TAC: Plumbing

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Building

1

S11763

Date Submitted	01/31/2025	**Section**	101	**Proponent**	Richard Logan
Chapter	1	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments Yes **Alternate Language Yes**

Related Modifications

None

Summary of Modification

The provisions contained in this Appendix P present recommendations for the design and construction of more resilient, healthier, and longer lasting buildings in Florida.

Rationale

The Florida Building Code, Building, does not adequately address or consider the role of moisture, flooding, or resource consumption in compromising building resilience, health, and long-term viability. By considering not only the destructive effects of moisture intrusion, but also the usage of water resources and flood-resistant construction best practices, users of this appendix will create more resilient, longer lasting, and safer facilities. See uploaded support file for further rationale.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

The Appendix will not have any impact to local entity unless it is adopted by local ordinance. While there may be minimal additional efforts to enforce, if adopted, there will be added benefits by making buildings and the community more resilient.

Impact to building and property owners relative to cost of compliance with code

The Appendix will not have any impact to property owners unless it is adopted by local ordinance. While there may be additional initial construction costs, if adopted, those costs will be outweighed by making buildings on the properties more resilient.

Impact to industry relative to the cost of compliance with code

The Appendix will not have any impact to industry unless it is adopted by local ordinance. While there may be additional initial construction costs, if adopted, those costs will be outweighed by making buildings and the community more resilient.

Impact to small business relative to the cost of compliance with code

more resilient.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The appendix, if adopted, has more than a reasonable and substantial connection with the health, safety, and welfare of the general public by making buildings and communities more resilient, especially against natural and manmade disasters.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

The appendix, if adopted, strengthens or improves the code, and provides equivalent or better methods, and systems of construction by making buildings and communities more resilient, especially against natural and manmade disasters.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

The appendix does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Does not degrade the effectiveness of the code

The appendix does not degrade the effectiveness of the code

Alternate Language

1st Comment Period History

S11763-A2

Proponent David Metzger **Submitted** 3/14/2025 1:28:42 PM **Attachments** No

Rationale:

"Consumption" includes use of water for cooking and hygiene in addition to drinking.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
None.

Impact to building and property owners relative to cost of compliance with code
None.

Impact to industry relative to the cost of compliance with code
None.

Impact to small business relative to the cost of compliance with code
The Appendix will not have any impact to small business unless it is adopted by local ordinance. While there may be additional initial construction costs, if adopted, those costs will be outweighed by making small businesses more resilient.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Water used for cooking and hygiene affects public health, safety, and welfare as much as water for drinking.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Recognizes that "potable water" is for more than only drinking.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities
Does not change current code-approved materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code
Improves code effectiveness by including recognized uses of water within the definition of "potable water".

1st Comment Period History

S11763-G2

Proponent Lourdes Solera Submitted 3/15/2025 3:19:48 PM Attachments No

Comment:

As a Florida architect, I am in full support of the addition of the appendix. This appendix provides clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

S11763-G3

Proponent Peter Hauerstein Submitted 3/24/2025 11:14:52 AM Attachments No

Comment:

As a Florida registered architect I fully support the adoption of this index as it offers clear direction on how to build more resilient, longer lasting, safer buildings.

1st Comment Period History

FS11763-G4

Proponent Carlos Marcet Submitted 3/24/2025 1:29:19 PM Attachments No

Comment:

As a Florida architect, I fully support the addition of this appendix because it offers clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

FS11763-G5

Proponent Rebecca Talbert Submitted 3/24/2025 2:08:36 PM Attachments No

Comment:

As a Florida architect, I am in full support of the addition of the appendix. This appendix provides clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

FS11763-G6

Proponent Arthur Molinari Submitted 3/24/2025 5:54:20 PM Attachments No

Comment:

As a Florida registered architect, I fully support the addition of this appendix because it offers clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

FS11763-G7

Proponent Stephen Panzarino Submitted 3/25/2025 11:37:32 AM Attachments No

Comment:

As a Florida architect, I fully support the addition of this appendix because it offers clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings

1st Comment Period History

FS11763-G8

Proponent marjorie weibe reed Submitted 3/25/2025 1:25:34 PM Attachments No

Comment:

As a Florida architect, I fully support the addition of this appendix because it offers clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

FS11763-G9

Proponent Barbara Hughes Submitted 3/25/2025 1:28:32 PM Attachments No

Comment:

As a Florida architectural designer, I fully support the addition of this appendix because it offers clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

S11763-G10

Proponent Robert Graboski Submitted 3/25/2025 1:54:02 PM Attachments No

Comment:

I am a registered Architect in the state of Florida. I am in full support of the appendix and wish it was part of the building code. The appendix provides clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings. I would also support a similar appendix specifically for Residential.

1st Comment Period History

S11763-G11

Proponent Elizabeth Camargo Submitted 3/25/2025 2:55:05 PM Attachments No

Comment:

As a Florida architect, I fully support the addition of this appendix because it offers clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings. As a consequence, re-construction of buildings after natural disasters will be minimized, saving millions of dollars and allowing communities to normalize their activities in a much shorter period of time.

1st Comment Period History

S11763-G12

Proponent Daniel Silverman Submitted 4/4/2025 2:51:35 PM Attachments No

Comment:

As a Florida architect, I fully support the appendix, which offers clear guidelines for designing and constructing more resilient, healthier, and longer-lasting buildings.

1st Comment Period History

S11763-G13

Proponent Denis Daniel Submitted 4/9/2025 10:42:33 AM Attachments No

Comment:

As a Florida design and construction professional, I am in full support of the addition of the appendix as it provides clear guidelines and recommendations for the design and construction of more resilient, healthier, and longer last buildings.

1st Comment Period History

S11763-G14

Proponent Stephen Hruby Submitted 4/9/2025 4:25:38 PM Attachments No

Comment:

I am a Florida architect and member of the AIA. I fully support the inclusion of the AIA Resiliency Appendix to the 9th edition of the FBC. It is a impactful useful guide to making our buildings more resistant to impacts of natural disasters. Ultimately make our buildings safe and healthier for our citizens. Please consider its inclusion.

1st Comment Period History

S11763-G15

Proponent iuliia Fomina Submitted 4/11/2025 12:23:42 PM Attachments No

Comment:

Resilience is the main concern to Florida buildings. I support the appendix.

1st Comment Period History

S11763-G16

Proponent Adam Gayle Submitted 4/11/2025 1:08:29 PM Attachments No

Comment:

As a licensed architect, interior designer, and real estate professional in the state of Florida, I wholeheartedly support the inclusion of this appendix. It provides a thoughtful and much-needed framework of clear guidelines and best practices that will enhance the resilience, health, and longevity of our built environment. This addition represents a meaningful step forward in promoting smarter, more sustainable design and construction across our communities.

1st Comment Period History

S11763-G17

Proponent Brian Coldwell Submitted 4/11/2025 1:48:42 PM Attachments No

Comment:

As a Florida engineer, I support the addition of this appendix. This appendix provides clear guidelines and recommendations for more resilient designs and construction to ultimately benefit our State.

1st Comment Period History

S11763-G18

Proponent Paul Lauber Submitted 4/14/2025 5:44:34 PM Attachments No

Comment:

As a Florida architect, I am in full support of the addition of this appendix. This appendix provides clear guidelines and recommendations for the design and construction of more resilient, healthier and longer lasting buildings.

1st Comment Period History

S11763-G19

Proponent Dallas Thiesen Submitted 4/16/2025 9:05:13 AM Attachments No

Comment:

The Florida Swimming Pool Associations Opposes this modification. The Florida Building Section address issue of damp-proofing and secondary containment for elevated swimming pools and spa. The addition of an appendix is unnecessary and will add confusion in plan review and inspections. Contractors, architects, engineers, and code officials are free consult unadopted standards for their own education and information but such standards should not be given a place in the Florida Building Code even as an appendix.

1st Comment Period History

S11763-G20

Proponent Jane Gilbert Submitted 4/16/2025 5:19:20 PM Attachments No

Comment:

As a member of Miami-Dade County's Office of Environmental Risk and Resilience, we fully support the addition of this resource for architects and builders to consider in making new buildings more resilient to increasing flood and water damage risks.

1st Comment Period History

S11763-G21

Proponent Jennifer Hatfield Submitted 4/16/2025 6:58:12 PM Attachments No

Comment:

On behalf of the Building Officials Association of Florida (BOAF), we must oppose this modification. Although there is possible merit as to what this proposal seeks to do, it requires additional work to ensure it is in enforceable code language. BOAF would welcome the opportunity to work with AIA on both the concept itself and crafting enforceable code language.

S11763-A2Text Modification

Under 201.1 Intent

Potable (Water): Suitable for ~~drinking~~ human consumption.

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APPENDIX P - ENHANCING THE RESILIENCE OF BUILDINGS: MOISTURE, RESOURCES AND FLOOD

Introduction
101 - General
201 - Definitions
301 - Moisture Control in Buildings
401 - Resources - Water Efficiency and Conservation
501 - Flood Resistant Construction

INTRODUCTION

The Florida Building Code, Building, does not adequately address or consider the role of moisture, flooding, or resource consumption in compromising building resilience, health, and long-term viability. By considering not only the destructive effects of moisture intrusion, but also the usage of water resources and flood-resistant construction best practices, users of the current appendix will create more resilient, longer lasting, and safer facilities.

MOISTURE CONTROL

The building envelope, which includes the walls, windows, roofs and foundation, forms the primary barrier between the interior and exterior environments. The integrity of this barrier is critical to its performance. If the building envelope is compromised, then problems within the interior of the building will develop. These problems often present themselves as mold or stains on the interior. Moving the air, moisture, vapor and thermal control layers outward of the structural layer mitigates intrusion of exterior elements into the wall assembly and allows a method for vapor to drain outward of the building instead of within the wall assembly to the interior of the building.This appendix proposes to prevent moisture intrusion opportunities.

The Florida Building Code, Building, does not define moisture and related terminology regarding structural integrity and design considerations. This appendix proposes establishing terminology and measures to limit moisture intrusion to manage this aspect of our constructed world.

This appendix aims to limit costs of such aspects of prevention and control of moisture as considered by code. The costs of preventing and controlling moisture are a fraction of those required to replace and rebuild and the long-term health costs building occupants could face.

Uncontrolled moisture and rot also cause the growth of organisms found to be unhealthy for human habitation: most commonly, mold. Moisture allows or even encourages mold to grow and creates environments that are dangerous to occupy, if given enough time.

Rust, corrosion, and rot *(see definitions section for more discussion of rust/corrosion & rot)* create slow, quiet, and considerable damage, until discovered by inspection or observation of failure. Currently these are fairly normal occurrences if the building is not designed and constructed to a more resilient standard.

Resilient design and construction can be cost effective. Over time, the savings add up. Making buildings resilient to these processes is not only economical but safe: structurally, for occupants, for communities, and for investment.

The final benefit to enhanced resiliency standards is to maintain healthy buildings for us all to occupy. Rot, mildew, humidity, and other factors allowing uncontrolled moisture and the growth of molds and organisms that endanger healthy spaces are known to create hazards and conditions whose only solutions are those of time and funding spent into our healthcare systems. Victims of such conditions must expend a great deal of funds, time and effort to heal from them. These incidents and circumstances can be greatly reduced, controlled, and even prevented by increasing building resiliency factors.

RESOURCES -Water Efficiency and Conservation

With a growing population constantly increasing the need for water for human habitation, industry, and agriculture, Florida is running the risk of having an inadequate water supply for the state's needs. As the aquifer is increasingly drained, saltwater intrusion from the Atlantic Ocean and the Gulf of Mexico becomes an ever-greater risk. Water is a basic need of any human population and for the state to thrive and be resilient, without resorting to costly desalination plants and incurring water shortages, then the population can be ensured they can live within its resources. Ensuring plentiful water is available to all will require greater efficiency in its usage and this Appendix provides the tools to achieve that.

FLOOD-RESISTANT CONSTRUCTION

The Florida Building Code, Building, currently addresses measures to increase the resilience of buildings to flooding only in new construction and alterations/additions that constitute substantial damage or substantial improvement (when the cost equals or exceeds 50 percent of the market value of the structure, before the improvement or repair is started). However, existing buildings undergoing alterations/additions of a smaller scale can greatly benefit from available measures to increase their resilience to flooding and avoid future costly reconstruction due to the impact of flood water. This appendix presents strategies for new and existing buildings to confront the ever-increasing frequency and severity of flooding events and their associated environmental challenges to health, safety and long-lasting structures.Resilient construction from the outset is more cost-effective than rebuilding and reconstruction. Added initial costs are between 5 – 10% for new construction. Replacement costs to rebuild and replace a structure are at least the original costs plus inflation, but those costs can be considerably higher in total expenditure.

COST REFERENCES

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Insurance Institute for Business & Home Safety (IIBHS)

Increased construction cost ranges from .29 to 1.43 percent of the building's total cost, depending upon designation sought and building location. This added cost was more than offset by insurance savings and/or increased rent (value to the occupants).

Columbia University / Columbia Climate School

"Technologies exist to protect homes against severe weather — but those innovations have been slow to seep into mainstream homebuilding, leaving most Americans increasingly exposed to climate shocks, experts say… Houses made from steel and concrete can be more resilient to heat, wildfire and storms. Even traditional wood-framed homes can be constructed in ways that greatly reduce the odds of severe damage from hurricanes or flooding. But the costs of added resiliency can be about 10 percent higher than conventional construction."

Building Resilience: FEMA's Building Codes Policies and considerations for Congress June 27, 2023

The National Institute of Building Sciences emphasizes the importance of building codes in a widely cited study which found that adopting the most recent building code could save $11 for every dollar invested in hazard-resistant codes and standards, and above-code design could save $4 for each dollar invested. The study also found that adopting the 2015 International Code Council building codes added about 1% in costs relative to 1990 standards.

Columbia University / Columbia Climate School

"Weather-related disasters pushed more than 3.3 million American adults out of their homes in 2022, census data shows. Of those, at least 1.2 million people were out of their homes for at least a month or longer; more than half a million of them never returned.

Homeland Security Affairs, Volume VI no 3 September 2010. www.hsaj.org

The idea of building resilience to natural and manmade disasters is now a dominant strategic theme and operational goal in the current U.S. national security policy discourse. Resilience is a critical priority that can be planned for, managed and experienced real value in. It's not a matter of "IF" something happens, it's a matter of when.

CONCLUSION

> ***"A study in 2005** estimated that for every $1 invested in disaster risk mitigation, $4 was saved in post-disaster rebuilding efforts. **New Data in 2019** showed $1 spent on mitigation measures could save $11 post-disaster"*

The Harvard Gazette, April 5 2023. https://news.harvard.edu/gazette/story/2023/04/natural-disaster-recovery-costs-set-to-spiral-study-shows/

The costs of reconstruction (and all the concerns outlined above) will likely grow over time. As costs associated with construction increase–such as wages, property values, products & services, transportation, shipping, etc.-- so too will reconstruction costs, making the investment in resilient structures and spaces even more valuable and wise. From structural stability to healthy spaces to economic wisdom, the health, safety and welfare of our state is better protected by resilient design and construction codes (and their enforcement).

SECTION 101 - GENERAL

101.1 Intent.

The intent of this appendix is to express the more specific principles of Resilient Design and Construction of buildings in the State of Florida. It is important to first comply with the minimum requirements of the Florida Building Code, Building, then meeting or exceeding additional objectives as stated in this appendix to further enhance building resilience.

101.2 Scope.

To be applicable to the increased resilience of any project requiring application of the Florida Administrative or Building Codes, through its planning, design, operation, construction, and occupancy.

101.3 Referenced codes and standards.

Refer to Florida Building Code, Building, 101.4 Referenced Codes and Ch. 35, Reference Standards. When dealing with the design and construction of existing buildings refer to the Florida Building Code, Existing Building for additional requirements.

101.4 Enforcement.

When this appendix is adopted by a local Authority Having Jurisdiction (AHJ) provisions for enforcement shall be proposed and adopted by ordinance. Enforcement then falls under that AHJ in accordance with their ordinance language.

SECTION 201 - SUPPLEMENTAL DEFINITIONS

201.1 Intent

The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of the Florida Building Code, Building for general definitions.

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BIOSWALE. A long, channeled depression or trench that receives and transports rainwater runoff (as from a parking lot) and has vegetation (such as grasses, flowering herbs, and shrubs) and organic matter (such as mulch) to slow water infiltration and filter out pollutants.

CONDENSATION. Natural condition of moisture from the atmosphere collecting on or within a surface when conditions of humidity and temperature of both atmosphere and surfaces align. While conditions of condensation vary depending upon the range of humidity and temperature of atmosphere and temperatures of adjacent surfaces and materials, these conditions are predictable and can be foreseen - as such in certain assemblies should be avoided or managed. [please consider a simplified definition. Suggestion: The process through which the moisture from the atmosphere becomes water droplets in contact with a cooler surface - refer to dewpoint]

CONTROL. (1) To exercise restraining or directing influence over : (2) to incorporate suitable controls.

CRITICAL FACILITIES. Those structures, as listed as Risk Categories III and IV in Florida Building Code, Building, - Building, Table 1604.5, Risk Category of Buildings and Other Structures from which essential services and functions for victim survival, continuation of public safety actions, and disaster recovery are performed or provided. See Florida Building Code, Building, Ch.2.

DEW (POINT). Dew point is the condition where the temperature and relative humidity of the atmosphere, and the interface of solid objects/surfaces of a certain temperature allows moisture of the atmosphere to appear as a liquid (water) in the forms of drops or droplets on the surface of an object. (See condensation) This circumstance also occurs within an architectural assembly of elements (ie: Wall/Ceiling assemblies) resulting in the presence of water no longer in the atmosphere but present as water on the surface of (or within) elements of an assembly.

EVAPOTRANSPIRATION ADJUSTMENT FACTOR (ETAF). An adjustment factor when applied to reference evapotranspiration that adjusts for plant factors and irrigation efficiency, which are two major influences on the amount of water that needs to be applied to the landscape.

GREYWATER. Graywater means untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing or operating wastes. "Graywater" includes, but is not limited to, wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers.

HAZARDOUS EVENT. An incident, situation or occurrence that has the potential to cause harm, damage or adverse effects.

HUMIDITY. Humidity is the amount of moisture in the air.

HYDROZONES. A Hydrozone is an area of landscape with plants sharing similar watering requirements.

METAL OXIDATION. A chemical reaction that occurs when metal is exposed to oxygen and an electrolyte, like water or moisture in the air, and electrons move from the metal to the oxygen.

METERING FAUCET. A self-closing faucet that dispenses a specific volume of water for each actuation cycle. The volume or cycle duration can be fixed or adjustable.

MIST. Exterior moisture in the form of particles floating or falling in the atmosphere at or near the surface of the earth.

MOISTURE. The presence of liquid diffused or condensed in small or trace quantities. These (sometimes) small quantities of moisture are difficult to measure but nevertheless present, and if disregarded can cause reactions to materials and assemblies concerned in this code: Rust, Rot, Mold, etc.

MOLD. Naturally occurring fungus that grows on organic elements within certain conditions of temperature and humidity.

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PERMEABILITY. Permeable material permits the passage of moisture.

POTABLE (WATER) Suitable for drinking.

RAIN. Moisture condensed from the atmosphere that falls visibly in separate drops. In calm (i.e., windless) weather, raindrops fall vertically. It can find its way into small gaps in a building, wetting the roofs, balconies, projections and causing damages.

RAIN, WIND DRIVEN. In wind, raindrop paths fall at oblique angles; the vertical component is called precipitation and the horizontal component is called wind-driven rain (WDR). While precipitation wets horizontal and sloped surfaces, wind-driven rain also wets vertical surfaces. It can find its way into small gaps in a building wetting the wall systems and causing damages.

RAINSCREEN. Rainscreen assemblies are those assemblies applied to an exterior wall that consist of, at minimum, an outer layer, an inner layer, and an airspace between them sufficient for the passive removal of liquid water and water vapor. Rainscreens are effective at managing moisture and provide exceptional opportunities for energy-efficient performance via continuous insulation and reducing thermal bridging.

RAIN GARDEN. Similar to a bioswale, but generally smaller in scale and does not transport water. It receives rainwater runoff (as from a parking lot) and has vegetation (such as grasses, flowering herbs, and shrubs) and organic matter (such as mulch) to slow water infiltration and filter out pollutants.

REMEDIATION OR REMEDIATE. intended as a remedy. Act of correcting an error or risk. Provide a remedy for; Redress or make right.

RESILIENT, RESILIENCE, RESILIENCY. The ability of a system and its component parts to anticipate, absorb, accommodate, and recover from the effects of a hazardous event in a timely and efficient manner, including the preservation, restoration, or improvements of its essential basic structures and functions. Adopted by AIA and IPCC (Intergovernmental Panel on Climate Change).

RUST. Rust is the result of oxidized iron or steel. Steel structures allowed to rust are compromised due to the corrosive effects of moisture. This results in compromised structural integrity, conditions calling into question their stability, and considerations of removal or renovation to maintain the health, safety, and welfare of occupants.

Concrete structures that allow moisture to migrate into the concrete form can allow the reinforcing steel within to rust and/or corrode. This corrosion often causes reinforcing steel to swell, often causing pieces of the protective layer of concrete to spall or break off, exposing the reinforcing steel. Left unabated, time and conditions permitting, a compromise of the structure can be expected.

ROT. the decomposition and loss of integrity from the action of bacteria and/or fungi. Rot is the natural effect of decay in organic material. Moisture almost always plays a pivotal role, as seen most notably in wood.

Wood structures that allow the presence of uncontrolled moisture will experience this decaying process over time. This process is quiet and steady, and unless found through inspections and routine investigation, it can almost always go far enough to require restructuring or replacement before being discovered. This compromise can and will require the replacement of structural elements in order to maintain the integrity of the structure.

SPECIAL LANDSCAPE AREA (SLA). An area of the landscape dedicated solely to edible plants, planting areas used for educational purposes, recreational areas, areas irrigated with recycled water, water features using recycled water, and where turf provides a playing surface or gathering space.

SUBMETER. A secondary device beyond a meter that measures water consumption of an individual section of a larger system.

VAPOR. Water in a gaseous state and often not visible.

VAPOR RETARDER. a material or assembly's ability to limit the amount of moisture that passes through that material or assembly.

VARIANCE. A grant of relief from the requirements of this section that permits construction in a manner otherwise prohibited by this section where specific enforcement results in undue hardship.

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VIOLATION. A development that is not fully compliant with this appendix, as applicable.

WATER. An inorganic compound with the chemical formula H2O. It is colorless, transparent, odorless liquid.

WIND SPEED. In a storm wind gusts can reach 60 miles per hour (mph) or greater. In a hurricane wind speed (sustained and/or gusts) can reach speeds of 75 mph and greater depending on locality and storm intensity.

SECTION 301 - MOISTURE CONTROL IN BUILDINGS

301.1 GENERAL

The provisions of this section address the detrimental impacts of moisture migrating through the building envelope, resulting in the degradation of materials and adversely affecting indoor environmental quality. Further, this section provides guidance and establishes the requirements for the design and construction for more resilient building envelope systems in buildings.

NOTE: Ensuring adherence to Florida Product Approval (FPA's) requirements is a critical step in designing and building a safe and resilient exterior building envelope in Florida.

The Florida Building Code, Building, presents the absolute minimum requirements for design and construction in the State of Florida. This section is intended to guide the designer and builder as to ways to implement improvements for moisture control, greater energy efficiency, greater safety, enhancing the longevity of Florida buildings.

- Design: Enhancing the design of buildings with better and more complete drawings and specifications is the first step in the process. Clear and concise communication of design intent is very important.
- Construction: The second step is the proper construction of buildings to most closely follow the design intent of the drawings and specifications, producing a higher quality building.

These requirements supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1, Section 107.3.5.

Exterior Wall & Balcony Requirements:

- 302.4 Drawings & Details - Wall details checklist
- 302.9 Balconies & Similar Projections -Balcony details checklists
- 302.11 Testing requirement

Roofing & Terrace Requirements:

- 303.4 Drawings & Details - Roofing details checklist
- 303.8 Rooftop Terraces & Decks - Waterproofing details checklist
- 303.15 Testing requirements

Additional Recommendations:

If not adopted by local ordinance, this appendix document presents recommendations for design and construction leading to more resilient, healthier, and longer lasting buildings. The voluntary user of this document is encouraged to implement as many of these recommendations as possible in their project. If all recommendations cannot be followed due to time or cost constraints, it is understood that all projects have limitations and challenges. Do implement as many as possible for greater moisture resistance resulting in more resilient and long-lasting buildings.

