job-site or measured, cut and stored inside the mobile impregnation unit prior to mobilization.

8.6 Once the mobile impregnation unit is ready for use and the liner tube is pre-measured and cut, the liner tube may be positioned on the roller bed and table. The terminating end of the liner shall be temporarily sealed before applying vacuum. Using a utility knife, a vacuum port, typically a straight 0.25-0.50 in. (6-12 mm) slit, shall be cut in a flat, even area of the liner coating (away from any seams) and tagged. Depending on the length and diameter of liner being impregnated, additional vacuum ports may be required. The vacuum pump shall be powered up using the HMI display and vacuum cup(s) applied to the liner tube over the vacuum port(s). The vacuum level shall be adjusted as needed to optimize the impregnation process. Ideal vacuum levels may range from -4.4 to -7.3 psi (-0.3 to -0.5 bar), depending on diameter and liner type utilized. If good vacuum is established, the liner will draw down as air is evacuated. If vacuum cannot be established, the liner should be inspected for defects. Once a good vacuum level is observed, the liner tube is ready for resin saturation.

8.7 The target mixing ratio on the HMI shall be achieved and maintained prior to transitioning into dispense mode. The end of the mixing tube or lance shall then be positioned over a metal or heat resistant container of suitable size for waste materials. Upon switching to dispense mode, a small volume of mixed resin shall be discharged into the container. Once the resin color and flow is normal and consistent as recommended by the manufacturer, the discharge flow shall be shut off by returning to circulation mode.

8.8 The mixing tube or lance shall be inserted into the open end of the liner tube. Upon switching back to dispense mode, mixed resin shall be pumped into the tube. A starter slug may be pumped in at the start to seal the end of the liner tube and assist with vacuum impregnation. Once a target resin slug quantity is achieved, the operator shall return to circulation mode and remove mixing tube or lance from the liner.

8.9 The end of the liner shall be positioned through the calibration rollers. The proper gap setting shall be employed, calculated and set based on liner tube thickness and manufacturer's recommendations. The default gap setting on the mobile impregnation unit shall be set automatically from input data but may be manually adjusted as needed to accommodate product specific needs. The rollers shall then be started and maintained at an optimal speed which is achieved when the resin saturation line is maintained at a constant position on the roller bed. If the roller is running too fast, the resin saturation line will migrate towards the pinch roller; if it's operating too slowly, the resin saturation line will move away from the roller.

8.10 When required, vacuum ports may be moved further along the length of the unsaturated liner as the wet out process progresses. Vacuum ports must be placed on unsaturated liner and must be sealed (patched) prior to reaching the resin saturation line. Vacuum patches shall be applied in accordance with manufacturer's recommendations.

8.11 If additional resin slugs are required, an injection slot shall be cut in impregnated liner a short distance upstream of the resin saturation line. The slot shall be large enough to allow penetration of the mixing tube or lance into the inner most felt layer (center of the liner). Once the target slug quantity is reached, the mixing tube or lance shall be removed and the slot patched in accordance with manufacturer's recommendations. Repeat steps 8.10 and 8.11 as necessary to complete the impregnation process.

8.12 Upon completion of the dispensing of mixed resin into the liner tube, the system shall be returned to recirculation mode and the pumps turned off. For each liner that is impregnated, data recorded onto the HMI internal and external memory device may be extracted and retained by the user for quality assurance and record-keeping purposes.

9. CIPP Installation

9.1 The resin-saturated tube shall be installed in accordance with manufacturer's guidelines and the applicable industry standard(s).

10. System Maintenance

10.1 The mixing chamber, static mixers and other components which come in contact with mixed resin shall be cleaned with acetone or other suitable solvent and inspected following each liner impregnation, or as otherwise recommended by the resin manufacturer. For stainless steel mixing elements, detach from the mixing chamber/discharge tubes and clean thoroughly. For plastic mixing elements/and tubes, detach from the mixing chamber and dispose of as recommended by the resin manufacturer.

10.2 The mobile impregnation unit shall be inspected and calibrated on a schedule recommended by the manufacturer, or at a minimum every six (6) months. Inspection shall include (but not be limited to) the following: verification of the calibration roller gap controls and displays, verification of the volumetric pump output and mixing ratio, verification of temperature and pressure readings, cleaning of filters, inspection of valves/fittings/hoses, testing of safety devices, testing of electrical overload and voltage detection/protection devices, and inspection of mechanical components such as: fasteners, roller beds, conveyors, pump motors, pump components, tank components, etc. A complete daily and periodic inspection checklist shall be provided by the manufacturer, completed by the contractor and be maintained as part of Quality Assurance documentation. Any deficiencies found during inspection shall be documented and corrected prior to use of the equipment. When not in use, mobile impregnation units shall be stored under conditions as recommended by the resin and equipment manufacturer(s). Considerations shall be made for temperature, humidity, UV exposure, routine exercising of mechanical components, emptying/purging of tanks, lines, hoses, etc.

10.3 Pump components, or any other components subject to wear or corrosion, or both shall be inspected and replaced according to the recommended schedule as provided by the manufacturer or as otherwise required by use.

11. Keywords

11.1 automation; calibration roller; certificate of analysis (COA); gap setting; human machine interface (HMI); programmable logic controller (PLC); static mixer; vacuum