See the sections below for the recommendations and guidance for the design and construction of wall systems and roofing systems for Florida buildings.

SECTION 302 - RESILIENT EXTERIOR WALLS

Exterior walls function as important aesthetic, structural, and weather resistant elements of the building. The design of today's exterior walls includes multiple enclosure systems of diverse materials and assemblies. Traditional opaque walls include masonry (brick, stone, concrete block), wood sidings, vinyl sidings, composite sidings, EIFS, rainscreens, metal panels, stucco, and other materials. Transparent and translucent walls include: glass walls (window wall, storefront, curtain wall), ceramic frits, reflective, insulated glass/glazing, tinted glass/glazing, mullion systems (aluminum, steel, fiberglass, composites, etc.).

302.1 Intent.

The intent of this section is to provide additional direction for the design and construction of more resilient exterior walls and other related wall components; exterior wall coverings; exterior wall openings; exterior windows and doors; exterior soffits and fascias; architectural trim; balconies and similar projections; and bay and oriel windows. See also appendix section 105 - Flood - Resistant Construction as it may pertain.

302.2 Degradation of materials.

As moisture enters the walls of a building, degradation of materials is just one undesirable impact. Moisture needs to be controlled or mitigated to the greatest extent possible. The long-term exposure of moisture to many building materials within exterior walls can adversely affect the lifespan of those

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materials. Other adverse impacts are weakened structural capabilities, probable health concerns, noxious odors [caused as wood and paper materials begin to grow mold (acting as a food source) and/or rot], rusting of metals (studs, fasteners, hold down straps, connectors, etc.)

All wall materials degrade over time. Solar load, temperature fluctuations, expansion and contraction, moisture saturation and drying, the natural aging cycle of materials (due to loss of moisture or loss of a component or components within the materials), the influence of other materials inducing stress and strain within the materials in question, carbonization, salts, mineral deposits, environmental dirt, water leakage, freezing water, and other influences. All wall materials are influenced by the location installed and the specific climate zone, weather patterns, distance from the saltwater coast, lake effects, shading or lack of shading, varying climate cycles and weather trends. Even wild animals can be a source of degradation of the wall materials (rats, mice, squirrels and others) by abrasion and/or gnawing of the materials, especially if the materials have an organic or mineral content within the material.

Wall Degradation Examples:

- Concrete (poured in place, precast, tilt wall).
- Stucco (direct application to masonry, lathing, joint materials).
- Wood siding (various configurations).
- Wood paneling (various sizes and surface treatments).
- Composition siding.
- Shingle siding.
- Painting & Staining.
- Vented skins (varying materials with underlying air/water barriers).
- Glass & Glazing.
- Sloped glazing.

Balcony Degradation Examples:

- Bare concrete.
- Sealed concrete.
- Membrane systems over concrete.
- Membrane systems over wood.
- Safety railings (wood, metal, glass, composites).
- Floor drains and scuppers.

302.3 Moisture control within the building walls.

Moisture control within the wall system of a building is critical to the long-term health of the wall systems and the building occupants. Some materials are more moisture sensitive than others. There are several ways of designing framed (wood framing, metal framing, wood and composite sheathings, etc.) walls:

- Barrier Systems, where the primary form of moisture resistance is the facing of the wall to keep moisture from entering the wall system and interior.
- Drainage Systems, where there is a secondary form of moisture protection by the installation of a weather resistant barrier (WRB) installed within the wall system to protect the wall framing and interior wall from moisture penetration.
- Rainscreen Systems, where the primary moisture barrier is mounted behind the exterior cladding with a drainage space between the moisture barrier and backside of the exterior cladding. This allows the exterior wall cladding to provide solar, wind and water protection of the primary moisture barrier. Note that this moisture barrier must be robust in design to fully protect the structural substrate from moisture intrusion over the life of the building.
- Hybrid Systems,combining multiple combinations of wall systems in accordance with the design intent of the architect or design professional.

Likewise, masonry (brick, CMU, stone, cement products, etc.) and concrete (cast in place, tilt wall, precast, etc.) walls can incorporate some of the same features as framed walls depending on design intent.

- Masonry cavity wall construction, internal space allows for drying and drainage
- Exposed masonry construction, face sealed is the most economical systems
- Hybrid Systems, combining multiple combinations of wall systems in accordance with the design intent

Comply with chapter 14 of the Florida Building Code, Building for all Exterior Wall requirements;

- 1401 General.
- 1402 Definitions.
- 1403 Performance Requirements.
- 1404 Materials.
- 1405 Installation of Wall Coverings.
- 1406 Combustible Materials on the Exterior Side of Exterior Walls.
- 1407 Metal Composite Materials (MCM).
- 1408 Exterior Insulation and Finish Systems (EIFS).
- 1409 High-Pressure Decorative Exterior-Grade Compact Laminates (HPL).
- 1410 Soffits and Fascias at Roof Overhangs.
- 1411 Plastic Composite Decking.

Note: see HVHZ requirements in Chapter 24, Glass and Glazing, section 2411.3.2, Tests in the Florida Building Code, Building.

Wall and Opening Details

These wall and opening detail requirements supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1, section 107.3.5.

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For more resilient design and construction, the architectural and engineering drawing details must be more comprehensive and concise as to the intended materials and their connections. The path of water is important to indicate if water is allowed within the wall system.

Required Wall and Opening Details Checklist:

- Where an underlying weather barrier is a part of the assembly (specific type, thickness, manufacturer, specific directions for use, application diagrams and details from the manufacturer).
- All wall penetrations (vents, louvers, scuppers, fasteners).
- All window & frame penetrations (sill, jambs, head, flashings).
- All door & frame penetrations.
- If above a balcony, see section 302.11 for additional information.
- All copings on top of walls.
- All flashings by location, material, sizes & profiles, underlayments, fastening patterns.
- Where sealants are used, clearly indicating the location type of seal, material, sizes & profiles, backer rods.
- Integration of horizontal to vertical envelope systems.
- Below grade details(occupied and slab on grade conditions).
- Footing and foundation.
- Expansion joints.
- Interconnection between different wall systems(often overlooked until construction).
- For other special features see sections below.

302.4 Exterior wall coverings.

Exterior wall coverings are the outermost surfacing material of the exterior wall system. The possible exterior wall covering materials are many; wood (lap siding, panel siding, trim and moldings), masonry (brick, stone, CMU with various surface textures and treatments), stucco, metal panels, composite panels, plastic panels and lapped siding, and various combinations of materials. Exterior wall coverings can be painted, coated, stained or left natural to weather depending on what the building designer has in mind for the building.

For the Florida climate, building design and construction should consider a coating or stain to shed as much surface moisture as possible before the moisture contacts the actual surface material. While then the coating or stain must be maintained, it is invaluable in preserving the surface of the exterior wall covering to maximize its lifespan.

302.5 Exterior wall openings.

Exterior wall openings include any number of penetrations through the building wall envelope. Anything that penetrates the wall is a wall opening and makes the wall more susceptible to moisture entry into the wall system. All exterior wall openings are required by the Florida Building Code, Building, to be flashed or sealed and therefore need to be detailed by the designer of record so that construction teams can understand the approach to creating a watertight wall opening. See other sections of this appendix that further detail exterior walls and exterior wall openings.

302.6 Exterior soffits and fascias.

Exterior soffits are related to the underside of projecting elements (roof overhangs and other building elements) or ceiling surfaces of upper-level floors or balconies.

Fascias are related to the vertical surface of building overhangs or roofing terminations.

Exterior soffits and fascias shall be properly detailed to tie into the fascia on the outboard side and the wall and wall materials on the inboard side of the soffit. Size all components and connectors for the actual loading pressures (corner and field) to assure that the soffit material is stable in hurricane force winds and rain. Soffits are often the first wind damages and blow-offs in even nominal wind events.

Soffits should have a slight positive slope to the outboard side of the soffit so as to avoid moisture entering the attic or upper wall materials in the event of roof or eave leakage.

302.7 Architectural trim.

Architectural trim can be defined as ‘minor’ projections (less than 2” of horizontal dimension) of the building wall used for aesthetic articulation of the building facade. Where the horizontal dimension exceeds 2”, see the next section on ‘similar’ projections.

Architectural trim must minimize water penetration into the wall surface, whenever possible. The horizontal surfaces shall slope to drain (6% is the minimum slope recommended) to effectively drain water from the horizontal top surface of the trim. It is recommended that where possible, the bottom horizontal surface have a slope toward the exterior creating an effective dripline.

When the architectural trim consists of proprietary materials such as EIFS or single-coat stucco systems, follow the manufacturer’s requirements in addition to the base building code and this section.

When the architectural trim consists of wood, metals, composite materials, pvc, or other materials special architectural detailing will be required for those trim details, consult available manufacturer details and requirements. Industry publications can also be consulted for detailing information and direction.

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Provide details as to the architectural intent of the architectural trim. Always make sure that architectural trim is properly attached. Often the method is nails, screws or construction adhesive. The best method is to combine mechanical attachment with a construction grade adhesive.

If metal flashing is used to prevent water entry, it must be properly detailed. If a liquid applied coating is used follow the manufacturer's instructions. If sealants are used follow the manufacturer's instructions.

302.8 Balconies and similar projections.

There can be public and private balconies serving the building and its occupants in multi-level buildings.

- Public balconies are common in hotels, motels, apartments/condominiums and sometimes on office or retail buildings. Public balconies must provide safe and easy access to the doors and entries to the occupied spaces daily. They must also provide safe egress to building stairways and elevators for fire services to assist in evacuating occupants from the building during emergency evacuations (smoke, fire, other emergencies).

- Private balconies provide multi-level buildings to allow their residents to enjoy the outdoor environment directly outside their residences, hotel rooms, or offices. Balconies also provide weather protection (shading, shadows, shielding from rain) to the walls, windows, glass doors and other parts of the wall systems. Private balconies can also be screened to defend against insects during the warm and hot months of the year.

Balconies on buildings have been one of the most challenging design, detailing, and construction elements of a building. Whether in single family residences, hotels, apartments/condominiums, office buildings using many types of construction (wood framing, metal framing, concrete, and composite materials). Balconies can be solid decking surfaces (and undersides) or constructed of open deck boards (and exposed structural elements) constructed of wood or composite materials.

If water is not effectively resisted (keeping it out of the building and structure) damage to structural components and other building materials can result. Florida wind especially along coastal areas are especially vulnerable to wind driven rains. In addition, coastal construction must withstand the effects of sand and salts weathering the finishes of balconies much faster than in inland locations.

There are no real standards for exactly how to detail balconies so as to maximize weather resistance and provide for their longevity, yet they all must be constructable providing safe railing systems, effectively shedding water, and resisting high velocity winds. Often wind driven rain soaks or even floods balconies with water under both dynamic and hydrostatic pressures.

Many sets of construction drawings and specifications fall short in providing adequate drawing details and clearly written specifications for the materials and workmanship that is needed. Many times the trades constructing balconies do not understand the design intent, so construct the balconies with breaches and voids in water resistant membrane materials and surfaces. Often, effective flashing materials are omitted or poorly installed, so as to leak water into the balcony and adjacent wall structures. When patio door thresholds and sliding glass door tracks are not correctly installed they leak and damage interior flooring materials, baseboards, and finished wall materials. When surface finishes and materials exhibit damage, then in most cases further damages underlie those materials causing structural damages to floor and balcony structural members and the wall systems (and columns) supporting those balconies.

Balcony Details

These balcony detail requirements supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1 section 107.3.5.

Wood framed balconies (solid surface and open decking) are the most problematic for proper waterproofing, so minimum details are required as follows:

Minimum ‘solid surface decking’ balcony waterproofing details:

- Balcony cross sections with a minimum ¼” per foot of slope to drain.
- Scuppers (when utilized).
- Floor drains (when utilized).
- Terrace door thresholds (and jamb and head flashings).
- Sliding glass door tracks (and jamb and head flashings).
- Windowsill flashings at balcony locations (and jamb and head flashings).
- Wall to balcony flashing conditions.
- Railing attachment details (structural and waterproofing).
- Water discharge flashings at corner discharge points.
- Supporting beam details.
- Supporting column details (when present).
- Specifications of membrane waterproofing and walking surfaces.

Minimum ‘open surface decking’ balcony waterproofing details:

- Balcony cross sections.
- Terrace door thresholds (and jamb and head flashings).
- Sliding glass door tracks (and jamb and head flashings).
- Window sill flashings at balcony locations (and jamb and head flashings).
- Wall to balcony flashing conditions.
- Railing attachment details (structural and waterproofing).
- Joist framing connections to beam details.
- Ledger framing flashing at walls.
- Supporting beam cap flashing and saddle flashing (beam to wall) details.
- Supporting column details (when present).

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- Specifications of wood or composite walking surfaces.

Concrete balconies are less problematic, details are still required as follow:

- Balcony cross sections with a minimum ¼" per foot of slope to drain.
- Scuppers (when utilized).
- Floor drains (when utilized).
- Terrace door thresholds (and jamb and head flashings).
- Sliding glass door tracks (and jamb and head flashings).
- Windowsill flashings at balcony locations (and jamb and head flashings).
- Wall to balcony flashing conditions.
- Railing attachment details (structural and waterproofing).
- Water discharge flashings at corner discharge points.
- Specifications of liquid applied waterproofing and walking surfaces (tile or liquid applied wearing surface.

Similar Projections:

Similar projections come in various types. If the projection is a bay window or oriel window, see the next section addressing those elements as these are 'capped' with various types of roofing materials that must be properly flashed to the wall system.

Other projections include trim bands, cornice lines, and projections generally detailed as aesthetic elements of the wall system comprising the building facade. Projections can be detailed using traditional wall to horizontal flashings (generally metal 'L' and 'Z' shaped) sloping to effectively drain water off the horizontal element of the projection.

Minor projections can also be detailed using sealants and liquid applied flashings sloping to drain water off the horizontal element. When detailed using sealant and liquid applied flashings, those surfaces generally have a higher degree of maintenance required than metal flashings, so maintenance programs must be established and followed for the maintenance and refinishing for effective waterproofing.

302.9 Insulation.

The thermal performance of a wall system depends on all the wall materials with careful consideration of the insulation type, thickness, and material properties within the wall assembly. It is highly recommended that a hygrothermal analysis be completed on all exterior wall assemblies using both historic and future predicted climate characteristics of the project location including mean temperature, dewpoint, etc. to determine the best course of action for specifying the specific wall assembly for a project. It is best practice in a hot, humid climate to locate the air, moisture, vapor, and thermal control layers outward of the structural layer to mitigate intrusion of moisture into the wall assembly and provides a method for vapor to drain outward of the building versus within the wall assembly on the interior of the building. However this type of insulation and water-resistive barrier layering is not always possible so proper architectural detailing must be followed to achieve the code compliant installation that prevents entrapment of moisture within a wall assembly and interior to the building.

302.10 Building Envelope Testing requirements.

Building envelope testing as a holistic approach to moisture and air management in building design and construction is essential for achieving long-term resilience and viability. It integrates preventive measures against moisture intrusion and air leakage, enhances energy efficiency, supports indoor air quality, and ensures the durability and performance of buildings throughout their lifecycle. Investing in building envelope testing during the design and construction phases pays dividends in terms of reduced maintenance costs, improved occupant comfort, and sustainable building operations.

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Moisture Management

- Preventing Water Intrusion: Building envelope testing, such as water penetration resistance testing (e.g., ASTM E1105), helps identify potential points of water entry during rain events or under high wind conditions. This early detection allows for necessary adjustments in design or construction to prevent water intrusion, which can lead to structural damage, mold growth, and degradation of building materials over time.
- Moisture Control: Properly designed and tested building envelopes include vapor barriers, drainage systems, and waterproofing materials that manage moisture effectively. Testing ensures that these components function as intended, reducing the risk of moisture buildup within wall assemblies and improving the durability of building materials.

Air Management

- Minimizing Air Leakage: Air leakage through the building envelope can compromise energy efficiency by allowing conditioned air to escape and unconditioned air to enter. Air leakage testing (e.g., ASTM E783) identifies areas of concern and allows for corrective measures to be implemented, such as improving air barriers and sealing penetrations.
- Enhancing Indoor Air Quality: A well-sealed building envelope helps maintain consistent indoor air quality by preventing the infiltration of outdoor pollutants, allergens, and moisture-laden air. This is crucial for occupant health and comfort, particularly in tightly sealed and energy-efficient buildings.

Energy Efficiency

- Reducing Heating and Cooling Loads: A tightly sealed building envelope with effective insulation and minimal air leakage reduces the demand for heating and cooling energy. This results in lower energy costs over the building's lifespan and contributes to sustainability goals by reducing greenhouse gas emissions associated with energy consumption.
- Optimizing HVAC Performance: By minimizing air leakage and controlling moisture, building envelope testing ensures that HVAC systems operate more efficiently. This can help optimize HVAC size reducing redundancy due to unknowns and saving upfront costs, reduces the workload on HVAC equipment, prolongs their lifespan, and lowers maintenance costs.

Long-Term Resilience

- Durability and Maintenance: Building envelope testing helps identify potential weaknesses or defects early in the construction phase, allowing for proactive maintenance and repairs. This proactive approach extends the lifespan of the building envelope and reduces the likelihood of costly repairs or premature replacement.
- Adaptability to Climate Change: A resilient building envelope, verified through testing, is better equipped to withstand extreme weather events and climate change impacts. It ensures that buildings remain habitable and functional, providing shelter and safety to occupants over the long term.

Viability and Performance Verification

- Meeting Design Intent: Building envelope testing verifies that the design and construction meet specified performance criteria, including compliance with building codes, standards, and project requirements. This ensures that the building envelope performs as intended by the owner, authority having jurisdiction, and design team and meets regulatory expectations.
- Documentation and Warranty Compliance: Testing provides documented evidence of the building envelope's performance, which is essential for warranty coverage and insurance purposes. It establishes accountability and ensures that stakeholders have confidence in the building's quality and longevity.

Field Testing

Field testing of exterior enclosure components and systems *as they relate to moisture* can include:

Water Penetration Resistance Testing

Purpose: To evaluate how well a wall system prevents water ingress under real-world conditions.

Standards:

1. ASTM E1105 - Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference:
   - Purpose: This test method covers the determination of the resistance of installed exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a static air pressure at the outdoor face higher than the pressure at the indoor face.(Source: ASTM)
   - Method: This test involves the use of a wall-mounted pressure chamber where air is exhausted to create a lower pressure on the test surface. Water is then sprayed at a controlled rate on the opposite surface using a calibrated nozzle rack over a specified time period.
2. ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference:
   - Purpose: This test specifies a method for testing the water penetration resistance of exterior windows, skylights, doors, and curtain walls under uniform static air pressure differences.
   - Method: It involves subjecting the specimen to a specified pressure differential while applying water to the exterior surface and monitoring for water infiltration.
3. ASTM E2128 - Standard Guide for Evaluating Water Leakage of Building Walls:

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- Purpose: This guide provides principles and procedures for evaluating water leakage through building walls, including exterior cladding and curtain walls.
- Method: ASTM E2128 outlines methods for field and laboratory evaluations to identify sources of water infiltration and potential remediation measures.

4. AAMA 501.1 - Standard Test Method for Water Penetration of Windows, Curtain Walls, and Doors Using Dynamic Pressure:
   - Purpose: Published by the American Architectural Manufacturers Association (AAMA), this standard specifies procedures for evaluating the water penetration resistance of windows, curtain walls, and doors under dynamic pressure conditions.
   - Method: Dynamic water penetration testing is conducted at the specified air pressure differential by utilizing a wind generator employing an 84" diameter propeller. Water is simultaneously sprayed onto the exterior face of the assembly at the required rate of 5 gph/SF. Testing continues for 15 minutes. During testing, the interior face of the test area is inspected for water leakage.
5. AAMA 501.2 - Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems:
   - Purpose: Another standard from AAMA, this document provides guidance for quality assurance and diagnostic field checks designed to aid in the water-tight testing of large glass areas meant to be permanently closed, such as store fronts, curtain walls, and sloped glazing systems to verify water leakage resistance.
   - Method: A constant pressure of between 30-35 psi is applied from a ¾" (19 mm) diameter hose fitted with a nozzle. This ½" diameter brass nozzle is to be part B-25 #6.030, sourced only from Monarch Manufacturing, to standardize test results. It is recommended to fit the nozzle with a gauge to measure distance from the test surface.

Air Leakage Testing

Notes: Air Leakage testing is indicated as an optional testing direction, not required for 'liquid' moisture mitigation in buildings. Although moisture does enter via air infused with moisture (known as humidity), it is not as critical as minimizing liquid moisture entering the wall cavities. When air conditioning (air cooling) is present in indoor spaces, there is also a possibility of liquid condensation on wall materials within the wall assembly.

Purpose: To measure the air tightness of building envelope walls.

Standards:

1. ASTM E779 - Standard Test Method for Determining Air Leakage Rate by Fan Pressurization:
   - Purpose: ASTM E779 outlines procedures for measuring air leakage rates of buildings by pressurizing or depressurizing the building envelope with a fan and measuring airflow.
   - Method: It quantifies air leakage through the building envelope under specified pressure differentials, providing a metric such as air changes per hour (ACH) or air leakage rate per unit area.
2. ASTM E1827 - Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door:
   - Purpose: ASTM E1827 provides alternative methods for determining the airtightness of buildings using a blower door test, which measures air leakage through the building envelope.
   - Method: It includes procedures for installing and operating the blower door equipment, controlling test conditions, and calculating air leakage rates.
3. ASTME3158 – Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building
   - **Purpose: ASTME3158 provides a quantitative field test procedure and calculation method for assessing an air leakage rate using a fan-induced pressure differential(s) across the building envelope, generated by blower doors or equivalent equipment.**
   - Method: This test method applies to all multizone and large building types and portions or subsections of buildings. It can be used to test envelopes that consist of a single zone or subsections of a zone that can be tested as a single zone. Test envelopes that are entirely composed of subsections separated by interior partitions or floors, or both, may be tested as a single zone by maintaining baseline relationships between these subsections throughout testing. The relationship between the airflows and induced pressures are used to measure the air leakage rate of the envelope. Specifications for air leakage rates of an envelope are written in terms of the maximum allowable airflow rate from a specified induced pressure differential.
4. ASTM E783 - Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors:
   - Purpose: ASTM E783 specifies procedures for measuring air leakage through installed exterior windows, doors, and curtain walls under specified pressure differentials.
   - Method: The testing is performed by sealing a chamber to the interior or exterior face of the test specimen, supplying or exhausting air from the chamber at a rate required to maintain the specified test pressure, and measuring the air flow lost or gained across the testing chamber.
5. ISO 9972 - Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method:
   - Purpose: This international standard provides methods for determining the air permeability of buildings using a fan pressurization method, similar to ASTM E779.
   - Method: ISO 9972 To compare the relative air permeability of several similar buildings or parts of buildings, and to determine the air-leakage reduction resulting from individual retrofit measures applied incrementally to an existing building or part of a building. The fan pressurization method does not measure the air infiltration rate of a building. The results of this method can be used to estimate the air infiltration rate and resulted heat load by means of calculation.
6. AAMA 502 - Voluntary Specification for Field Testing of Newly Installed Fenestration Products:
   - Purpose: Published by the American Architectural Manufacturers Association (AAMA), AAMA 502 specifies procedures for field testing newly installed fenestration products (windows, doors) to verify air leakage resistance.
   - Method: Chamber test method where chamber is attached and sealed to adjacent frame members, concrete, structural steel or drywall at the top, bottom and sides of the specimen. The chamber is equipped with a centrifugal blower/vacuum pump, air flow meter, and a pressure sensing device to maintain the desired air pressure differential across the assembly

Thermal Performance Testing

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Note: Thermal performance testing is indicated as an optional testing direction, not required for moisture mitigation in buildings.

Purpose: To assess the insulation properties of walls.

Standards: ASTM C1153.

Method: Involves measuring the thermal resistance (R-value) or thermal transmittance (U-value) using heat flow meter devices or infrared thermography.

Field Application: Can be performed in-situ to evaluate the actual thermal performance of installed wall assemblies.

SECTION 303 RESILIENT ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

A building's roof assembly provides multiple functions, aesthetic, structural, and weather resistance for the building. The design of today's roofing includes multiple roofing comprised of diverse materials and assemblies. Traditional roofs include steeply sloped and 'flat' membrane roofing materials, depending on the design and construction of the roofing system. Roof structures can be comprised of various materials including; wood (wood rafters, joists, trusses, plywood roof decking), metal (usually steel, light gauge, forged), concrete (reinforced, prestressed, post tensioned), hybrid structures (system buildings, prefabricated buildings, relocatable buildings). Sloped roof coverings include shingles (wood, asphaltic, tile), metal (standing seam, corrugated, composite panels), and other hybrid systems.

For minimum code requirements see chapter 15 ROOF ASSEMBLIES AND ROOFTOP STRUCTURES in the Florida Building Code, Building,.

303.1 Intent.

The intent of this section is to provide additional direction for the design and construction of more resilient roof assemblies and rooftop structures. Increasing wind and moisture resistance is critical to the ultimate longevity of the roofing system and materials within the roofing system.

303.2 Degradation of materials.

All roofing materials degrade over time. Solar load, heat/cold, temperature fluctuations, expansion and contraction, moisture saturation and drying, the natural aging cycle of materials (due to loss of moisture or loss of a component or components within the materials), the influence of other materials inducing stress and strain within the materials in question, carbonization, salts, mineral deposits, environmental dirt, ponding water, freezing water, and other influences. All roofing materials are influenced by the location installed and the specific climate zone, weather patterns, distance from the saltwater coast, lake effects, tree coverage, varying climate cycles and weather trends. Even wild animals can be a source of degradation of the materials (rats, mice, squirrels and others) by abrasion and/or gnawing of the materials, especially if the materials have an organic or mineral element within the material.

Roofing Degradation Examples:

- Asphaltic shingles: Loss of granules, fading, mold growth, brittleness, cracking, loss of shingles and portions of shingles.
- Asphaltic membranes: Loss of granules, dirt build up, brittleness, cracking and splitting.
- Acrylic membranes: Loss of flexibility, dirt build up, brittleness, cracking and splitting.
- Cement and clay tiles: Color loss, fading, mold growth, loss of surface finish due to erosion, exposure of aggregate.
- Slate shingles: Mold growth, loss of natural surface finish due to erosion, delamination of the slate.
- Cedar shakes and shingles: Mold growth, shrinkage, separation, curing, loosening of fasteners.
- Metal roofing: Fading, color loss, mold growth, streaking of surface finish, rust bleed through.
- Hybrid roofing materials: TBD based upon the technology of the materials.

303.3 Moisture control within building roof assemblies and rooftop structures.

Moisture control through the roofing elements of the project is of critical importance for the proper health of the occupants and longevity of the building components. No one likes or can even tolerate a leaking roof! A roof leak is one of the most devastating occurrences that can happen to a building and its occupants. It can upset a building occupant beyond most any other issues with a building. Note, we acknowledge that there are other devastating occurrences such as fires, gas explosions, plumbing leaks, mechanical and electrical system problems, structural collapses and even vermin infestations however this portion of the appendix addresses moisture related building issues.

Comply with chapter 15 of the 2023 Florida Building Code, Building, for all roofing requirements;

- 1501 General.
- 1502 Definitions.
- 1503 Weather Protection.
- 1504 Performance Requirements.
- 1505 Fire Classification.
- 1506 Materials.

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- 1507 Requirements for Roof Coverings.
- 1508 Roof Insulation.
- 1509 Roof Coatings.
- 1510 Rooftop Structures.
- 1511 Existing Roofing.
- 1512 - 1524 High-Velocity Hurricane Zones Requirements (Miami-Dade and Broward Counties).

Roofing Details

These roofing details supplement the listing for buildings constructed under the Florida Building Code, Building, in Ch. 1 section 107.3.5.

Roofing details checklist:

- Roof type performance metrics (Durability, heat transfer, vapor drive, fire ratings, etc.):
  - Climate zone considerations.
  - Vapor drive.
  - Roof top activities or additional installations.
  - Insulation type, performance, size.
- Roofing system cross sections with a minimum ¼" per foot of slope to drain.
- Continuity of air/moisture barrier from horizontal to vertical surfaces.
- Roof scuppers (when utilized).
- Roof drains (when utilized).
- Sumps at roof drains and continuous insulation.
- Roof gutters & downspouts (when utilized).
- Roof access door thresholds (and jamb and head flashings) (when utilized).
- Roof hatch details (when utilized).
- Roof to Wall flashing conditions.
- Integration of additional roof-top mounted systems:
  - Green roof.
  - Photovoltaics.
  - Solar hot water.
  - Deck, paver, equipment.
- Roof curbs for mechanical, plumbing, electrical equipment.
- Roof penetrations(Pipe, duct, etc.), avoiding pitch pockets.
- Parapet wall details (indicating vertical membranes, other vertical materials, and cap flashings) (when utilized).
- Railing attachment details (structural and waterproofing) (when utilized).
- Water discharge flashings at corner discharge points (as example, kick out flashings).
- Cricket details to drain difficult locations.
- Expansion joints.
- Integration and interconnection between different roof systems.
- Roof underlayment and vapor barrier details(when and where to incorporate).
- Continuous insulation and cover board.
- Supporting beam details.
- Supporting column details (when present).
- Specifications of roofing materials and systems required on the drawings.

303.4 Steep slope roof coverings.

A steep sloped roof is a roof that slopes at 2:12 and greater slope. Roofs that slope less than 2:12 are considered low slope roofs. Steep sloped roof coverings are very popular in residential buildings and in many commercial buildings as well.

Consult chapter 15 in the Florida Building Code, Building, for more information on commercial roofing systems.

There are multiple types of steep sloped roof coverings. They depend on their slope to quickly remove water from the roof surface but must be detailed and constructed correctly to properly protect the building from moisture intrusion through the roof covering and into the roof structure itself and ultimately into the occupied spaces of the building.

Types of steep sloped roof coverings include:

- Shingle roofing- multiple types:
  - Asphalt shingles.
  - Concrete tile shingles.
  - Clay tile shingles.
  - Slate tile shingles.
  - Cedar shake and cedar shingles.
  - Metal shingles.

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- Metal roofing:
  - Various types of seamed roofing, standing, interlocking, capped.
  - Overlapping seamed roofing, like '5V crimp' roofing, with exposed fasteners (this was commonly known as "barn siding" that then became used as a metal roof covering.
  - Structural metal roofing (where the roof panels are also structurally spanning between metal purlins as in manufactured building systems).
  - Metal roofing that covers membrane roofing acting like a rain screen for the membrane roof below.
- Hybrid and composite material roofing.
- Membrane roofing.
- Thatched roofing.

These steep sloped roofs require underlayments that come in different types of materials. Consult the building codes for more specific information. The function of the underlayment is multifold.

- Dry-in Protection: Builders commonly call the underlayment 'the dry-in' since once the underlayment is installed the building becomes mostly dry for the balance of the interior construction to continue without moisture damage from the roofing level. The underlayments generally have a restricted amount of time until the final roof covering is installed. This can range from as little as 3 months to as much as 9 months depending on the type of underlayment used. Consult the manufacturer for these time limits.
- Secondary Protection: Another function of the underlayment is for secondary protection to the building. This secondary protection will generally add life to the roof, even if during the aging of the roof shingles or other material causes degradation, the underlayment during wind and rain events, the underlayment provides a level of protection against moisture intrusion in such an event.
- Condensation protection: Airborne moisture known as humidity can cause problems below the roof covering when the outdoor temperatures drop on the exterior of the roof covering surfaces and the dew point is reached, condensation of liquid water occurs. This also occurs during nightly radiant cooling known as 'night sky radiation' where the dark night sky acts as a 'heat sink', cooling the roof covering below the dew point, causing condensation of liquid water below the roof covering. In these cases the underlayment provides condensation protection for the building.

303.5 Low slope membrane roof coverings.

Always comply with manufacturers minimum slope requirements, even if roofs appear close to flat for longevity and proper drainage. The following sections address the various systems and the importance of specific design, detailing and construction quality control and assurance.

303.6 Liquid applied roofing and roof coatings.

Liquid applied membrane roofing systems are reinforced membranes that are applied in the field using liquid membrane materials and fiber reinforcing combined as a part of the roofing application process. These are considered membrane roofs and must slope at a minimum of ¼" per foot to the roof drains, scuppers, gutters and other devices for final drainage. Manufacturers typically offer extended warranties for 5 and 10 years and longer.

Roof coatings are liquid applied coatings that are not reinforced and are designed to extend the life of the underlying roofing. They can be applied to sloped roofing and membrane roofing. As an example, shingle roofing can be coated to extend their life. These are considered as remedial measures and are considerably less expensive than full roof replacements. Before applying a liquid roof coating, the base roof must be dry and free of defects so these issues must be corrected prior to the installation of the roof coating.

303.7 Rooftop terraces and decks.

Waterproofing membranes designed for use under tile and paver systems are critically important for the watertight performance of the waterproof membrane. Since these waterproofing membrane systems are concealed throughout their lifespan they must perform to prevent water leakage. Leaks are difficult to find the source of leaks and are extremely difficult to locate and difficult and expensive to repair and/or replace. Most of these systems are membrane based, some are hot applied, others cold applied, some are liquid applied roofing membranes.

Major manufacturers should be consulted during the design, submittal and installation phases to assure that the correct systems are being selected, detailed and installed. Many manufacturers require certified and approved installation contractors who must use workers/installers that have been trained and certified to install the systems.

Design and construction conditions that must be thoroughly detailed and carefully constructed to be properly waterproofed for the life of the terrace or amenity deck. Features such as pools, spas, planters, seatwalls, lighting, showers and other features must be considered in the final detailing and design. These features will require specialized attention to a high level of detail.

Waterproofing Details

These waterproofing details supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1 section 107.3.5.

Waterproofing details checklist:

- Membrane waterproofing system cross sections with a minimum ¼" per foot of slope to drain (note, generally greater than minimum slope is encouraged to account for construction tolerances).
- Terrace and deck scuppers (when utilized).
- Terrace and deck gutters & downspouts (when utilized).
- Terrace access door thresholds (and jamb and head flashings) (when utilized).
- Sliding glass doors and door thresholds (and jamb and head flashings) (when utilized) when used.
- Terrace and deck to Wall flashing conditions.
- Terrace and deck parapet wall details (indicating vertical membranes, other vertical materials, and cap flashings) (when utilized).
- Railing attachment details (structural and waterproofing) (when utilized).
- Water discharge flashings at corner discharge points (as example, kick out flashings).
- Cricket details to drain difficult locations.
- Supporting column details (when present).

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- Specifications of waterproofing materials and systems.
- Where a pool or spa is present, see section 303.9.

303.8 Rooftop structures.

A rooftop structure is defined in section 1502 as “An enclosed structure on or above the roof of any part of the building.” See Florida Building Code, Building, section 1510, for minimum requirements for rooftop structures. This Florida Building Code, Building, section covers penthouses, tanks, cooling towers, towers, spires, domes and cupolas, mechanical equipment screens, photovoltaic systems, other rooftop structures, structural fire resistance, mechanical units, cable and raceway type wiring methods, and Lines, pipes, conduit and cables under roof decks. These resiliency recommendations do not modify those Florida Building Code, Building, minimum requirements. The key requirement of this resiliency appendix is to provide long term and durable weather protection in the design and construction of rooftop structures of all types. Water leakage through any rooftop structures will ultimately find its way into the roofing system and ultimately into the building structure and is not acceptable. All water leakage must be prevented.

303.9 Rooftop pools and spas.

See the Florida Building Code, Building, section 454 Swimming Pools and Bathing Places (Public and Private) for minimum code requirements. These resiliency recommendations do not modify those Florida Building Code, Building, minimum requirements.

In addition to the Florida Building Code, Building, rooftop pools and spas are governed by the local health department in local governments. Those health department requirements should be consulted and complied with, so must be followed and are not affected by this section.

Critical to all rooftop pools and spas is the requirement that they be structurally sound and watertight at the structural walls and floors. They must also be watertight at the junctures between the walls of these elements and the adjoining roof top terraces and decks. These junctures must be properly designed, detailed and constructed. Any leakage noted under these elevated pools and spas must be diagnosed and repaired. Periodic inspections by trained design and construction professionals should be undertaken by ownership of the property.

Design and Construction: It is critical that they are designed and constructed by responsible and knowledgeable designers and builders. Often they are designed and constructed by a third party who specializes in that design and construction as a specialty. Most pools and spas are made out of poured and reinforced concrete, which is a durable and long–lasting material.

However, some pools and spas are made of plasticized liners for the pool walls and pool bottoms. Those types of pools and spas also need their unique details designed and constructed to be watertight.

303.10 RESERVED.

303.11 Other considerations.

Cost of installation and lifespan of the roofing systems of a building must be considered in the selection, design and installation of roofing systems. The value of a roof is generally considered as the most important component of the building for keeping water out of the building. While cost is one of the elements, aesthetics, lifespan and maintenance requirements are other elements to be considered.

For roofing in Florida water resistance is one very important requirement. Wind resistance is another very important requirement in the performance of the roofing system. Storms tend to pull upward at the roof edges and corners in such a manner that those areas can begin to lift during strong winds and may ultimately cause a full roofing failure. Severe failures can result in the complete roofing system being lifted off of the roof structure. In the most severe failures when the underlying structure is then subjected to moisture intrusion and further lifting of the roof structure and when the roof structure is damaged the support of the top of the walls is then in danger of complete collapse. Such a collapse can kill and injure the occupants and result in large property losses.

303.12 Compliance.

Compliance with this section should enhance the resilience of a building’s roofing system. Proper design, detailing and construction is paramount to a successful roofing system to protect the building from the elements (water, wind, windborne debris, etc.)

303.13 Testing requirements.

Roofing systems are one of the most critical components of a buildings enclosure and its ability to provide protection from moisture intrusion and ensure the long-term health, safety, and welfare of the building occupants.While individual components of roof systems are manufactured, almost all roofing systems are field installed, sometimes by multiple trades over a period of time. The importance of testing and verification cannot be understated when it comes to the long-term viability, resilience, and success of the roofing system. There are many standards for both laboratory and field-testing roofing components and installed systems. Any testing should be part of a complete project strategy for the building envelope and its commissioning. This process is a key factor in the long-term resilience of a roofing system. Testing of roof systems, like walls, can be broken into two categories, lab testing and field testing.

Lab Testing: Involves controlled experiments to assess structural integrity, fire resistance, and other critical properties of roof assemblies using standardized test methods.

Field Testing: Focuses on evaluating the performance of installed roof systems under real-world conditions such as water penetration, air leakage, and thermal efficiency.

These tests should be performed by a third-party licensed and experienced testing agency and should be observed by both the project envelope commissioning agent and the design professional of record. Testing should be specified to be completed at the appropriate intervals during the construction phase and completed until a passing condition has been achieved.

A successful roofing system that ensures long-term viability and resilience begins with proper specifying and detailing of the system during the design phase. The design professional must understand how the various components become integrated to achieve viability. This includes ensuring compatibility of materials between manufacturers, vapor drive within the roofing system under different climatic conditions(and in anticipation of future conditions), internal program moisture load(natatorium, labs, etc), and process for installation and maintenance.

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It's important to begin the construction phase of the project with an holistic approach to developing a plan by the contractor to ensure the understanding of the coordination and installation of all roofing systems components and that testing is understood by all trades and is properly integrated into the project schedule and workflow(this includes allowing time for evaluation and retesting if needed).

Specific tests can include:

ASTM D5957 - Standard Guide for Flood Testing Horizontal Waterproofing Installations: This standard outlines procedures for flood testing horizontal waterproofing installations having a slope not greater than 20 mm/m (2% slope) (1/4" per ft).

ASTM D7877 - Standard Guide for Electronic Methods for Detecting and Locating Leaks in Waterproof Membranes: This guide covers electronic methods for detecting leaks in waterproof membranes. This guide is applicable for waterproofing membranes installed in roofs, plaza decks, pools, water features, covered reservoirs and other waterproofing applications.

ANSI/SPRI RP 14 - Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems: This standard includes guidelines for wind resistance but can indirectly contribute to evaluating roof systems' ability to resist moisture intrusion by ensuring tight seals and connections.

Additional testing considerations to ensure long-term viability and resilience over time include:

Wind Uplift Resistance Testing: This tests how well a roof system can resist being uplifted by wind forces. Standards like ASTM E1592 outline procedures for determining the wind resistance of various roofing materials and systems.

Durability and Longevity Testing: Assesses the expected lifespan and durability of roofing materials under normal and extreme conditions, including exposure to sunlight (UV radiation), temperature fluctuations, and chemical exposure.

Energy Efficiency Testing: Measures the ability of a roof system to reflect sunlight (solar reflectance) and emit absorbed heat (thermal emittance). ASTM E1980 and ASTM E903 are standards used to quantify these properties.

Mechanical Testing: Evaluates the mechanical properties of roofing materials such as tensile strength, flexibility, and dimensional stability. ASTM D638 and ASTM D412 are examples of standards used for such testing.

Environmental Testing: Determines the environmental impact of roofing materials, including their recyclability, sustainability, and compliance with environmental regulations.

SECTION 304 CONCRETE SLABS

In Florida the concrete slab is an often-used component of buildings, both residential and commercial. Due to its economy, ease of installation, durability, and longevity it is used in all types of buildings and in all types of construction.

Concrete slabs can be load bearing and non-load bearing in function. Slabs can be as thin as 3.5 inches to as thick as 12 to 18 inches (or even greater) depending on the structural conditions of the soils below and loading of the building slab requirements.

All concrete slabs bear a certain amount of live and dead loads. Load bearing concrete slabs are often thickened with heavier reinforcing to support the superimposed loads from columns and walls.

In addition to their structural capacity concrete slabs must also provide protection from air, water vapor, and liquid water penetration from below the slab coming from the moisture in the soils below.

See chapters 18 - SOILS and FOUNDATIONS, and 19 - CONCRETE of the Florida Building Code, Building for additional requirements. See also appendix section 105 - Flood - Resistant Construction as it may pertain.

SECTION 305 FOUNDATION WALLS

While Florida buildings typically do not often include basements in most residential construction, basements are becoming increasingly more beneficial in commercial construction. The most common use for a basement in larger Florida buildings is to accommodate the parking of vehicles while not increasing the height of the building. Most zoning regulations set a height limitation on the building, basements for parking then give the building design greater flexibility for use of floor levels above grade.

When basements are used for parking and other purposes (storage, mechanical equipment, etc.) they must be waterproofed for hydrostatic pressure for maximum use and longevity. Hydrostatic pressure of moist soils and water can impose hundreds of pounds per square foot on the foundation walls, in addition to superimposed loading of columns and walls supported by the foundation walls. Waterproofing of these walls is highly specialized and should only be designed by licensed professionals and constructed by knowledgeable builders and subcontractors using materials and methods specifically designed for that purpose.

See chapters 18- SOILS and FOUNDATIONS, and 19 - CONCRETE, and 20 - MASONRY of the Florida Building Code for additional requirements. See also appendix section 105 - Flood - Resistant Construction as it may pertain.

SECTION 401 - RESOURCES - Water Efficiency and Conservation

401.1 Intent

The intent of this section shall establish the means of conserving water used indoors, outdoors, and in wastewater conveyance.

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401.2 Scope

The following terms are described in Section 201:

- EVAPOTRANSPIRATION ADJUSTMENT FACTOR (ETAF).
- GREYWATER.
- HYDROZONES.
- METERING FAUCET.
- POTABLE WATER.
- SPECIAL LANDSCAPE AREA (SLA).
- SUBMETER.

SECTION 402 INDOOR WATER USE

402.1 Meters.

Separate submeters or metering devices shall be installed for the uses described in Sections 402.2, 402.3, and by the Irrigation Design Plan.

402.2 New buildings or additions more than 50,000 square feet.

Separate submeters shall be installed as follows:

1. For each individual leased, rented or other tenant space within the building projected to consume more than 100 gallons/day, including, but not limited to, spaces used for laundry or cleaners, restaurant or food service, medical or dental office, laboratory, or beauty salon or barber shop.
2. Where separate submeters for individual building tenants are unfeasible, for water supplied to the following subsystems.
3. Makeup water for cooling towers where flow through is greater than 500 gpm.
4. Makeup water for evaporative coolers greater than 6 gpm.
5. Steam and hot-water boilers with energy input more than 500,000 Btu/h (147 kW).

402.3 Excess consumption.

A separate submeter or metering device shall be provided for any tenant within a new building or within an addition that is projected to consume more than 1000 gal/day.

402.4 Water conserving plumbing fixtures and fittings.

Plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following:

402.5 Water Closets

The effective flush volume of all water closets shall not exceed 1.28 gallons per flush. Tank-type water closets shall be certified to the performance criteria of the US EPA WaterSense Specification for Tank-Type Toilets.

Note: The effective flush volume of dual flush toilets is defined as the composite, average flush volume of two reduced flushes and one full flush.

402.6 Urinals.

Wall-mounted urinals. The effective flush volume of wall-mounted urinals shall not exceed 0.125 gallons per flush.

Floor-mounted urinals. The effective flush volume of floor-mounted or other urinals shall not exceed 0.5 gallons per flush.

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402.7 Showerheads.

Single shower head. Shower Heads shall have a maximum flow rate of not more than 1.8 gallons per minute at 80 psi. Shower Heads shall be certified to the performance criteria of the US EPA WaterSense Specification for Showerheads.

Multiple shower heads serving one shower. When a shower is served by more than one shower head, the combined flow rate of all showerheads and/or other shower outlets controlled by a single valve shall not exceed 1.8 gallons per minute at 80 psi, or the shower shall be designed to allow only one shower outlet to be in operation at a time.

Note: A hand-held shower shall be considered a showerhead.

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402.8 Faucets and fountains.

Nonresidential lavatory faucets.

Lavatory faucets shall have a maximum flow rate of not more than 0.5 gallons per minute at 60 psi.

Kitchen faucets.

Kitchen faucets shall have a maximum flow rate of not more than 1.8 gallons per minute at 60 psi. Kitchen faucets may temporarily increase the flow above the maximum rate, but not to exceed 2.2 gallons per minute at 60 psi, and must default to a maximum flow rate of 1.8 gallons per minute at 60 psi.

Wash fountains.

Wash fountains shall have a maximum flow rate of not more than 1.8 gallons per minute/20 [rim space (inches) at 60 psi].

Metering faucets.

Metering faucets shall not deliver more than 0.20 gallons per cycle.

Metering faucets for wash fountains.

Metering faucets for wash fountains shall have a maximum flow rate of not more than 0.20 gallons per cycle/20 [rim space (inches) at 60 psi].

Note: Where complying faucets are unavailable, aerators or other means may be used to achieve reduction.

SECTION 403 OUTDOOR WATER USE

403.1 Outdoor potable water use in landscape areas

WATER EFFICIENT LANDSCAPE WORKSHEET

A project applicant shall complete the Water Efficient Landscape Worksheet which contains information on the plant factor, irrigation method, irrigation efficiency, and area associated with each hydrozone. Calculations are then made to show that the evapotranspiration adjustment factor (ETAF) for the landscape project does not exceed a factor of 0.55 for multi-family residential areas and 0.45 for non-residential areas, exclusive of Special Landscape Areas. The ETAF for a landscape project is based on the plant factors and irrigation methods selected. The Maximum Applied Water Allowance is calculated based on the maximum ETAF allowed (0.55 for multi-family residential areas and 0.45 for non-residential areas) and expressed as annual gallons required. The Estimated Total Water Use (ETWU) is calculated based on the plants used and irrigation method selected for the landscape design. Estimated Total Water Use (ETWU) must be below the Maximum Applied Water Allowance (MAWA).

In calculating the MAWA and ETWU, a project applicant shall use historic Evapotranspiration values for the relevant County as issued by the Florida Automated Weather Network and UF | IFAS Extension.

Water budget calculations shall adhere to the following

- The plant factor used shall be from horticultural researchers with academic institutions or professional associations. The plant factor ranges from 0 to 0.1 for very low water using plants, 0.1 to 0.3 for low water use plants, from 0.4 to 0.6 for moderate water use plants, and from 0.7 to 1.0 for high water use plants.
- All water features shall be included in the high water use hydrozone and temporarily irrigated areas shall be included in the low water use hydrozone.
- All Special Landscape Areas shall be identified and their water use calculated.

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- ETAF for new and existing (non-rehabilitated) Special Landscape Areas shall not exceed 1.0.

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WATER EFFICIENT LANDSCAPE WORKSHEET

This worksheet is filled out by the project applicant and it is a required element of the Landscape Documentation Package.

Reference Evapotranspiration (ETo) _____

Hydrozone # /Planting Description[a]	Plant Factor (PF)	Irrigation Method[b]	Irrigation Efficiency (IE)[c]	ETAF (PF/IE)	Landscape Area (sq, ft,)	ETAF x Area	Estimated Total Water Use (ETWU)[e]
Regular Landscape Areas							
				Totals	(A)	(B)	
Special Landscape Areas							
				1			
				1			
				1			
				Totals	(C)	(D)	
						ETWU Total	
						Maximum Allowed Water Allowance (MAWA)[e]	

[redacted]

[a] ***Hydrozone #/Planting Description***
E.g
1.) front lawn
2.) low water use plantings
3.) medium water use planting

[b] ***Irrigation Method***
overhead spray
or drip

[c] ***Irrigation Efficiency***
0.75 for spray head
0.81 for drip

[d] ***ETWU*** **(Annual Gallons Required) =**
Eto x 0.62 x ETAF x Area
where 0.62 is a conversion factor that converts acre-inches per acre per year to gallons per square foot per year.

[e] ***MAWA (Annual Gallons Allowed)*** = *(Eto) (0.62) [(ETAF x LA) + ((1-ETAF) x SLA)]*
where 0.62 is a conversion factor that converts acre-inches per acre per year to gallons per square foot per year, LA is the total landscape area in square feet, SLA is the total special landscape area in square feet, and ETAF is .55 for residential areas and 0.45 for non-residential areas.

ETAF Calculations

Regular Landscape Areas

Total ETAF x Area	(B)
Total Area	(A)
Average ETAF	**B ÷ A**

Average ETAF for Regular Landscape Areas must be 0.55 or below for residential areas, and 0.45 or below for non-residential areas.

All Landscape Areas

Total ETAF x Area	(B+D)
Total Area	(A+C)
Sitewide ETAF	**(B+D) ÷ (A+C)**

SOIL MANAGEMENT REPORT

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In order to reduce runoff and encourage healthy plant growth, a soil management report shall be completed by the project applicant, or his/her designee, as follows:

- Submit soil samples to a laboratory for analysis and recommendations.
  - Soil sampling shall be conducted in accordance with laboratory protocol, including protocols regarding adequate sampling depth for the intended plants.
- The soil analysis shall include:
  - soil texture;
  - infiltration rate determined by laboratory test or soil texture infiltration rate table;
  - pH;
  - total soluble salts;
  - Sodium;
  - percent organic matter; and
  - Recommendations.
- In projects with multiple landscape installations (i.e. production home developments) a soil sampling rate of 1 in 7 lots or approximately 15% will satisfy this requirement. Large landscape projects shall sample at a rate equivalent to 1 in 7 lots.
  - The project applicant, or his/her designee, shall comply with one of the following:
    - If significant mass grading is not planned, the soil analysis report shall be submitted to the local agency as part of the Landscape Documentation Package; or
    - If significant mass grading is planned, the soil analysis report shall be submitted to the local agency as part of the Certificate of Completion.
    - The soil analysis report shall be made available, in a timely manner, to the professionals preparing the landscape design plans and irrigation design plans to make any necessary adjustments to the design plans.
    - The project applicant, or his/her designee, shall submit documentation verifying implementation of soil analysis report recommendations to the local agency with Certificate of Completion.

LANDSCAPE DESIGN PLAN

For the efficient use of water, a landscape shall be carefully designed and planned for the intended function of the project. A landscape design plan meeting the following design criteria shall be submitted as part of the Landscape Documentation Package.

Plant Material

Any plant may be selected for the landscape, providing the Estimated Total Water Use in the landscape area does not exceed the Maximum Applied Water Allowance. Methods to achieve water efficiency shall include one or more of the following:

- protection and preservation of native species and natural vegetation;
- selection of water-conserving plant, tree and turf species, especially local native plants;
- selection of plants based on local climate suitability, disease and pest resistance;
- selection of trees based on applicable local tree ordinances or tree shading guidelines, and size at maturity as appropriate for the planting area; and
- selection of plants from local and regional landscape program plant lists.

Each hydrozone shall have plant materials with similar water use, with the exception of hydrozones with plants of mixed water use.

Plants shall be selected and planted appropriately based upon their adaptability to the climatic, geologic, and topographical conditions of the project site. Methods to achieve water efficiency shall include one or more of the following:

- Recognize the horticultural attributes of plants (i.e., mature plant size, invasive surface roots) to minimize damage to property or infrastructure [e.g., buildings, sidewalks, power lines]; allow for adequate soil volume for healthy root growth; and consider the solar orientation for plant placement to maximize summer shade and winter solar gain.
- Turf is not allowed on slopes greater than 25% where the toe of the slope is adjacent to an impermeable hardscape and where 25% means 1 foot of vertical elevation change for every 4 feet of horizontal length (rise divided by run x 100 = slope percent).
- High water use plants, characterized by a plant factor of 0.7 to 1.0, are prohibited in street medians.
- The use of invasive plant species, such as those listed by the Florida Invasive Species Council (FISC), is strongly discouraged.
- The architectural guidelines of a common interest development, which include community apartment projects, condominiums, planned developments, and stock cooperatives, shall not prohibit or include conditions that have the effect of prohibiting the use of low-water use plants as a group.

Water Features

- Recirculating water systems shall be used for water features.
- Where available, recycled water shall be used as a source for decorative water features.
- Surface area of a water feature shall be included in the high water use hydrozone area of the water budget calculation.
- Pool and spa covers are highly recommended.

Soil Preparation, Mulch and Amendments

- Prior to the planting of any materials, compacted soils shall be transformed to a friable condition. On engineered slopes, only amended planting holes need meet this requirement.
- Soil amendments shall be incorporated according to recommendations of the soil report and what is appropriate for the plants selected.
- For landscape installations, compost at a rate of a minimum of four cubic yards per 1,000 square feet of permeable area shall be incorporated to a depth of six inches into the soil. Soils with greater than 6% organic matter in the top 6 inches of soil are exempt from adding compost and tilling.
- A minimum three inch (3") layer of mulch shall be applied on all exposed soil surfaces of planting areas except in turf areas, creeping or rooting groundcovers, or direct seeding applications where mulch is contraindicated. To provide habitat for beneficial insects and other wildlife, up to 5 % of the landscape area may be left without mulch. Designated insect habitat must be included in the landscape design plan as such.
- Stabilizing mulching products shall be used on slopes that meet current engineering standards.

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- The mulching portion of the seed/mulch slurry in hydro-seeded applications shall meet the mulching requirement.
- Organic mulch materials made from recycled or post-consumer shall take precedence over inorganic materials or virgin forest products unless the recycled post-consumer organic products are not locally available. Organic mulches are not required where prohibited by local ordinances.

The landscape design plan, at a minimum, shall:

- delineate and label each hydrozone by number, letter, or other method;
- identify each hydrozone as low, moderate, high water, or mixed water use. Temporarily irrigated areas of the landscape shall be included in the low water use hydrozone for the water budget calculation;
- identify recreational areas;
- identify areas permanently and solely dedicated to edible plants;
- identify areas irrigated with recycled water;
- identify type of mulch and application depth;
- identify soil amendments, type, and quantity;
- identify type and surface area of water features;
- identify hardscapes (pervious and non-pervious);
- identify location, installation details, and 24-hour retention or infiltration capacity of any applicable stormwater best management practices that encourage on-site retention and infiltration of stormwater. Project applicants shall refer to the local agency or Water Management Board for information on any applicable stormwater technical requirements. Stormwater best management practices are encouraged in the landscape design plan and examples are provided in Section 492.16.
- identify any applicable rain harvesting or catchment technologies and their 24-hour retention or infiltration capacity;
- identify any applicable graywater discharge piping, system components and area(s) of distribution;
- contain the following statement: "I have complied with the criteria of the ordinance and applied them for the efficient use of water in the landscape design plan"; and
- bear the signature of a licensed landscape architect, licensed landscape contractor, or any other person authorized to design a landscape.

IRRIGATION DESIGN PLAN

This section applies to landscaped areas requiring permanent irrigation, not areas that require temporary irrigation solely for the plant establishment period. For the efficient use of water, an irrigation system shall meet all the requirements listed in this section and the manufacturers' recommendations. The irrigation system and its related components shall be planned and designed to allow for proper installation, management, and maintenance. An irrigation design plan meeting the following design criteria shall be submitted:

System

Landscape water meters, defined as either a dedicated water service meter or private submeter, shall be installed for all non-residential irrigated landscapes of 1,000 sq. ft. but not more than 5,000 sq.ft. and multi-family residential irrigated landscapes of 5,000 sq. ft. or greater. A landscape water meter may be either:

- a customer service meter dedicated to landscape use provided by the local water purveyor; or
- a privately owned meter or submeter.

Automatic irrigation controllers utilizing either evapotranspiration or soil moisture sensor data utilizing non-volatile memory shall be required for irrigation scheduling in all irrigation systems.

If the water pressure is below or exceeds the recommended pressure of the specified irrigation devices, the installation of a pressure regulating device is required to ensure that the dynamic pressure at each emission device is within the manufacturer's recommended pressure range for optimal performance.

If the static pressure is above or below the required dynamic pressure of the irrigation system, pressure-regulating devices such as inline pressure regulators, booster pumps, or other devices shall be installed to meet the required dynamic pressure of the irrigation system.

Static water pressure, dynamic or operating pressure, and flow reading of the water supply shall be measured at the point of connection. These pressure and flow measurements shall be conducted at the design stage. If the measurements are not available at the design stage, the measurements shall be conducted at installation.

Sensors (rain, freeze, wind, etc.), either integral or auxiliary, that suspend or alter irrigation operation during unfavorable weather conditions shall be required on all irrigation systems, as appropriate for local climatic conditions. Irrigation should be avoided during windy or freezing weather or during rain.

Manual shut-off valves (such as a gate valve, ball valve, or butterfly valve) shall be required, as close as possible to the point of connection of the water supply, to minimize water loss in case of an emergency (such as a main line break) or routine repair.

Backflow prevention devices shall be required to protect the water supply from contamination by the irrigation system. A project applicant shall refer to the applicable local agency code (i.e., public health) for additional backflow prevention requirements.

Flow sensors that detect high flow conditions created by system damage or malfunction are required for all non-residential landscapes and multi-family residential landscapes of 5000 sq. ft. or larger.

Master shut-off valves are required on all projects except landscapes that make use of technologies that allow for the individual control of sprinklers that are individually pressurized in a system equipped with low pressure shut down features.

The irrigation system shall be designed to prevent runoff, low head drainage, overspray, or other similar conditions where irrigation water flows onto non-targeted areas, such as adjacent property, non-irrigated areas, hardscapes, roadways, or structures.

Relevant information from the soil management plan, such as soil type and infiltration rate, shall be utilized when designing irrigation systems.

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- The design of the irrigation system shall conform to the hydrozones of the landscape design plan.
- All irrigation emission devices must meet the requirements set in the American National Standards Institute (ANSI) standard, American Society of Agricultural and Biological Engineers'/International Code Council's (ASABE/ICC) 802-2014 "Landscape Irrigation Sprinkler and Emitter Standard. All sprinkler heads installed in the landscape must document a distribution uniformity low quarter of 0.65 or higher using the protocol defined in ASABE/ICC 802-2014.
- It is highly recommended that the project applicant or local agency inquire with the local water purveyor about peak water operating demands (on the water supply system) or water restrictions that may impact the effectiveness of the irrigation system.
- In mulched planting areas, the use of low volume irrigation is required to maximize water infiltration into the root zone.
- Sprinkler heads and other emission devices shall have matched precipitation rates, unless otherwise directed by the manufacturer's recommendations.
- Head to head coverage is recommended. However, sprinkler spacing shall be designed to achieve the highest possible distribution uniformity using the manufacturer's recommendations.
- Swing joints or other riser-protection components are required on all risers subject to damage that are adjacent to hardscapes or in high traffic areas of turfgrass.
- Check valves or anti-drain valves are required on all sprinkler heads where low point drainage could occur.
- Areas less than ten (10) feet in width in any direction shall be irrigated with subsurface irrigation or other means that produces no runoff or overspray.
- Overhead irrigation shall not be permitted within 24 inches of any non-permeable surface. Allowable irrigation within the setback from non-permeable surfaces may include drip, drip line, or other low flow non-spray technology. The setback area may be planted or unplanted. The surfacing of the setback may be mulch, gravel, or other porous material. These restrictions may be modified if:
  - the landscape area is adjacent to permeable surfacing and no runoff occurs; or
  - the adjacent non-permeable surfaces are designed and constructed to drain entirely to landscaping; or
- Slopes greater than 25% shall not be irrigated with an irrigation system with an application rate exceeding 0.75 inches per hour. This restriction may be modified if the landscape designer specifies an alternative design or technology, as part of the Landscape Documentation Package, and clearly demonstrates no runoff or erosion will occur. Prevention of runoff and erosion must be confirmed during the irrigation audit.

Hydrozone

- Each valve shall irrigate a hydrozone with similar site, slope, sun exposure, soil conditions, and plant materials with similar water use.
- Sprinkler heads and other emission devices shall be selected based on what is appropriate for the plant type within that hydrozone.
- Where feasible, trees shall be placed on separate valves from shrubs, groundcovers, and turf to facilitate the appropriate irrigation of trees. The mature size and extent of the root zone shall be considered when designing irrigation for the tree.
- Individual hydrozones that mix plants of moderate and low water use, or moderate and high water use, may be allowed if:
  - The plant factor calculation is based on the proportions of the respective plant water uses and their plant factor; or
  - The plant factor of the higher water using plants is used for calculations.
- Individual hydrozones that mix high and low water use plants shall not be permitted.
- On the landscape design plan and irrigation design plan, hydrozone areas shall be designated by number, letter, or other designation. On the irrigation design plan, designate the areas irrigated by each valve, and assign a number to each valve.

The irrigation design plan, at a minimum, shall contain:

- location and size of separate water meters for landscape;
- location, type and size of all components of the irrigation system, including controllers, main and lateral lines, valves, sprinkler heads, moisture sensing devices, rain switches, quick couplers, pressure regulators, and backflow prevention devices;
- static water pressure at the point of connection to the public water supply;
- flow rate (gallons per minute), application rate (inches per hour), and design operating pressure (pressure per square inch) for each station;
- recycled water irrigation systems
- the following statement: "I have complied with the criteria of the ordinance and applied them accordingly for the efficient use of water in the irrigation design plan"; and
- the signature of a licensed landscape architect, certified irrigation designer, licensed landscape contractor, or any other person authorized to design an irrigation system.

Irrigation Scheduling

For the efficient use of water, all irrigation schedules shall be developed, managed, and evaluated to utilize the minimum amount of water required to maintain plant health.

Irrigation schedules shall meet the following criteria:

- Irrigation scheduling shall be regulated by automatic irrigation controllers.
- Overhead irrigation shall be scheduled between 8:00 p.m. and 10:00 a.m. unless weather conditions prevent it. If allowable hours of irrigation differ from the local water purveyor, the stricter of the two shall apply. Operation of the irrigation system outside the normal watering window is allowed for auditing and system maintenance.
- For implementation of the irrigation schedule, particular attention must be paid to irrigation run times, emission device, flow rate, and current reference evapotranspiration, so that applied water meets the Estimated Total Water Use. Total annual applied water shall be less than or equal to Maximum Applied Water Allowance (MAWA). Actual irrigation schedules shall be regulated by automatic irrigation controllers using current reference evapotranspiration data (e.g., from the Florida Automated Weather Network (FAWN) or soil moisture sensor data.
- Parameters used to set the automatic controller shall be developed and submitted for each of the following:
  - the plant establishment period;
  - the established landscape; and
  - temporarily irrigated areas.

Each irrigation schedule shall consider for each station all of the following that apply:

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- irrigation interval (days between irrigation);
- irrigation run times (hours or minutes per irrigation event to avoid runoff);
- number of cycle starts required for each irrigation event to avoid runoff;
- amount of applied water scheduled to be applied on a monthly basis;
- application rate setting;
- root depth setting;
- plant type setting;
- soil type;
- slope factor setting;
- shade factor setting; and
- irrigation uniformity or efficiency setting.

Landscape and Irrigation Maintenance Schedule

Landscapes shall be maintained to ensure water use efficiency. A regular maintenance schedule shall be submitted with the Certificate of Completion.

A regular maintenance schedule shall include, but not be limited to, routine inspection; auditing, adjustment and repair of the irrigation system and its components; aerating and dethatching turf areas; topdressing with compost, replenishing mulch; fertilizing; pruning; weeding in all landscape areas, and removing obstructions to emission devices. Operation of the irrigation system outside the normal watering window is allowed for auditing and system maintenance.

Repair of all irrigation equipment shall be done with the originally installed components or their equivalents or with components with greater efficiency.

A project applicant is encouraged to implement established landscape industry sustainable Best Practices for all landscape maintenance activities.

Irrigation Efficiency

For the purpose of determining Estimated Total Water Use, average irrigation efficiency is assumed to be 0.75 for overhead spray devices and 0.81 for drip system devices.

Recycled Water Systems

The installation of recycled water irrigation systems shall allow for the current and future use of recycled water.

All recycled water irrigation systems shall be designed and operated in accordance with all applicable local and State laws.

Landscapes using recycled water are considered Special Landscape Areas. The ET Adjustment Factor (ETAF) for new and existing (non-rehabilitated) Special Landscape Areas shall not exceed 1.0.

Graywater Systems

Graywater systems promote the efficient use of water and are encouraged to assist in on-site landscape irrigation.

Water Waste Prevention

Local agencies shall prevent water waste resulting from inefficient landscape irrigation by prohibiting runoff from leaving the target landscape due to low head drainage, overspray, or other similar conditions where water flows onto adjacent property, non-irrigated areas, walks, roadways, parking lots, or structures. Penalties for violation of these prohibitions shall be established locally.

Restrictions regarding overspray and runoff may be modified if:

- the landscape area is adjacent to permeable surfacing and no runoff occurs; or
- the adjacent non-permeable surfaces are designed and constructed to drain entirely to landscaping.

SECTION 501 – FLOOD-RESISTANT CONSTRUCTION

Reference: Building Code Requirements That Exceed or Are More Specific Than the National Flood Insurance Program

501.1 Intent

The intent of this section is to provide additional protections beyond those required by the Florida Building Code, Building, Section 1612, Flood Loads, ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and other Structures (Chapter 8) and ASCE 24, Flood Resistant Design and Construction.

This section and the flood load and flood-resistant construction requirements of the Florida Building Code, Building are to establish minimum requirements to safeguard the public health, safety, and general welfare and to minimize public and private losses due to flooding through regulation of development in flood hazard areas to:

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1. Minimize unnecessary disruption of commerce, access and public service during times of flooding.
2. Require the use of appropriate construction practices in order to prevent or minimize future flood damage.
3. Minimize damage to public and private facilities and utilities.
4. Help maintain a stable tax base by providing for the sound use and development of flood prone areas.
5. Minimize the need for future expenditure of public funds for flood control projects and response to and recovery from flood events.

Requirements set forth in this section shall not supersede more stringent local code requirements.

501.2 Scope

The provisions of this section shall apply to all existing construction and new construction that are located in a *flood hazard area* as established in Section 1612, Flood Loads of this code.

SECTION 502 SPECIAL REQUIREMENTS FOR CRITICAL FACILITIES

502.1 Intent

Promote the health, safety and general welfare, and to minimize losses due to flood hazards and flood loads to facilities classified as critical either because of the services they provide (e.g., hospitals) or their importance during an emergency (e.g., storm shelters) by establishing regulations that reduce disruption of the use of the structure during and after a flood event.

502.2 Scope

Critical Facilities, as defined in Sections 201.1 and 502.3 of this appendix, shall be constructed as Risk Category III and IV structures in accordance with the Florida Building Code, Building, Section
1604.5, Risk Category and Table 1604.5, Risk

502.3 List of Critical Facilities

- Storm shelters (as per the Florida Building Code, Building, Section 423)
- Hospitals and health care facilities (as per the Florida Building Code, Building, Section 449);
- Jails, correctional facilities and detention facilities;
- Facilities used in communications, operation centers, communication towers, electrical substations, back-up generators, fuel or water storage tanks, power generating stations and other public utility facilities;
- Major food distribution centers (with an annual expected volume of greater than 170,000,000 pounds);
- Infrastructure in transportation, telecommunications, or power networks including bridges, tunnels (vehicular and rail), traffic signals, (and other right of way elements including street lights and utilities), power transmission facilities, substations, circuit breaker houses, city gate stations, arterial roadways, telecommunications central offices, switching facilities, etc.;
- Ventilation buildings and fan plants;
- Operations centers;
- Pumping stations (sanitary and stormwater);
- Train and transit maintenance yards and shops;
- Wastewater treatment plants;
- Water supply infrastructure;
- Combined-sewer overflow (CSO) retention tanks;
- Fueling stations;
- Waste transfer stations; and
- Facilities where residents have limited mobility or ability, including care facilities and nursing homes (as per the Florida Building Code, Building, Section 450).

SECTION 503 EXISTING BUILDINGS

503.1 Intent

The Florida Building Code, Existing Buildings, Section 401.5, Flood Loads, addresses only buildings in flood hazard areas going through *repairs, alterations, additions and/or rehabilitation* that constitute *substantial improvements*, requiring resistance to the effects of flood hazards and flood loads as per Section 1612. This section provides measures to increase flood damage resistance of existing buildings in flood hazard areas that are going through *repairs, alterations, additions and/or rehabilitation* that do not constitute *substantial improvement*.

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503.2 General.

In flood hazard areas, any *repair, alteration ,addition and/or rehabilitation* shall include all requirements *technically feasible* from the Florida Building Code - Building, Section 1612, Flood Loads.

503.3 Additional Requirements.

503.3.1 Protection of critical mechanical, plumbing and electrical systems

Mechanical, plumbing, electrical, and life safety system (including but not limited to HVAC units, emergency generators, duct work, alarm systems, electrical panels, electrical distribution, switching areas, gas and electrical meters, suppression equipment, telecommunications equipment, motors and controllers, fuel storage tanks) shall be elevated to or above the design flood elevation in *repairs*, *alterations*, *additions* and/or *rehabilitation* that do not constitute substantial improvement occurring below the design flood elevation in buildings in flood hazard areas. Exceptions may be made for life safety, egress, and low voltage components when necessary.

503.3.2 Dry Flood Proofing

The objective of dry floodproofing is to seal the portion of a structure (walls and other exterior components) that is below the design flood elevation making it watertight and impermeable to floodwaters as recommended by the Coastal Construction Manual FEMA P-55, Chapter 15.3.3.

503.3.3 Wet Flood Proofing

Wet floodproofing involves modifying a building to allow floodwaters to enter it in such a way that damage to the structure and its contents is minimized. Wet floodproofing is often used in a non-habitable understory of structures in flood prone areas, where the first habitable floor is elevated above the design flood elevation. The Coastal Construction Manual FEMA P-55, Chapter 15.3.4 provides guidance concerning wet proofing alternatives.

SECTION 504 FLOOD DAMAGE-RESISTANT MATERIALS

Reference: Coastal Construction Manual FEMA P-55, Chapter 9 and the FEMA National Flood Insurance Program (NFIP)Technical Bulletin 2.

504.1 Intent

Not currently required by the Florida Building Code, Existing Buildings, the use of the proper materials could assist in avoiding significant future material losses and disruption to people's lives.This section encourages the use of flood damage-resistant materials in *repairs, alterations, additions and/or rehabilitation* that do not constitute a *substantial improvement* occurring below the design flood elevation in buildings in flood hazard areas.

504.2 Scope

Repairs, alterations, additions and/or rehabilitation that do not constitute a substantial improvement occurring below the design flood elevation in buildings in high hazard areas shall be constructed using flood damage-resistant materials as required by the Coastal Construction Manual FEMA P-55, Chapter 9.4, and the FEMA NFIP Technical Bulletin 2 .

504.3 Additional Interventions to Mitigate Flood Damage to Buildings

- Storm water damage by relocating them above the design flood elevation.
- Install backwater prevention valves.
- Install sump pumps.
- Direct floodwaters away from critical equipment and building access towards detention areas if available.
- Reduce impervious surfaces in the building vicinity by using permeable paving and drainage underlayment.
- Increase water infiltration by planting trees, grass/ground coverage vegetation and vegetated swales per Section 403.
- Create stormwater detention areas in the landscape.
- Provide exterior waterproofing.
- Utilize flood-resistant materials.
- Seal penetrations below the design flood elevation.
- Provide redundant/elevated conduit entrances.
- Install back-up power.

Raise utilities installed below design flood elevation building/structure footprint in the direction of flow of oncoming floodwaters, allowing for free passage of water at or more than sixty (60), percent of the footprint after breakaway construction has been dislodged and scour has taken place.

SECTION 505 ELEMENTS BELOW DESIGN FLOOD ELEVATION

505.1 Obstruction Free Design

Free of Obstruction. In order to reduce the effects of flow diversion, wave reflection, and wave runup, the use of permanent structural components and systems designed to resist the combined effects of wind and flood loads below the Design Flood Elevation must not block or impede the passage of water more than an

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aggregate forty (40) percent of the total width of the building/structure footprint in the direction of flow of oncoming floodwaters, allowing for free passage of water at or more than sixty (60) percent of the footprint after breakaway construction has been dislodged and scour has taken place.

505.2 Enclosed Areas

Enclosed Areas below design flood elevation. Enclosed areas, including crawl spaces, that are below the design flood elevation shall be used solely for parking of vehicles, building access and/or storage. The enclosed area shall not be conditioned space (temperature controlled) or finished or partitioned except for one storage area no larger than one hundred (100) square feet with one dimension not to exceed six (6) feet, access stairwells, ramps, and elevators, unless a partition is required by the Fire Prevention Code. The limitation on partitions does not apply to load bearing walls interior to perimeter wall (crawlspace) foundations.

505.3 Walls

Walls below design flood elevation. Walls and partitions are permitted below the elevated floor, provided that such walls and partitions are not part of the structural support of the building or structure and electrical, mechanical and plumbing system components are not mounted on or penetrate through such walls and partitions that are designed to break away under flood loads.

505.4 Accessory Structures

Accessory structures are permitted below the base flood elevation provided the accessory structures are used only for parking or storage and:

1. If located in special flood hazard areas (Zone A/AE) other than coastal high hazard areas or coastal A zones, they are one-story and not larger than six hundred (600) square feet.
2. If located in coastal high-hazard areas (Zone V/VE) or coastal A zones, they are not located below elevated buildings and are not larger than one hundred (100) square feet.

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WATER EFFICIENT LANDSCAPE WORKSHEET

This worksheet is filled out by the project applicant and it is a required element of the Landscape Documentation Package.

Reference Evapotranspiration (ETo) _____

Hydrozone # /Planting Description[a]	Plant Factor (PF)	Irrigation Method[b]	Irrigation Efficiency (IE)[c]	ETAF (PF/IE)	Landscape Area (sq, ft,)	ETAF x Area	Estimated Total Water Use (ETWU)[e]
Regular Landscape Areas							
				Totals	0 (A)	0 (B)	
Special Landscape Areas							
	[redacted]			1			
				1			
				1			
				Totals	0 (C)	0 (D)	
						ETWU Total	
						Maximum Allowed Water Allowance (MAWA)[e]	

[a] ***Hydrozone #/Planting Description***
E.g
1.) front lawn
2.) low water use plantings
3.) medium water use planting

[b] ***Irrigation Method***
overhead spray or drip

[c] ***Irrigation Efficiency***
0.75 for spray head
0.81 for drip

[d] ***ETWU*** **(Annual Gallons Required) =**
Eto x 0.62 x ETAF x Area
where 0.62 is a conversion factor that converts acre-inches per acre per year to gallons per square foot per year.

[e] ***MAWA (Annual Gallons Allowed) =*** *(Eto) (0.62) [(ETAF x LA) + ((1-ETAF) x SLA)]*
where 0.62 is a conversion factor that converts acre-inches per acre per year to gallons per square foot per year, LA is the total landscape area in square feet, SLA is the total special landscape area in square feet, and ETAF is .55 for residential areas and 0.45 for non-residential areas.

ETAF Calculations

Regular Landscape Areas

Total ETAF x Area	(B)	
Total Area	(A)	
Average ETAF	**B ÷ A**	

Average ETAF for Regular Landscape Areas must be 0.55 or below for residential areas, and 0.45 or below for non-residential areas.

All Landscape Areas

Total ETAF x Area	(B+D)	
Total Area	(A+C)	
Sitewide ETAF	**(B+D) ÷ (A+C)**	

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APPENDIX P - ENHANCING THE RESILIENCE OF BUILDINGS: MOISTURE, RESOURCES AND FLOOD

Introduction
101 - General
201 - Definitions
301 - Moisture Control in Buildings
401 - Resources - Water Efficiency and Conservation
501 - Flood Resistant Construction

INTRODUCTION

The Florida Building Code, Building, does not adequately address or consider the role of moisture, flooding, or resource consumption in compromising building resilience, health, and long-term viability. By considering not only the destructive effects of moisture intrusion, but also the usage of water resources and flood-resistant construction best practices, users of the current appendix will create more resilient, longer lasting, and safer facilities.

MOISTURE CONTROL

The building envelope, which includes the walls, windows, roofs and foundation, forms the primary barrier between the interior and exterior environments. The integrity of this barrier is critical to its performance. If the building envelope is compromised, then problems within the interior of the building will develop. These problems often present themselves as mold or stains on the interior. Moving the air, moisture, vapor and thermal control layers outward of the structural layer mitigates intrusion of exterior elements into the wall assembly and allows a method for vapor to drain outward of the building instead of within the wall assembly to the interior of the building.
This appendix proposes to prevent moisture intrusion opportunities.

The Florida Building Code, Building, does not define moisture and related terminology regarding structural integrity and design considerations. This appendix proposes establishing terminology and measures to limit moisture intrusion to manage this aspect of our constructed world.

This appendix aims to limit costs of such aspects of prevention and control of moisture as considered by code. The costs of preventing and controlling moisture are a fraction

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of those required to replace and rebuild and the long-term health costs building occupants could face.

Uncontrolled moisture and rot also cause the growth of organisms found to be unhealthy for human habitation: most commonly, mold. Moisture allows or even encourages mold to grow and creates environments that are dangerous to occupy, if given enough time.

Rust, corrosion, and rot *(see definitions section for more discussion of rust/corrosion & rot)* create slow, quiet, and considerable damage, until discovered by inspection or observation of failure. Currently these are fairly normal occurrences if the building is not designed and constructed to a more resilient standard.

Resilient design and construction can be cost effective. Over time, the savings add up. Making buildings resilient to these processes is not only economical but safe: structurally, for occupants, for communities, and for investment.

The final benefit to enhanced resiliency standards is to maintain healthy buildings for us all to occupy. Rot, mildew, humidity, and other factors allowing uncontrolled moisture and the growth of molds and organisms that endanger healthy spaces are known to create hazards and conditions whose only solutions are those of time and funding spent into our healthcare systems. Victims of such conditions must expend a great deal of funds, time and effort to heal from them. These incidents and circumstances can be greatly reduced, controlled, and even prevented by increasing building resiliency factors.

RESOURCES -Water Efficiency and Conservation

With a growing population constantly increasing the need for water for human habitation, industry, and agriculture, Florida is running the risk of having an inadequate water supply for the state's needs. As the aquifer is increasingly drained, saltwater intrusion from the Atlantic Ocean and the Gulf of Mexico becomes an ever-greater risk. Water is a basic need of any human population and for the state to thrive and be resilient, without resorting to costly desalination plants and incurring water shortages, then the population can be ensured they can live within its resources. Ensuring plentiful water is available to all will require greater efficiency in its usage and this Appendix provides the tools to achieve that.

FLOOD-RESISTANT CONSTRUCTION

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The Florida Building Code, Building, currently addresses measures to increase the resilience of buildings to flooding only in new construction and alterations/additions that constitute substantial damage or substantial improvement (when the cost equals or exceeds 50 percent of the market value of the structure, before the improvement or repair is started). However, existing buildings undergoing alterations/additions of a smaller scale can greatly benefit from available measures to increase their resilience to flooding and avoid future costly reconstruction due to the impact of flood water. This appendix presents strategies for new and existing buildings to confront the ever-increasing frequency and severity of flooding events and their associated environmental challenges to health, safety and long-lasting structures.
Resilient construction from the outset is more cost-effective than rebuilding and reconstruction. Added initial costs are between 5 – 10% for new construction. Replacement costs to rebuild and replace a structure are at least the original costs plus inflation, but those costs can be considerably higher in total expenditure.

COST REFERENCES
Insurance Institute for Business & Home Safety (IIBHS)

Increased construction cost ranges from .29 to 1.43 percent of the building's total cost, depending upon designation sought and building location. This added cost was more than offset by insurance savings and/or increased rent (value to the occupants).

Columbia University / Columbia Climate School

"Technologies exist to protect homes against severe weather — but those innovations have been slow to seep into mainstream homebuilding, leaving most Americans increasingly exposed to climate shocks, experts say… Houses made from steel and concrete can be more resilient to heat, wildfire and storms. Even traditional wood-framed homes can be constructed in ways that greatly reduce the odds of severe damage from hurricanes or flooding. But the costs of added resiliency can be about 10 percent higher than conventional construction."

Building Resilience: FEMA's Building Codes Policies and considerations for Congress June 27, 2023

The National Institute of Building Sciences emphasizes the importance of building codes in a widely cited study which found that adopting the most recent building code could save $11 for every dollar invested in hazard-resistant codes and standards, and above-code design could save $4 for each dollar invested. The study also found that

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adopting the 2015 International Code Council building codes added about 1% in costs relative to 1990 standards.

Columbia University / Columbia Climate School

"Weather-related disasters pushed more than 3.3 million American adults out of their homes in 2022, census data shows. Of those, at least 1.2 million people were out of their homes for at least a month or longer; more than half a million of them never returned.

Homeland Security Affairs, Volume VI no 3 September 2010. www.hsaj.org
The idea of building resilience to natural and manmade disasters is now a dominant strategic theme and operational goal in the current U.S. national security policy discourse. Resilience is a critical priority that can be planned for, managed and experienced real value in. It's not a matter of "IF" something happens, it's a matter of when.

CONCLUSION

A study in 2005 estimated that for every $1 invested in disaster risk mitigation, $4 was saved in post-disaster rebuilding efforts. **New data in 2019** showed $1 spent on mitigation measures could save $11 post-disaster.

The Harvard Gazette, April 5 2023.
https://news.harvard.edu/gazette/story/2023/04/natural-disaster-recovery-costs-set-to-spiral-study-shows/

The costs of reconstruction (and all the concerns outlined above) will likely grow over time. As costs associated with construction increase–such as wages, property values, products & services, transportation, shipping, etc.-- so too will reconstruction costs, making the investment in resilient structures and spaces even more valuable and wise. From structural stability to healthy spaces to economic wisdom, the health, safety and welfare of our state is better protected by resilient design and construction codes (and their enforcement).

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SECTION 101 - GENERAL

101.1 Intent.

The intent of this appendix is to express the more specific principles of Resilient Design and Construction of buildings in the State of Florida. It is important to first comply with the minimum requirements of the Florida Building Code, Building, then meeting or exceeding additional objectives as stated in this appendix to further enhance building resilience.

101.2 Scope.

To be applicable to the increased resilience of any project requiring application of the Florida Administrative or Building Codes, through its planning, design, operation, construction, and occupancy.

101.3 Referenced codes and standards.

Refer to Florida Building Code, Building, 101.4 Referenced Codes and Ch. 35, Reference Standards. When dealing with the design and construction of existing buildings refer to the Florida Building Code, Existing Building for additional requirements.

101.4 Enforcement.

When this appendix is adopted by a local Authority Having Jurisdiction (AHJ) provisions for enforcement shall be proposed and adopted by ordinance. Enforcement then falls under that AHJ in accordance with their ordinance language.

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SECTION 201 - SUPPLEMENTAL DEFINITIONS

201.1 Intent

The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of the Florida Building Code, Building for general definitions.

BIOSWALE. A long, channeled depression or trench that receives and transports rainwater runoff (as from a parking lot) and has vegetation (such as grasses, flowering herbs, and shrubs) and organic matter (such as mulch) to slow water infiltration and filter out pollutants.

CONDENSATION. Natural condition of moisture from the atmosphere collecting on or within a surface when conditions of humidity and temperature of both atmosphere and surfaces align. While conditions of condensation vary depending upon the range of humidity and temperature of atmosphere and temperatures of adjacent surfaces and materials, these conditions are predictable and can be foreseen - as such in certain assemblies should be avoided or managed. [please consider a simplified definition. Suggestion: The process through which the moisture from the atmosphere becomes water droplets in contact with a cooler surface - refer to dewpoint]

CONTROL. (1) To exercise restraining or directing influence over : (2) to incorporate suitable controls.

CRITICAL FACILITIES. Those structures and essential facilities, listed as Risk Categories III and IV in the Florida Building Code, Building, Table 1604.5, “Risk Category of Buildings and Other Structures”, from which essential services and functions for victim survival, continuation of public safety actions, and disaster recovery are performed or provided. See Florida Building Code, Building, Ch. 2.

DEW (POINT). Dew point is the condition where the temperature and relative humidity of the atmosphere, and the interface of solid objects/surfaces of a certain temperature allows moisture of the atmosphere to appear as a liquid (water) in the forms of drops or droplets on the surface of an object. (See condensation) This circumstance also occurs within an architectural assembly of elements (ie: Wall/Ceiling assemblies) resulting in the presence of water no

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longer in the atmosphere but present as water on the surface of (or within) elements of an assembly.

EVAPOTRANSPIRATION ADJUSTMENT FACTOR (ETAF). An adjustment factor when applied to reference evapotranspiration that adjusts for plant factors and irrigation efficiency, which are two major influences on the amount of water that needs to be applied to the landscape.

GREYWATER. Graywater means untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing or operating wastes. "Graywater" includes, but is not limited to, wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers.

HAZARDOUS EVENT. An incident, situation or occurrence that has the potential to cause harm, damage or adverse effects.

HUMIDITY. Humidity is the amount of moisture in the air.

HYDROZONES. A Hydrozone is an area of landscape with plants sharing similar watering requirements.

METAL OXIDATION. A chemical reaction that occurs when metal is exposed to oxygen and an electrolyte, like water or moisture in the air, and electrons move from the metal to the oxygen.

METERING FAUCET. A self-closing faucet that dispenses a specific volume of water for each actuation cycle. The volume or cycle duration can be fixed or adjustable.

MIST. Exterior moisture in the form of particles floating or falling in the atmosphere at or near the surface of the earth.

MOISTURE. The presence of liquid diffused or condensed in small or trace quantities. These (sometimes) small quantities of moisture are difficult to measure but nevertheless present, and if disregarded can cause reactions to materials and assemblies concerned in this code: Rust, Rot, Mold, etc.

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MOLD. Naturally occurring fungus that grows on organic elements within certain conditions of temperature and humidity.

PERMEABILITY. Permeable material permits the passage of moisture.

POTABLE (WATER) Suitable for drinking.

RAIN. Moisture condensed from the atmosphere that falls visibly in separate drops. In calm (i.e., windless) weather, raindrops fall vertically. It can find its way into small gaps in a building, wetting the roofs, balconies, projections and causing damages.

RAIN, WIND DRIVEN. In wind, raindrop paths fall at oblique angles; the vertical component is called precipitation and the horizontal component is called wind-driven rain (WDR). While precipitation wets horizontal and sloped surfaces, wind-driven rain also wets vertical surfaces. It can find its way into small gaps in a building wetting the wall systems and causing damages.

RAINSCREEN. Rainscreen assemblies are those assemblies applied to an exterior wall that consist of, at minimum, an outer layer, an inner layer, and an airspace between them sufficient for the passive removal of liquid water and water vapor. Rainscreens are effective at managing moisture and provide exceptional opportunities for energy-efficient performance via continuous insulation and reducing thermal bridging.

RAIN GARDEN. Similar to a bioswale, but generally smaller in scale and does not transport water. It receives rainwater runoff (as from a parking lot) and has vegetation (such as grasses, flowering herbs, and shrubs) and organic matter (such as mulch) to slow water infiltration and filter out pollutants.

REMEDIATION OR REMEDIATE. intended as a remedy. Act of correcting an error or risk. Provide a remedy for; Redress or make right.

RESILIENT, RESILIENCE, RESILIENCY. The ability of a system and its component parts to anticipate, absorb, accommodate, and recover from the effects of a hazardous event in a timely and efficient manner, including the preservation, restoration, or improvements of its essential basic structures and functions. Adopted by AIA and IPCC (Intergovernmental Panel on Climate Change).

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RUST. Rust is the result of oxidized iron or steel. Steel structures allowed to rust are compromised due to the corrosive effects of moisture. This results in compromised structural integrity, conditions calling into question their stability, and considerations of removal or renovation to maintain the health, safety, and welfare of occupants.

Concrete structures that allow moisture to migrate into the concrete form can allow the reinforcing steel within to rust and/or corrode. This corrosion often causes reinforcing steel to swell, often causing pieces of the protective layer of concrete to spall or break off, exposing the reinforcing steel. Left unabated, time and conditions permitting, a compromise of the structure can be expected.

ROT. the decomposition and loss of integrity from the action of bacteria and/or fungi. Rot is the natural effect of decay in organic material. Moisture almost always plays a pivotal role, as seen most notably in wood.

Wood structures that allow the presence of uncontrolled moisture will experience this decaying process over time. This process is quiet and steady, and unless found through inspections and routine investigation, it can almost always go far enough to require restructuring or replacement before being discovered. This compromise can and will require the replacement of structural elements in order to maintain the integrity of the structure.

SPECIAL LANDSCAPE AREA (SLA). An area of the landscape dedicated solely to edible plants, planting areas used for educational purposes, recreational areas, areas irrigated with recycled water, water features using recycled water, and where turf provides a playing surface or gathering space.

SUBMETER. A secondary device beyond a meter that measures water consumption of an individual section of a larger system.

VAPOR. Water in a gaseous state and often not visible.

VAPOR RETARDER. a material or assembly's ability to limit the amount of moisture that passes through that material or assembly.

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VARIANCE. A grant of relief from the requirements of this section that permits construction in a manner otherwise prohibited by this section where specific enforcement results in undue hardship.

VIOLATION. A development that is not fully compliant with this appendix, as applicable.

WATER. An inorganic compound with the chemical formula H2O. It is colorless, transparent, odorless liquid.

WIND SPEED. In a storm wind gusts can reach 60 miles per hour (mph) or greater. In a hurricane wind speed (sustained and/or gusts) can reach speeds of 75 mph and greater depending on locality and storm intensity.

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SECTION 301 - MOISTURE CONTROL IN BUILDINGS

301.1 GENERAL

The provisions of this section address the detrimental impacts of moisture migrating through the building envelope, resulting in the degradation of materials and adversely affecting indoor environmental quality. Further, this section provides guidance and establishes the requirements for the design and construction for more resilient building envelope systems in buildings.

NOTE: Ensuring adherence to Florida Product Approval (FPA's) requirements is a critical step in designing and building a safe and resilient exterior building envelope in Florida.

The Florida Building Code, Building, presents the absolute minimum requirements for design and construction in the State of Florida. This section is intended to guide the designer and builder as to ways to implement improvements for moisture control, greater energy efficiency, greater safety, enhancing the longevity of Florida buildings.

- Design: Enhancing the design of buildings with better and more complete drawings and specifications is the first step in the process. Clear and concise communication of design intent is very important.
- Construction: The second step is the proper construction of buildings to most closely follow the design intent of the drawings and specifications, producing a higher quality building.

These requirements supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1, Section 107.3.5.

Exterior Wall & Balcony Requirements:

- 302.4 Drawings & Details - Wall details checklist
- 302.9 Balconies & Similar Projections -Balcony details checklists
- 302.11 Testing requirements

Roofing & Terrace Requirements:

- 303.4 Drawings & Details - Roofing details checklist
- 303.8 Rooftop Terraces & Decks - Waterproofing details checklist
- 303.15 Testing requirements

Additional Recommendations:

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If not adopted by local ordinance, this appendix document presents recommendations for design and construction leading to more resilient, healthier, and longer lasting buildings. The voluntary user of this document is encouraged to implement as many of these recommendations as possible in their project. If all recommendations cannot be followed due to time or cost constraints, it is understood that all projects have limitations and challenges. Do implement as many as possible for greater moisture resistance resulting in more resilient and long-lasting buildings.

See the sections below for the recommendations and guidance for the design and construction of wall systems and roofing systems for Florida buildings.

SECTION 302 RESILIENT EXTERIOR WALLS

Exterior walls function as important aesthetic, structural, and weather resistant elements of the building. The design of today's exterior walls includes multiple enclosure systems of diverse materials and assemblies. Traditional opaque walls include masonry (brick, stone, concrete block), wood sidings, vinyl sidings, composite sidings, EIFS, rainscreens, metal panels, stucco, and other materials. Transparent and translucent walls include; glass walls (window wall, storefront, curtain wall), ceramic frits, reflective, insulated glass/glazing, tinted glass/glazing, mullion systems (aluminum, steel, fiberglass, composites, etc).

302.1 Intent.

The intent of this section is to provide additional direction for the design and construction of more resilient exterior walls and other related wall components; exterior wall coverings; exterior wall openings; exterior windows and doors; exterior soffits and fascias; architectural trim; balconies and similar projections; and bay and oriel windows. See also appendix section 105 - Flood - Resistant Construction as it may pertain.

302.2 Degradation of materials.

As moisture enters the walls of a building, degradation of materials is just one undesirable impact. Moisture needs to be controlled or mitigated to the greatest extent possible. The long-term exposure of moisture to many building materials within exterior walls can adversely affect the lifespan of those materials. Other adverse impacts are weakened structural capabilities, probable health concerns, noxious odors [caused as wood and paper materials begin to grow mold (acting as a food source) and/or rot], rusting of metals (studs, fasteners, hold down straps, connectors, etc.)

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All wall materials degrade over time. Solar load, temperature fluctuations, expansion and contraction, moisture saturation and drying, the natural aging cycle of materials (due to loss of moisture or loss of a component or components within the materials), the influence of other materials inducing stress and strain within the materials in question, carbonization, salts, mineral deposits, environmental dirt, water leakage, freezing water, and other influences. All wall materials are influenced by the location installed and the specific climate zone, weather patterns, distance from the saltwater coast, lake effects, shading or lack of shading, varying climate cycles and weather trends. Even wild animals can be a source of degradation of the wall materials (rats, mice, squirrels and others) by abrasion and/or gnawing of the materials, especially if the materials have an organic or mineral content within the material.

Wall Degradation Examples:

- Concrete (poured in place, precast, tilt wall).
- Stucco (direct application to masonry, lathing, joint materials).
- Wood siding (various configurations).
- Wood paneling (various sizes and surface treatments).
- Composition siding.
- Shingle siding.
- Painting & Staining.
- Vented skins (varying materials with underlying air/water barriers).
- Glass & Glazing.
- Sloped glazing.

Balcony Degradation Examples:

- Bare concrete.
- Sealed concrete.
- Membrane systems over concrete.
- Membrane systems over wood.
- Safety railings (wood, metal, glass, composites).
- Floor drains and scuppers.

302.3 Moisture control within the building walls.

Moisture control within the wall system of a building is critical to the long-term health of the wall systems and the building occupants.

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Some materials are more moisture sensitive than others. There are several ways of designing framed (wood framing, metal framing, wood and composite sheathings, etc.) walls:

- Barrier Systems, where the primary form of moisture resistance is the facing of the wall to keep moisture from entering the wall system and interior.
- Drainage Systems, where there is a secondary form of moisture protection by the installation of a weather resistant barrier (WRB) installed within the wall system to protect the wall framing and interior wall from moisture penetration.
- Rainscreen Systems, where the primary moisture barrier is mounted behind the exterior cladding with a drainage space between the moisture barrier and backside of the exterior cladding. This allows the exterior wall cladding to provide solar, wind and water protection of the primary moisture barrier. Note that this moisture barrier must be robust in design to fully protect the structural substrate from moisture intrusion over the life of the building.
- Hybrid Systems, combining multiple combinations of wall systems in accordance with the design intent of the architect or design professional.

Likewise, masonry (brick, CMU, stone, cement products, etc.) and concrete (cast in place, tilt wall, precast, etc.) walls can incorporate some of the same features as framed walls depending on design intent.

- Masonry cavity wall construction, internal space allows for drying and drainage
- Exposed masonry construction, face sealed is the most economical systems
- Hybrid Systems, combining multiple combinations of wall systems in accordance with the design intent

Comply with chapter 14 of the Florida Building Code, Building for all Exterior Wall requirements;

- 1401 General.
- 1402 Definitions.
- 1403 Performance Requirements.
- 1404 Materials.
- 1405 Installation of Wall Coverings.
- 1406 Combustible Materials on the Exterior Side of Exterior Walls.
- 1407 Metal Composite Materials (MCM).
- 1408 Exterior Insulation and Finish Systems (EIFS).
- 1409 High-Pressure Decorative Exterior-Grade Compact Laminates (HPL).
- 1410 Soffits and Fascias at Roof Overhangs.

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- 1411 Plastic Composite Decking.

Note: see HVHZ requirements in Chapter 24, Glass and Glazing, section 2411.3.2, Tests in the Florida Building Code, Building.

Wall and Opening Details

These wall and opening detail requirements supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1, section 107.3.5.

For more resilient design and construction, the architectural and engineering drawing details must be more comprehensive and concise as to the intended materials and their connections. The path of water is important to indicate if water is allowed within the wall system.

Required Wall and Opening Details Checklist:

- Where an underlying weather barrier is a part of the assembly (specific type, thickness, manufacturer, specific directions for use, application diagrams and details from the manufacturer).
- All wall penetrations (vents, louvers, scuppers, fasteners).
- All window & frame penetrations (sill, jambs, head, flashings).
- All door & frame penetrations.
- If above a balcony, see section 302.11 for additional information.
- All copings on top of walls.
- All flashings by location, material, sizes & profiles, underlayments, fastening patterns.
- Where sealants are used, clearly indicating the location type of seal, material, sizes & profiles, backer rods.
- Integration of horizontal to vertical envelope systems.
- Below grade details(occupied and slab on grade conditions).
- Footing and foundation.
- Expansion joints.
- Interconnection between different wall systems(often overlooked until construction).
- For other special features see sections below.

302.4 Exterior wall coverings.

Exterior wall coverings are the outermost surfacing material of the exterior wall system. The possible exterior wall covering materials are many; wood (lap siding, panel siding,

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trim and moldings), masonry (brick, stone, CMU with various surface textures and treatments), stucco, metal panels, composite panels, plastic panels and lapped siding, and various combinations of materials. Exterior wall coverings can be painted, coated, stained or left natural to weather depending on what the building designer has in mind for the building.

For the Florida climate, building design and construction should consider a coating or stain to shed as much surface moisture as possible before the moisture contacts the actual surface material. While then the coating or stain must be maintained, it is invaluable in preserving the surface of the exterior wall covering to maximize its lifespan.

302.5 Exterior wall openings.

Exterior wall openings include any number of penetrations through the building wall envelope. Anything that penetrates the wall is a wall opening and makes the wall more susceptible to moisture entry into the wall system. All exterior wall openings are required by the Florida Building Code, Building, to be flashed or sealed and therefore need to be detailed by the designer of record so that construction teams can understand the approach to creating a watertight wall opening. See other sections of this appendix that further detail exterior walls and exterior wall openings.

302.6 Exterior soffits and fascias.

Exterior soffits are related to the underside of projecting elements (roof overhangs and other building elements) or ceiling surfaces of upper-level floors or balconies.

Fascias are related to the vertical surface of building overhangs or roofing terminations.

Exterior soffits and fascias shall be properly detailed to tie into the fascia on the outboard side and the wall and wall materials on the inboard side of the soffit. Size all components and connectors for the actual loading pressures (corner and field) to assure that the soffit material is stable in hurricane force winds and rain. Soffits are often the first wind damages and blow-offs in even nominal wind events.

Soffits should have a slight positive slope to the outboard side of the soffit so as to avoid moisture entering the attic or upper wall materials in the event of roof or eave leakage.

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302.7 Architectural trim.

Architectural trim can be defined as ‘minor’ projections (less than 2” of horizontal dimension) of the building wall used for aesthetic articulation of the building facade. Where the horizontal dimension exceeds 2”, see the next section on ‘similar’ projections.

Architectural trim must minimize water penetration into the wall surface, whenever possible. The horizontal surfaces shall slope to drain (6% is the minimum slope recommended) to effectively drain water from the horizontal top surface of the trim. It is recommended that where possible, the bottom horizontal surface have a slope toward the exterior creating an effective dripline.

When the architectural trim consists of proprietary materials such as EIFS or single-coat stucco systems, follow the manufacturer’s requirements in addition to the base building code and this section.

When the architectural trim consists of wood, metals, composite materials, pvc, or other materials special architectural detailing will be required for those trim details, consult available manufacturer details and requirements. Industry publications can also be consulted for detailing information and direction.

Provide details as to the architectural intent of the architectural trim. Always make sure that architectural trim is properly attached. Often the method is nails, screws or construction adhesive. The best method is to combine mechanical attachment with a construction grade adhesive.

If metal flashing is used to prevent water entry, it must be properly detailed. If a liquid applied coating is used follow the manufacturer's instructions. If sealants are used follow the manufacturer’s instructions.

302.8 Balconies and similar projections.

There can be public and private balconies serving the building and its occupants in multi-level buildings.

- Public balconies are common in hotels, motels, apartments/condominiums and sometimes on office or retail buildings. Public balconies must provide safe and easy access to the doors and entries to the occupied spaces daily. They must also provide safe egress to building stairways and elevators for fire services to

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assist in evacuating occupants from the building during emergency evacuations (smoke, fire, other emergencies).

- Private balconies provide multi-level buildings to allow their residents to enjoy the outdoor environment directly outside their residences, hotel rooms, or offices. Balconies also provide weather protection (shading, shadows, shielding from rain) to the walls, windows, glass doors and other parts of the wall systems. Private balconies can also be screened to defend against insects during the warm and hot months of the year.

Balconies on buildings have been one of the most challenging design, detailing, and construction elements of a building. Whether in single family residences, hotels, apartments/condominiums, office buildings using many types of construction (wood framing, metal framing, concrete, and composite materials). Balconies can be solid decking surfaces (and undersides) or constructed of open deck boards (and exposed structural elements) constructed of wood or composite materials.

If water is not effectively resisted (keeping it out of the building and structure) damage to structural components and other building materials can result. Florida wind especially along coastal areas are especially vulnerable to wind driven rains. In addition, coastal construction must withstand the effects of sand and salts weathering the finishes of balconies much faster than in inland locations.

There are no real standards for exactly how to detail balconies so as to maximize weather resistance and provide for their longevity, yet they all must be constructable providing safe railing systems, effectively shedding water, and resisting high velocity winds. Often wind driven rain soaks or even floods balconies with water under both dynamic and hydrostatic pressures.

Many sets of construction drawings and specifications fall short in providing adequate drawing details and clearly written specifications for the materials and workmanship that is needed. Many times the trades constructing balconies do not understand the design intent, so construct the balconies with breaches and voids in water resistant membrane materials and surfaces. Often, effective flashing materials are omitted or poorly installed, so as to leak water into the balcony and adjacent wall structures. When patio door thresholds and sliding glass door tracks are not correctly installed they leak and damage interior flooring materials, baseboards, and finished wall materials. When surface finishes and materials exhibit damage, then in most cases further damages underlie those materials causing structural damages to floor and balcony structural members and the wall systems (and columns) supporting those balconies.

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Balcony Details
These balcony detail requirements supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1 section 107.3.5.

Wood framed balconies (solid surface and open decking) are the most problematic for proper waterproofing, so minimum details are required as follows:

Minimum 'solid surface decking' balcony waterproofing details:

- Balcony cross sections with a minimum ¼" per foot of slope to drain.
- Scuppers (when utilized).
- Floor drains (when utilized).
- Terrace door thresholds (and jamb and head flashings).
- Sliding glass door tracks (and jamb and head flashings).
- Windowsill flashings at balcony locations (and jamb and head flashings).
- Wall to balcony flashing conditions.
- Railing attachment details (structural and waterproofing).
- Water discharge flashings at corner discharge points.
- Supporting beam details.
- Supporting column details (when present).
- Specifications of membrane waterproofing and walking surfaces.

Minimum 'open surface decking' balcony waterproofing details:

- Balcony cross sections.
- Terrace door thresholds (and jamb and head flashings).
- Sliding glass door tracks (and jamb and head flashings).
- Window sill flashings at balcony locations (and jamb and head flashings).
- Wall to balcony flashing conditions.
- Railing attachment details (structural and waterproofing).
- Joist framing connections to beam details.
- Ledger framing flashing at walls.
- Supporting beam cap flashing and saddle flashing (beam to wall) details.
- Supporting column details (when present).
- Specifications of wood or composite walking surfaces.

Concrete balconies are less problematic, details are still required as follow:

- Balcony cross sections with a minimum ¼" per foot of slope to drain.
- Scuppers (when utilized).

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- Floor drains (when utilized).
- Terrace door thresholds (and jamb and head flashings).
- Sliding glass door tracks (and jamb and head flashings).
- Windowsill flashings at balcony locations (and jamb and head flashings).
- Wall to balcony flashing conditions.
- Railing attachment details (structural and waterproofing).
- Water discharge flashings at corner discharge points.
- Specifications of liquid applied waterproofing and walking surfaces (tile or liquid applied wearing surface.

Similar Projections:

Similar projections come in various types. If the projection is a bay window or oriel window, see the next section addressing those elements as these are 'capped' with various types of roofing materials that must be properly flashed to the wall system.

Other projections include trim bands, cornice lines, and projections generally detailed as aesthetic elements of the wall system comprising the building facade. Projections can be detailed using traditional wall to horizontal flashings (generally metal 'L' and 'Z' shaped) sloping to effectively drain water off the horizontal element of the projection.

Minor projections can also be detailed using sealants and liquid applied flashings sloping to drain water off the horizontal element. When detailed using sealant and liquid applied flashings, those surfaces generally have a higher degree of maintenance required than metal flashings, so maintenance programs must be established and followed for the maintenance and refinishing for effective waterproofing.

302.9 Insulation.

The thermal performance of a wall system depends on all the wall materials with careful consideration of the insulation type, thickness, and material properties within the wall assembly. It is highly recommended that a hygrothermal analysis be completed on all exterior wall assemblies using both historic and future predicted climate characteristics of the project location including mean temperature, dewpoint, etc. to determine the best course of action for specifying the specific wall assembly for a project. It is best practice in a hot, humid climate to locate the air, moisture, vapor, and thermal control layers outward of the structural layer to mitigate intrusion of moisture into the wall assembly and provides a method for vapor to drain outward of the building versus within the wall assembly on the interior of the building. However this type of insulation and water-resistive barrier layering is not always possible so proper

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architectural detailing must be followed to achieve the code compliant installation that prevents entrapment of moisture within a wall assembly and interior to the building.

302.10 Building Envelope Testing requirements.

Building envelope testing as a holistic approach to moisture and air management in building design and construction is essential for achieving long-term resilience and viability. It integrates preventive measures against moisture intrusion and air leakage, enhances energy efficiency, supports indoor air quality, and ensures the durability and performance of buildings throughout their lifecycle. Investing in building envelope testing during the design and construction phases pays dividends in terms of reduced maintenance costs, improved occupant comfort, and sustainable building operations.

Moisture Management

- Preventing Water Intrusion: Building envelope testing, such as water penetration resistance testing (e.g., ASTM E1105), helps identify potential points of water entry during rain events or under high wind conditions. This early detection allows for necessary adjustments in design or construction to prevent water intrusion, which can lead to structural damage, mold growth, and degradation of building materials over time.
- Moisture Control: Properly designed and tested building envelopes include vapor barriers, drainage systems, and waterproofing materials that manage moisture effectively. Testing ensures that these components function as intended, reducing the risk of moisture buildup within wall assemblies and improving the durability of building materials.

Air Management

- Minimizing Air Leakage: Air leakage through the building envelope can compromise energy efficiency by allowing conditioned air to escape and unconditioned air to enter. Air leakage testing (e.g., ASTM E783) identifies areas of concern and allows for corrective measures to be implemented, such as improving air barriers and sealing penetrations.
- Enhancing Indoor Air Quality: A well-sealed building envelope helps maintain consistent indoor air quality by preventing the infiltration of outdoor pollutants, allergens, and moisture-laden air. This is crucial for occupant health and comfort, particularly in tightly sealed and energy-efficient buildings.

Energy Efficiency

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- Reducing Heating and Cooling Loads: A tightly sealed building envelope with effective insulation and minimal air leakage reduces the demand for heating and cooling energy. This results in lower energy costs over the building's lifespan and contributes to sustainability goals by reducing greenhouse gas emissions associated with energy consumption.
- Optimizing HVAC Performance: By minimizing air leakage and controlling moisture, building envelope testing ensures that HVAC systems operate more efficiently. This can help optimize HVAC size reducing redundancy due to unknowns and saving upfront costs, reduces the workload on HVAC equipment, prolongs their lifespan, and lowers maintenance costs.

Long-Term Resilience

- Durability and Maintenance: Building envelope testing helps identify potential weaknesses or defects early in the construction phase, allowing for proactive maintenance and repairs. This proactive approach extends the lifespan of the building envelope and reduces the likelihood of costly repairs or premature replacement.
- Adaptability to Climate Change: A resilient building envelope, verified through testing, is better equipped to withstand extreme weather events and climate change impacts. It ensures that buildings remain habitable and functional, providing shelter and safety to occupants over the long term.

Viability and Performance Verification

- Meeting Design Intent: Building envelope testing verifies that the design and construction meet specified performance criteria, including compliance with building codes, standards, and project requirements. This ensures that the building envelope performs as intended by the owner, authority having jurisdiction, and design team and meets regulatory expectations.
- Documentation and Warranty Compliance: Testing provides documented evidence of the building envelope's performance, which is essential for warranty coverage and insurance purposes. It establishes accountability and ensures that stakeholders have confidence in the building's quality and longevity.

Field Testing

Field testing of exterior enclosure components and systems *as they relate to moisture* can include:

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Water Penetration Resistance Testing

Purpose: To evaluate how well a wall system prevents water ingress under real-world conditions.

Standards:

1. ASTM E1105 - Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference:
    - Purpose: This test method covers the determination of the resistance of installed exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a static air pressure at the outdoor face higher than the pressure at the indoor face.(Source: ASTM)
    - Method: This test involves the use of a wall-mounted pressure chamber where air is exhausted to create a lower pressure on the test surface. Water is then sprayed at a controlled rate on the opposite surface using a calibrated nozzle rack over a specified time period.
2. ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference:
    - Purpose: This test specifies a method for testing the water penetration resistance of exterior windows, skylights, doors, and curtain walls under uniform static air pressure differences.
    - Method: It involves subjecting the specimen to a specified pressure differential while applying water to the exterior surface and monitoring for water infiltration.
3. ASTM E2128 - Standard Guide for Evaluating Water Leakage of Building Walls:
    - Purpose: This guide provides principles and procedures for evaluating water leakage through building walls, including exterior cladding and curtain walls.
    - Method: ASTM E2128 outlines methods for field and laboratory evaluations to identify sources of water infiltration and potential remediation measures.
4. AAMA 501.1 - Standard Test Method for Water Penetration of Windows, Curtain Walls, and Doors Using Dynamic Pressure:

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- Purpose: Published by the American Architectural Manufacturers Association (AAMA), this standard specifies procedures for evaluating the water penetration resistance of windows, curtain walls, and doors under dynamic pressure conditions.
- Method: Dynamic water penetration testing is conducted at the specified air pressure differential by utilizing a wind generator employing an 84" diameter propeller. Water is simultaneously sprayed onto the exterior face of the assembly at the required rate of 5 gph/SF. Testing continues for 15 minutes. During testing, the interior face of the test area is inspected for water leakage.

5. AAMA 501.2 - Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems:
    - Purpose: Another standard from AAMA, this document provides guidance for quality assurance and diagnostic field checks designed to aid in the water-tight testing of large glass areas meant to be permanently closed, such as store fronts, curtain walls, and sloped glazing systems to verify water leakage resistance.
    - Method: A constant pressure of between 30-35 psi is applied from a ¾" (19 mm) diameter hose fitted with a nozzle. This ½" diameter brass nozzle is to be part B-25 #6.030, sourced only from Monarch Manufacturing, to standardize test results. It is recommended to fit the nozzle with a gauge to measure distance from the test surface.

Air Leakage Testing

Notes: Air Leakage testing is indicated as an optional testing direction, not required for 'liquid' moisture mitigation in buildings. Although moisture does enter via air infused with moisture (known as humidity), it is not as critical as minimizing liquid moisture entering the wall cavities. When air conditioning (air cooling) is present in indoor spaces, there is also a possibility of liquid condensation on wall materials within the wall assembly.

Purpose: To measure the air tightness of building envelope walls.

Standards:

1. ASTM E779 - Standard Test Method for Determining Air Leakage Rate by Fan Pressurization:

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- Purpose: ASTM E779 outlines procedures for measuring air leakage rates of buildings by pressurizing or depressurizing the building envelope with a fan and measuring airflow.
- Method: It quantifies air leakage through the building envelope under specified pressure differentials, providing a metric such as air changes per hour (ACH) or air leakage rate per unit area.

2. ASTM E1827 - Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door:
   - Purpose: ASTM E1827 provides alternative methods for determining the airtightness of buildings using a blower door test, which measures air leakage through the building envelope.
   - Method: It includes procedures for installing and operating the blower door equipment, controlling test conditions, and calculating air leakage rates.
3. ASTM E3158 – Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building
   - Purpose: ASTM E3158 provides a quantitative field test procedure and calculation method for assessing an air leakage rate using a fan-induced pressure differential(s) across the building envelope, generated by blower doors or equivalent equipment.
   - Method: This test method applies to all multizone and large building types and portions or subsections of buildings. It can be used to test envelopes that consist of a single zone or subsections of a zone that can be tested as a single zone. Test envelopes that are entirely composed of subsections separated by interior partitions or floors, or both, may be tested as a single zone by maintaining baseline relationships between these subsections throughout testing. The relationship between the airflows and induced pressures are used to measure the air leakage rate of the envelope. Specifications for air leakage rates of an envelope are written in terms of the maximum allowable airflow rate from a specified induced pressure differential.
4. ASTM E783 - Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors:
   - Purpose: ASTM E783 specifies procedures for measuring air leakage through installed exterior windows, doors, and curtain walls under specified pressure differentials.
   - Method: The testing is performed by sealing a chamber to the interior or exterior face of the test specimen, supplying or exhausting air from the

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chamber at a rate required to maintain the specified test pressure, and measuring the air flow lost or gained across the testing chamber.

5. ISO 9972 - Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method:
    - Purpose: This international standard provides methods for determining the air permeability of buildings using a fan pressurization method, similar to ASTM E779.
    - Method: ISO 9972 To compare the relative air permeability of several similar buildings or parts of buildings, and to determine the air-leakage reduction resulting from individual retrofit measures applied incrementally to an existing building or part of a building. The fan pressurization method does not measure the air infiltration rate of a building. The results of this method can be used to estimate the air infiltration rate and resulted heat load by means of calculation.
6. AAMA 502 - Voluntary Specification for Field Testing of Newly Installed Fenestration Products:
    - Purpose: Published by the American Architectural Manufacturers Association (AAMA), AAMA 502 specifies procedures for field testing newly installed fenestration products (windows, doors) to verify air leakage resistance.
    - Method: Chamber test method where chamber is attached and sealed to adjacent frame members, concrete, structural steel or drywall at the top, bottom and sides of the specimen. The chamber is equipped with a centrifugal blower/vacuum pump, air flow meter, and a pressure sensing device to maintain the desired air pressure differential across the assembly

Thermal Performance Testing

Note: Thermal performance testing is indicated as an optional testing direction, not required for moisture mitigation in buildings.

Purpose: To assess the insulation properties of walls.

Standards: ASTM C1153.

Method: Involves measuring the thermal resistance (R-value) or thermal transmittance (U-value) using heat flow meter devices or infrared thermography.

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Field Application: Can be performed in-situ to evaluate the actual thermal performance of installed wall assemblies.

SECTION 303 RESILIENT ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

A building's roof assembly provides multiple functions, aesthetic, structural, and weather resistance for the building. The design of today's roofing includes multiple roofing comprised of diverse materials and assemblies. Traditional roofs include steeply sloped and 'flat' membrane roofing materials, depending on the design and construction of the roofing system. Roof structures can be comprised of various materials including; wood (wood rafters, joists, trusses, plywood roof decking), metal (usually steel, light gauge, forged), concrete (reinforced, prestressed, post tensioned), hybrid structures (system buildings, prefabricated buildings, relocatable buildings). Sloped roof coverings include shingles (wood, asphaltic, tile), metal (standing seam, corrugated, composite panels), and other hybrid systems.

For minimum code requirements see chapter 15 ROOF ASSEMBLIES AND ROOFTOP STRUCTURES in the Florida Building Code, Building..

303.1 Intent.

The intent of this section is to provide additional direction for the design and construction of more resilient roof assemblies and rooftop structures. Increasing wind and moisture resistance is critical to the ultimate longevity of the roofing system and materials within the roofing system.

303.2 Degradation of materials.

All roofing materials degrade over time. Solar load, heat/cold, temperature fluctuations, expansion and contraction, moisture saturation and drying, the natural aging cycle of materials (due to loss of moisture or loss of a component or components within the materials), the influence of other materials inducing stress and strain within the materials in question, carbonization, salts, mineral deposits, environmental dirt, ponding water, freezing water, and other influences. All roofing materials are influenced by the location installed and the specific climate zone, weather patterns, distance from the saltwater coast, lake effects, tree coverage, varying climate cycles and weather trends. Even wild animals can be a source of degradation of the materials (rats, mice, squirrels and others) by abrasion and/or gnawing of the materials, especially if the materials have an organic or mineral element within the material.

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Roofing Degradation Examples:

- Asphaltic shingles: Loss of granules, fading, mold growth, brittleness, cracking, loss of shingles and portions of shingles.
- Asphaltic membranes: Loss of granules, dirt build up, brittleness, cracking and splitting.
- Acrylic membranes: Loss of flexibility, dirt build up, brittleness, cracking and splitting.
- Cement and clay tiles: Color loss, fading, mold growth, loss of surface finish due to erosion, exposure of aggregate.
- Slate shingles: Mold growth, loss of natural surface finish due to erosion, delamination of the slate.
- Cedar shakes and shingles: Mold growth, shrinkage, separation, curing, loosening of fasteners.
- Metal roofing: Fading, color loss, mold growth, streaking of surface finish, rust bleed through.
- Hybrid roofing materials: TBD based upon the technology of the materials.

303.3 Moisture control within building roof assemblies and rooftop structures.

Moisture control through the roofing elements of the project is of critical importance for the proper health of the occupants and longevity of the building components. No one likes or can even tolerate a leaking roof! A roof leak is one of the most devastating occurrences that can happen to a building and its occupants. It can upset a building occupant beyond most any other issues with a building. Note, we acknowledge that there are other devastating occurrences such as fires, gas explosions, plumbing leaks, mechanical and electrical system problems, structural collapses and even vermin infestations however this portion of the appendix addresses moisture related building issues.

Comply with chapter 15 of the 2023 Florida Building Code, Building, for all roofing requirements;

- 1501 General.
- 1502 Definitions.
- 1503 Weather Protection.
- 1504 Performance Requirements.

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- 1505 Fire Classification.
- 1506 Materials.
- 1507 Requirements for Roof Coverings.
- 1508 Roof Insulation.
- 1509 Roof Coatings.
- 1510 Rooftop Structures.
- 1511 Existing Roofing.
- 1512 - 1524 High-Velocity Hurricane Zones Requirements *(Miami-Dade and Broward Counties).*

Roofing Details

These roofing details supplement the listing for buildings constructed under the Florida Building Code, Building, in Ch. 1 section 107.3.5.

Roofing details checklist:

- Roof type performance metrics (Durability, heat transfer, vapor drive, fire ratings, etc.):
  - Climate zone considerations.
  - Vapor drive.
  - Roof top activities or additional installations.
  - Insulation type, performance, size.
- Roofing system cross sections with a minimum ¼" per foot of slope to drain.
- Continuity of air/moisture barrier from horizontal to vertical surfaces.
- Roof scuppers (when utilized).
- Roof drains (when utilized).
- Sumps at roof drains and continuous insulation.
- Roof gutters & downspouts (when utilized).
- Roof access door thresholds (and jamb and head flashings) (when utilized).
- Roof hatch details (when utilized).
- Roof to Wall flashing conditions.
- Integration of additional roof-top mounted systems:
  - Green roof.
  - Photovoltaics.
  - Solar hot water.
  - Deck, paver, equipment.
- Roof curbs for mechanical, plumbing, electrical equipment.
- Roof penetrations(Pipe, duct, etc.), avoiding pitch pockets.
- Parapet wall details (indicating vertical membranes, other vertical materials, and cap flashings) (when utilized).

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- Railing attachment details (structural and waterproofing) (when utilized).
- Water discharge flashings at corner discharge points (as example, kick out flashings).
- Cricket details to drain difficult locations.
- Expansion joints.
- Integration and interconnection between different roof systems.
- Roof underlayment and vapor barrier details(when and where to incorporate).
- Continuous insulation and cover board.
- Supporting beam details.
- Supporting column details (when present).
- Specifications of roofing materials and systems required on the drawings.

303.4 Steep slope roof coverings.

A steep sloped roof is a roof that slopes at 2:12 and greater slope. Roofs that slope less than 2:12 are considered low slope roofs. Steep sloped roof coverings are very popular in residential buildings and in many commercial buildings as well.

Consult chapter 15 in the Florida Building Code, Building, for more information on commercial roofing systems.

There are multiple types of steep sloped roof coverings. They depend on their slope to quickly remove water from the roof surface but must be detailed and constructed correctly to properly protect the building from moisture intrusion through the roof covering and into the roof structure itself and ultimately into the occupied spaces of the building.

Types of steep sloped roof coverings include:

- Shingle roofing- multiple types:
  - Asphalt shingles.
  - Concrete tile shingles.
  - Clay tile shingles.
  - Slate tile shingles.
  - Cedar shake and cedar shingles.
  - Metal shingles.
- Metal roofing:
  - Various types of seamed roofing, standing, interlocking, capped.

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    - Overlapping seamed roofing, like '5V crimp' roofing, with exposed fasteners (this was commonly known as "barn siding" that then became used as a metal roof covering.
    - Structural metal roofing (where the roof panels are also structurally spanning between metal purlins as in manufactured building systems).
    - Metal roofing that covers membrane roofing acting like a rain screen for the membrane roof below.
- Hybrid and composite material roofing.
- Membrane roofing.
- Thatched roofing.

These steep sloped roofs require underlayments that come in different types of materials. Consult the building codes for more specific information. The function of the underlayment is multifold.

- Dry-in Protection: Builders commonly call the underlayment 'the dry-in' since once the underlayment is installed the building becomes mostly dry for the balance of the interior construction to continue without moisture damage from the roofing level. The underlayments generally have a restricted amount of time until the final roof covering is installed. This can range from as little as 3 months to as much as 9 months depending on the type of underlayment used. Consult the manufacturer for these time limits.
- Secondary Protection: Another function of the underlayment is for secondary protection to the building. This secondary protection will generally add life to the roof, even if during the aging of the roof shingles or other material causes degradation, the underlayment during wind and rain events, the underlayment provides a level of protection against moisture intrusion in such an event.
- Condensation protection: Airborne moisture known as humidity can cause problems below the roof covering when the outdoor temperatures drop on the exterior of the roof covering surfaces and the dew point is reached, condensation of liquid water occurs. This also occurs during nightly radiant cooling known as 'night sky radiation' where the dark night sky acts as a 'heat sink', cooling the roof covering below the dew point, causing condensation of liquid water below the roof covering. In these cases the underlayment provides condensation protection for the building.

303.5 Low slope membrane roof coverings.

Always comply with manufacturers minimum slope requirements, even if roofs appear close to flat for longevity and proper drainage. The following sections address the

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various systems and the importance of specific design, detailing and construction quality control and assurance.

303.6 Liquid applied roofing and roof coatings.

Liquid applied membrane roofing systems are reinforced membranes that are applied in the field using liquid membrane materials and fiber reinforcing combined as a part of the roofing application process. These are considered membrane roofs and must slope at a minimum of ¼" per foot to the roof drains, scuppers, gutters and other devices for final drainage. Manufacturers typically offer extended warranties for 5 and 10 years and longer.

Roof coatings are liquid applied coatings that are not reinforced and are designed to extend the life of the underlying roofing. They can be applied to sloped roofing and membrane roofing. As an example, shingle roofing can be coated to extend their life. These are considered as remedial measures and are considerably less expensive than full roof replacements. Before applying a liquid roof coating, the base roof must be dry and free of defects so these issues must be corrected prior to the installation of the roof coating.

303.7 Rooftop terraces and decks.

Waterproofing membranes designed for use under tile and paver systems are critically important for the watertight performance of the waterproof membrane. Since these waterproofing membrane systems are concealed throughout their lifespan they must perform to prevent water leakage. Leaks are difficult to find the source of leaks and are extremely difficult to locate and difficult and expensive to repair and/or replace. Most of these systems are membrane based, some are hot applied, others cold applied, some are liquid applied roofing membranes.

Major manufacturers should be consulted during the design, submittal and installation phases to assure that the correct systems are being selected, detailed and installed. Many manufacturers require certified and approved installation contractors who must use workers/installers that have been trained and certified to install the systems.

Design and construction conditions that must be thoroughly detailed and carefully constructed to be properly waterproofed for the life of the terrace or amenity deck. Features such as pools, spas, planters, seatwalls, lighting, showers and other features must be considered in the final detailing and design. These features will require specialized attention to a high level of detail.

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Waterproofing Details

These waterproofing details supplement the listing for buildings constructed under the Florida Building Code, Building in Ch. 1 section 107.3.5.

Waterproofing details checklist:

- Membrane waterproofing system cross sections with a minimum ¼" per foot of slope to drain (note, generally greater than minimum slope is encouraged to account for construction tolerances).
- Terrace and deck scuppers (when utilized).
- Terrace and deck drains (when utilized).
- Terrace and deck gutters & downspouts (when utilized).
- Terrace access door thresholds (and jamb and head flashings) (when utilized).
- Sliding glass doors and door thresholds (and jamb and head flashings) (when utilized) when used.
- Terrace and deck to Wall flashing conditions.
- Terrace and deck parapet wall details (indicating vertical membranes, other vertical materials, and cap flashings) (when utilized).
- Railing attachment details (structural and waterproofing) (when utilized).
- Water discharge flashings at corner discharge points (as example, kick out flashings).
- Cricket details to drain difficult locations.
- Supporting beam details.
- Supporting column details (when present).
- Specifications of waterproofing materials and systems.
- Where a pool or spa is present, see section 303.9.

303.8 Rooftop structures.

A rooftop structure is defined in section 1502 as "An enclosed structure on or above the roof of any part of the building." See Florida Building Code, Building, section 1510, for minimum requirements for rooftop structures. This Florida Building Code, Building, section covers penthouses, tanks, cooling towers, towers, spires, domes and cupolas, mechanical equipment screens, photovoltaic systems, other rooftop structures, structural fire resistance, mechanical units, cable and raceway type wiring methods, and Lines, pipes, conduit and cables under roof decks. These resiliency recommendations do not modify those Florida Building Code, Building, minimum requirements. The key requirement of this resiliency appendix is to provide long term and durable weather

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protection in the design and construction of rooftop structures of all types. Water leakage through any rooftop structures will ultimately find its way into the roofing system and ultimately into the building structure and is not acceptable. All water leakage must be prevented.

303.9 Rooftop pools and spas.

See the Florida Building Code, Building, section 454 Swimming Pools and Bathing Places (Public and Private), for minimum code requirements. These resiliency recommendations do not modify those Florida Building Code, Building, minimum requirements.

In addition to the Florida Building Code, Building, rooftop pools and spas are governed by the local health department in local governments. Those health department requirements should be consulted and complied with, so must be followed and are not affected by this section.

Critical to all rooftop pools and spas is the requirement that they be structurally sound and watertight at the structural walls and floors. They must also be watertight at the junctures between the walls of these elements and the adjoining roof top terraces and decks. These junctures must be properly designed, detailed and constructed. Any leakage noted under these elevated pools and spas must be diagnosed and repaired. Periodic inspections by trained design and construction professionals should be undertaken by ownership of the property.

Design and Construction: It is critical that they are designed and constructed by responsible and knowledgeable designers and builders. Often they are designed and constructed by a third party who specializes in that design and construction as a specialty. Most pools and spas are made out of poured and reinforced concrete, which is a durable and long–lasting material.

However, some pools and spas are made of plasticized liners for the pool walls and pool bottoms. Those types of pools and spas also need their unique details designed and constructed to be watertight.

303.10 RESERVED.

303.11 Other considerations.

Cost of installation and lifespan of the roofing systems of a building must be considered in the selection, design and installation of roofing systems. The value of a

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roof is generally considered as the most important component of the building for keeping water out of the building. While cost is one of the elements, aesthetics, lifespan and maintenance requirements are other elements to be considered.

For roofing in Florida water resistance is one very important requirement. Wind resistance is another very important requirement in the performance of the roofing system. Storms tend to pull upward at the roof edges and corners in such a manner that those areas can begin to lift during strong winds and may ultimately cause a full roofing failure. Severe failures can result in the complete roofing system being lifted off of the roof structure. In the most severe failures when the underlying structure is then subjected to moisture intrusion and further lifting of the roof structure and when the roof structure is damaged the support of the top of the walls is then in danger of complete collapse. Such a collapse can kill and injure the occupants and result in large property losses.

303.12 Compliance.

Compliance with this section should enhance the resilience of a building's roofing system. Proper design, detailing and construction is paramount to a successful roofing system to protect the building from the elements (water, wind, windborne debris, etc.)

303.13 Testing requirements.

Roofing systems are one of the most critical components of a buildings enclosure and its ability to provide protection from moisture intrusion and ensure the long-term health, safety, and welfare of the building occupants. While individual components of roof systems are manufactured, almost all roofing systems are field installed, sometimes by multiple trades over a period of time. The importance of testing and verification cannot be understated when it comes to the long-term viability, resilience, and success of the roofing system. There are many standards for both laboratory and field-testing roofing components and installed systems. Any testing should be part of a complete project strategy for the building envelope and its commissioning. This process is a key factor in the long-term resilience of a roofing system. Testing of roof systems, like walls, can be broken into two categories, lab testing and field testing.

Lab Testing: Involves controlled experiments to assess structural integrity, fire resistance, and other critical properties of roof assemblies using standardized test methods.

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Field Testing: Focuses on evaluating the performance of installed roof systems under real-world conditions such as water penetration, air leakage, and thermal efficiency.

These tests should be performed by a third-party licensed and experienced testing agency and should be observed by both the project envelope commissioning agent and the design professional of record. Testing should be specified to be completed at the appropriate intervals during the construction phase and completed until a passing condition has been achieved.

A successful roofing system that ensures long-term viability and resilience begins with proper specifying and detailing of the system during the design phase. The design professional must understand how the various components become integrated to achieve viability. This includes ensuring compatibility of materials between manufacturers, vapor drive within the roofing system under different climatic conditions(and in anticipation of future conditions), internal program moisture load(natatorium, labs, etc), and process for installation and maintenance.

It's important to begin the construction phase of the project with an holistic approach to developing a plan by the contractor to ensure the understanding of the coordination and installation of all roofing systems components and that testing is understood by all trades and is properly integrated into the project schedule and workflow(this includes allowing time for evaluation and retesting if needed).

Specific tests can include:

ASTM D5957 - Standard Guide for Flood Testing Horizontal Waterproofing Installations: This standard outlines procedures for flood testing horizontal waterproofing installations having a slope not greater than 20 mm/m (2% slope) (1/4" per ft).

ASTM D7877 - Standard Guide for Electronic Methods for Detecting and Locating Leaks in Waterproof Membranes: This guide covers electronic methods for detecting leaks in waterproof membranes. This guide is applicable for waterproofing membranes installed in roofs, plaza decks, pools, water features, covered reservoirs and other waterproofing applications.

ANSI/SPRI RP 14 - Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems: This standard includes guidelines for wind resistance but can indirectly contribute to evaluating roof systems' ability to resist moisture intrusion by ensuring tight seals and connections.

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Additional testing considerations to ensure long-term viability and resilience over time include:

Wind Uplift Resistance Testing: This tests how well a roof system can resist being uplifted by wind forces. Standards like ASTM E1592 outline procedures for determining the wind resistance of various roofing materials and systems.

Durability and Longevity Testing: Assesses the expected lifespan and durability of roofing materials under normal and extreme conditions, including exposure to sunlight (UV radiation), temperature fluctuations, and chemical exposure.

Energy Efficiency Testing: Measures the ability of a roof system to reflect sunlight (solar reflectance) and emit absorbed heat (thermal emittance). ASTM E1980 and ASTM E903 are standards used to quantify these properties.

Mechanical Testing: Evaluates the mechanical properties of roofing materials such as tensile strength, flexibility, and dimensional stability. ASTM D638 and ASTM D412 are examples of standards used for such testing.

Environmental Testing: Determines the environmental impact of roofing materials, including their recyclability, sustainability, and compliance with environmental regulations.

SECTION 304 CONCRETE SLABS

In Florida the concrete slab is an often-used component of buildings, both residential and commercial. Due to its economy, ease of installation, durability, and longevity it is used in all types of buildings and in all types of construction.

Concrete slabs can be load bearing and non-load bearing in function. Slabs can be as thin as 3.5 inches to as thick as 12 to 18 inches (or even greater) depending on the structural conditions of the soils below and loading of the building slab requirements.

All concrete slabs bear a certain amount of live and dead loads. Load bearing concrete slabs are often thickened with heavier reinforcing to support the superimposed loads from columns and walls.

In addition to their structural capacity concrete slabs must also provide protection from air, water vapor, and liquid water penetration from below the slab coming from the moisture in the soils below.

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See chapters 18 - SOILS and FOUNDATIONS, and 19 - CONCRETE of the Florida Building Code, Building for additional requirements. See also appendix section 105 - Flood - Resistant Construction as it may pertain.

SECTION 305 FOUNDATION WALLS

While Florida buildings typically do not often include basements in most residential construction, basements are becoming increasingly more beneficial in commercial construction. The most common use for a basement in larger Florida buildings is to accommodate the parking of vehicles while not increasing the height of the building. Most zoning regulations set a height limitation on the building, basements for parking then give the building design greater flexibility for use of floor levels above grade.

When basements are used for parking and other purposes (storage, mechanical equipment, etc.) they must be waterproofed for hydrostatic pressure for maximum use and longevity. Hydrostatic pressure of moist soils and water can impose hundreds of pounds per square foot on the foundation walls, in addition to superimposed loading of columns and walls supported by the foundation walls. Waterproofing of these walls is highly specialized and should only be designed by licensed professionals and constructed by knowledgeable builders and subcontractors using materials and methods specifically designed for that purpose.

See chapters 18- SOILS and FOUNDATIONS, and 19 - CONCRETE, and 20 - MASONRY of the Florida Building Code for additional requirements. See also appendix section 105 - Flood - Resistant Construction as it may pertain.

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SECTION 401 - RESOURCES - Water Efficiency and Conservation

401.1 Intent

The intent of this section shall establish the means of conserving water used indoors, outdoors, and in wastewater conveyance.

401.2 Scope

The following terms are described in Section 201:

- EVAPOTRANSPIRATION ADJUSTMENT FACTOR (ETAF).
- GREYWATER.
- HYDROZONES.
- METERING FAUCET.
- POTABLE WATER.
- SPECIAL LANDSCAPE AREA (SLA).
- SUBMETER.

SECTION 402 INDOOR WATER USE

402.1 Meters.

Separate submeters or metering devices shall be installed for the uses described in Sections 402.2, 402.3, and by the Irrigation Design Plan.

402.2 New buildings or additions more than 50,000 square feet.

Separate submeters shall be installed as follows:

1. For each individual leased, rented or other tenant space within the building projected to consume more than 100 gallons/day, including, but not limited to, spaces used for laundry or cleaners, restaurant or food service, medical or dental office, laboratory, or beauty salon or barber shop.

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2. Where separate submeters for individual building tenants are unfeasible, for water supplied to the following subsystems.
3. Makeup water for cooling towers where flow through is greater than 500 gpm.
4. Makeup water for evaporative coolers greater than 6 gpm.
5. Steam and hot-water boilers with energy input more than 500,000 Btu/h (147 kW).

402.3 Excess consumption.

A separate submeter or metering device shall be provided for any tenant within a new building or within an addition that is projected to consume more than 1000 gal/day.

402.4 Water conserving plumbing fixtures and fittings.

Plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following:

402.5 Water Closets

The effective flush volume of all water closets shall not exceed 1.28 gallons per flush. Tank-type water closets shall be certified to the performance criteria of the US EPA WaterSense Specification for Tank-Type Toilets.
Note: The effective flush volume of dual flush toilets is defined as the composite, average flush volume of two reduced flushes and one full flush.

402.6 Urinals.

Wall-mounted urinals. The effective flush volume of wall-mounted urinals shall not exceed 0.125 gallons per flush.

Floor-mounted urinals. The effective flush volume of floor-mounted or other urinals shall not exceed 0.5 gallons per flush.

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402.7 Showerheads.

Single shower head. Shower Heads shall have a maximum flow rate of not more than 1.8 gallons per minute at 80 psi. Shower Heads shall be certified to the performance criteria of the US EPA WaterSense Specification for Showerheads.

Multiple shower heads serving one shower. When a shower is served by more than one shower head, the combined flow rate of all showerheads and/or other shower outlets controlled by a single valve shall not exceed 1.8 gallons per minute at 80 psi, or the shower shall be designed to allow only one shower outlet to be in operation at a time.
Note: A hand-held shower shall be considered a showerhead.

402.8 Faucets and fountains.

Nonresidential lavatory faucets.
Lavatory faucets shall have a maximum flow rate of not more than 0.5 gallons per minute at 60 psi.

Kitchen faucets.
Kitchen faucets shall have a maximum flow rate of not more than 1.8 gallons per minute at 60 psi. Kitchen faucets may temporarily increase the flow above the maximum rate, but not to exceed 2.2 gallons per minute at 60 psi, and must default to a maximum flow rate of 1.8 gallons per minute at 60 psi.

Wash fountains.
Wash fountains shall have a maximum flow rate of not more than 1.8 gallons per minute/20 [rim space (inches) at 60 psi].

Metering faucets.
Metering faucets shall not deliver more than 0.20 gallons per cycle.

Metering faucets for wash fountains.
Metering faucets for wash fountains shall have a maximum flow rate of not more than 0.20 gallons per cycle/20 [rim space (inches) at 60 psi].
Note: Where complying faucets are unavailable, aerators or other means may be used to achieve reduction.

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402.9 Food waste disposers.

Disposers shall either modulate the use of water to no more than 1 gpm when the disposer is not in use (not actively grinding food waste/no-load) or shall automatically shut off after no more than 10 minutes of inactivity. Disposers shall use no more than 8 gpm of water.

SECTION 403 OUTDOOR WATER USE

403.1 Outdoor potable water use in landscape areas

WATER EFFICIENT LANDSCAPE WORKSHEET

A project applicant shall complete the Water Efficient Landscape Worksheet which contains information on the plant factor, irrigation method, irrigation efficiency, and area associated with each hydrozone. Calculations are then made to show that the evapotranspiration adjustment factor (ETAF) for the landscape project does not exceed a factor of 0.55 for multi-family residential areas and 0.45 for non-residential areas, exclusive of Special Landscape Areas. The ETAF for a landscape project is based on the plant factors and irrigation methods selected. The Maximum Applied Water Allowance is calculated based on the maximum ETAF allowed (0.55 for multi-family residential areas and 0.45 for non-residential areas) and expressed as annual gallons required. The Estimated Total Water Use (ETWU) is calculated based on the plants used and irrigation method selected for the landscape design. Estimated Total Water Use (ETWU) must be below the Maximum Applied Water Allowance (MAWA.)

In calculating the MAWA and ETWU, a project applicant shall use historic Evapotranspiration values for the relevant County as issued by the Florida Automated Weather Network and UF | IFAS Extension.

Water budget calculations shall adhere to the following

- The plant factor used shall be from horticultural researchers with academic institutions or professional associations. The plant factor ranges from 0 to 0.1 for very low water using plants, 0.1 to 0.3 for low water use plants, from 0.4 to 0.6 for moderate water use plants, and from 0.7 to 1.0 for high water use plants.
- All water features shall be included in the high water use hydrozone and temporarily irrigated areas shall be included in the low water use hydrozone.
- All Special Landscape Areas shall be identified and their water use calculated.

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- ETAF for new and existing (non-rehabilitated) Special Landscape Areas shall not exceed 1.0.

WATER EFFICIENT LANDSCAPE WORKSHEET

This worksheet is filled out by the project applicant and it is a required element of the Landscape Documentation Package.

Reference Evapotranspiration (ETo) _____

Hydrozone # /Planting Description[a]	Plant Factor (PF)	Irrigation Method[b]	Irrigation Efficiency (IE)[c]	ETAF (PF/IE)	Landscape Area (sq, ft,)	ETAF x Area	Estimated Total Water Use (ETWU)[e]
Regular Landscape Areas							
				Totals	(A)	(B)	
Special Landscape Areas							
	[redacted]			1			
				1			
				1			
				Totals	(C)	(D)	
						ETWU Total	
				Maximum Allowed Water Allowance (MAWA)[e]			

[a] ***Hydrozone #/Planting Description***
E.g
1.) front lawn
2.) low water use plantings
3.) medium water use planting

[b] ***Irrigation Method***
overhead spray or drip

[c] ***Irrigation Efficiency***
0.75 for spray head
0.81 for drip

[d] ***ETWU*** **(Annual Gallons Required) =**
Eto x 0.62 x ETAF x Area
where 0.62 is a conversion factor that converts acre-inches per acre per year to gallons per square foot per year.

[e] ***MAWA (Annual Gallons Allowed)*** = *(Eto) (0.62) [(ETAF x LA) + ((1-ETAF) x SLA)]*
where 0.62 is a conversion factor that converts acre-inches per acre per year to gallons per square foot per year, LA is the total landscape area in square feet, SLA is the total special landscape area in square feet, and ETAF is .55 for residential areas and 0.45 for non-residential areas.

ETAF Calculations

Regular Landscape Areas

Total ETAF x Area	(B)
Total Area	(A)
Average ETAF	**B ÷ A**

Average ETAF for Regular Landscape Areas must be 0.55 or below for residential areas, and 0.45 or below for non-residential areas.

All Landscape Areas

Total ETAF x Area	(B+D)
Total Area	(A+C)
Sitewide ETAF	**(B+D) ÷ (A+C)**

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SOIL MANAGEMENT REPORT

In order to reduce runoff and encourage healthy plant growth, a soil management report shall be completed by the project applicant, or his/her designee, as follows:

- Submit soil samples to a laboratory for analysis and recommendations.
    - Soil sampling shall be conducted in accordance with laboratory protocol, including protocols regarding adequate sampling depth for the intended plants.
- The soil analysis shall include:
    - soil texture;
    - infiltration rate determined by laboratory test or soil texture infiltration rate table;
    - pH;
    - total soluble salts;
    - Sodium;
    - percent organic matter; and
    - Recommendations.
- In projects with multiple landscape installations (i.e. production home developments) a soil sampling rate of 1 in 7 lots or approximately 15% will satisfy this requirement. Large landscape projects shall sample at a rate equivalent to 1 in 7 lots.
    - The project applicant, or his/her designee, shall comply with one of the following:
        - If significant mass grading is not planned, the soil analysis report shall be submitted to the local agency as part of the Landscape Documentation Package; or
        - If significant mass grading is planned, the soil analysis report shall be submitted to the local agency as part of the Certificate of Completion.
        - The soil analysis report shall be made available, in a timely manner, to the professionals preparing the landscape design plans and irrigation design plans to make any necessary adjustments to the design plans.
        - The project applicant, or his/her designee, shall submit documentation verifying implementation of soil analysis report recommendations to the local agency with Certificate of Completion.

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LANDSCAPE DESIGN PLAN

For the efficient use of water, a landscape shall be carefully designed and planned for the intended function of the project. A landscape design plan meeting the following design criteria shall be submitted as part of the Landscape Documentation Package.

Plant Material

Any plant may be selected for the landscape, providing the Estimated Total Water Use in the landscape area does not exceed the Maximum Applied Water Allowance. Methods to achieve water efficiency shall include one or more of the following:

- Protection and preservation of native species and natural vegetation;
- selection of water-conserving plant, tree and turf species, especially local native plants;
- selection of plants based on local climate suitability, disease and pest resistance;
- selection of trees based on applicable local tree ordinances or tree shading guidelines, and size at maturity as appropriate for the planting area; and
- selection of plants from local and regional landscape program plant lists.

Each hydrozone shall have plant materials with similar water use, with the exception of hydrozones with plants of mixed water use.

Plants shall be selected and planted appropriately based upon their adaptability to the climatic, geologic, and topographical conditions of the project site. Methods to achieve water efficiency shall include one or more of the following:

- Recognize the horticultural attributes of plants (i.e., mature plant size, invasive surface roots) to minimize damage to property or infrastructure [e.g., buildings, sidewalks, power lines]; allow for adequate soil volume for healthy root growth; and consider the solar orientation for plant placement to maximize summer shade and winter solar gain.
- Turf is not allowed on slopes greater than 25% where the toe of the slope is adjacent to an impermeable hardscape and where 25% means 1 foot of vertical elevation change for every 4 feet of horizontal length (rise divided by run x 100 = slope percent).
- High water use plants, characterized by a plant factor of 0.7 to 1.0, are prohibited in street medians.
- The use of invasive plant species, such as those listed by the Florida Invasive Species Council (FISC), is strongly discouraged.

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- The architectural guidelines of a common interest development, which include community apartment projects, condominiums, planned developments, and stock cooperatives, shall not prohibit or include conditions that have the effect of prohibiting the use of low-water use plants as a group.

Water Features

- Recirculating water systems shall be used for water features.
- Where available, recycled water shall be used as a source for decorative water features.
- Surface area of a water feature shall be included in the high water use hydrozone area of the water budget calculation.
- Pool and spa covers are highly recommended.

Soil Preparation, Mulch and Amendments

- Prior to the planting of any materials, compacted soils shall be transformed to a friable condition. On engineered slopes, only amended planting holes need meet this requirement.
- Soil amendments shall be incorporated according to recommendations of the soil report and what is appropriate for the plants selected.
- For landscape installations, compost at a rate of a minimum of four cubic yards per 1,000 square feet of permeable area shall be incorporated to a depth of six inches into the soil. Soils with greater than 6% organic matter in the top 6 inches of soil are exempt from adding compost and tilling.
- A minimum three inch (3") layer of mulch shall be applied on all exposed soil surfaces of planting areas except in turf areas, creeping or rooting groundcovers, or direct seeding applications where mulch is contraindicated. To provide habitat for beneficial insects and other wildlife, up to 5 % of the landscape area may be left without mulch. Designated insect habitat must be included in the landscape design plan as such.
- Stabilizing mulching products shall be used on slopes that meet current engineering standards.
- The mulching portion of the seed/mulch slurry in hydro-seeded applications shall meet the mulching requirement.
- Organic mulch materials made from recycled or post-consumer shall take precedence over inorganic materials or virgin forest products unless the recycled post-consumer organic products are not locally available. Organic mulches are not required where prohibited by local ordinances.

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The landscape design plan, at a minimum, shall:

- delineate and label each hydrozone by number, letter, or other method;
- identify each hydrozone as low, moderate, high water, or mixed water use. Temporarily irrigated areas of the landscape shall be included in the low water use hydrozone for the water budget calculation;
- identify recreational areas;
- identify areas permanently and solely dedicated to edible plants;
- identify areas irrigated with recycled water;
- identify type of mulch and application depth;
- identify soil amendments, type, and quantity;
- identify type and surface area of water features;
- identify hardscapes (pervious and non-pervious);
- identify location, installation details, and 24-hour retention or infiltration capacity of any applicable stormwater best management practices that encourage on-site retention and infiltration of stormwater. Project applicants shall refer to the local agency or Water Management Board for information on any applicable stormwater technical requirements. Stormwater best management practices are encouraged in the landscape design plan and examples are provided in Section 492.16.
- identify any applicable rain harvesting or catchment technologies and their 24-hour retention or infiltration capacity;
- identify any applicable graywater discharge piping, system components and area(s) of distribution;
- contain the following statement: “I have complied with the criteria of the ordinance and applied them for the efficient use of water in the landscape design plan”; and
- bear the signature of a licensed landscape architect, licensed landscape contractor, or any other person authorized to design a landscape.

IRRIGATION DESIGN PLAN

This section applies to landscaped areas requiring permanent irrigation, not areas that require temporary irrigation solely for the plant establishment period. For the efficient use of water, an irrigation system shall meet all the requirements listed in this section and the manufacturers' recommendations. The irrigation system and its related components shall be planned and designed to allow for proper installation, management, and maintenance. An irrigation design plan meeting the following design

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criteria shall be submitted.

System

Landscape water meters, defined as either a dedicated water service meter or private submeter, shall be installed for all non-residential irrigated landscapes of 1,000 sq. ft. but not more than 5,000 sq.ft. and multi-family residential irrigated landscapes of 5,000 sq. ft. or greater. A landscape water meter may be either:

- a customer service meter dedicated to landscape use provided by the local water purveyor; or
- a privately owned meter or submeter.

Automatic irrigation controllers utilizing either evapotranspiration or soil moisture sensor data utilizing non-volatile memory shall be required for irrigation scheduling in all irrigation systems.

If the water pressure is below or exceeds the recommended pressure of the specified irrigation devices, the installation of a pressure regulating device is required to ensure that the dynamic pressure at each emission device is within the manufacturer's recommended pressure range for optimal performance.

If the static pressure is above or below the required dynamic pressure of the irrigation system, pressure-regulating devices such as inline pressure regulators, booster pumps, or other devices shall be installed to meet the required dynamic pressure of the irrigation system.

Static water pressure, dynamic or operating pressure, and flow reading of the water supply shall be measured at the point of connection. These pressure and flow measurements shall be conducted at the design stage. If the measurements are not available at the design stage, the measurements shall be conducted at installation.

Sensors (rain, freeze, wind, etc.), either integral or auxiliary, that suspend or alter irrigation operation during unfavorable weather conditions shall be required on all irrigation systems, as appropriate for local climatic conditions. Irrigation should be avoided during windy or freezing weather or during rain.

Manual shut-off valves (such as a gate valve, ball valve, or butterfly valve) shall be required, as close as possible to the point of connection of the water supply, to

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minimize water loss in case of an emergency (such as a main line break) or routine repair.

Backflow prevention devices shall be required to protect the water supply from contamination by the irrigation system. A project applicant shall refer to the applicable local agency code (i.e., public health) for additional backflow prevention requirements.

Flow sensors that detect high flow conditions created by system damage or malfunction are required for all non-residential landscapes and multi-family residential landscapes of 5000 sq. ft. or larger.

Master shut-off valves are required on all projects except landscapes that make use of technologies that allow for the individual control of sprinklers that are individually pressurized in a system equipped with low pressure shut down features.

The irrigation system shall be designed to prevent runoff, low head drainage, overspray, or other similar conditions where irrigation water flows onto non-targeted areas, such as adjacent property, non-irrigated areas, hardscapes, roadways, or structures.

Relevant information from the soil management plan, such as soil type and infiltration rate, shall be utilized when designing irrigation systems.

- The design of the irrigation system shall conform to the hydrozones of the landscape design plan.
- All irrigation emission devices must meet the requirements set in the American National Standards Institute (ANSI) standard, American Society of Agricultural and Biological Engineers'/International Code Council's (ASABE/ICC) 802-2014 “Landscape Irrigation Sprinkler and Emitter Standard, All sprinkler heads installed in the landscape must document a distribution uniformity low quarter of 0.65 or higher using the protocol defined in ASABE/ICC 802-2014.
- It is highly recommended that the project applicant or local agency inquire with the local water purveyor about peak water operating demands (on the water supply system) or water restrictions that may impact the effectiveness of the irrigation system.
- In mulched planting areas, the use of low volume irrigation is required to maximize water infiltration into the root zone.
- Sprinkler heads and other emission devices shall have matched precipitation rates, unless otherwise directed by the manufacturer's recommendations.

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- Head to head coverage is recommended. However, sprinkler spacing shall be designed to achieve the highest possible distribution uniformity using the manufacturer's recommendations.
- Swing joints or other riser-protection components are required on all risers subject to damage that are adjacent to hardscapes or in high traffic areas of turfgrass.
- Check valves or anti-drain valves are required on all sprinkler heads where low point drainage could occur.
- Areas less than ten (10) feet in width in any direction shall be irrigated with subsurface irrigation or other means that produces no runoff or overspray.
- Overhead irrigation shall not be permitted within 24 inches of any non-permeable surface. Allowable irrigation within the setback from non-permeable surfaces may include drip, drip line, or other low flow non-spray technology. The setback area may be planted or unplanted. The surfacing of the setback may be mulch, gravel, or other porous material. These restrictions may be modified if:
    - the landscape area is adjacent to permeable surfacing and no runoff occurs; or
    - the adjacent non-permeable surfaces are designed and constructed to drain entirely to landscaping; or
- Slopes greater than 25% shall not be irrigated with an irrigation system with an application rate exceeding 0.75 inches per hour. This restriction may be modified if the landscape designer specifies an alternative design or technology, as part of the Landscape Documentation Package, and clearly demonstrates no runoff or erosion will occur. Prevention of runoff and erosion must be confirmed during the irrigation audit.

Hydrozone

- Each valve shall irrigate a hydrozone with similar site, slope, sun exposure, soil conditions, and plant materials with similar water use.
- Sprinkler heads and other emission devices shall be selected based on what is appropriate for the plant type within that hydrozone.
- Where feasible, trees shall be placed on separate valves from shrubs, groundcovers, and turf to facilitate the appropriate irrigation of trees. The mature size and extent of the root zone shall be considered when designing irrigation for the tree.
- Individual hydrozones that mix plants of moderate and low water use, or moderate and high water use, may be allowed if:

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    - The plant factor calculation is based on the proportions of the respective plant water uses and their plant factor; or
    - The plant factor of the higher water using plants is used for calculations.
- Individual hydrozones that mix high and low water use plants shall not be permitted.
- On the landscape design plan and irrigation design plan, hydrozone areas shall be designated by number, letter, or other designation. On the irrigation design plan, designate the areas irrigated by each valve, and assign a number to each valve.

The irrigation design plan, at a minimum, shall contain:

- location and size of separate water meters for landscape;
- location, type and size of all components of the irrigation system, including controllers, main and lateral lines, valves, sprinkler heads, moisture sensing devices, rain switches, quick couplers, pressure regulators, and backflow prevention devices;
- static water pressure at the point of connection to the public water supply;
- flow rate (gallons per minute), application rate (inches per hour), and design operating pressure (pressure per square inch) for each station;
- recycled water irrigation systems
- the following statement: “I have complied with the criteria of the ordinance and applied them accordingly for the efficient use of water in the irrigation design plan”; and
- the signature of a licensed landscape architect, certified irrigation designer, licensed landscape contractor, or any other person authorized to design an irrigation system.

Irrigation Scheduling

For the efficient use of water, all irrigation schedules shall be developed, managed, and evaluated to utilize the minimum amount of water required to maintain plant health.

Irrigation schedules shall meet the following criteria:

- Irrigation scheduling shall be regulated by automatic irrigation controllers.
- Overhead irrigation shall be scheduled between 8:00 p.m. and 10:00 a.m. unless weather conditions prevent it. If allowable hours of irrigation differ from the local water purveyor, the stricter of the two shall apply. Operation of the irrigation

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system outside the normal watering window is allowed for auditing and system maintenance.

- For implementation of the irrigation schedule, particular attention must be paid to irrigation run times, emission device, flow rate, and current reference evapotranspiration, so that applied water meets the Estimated Total Water Use. Total annual applied water shall be less than or equal to Maximum Applied Water Allowance (MAWA). Actual irrigation schedules shall be regulated by automatic irrigation controllers using current reference evapotranspiration data (e.g., from the Florida Automated Weather Network (FAWN)) or soil moisture sensor data.
- Parameters used to set the automatic controller shall be developed and submitted for each of the following:
    - the plant establishment period;
    - the established landscape; and
    - temporarily irrigated areas.

Each irrigation schedule shall consider for each station all of the following that apply:

- irrigation interval (days between irrigation);
- irrigation run times (hours or minutes per irrigation event to avoid runoff);
- number of cycle starts required for each irrigation event to avoid runoff;
- amount of applied water scheduled to be applied on a monthly basis;
- application rate setting;
- root depth setting;
- plant type setting;
- soil type;
- slope factor setting;
- shade factor setting; and
- irrigation uniformity or efficiency setting.

Landscape and Irrigation Maintenance Schedule

Landscapes shall be maintained to ensure water use efficiency. A regular maintenance schedule shall be submitted with the Certificate of Completion.

A regular maintenance schedule shall include, but not be limited to, routine inspection; auditing, adjustment and repair of the irrigation system and its components; aerating and dethatching turf areas; topdressing with compost, replenishing mulch; fertilizing; pruning; weeding in all landscape areas, and removing obstructions to emission

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devices. Operation of the irrigation system outside the normal watering window is allowed for auditing and system maintenance.

Repair of all irrigation equipment shall be done with the originally installed components or their equivalents or with components with greater efficiency.

A project applicant is encouraged to implement established landscape industry sustainable Best Practices for all landscape maintenance activities.

Irrigation Efficiency

For the purpose of determining Estimated Total Water Use, average irrigation efficiency is assumed to be 0.75 for overhead spray devices and 0.81 for drip system devices.

Recycled Water Systems

The installation of recycled water irrigation systems shall allow for the current and future use of recycled water.

All recycled water irrigation systems shall be designed and operated in accordance with all applicable local and State laws.

Landscapes using recycled water are considered Special Landscape Areas. The ET Adjustment Factor (ETAF) for new and existing (non-rehabilitated) Special Landscape Areas shall not exceed 1.0.

Graywater Systems

Graywater systems promote the efficient use of water and are encouraged to assist in on-site landscape irrigation.

Water Waste Prevention

Local agencies shall prevent water waste resulting from inefficient landscape irrigation by prohibiting runoff from leaving the target landscape due to low head drainage, overspray, or other similar conditions where water flows onto adjacent property, non-irrigated areas, walks, roadways, parking lots, or structures. Penalties for violation of these prohibitions shall be established locally.

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Restrictions regarding overspray and runoff may be modified if:

- the landscape area is adjacent to permeable surfacing and no runoff occurs; or
- the adjacent non-permeable surfaces are designed and constructed to drain entirely to landscaping.

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SECTION 501 – FLOOD-RESISTANT CONSTRUCTION

Reference: Building Code Requirements That Exceed or Are More Specific Than the National Flood Insurance Program

501.1 Intent

The intent of this section is to provide additional protections beyond those required by the Florida Building Code, Building, Section 1612, Flood Loads, ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and other Structures (Chapter 8) and ASCE 24, Flood Resistant Design and Construction.

This section and the flood load and flood-resistant construction requirements of the Florida Building Code, Building are to establish minimum requirements to safeguard the public health, safety, and general welfare and to minimize public and private losses due to flooding through regulation of development in flood hazard areas to:

1. Minimize unnecessary disruption of commerce, access and public service during times of flooding.
2. Require the use of appropriate construction practices in order to prevent or minimize future flood damage.
3. Minimize damage to public and private facilities and utilities.
4. Help maintain a stable tax base by providing for the sound use and development of flood prone areas.
5. Minimize the need for future expenditure of public funds for flood control projects and response to and recovery from flood events.

Requirements set forth in this section shall not supersede more stringent local code requirements.

501.2 Scope

The provisions of this section shall apply to all existing construction and new construction that are located in a *flood hazard area* as established in Section 1612, Flood Loads of this code.

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SECTION 502 SPECIAL REQUIREMENTS FOR CRITICAL FACILITIES

502.1 Intent

Promote the health, safety and general welfare, and to minimize losses due to flood hazards and flood loads to facilities classified as critical either because of the services they provide (e.g., hospitals) or their importance during an emergency (e.g., storm shelters) by establishing regulations that reduce disruption of the use of the structure during and after a flood event.

502.2 Scope

Critical Facilities, as defined in Sections 201.1 and 502.3 of this appendix, shall be constructed as Risk Category III and IV structures in accordance with the Florida Building Code, Building, Section 1604.5, Risk Category and Table 1604.5, Risk Category of Buildings and Other Structures.

502.3 List of Critical Facilities

- Storm shelters (as per the Florida Building Code, Building, Section 423)
- Hospitals and health care facilities (as per the Florida Building Code, Building, Section 449);
- Jails, correctional facilities and detention facilities;
- Facilities used in communications, operation centers, communication towers, electrical substations, back-up generators, fuel or water storage tanks, power generating stations and other public utility facilities;
- Major food distribution centers (with an annual expected volume of greater than 170,000,000 pounds);
- Infrastructure in transportation, telecommunications, or power networks including bridges, tunnels (vehicular and rail), traffic signals, (and other right of way elements including street lights and utilities), power transmission facilities, substations, circuit breaker houses, city gate stations, arterial roadways, telecommunications central offices, switching facilities, etc.;
- Ventilation buildings and fan plants;
- Operations centers;
- Pumping stations (sanitary and stormwater);
- Train and transit maintenance yards and shops;
- Wastewater treatment plants;
- Water supply infrastructure;
- Combined-sewer overflow (CSO) retention tanks;
- Fueling stations;
- Waste transfer stations; and

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- Facilities where residents have limited mobility or ability, including care facilities and nursing homes (as per the Florida Building Code, Building, Section 450).

SECTION 503 EXISTING BUILDINGS

503.1 Intent

The Florida Building Code, Existing Buildings, Section 401.5, Flood Loads, addresses only buildings in flood hazard areas going through *repairs, alterations, additions and/or rehabilitation* that constitute *substantial improvements*, requiring resistance to the effects of flood hazards and flood loads as per Section 1612. This section provides measures to increase flood damage resistance of existing buildings in flood hazard areas that are going through *repairs, alterations, additions and/or rehabilitation* that do not constitute *substantial improvement*.

503.2 General.

In flood hazard areas, any *repair, alteration ,addition and/or rehabilitation* shall include all requirements *technically feasible* from the Florida Building Code - Building, Section 1612, Flood Loads.

503.3 Additional Requirements.

503.3.1 Protection of mechanical, plumbing, electrical, and life safety systems

Mechanical, plumbing, electrical, and life safety systems (including but not limited to HVAC units, emergency generators, duct work, alarm systems, electrical panels, electrical distribution, switching areas, gas and electrical meters, suppression equipment, telecommunications equipment, motors and controllers, fuel storage tanks) shall be elevated to or above the design flood elevation in *repairs*, *alterations*, *additions* and/or *rehabilitation* that do not constitute substantial improvement occurring below the design flood elevation in buildings in flood hazard areas. Exceptions may be made for life safety, egress, and low voltage components when necessary.

503.3.2 Dry Flood Proofing

The objective of dry floodproofing is to seal the portion of a structure (walls and other exterior components) that is below the design flood elevation making it watertight and impermeable to floodwaters as recommended by the Coastal Construction Manual FEMA P-55, Chapter 15.3.3.

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503.3.3 Wet Flood Proofing

Wet floodproofing involves modifying a building to allow floodwaters to enter it in such a way that damage to the structure and its contents is minimized. Wet floodproofing is often used in a non-habitable understory of structures in flood prone areas, where the first habitable floor is elevated above the design flood elevation. The Coastal Construction Manual FEMA P-55, Chapter 15.3.4 provides guidance concerning wet proofing alternatives.

SECTION 504 FLOOD DAMAGE-RESISTANT MATERIALS

Reference: Coastal Construction Manual FEMA P-55, Chapter 9 and the FEMA National Flood Insurance Program (NFIP) Technical Bulletin 2 .

504.1 Intent

Not currently required by the Florida Building Code, Existing Buildings, the use of the proper materials could assist in avoiding significant future material losses and disruption to people's lives. This section encourages the use of flood damage-resistant materials in *repairs, alterations, additions and/or rehabilitation* that do not constitute a *substantial improvement* occurring below the design flood elevation in buildings in flood hazard areas.

504.2 Scope

Repairs, *alterations*, *additions* and/or *rehabilitation* that do not constitute a *substantial improvement* occurring below the design flood elevation in buildings in high hazard areas shall be constructed using flood damage-resistant materials as required by the Coastal Construction Manual FEMA P-55, Chapter 9.4, and the FEMA NFIP Technical Bulletin 2 .

504.3 Additional Interventions to Mitigate Flood Damage to Buildings

- Storm water damage by relocating them above the design flood elevation.
- Install backwater prevention valves.
- Install sump pumps.
- Direct floodwaters away from critical equipment and building access towards detention areas if available.
- Reduce impervious surfaces in the building vicinity by using permeable paving and drainage underlayment.

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- Increase water infiltration by planting trees, grass/ground coverage vegetation and vegetated swales per Section 403.
- Create stormwater detention areas in the landscape.
- Provide exterior waterproofing.
- Utilize flood-resistant materials.
- Seal penetrations below the design flood elevation.
- Provide redundant/elevated conduit entrances.
- Install back-up power.

Raise utilities installed below design flood elevation building/structure footprint in the direction of flow of oncoming floodwaters, allowing for free passage of water at or more than sixty (60) percent of the footprint after breakaway construction has been dislodged and scour has taken place.

SECTION 505 ELEMENTS BELOW DESIGN FLOOD ELEVATION

505.1 Obstruction Free Design

Free of Obstruction. In order to reduce the effects of flow diversion, wave reflection, and wave runup, the use of permanent structural components and systems designed to resist the combined effects of wind and flood loads below the *Design Flood Elevation* must not block or impede the passage of water more than an aggregate forty (40) percent of the total width of the building/structure footprint in the direction of flow of oncoming floodwaters, allowing for free passage of water at or more than sixty (60) percent of the footprint after breakaway construction has been dislodged and scour has taken place.

505.2 Enclosed Areas

Enclosed areas below design flood elevation. Enclosed areas, including crawl spaces, that are below the design flood elevation shall be used solely for parking of vehicles, building access and/or storage. The enclosed area shall not be conditioned space (temperature controlled) or finished or partitioned except for one storage area no larger than one hundred (100) square feet with one dimension not to exceed six (6) feet, access stairwells, ramps, and elevators, unless a partition is required by the Fire Prevention Code. The limitation on partitions does not apply to load bearing walls interior to perimeter wall (crawlspace) foundations.

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505.3 Walls

Walls below *design flood elevation*. Walls and partitions are permitted below the elevated floor, provided that such walls and partitions are not part of the structural support of the building or structure and electrical, mechanical and plumbing system components are not mounted on or penetrate through such walls and partitions that are designed to break away under flood loads.

505.4 Accessory Structures

Accessory structures are permitted below the base flood elevation provided the accessory structures are used only for parking or storage and:

1. If located in special flood hazard areas (Zone A/AE) other than coastal high hazard areas or coastal A zones, they are one-story and not larger than six hundred (600) square feet.
2. If located in coastal high-hazard areas (Zone V/VE) or coastal A zones, they are not located below elevated buildings and are not larger than one hundred (100) square feet.

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S11763Rationale

MOISTURE

Section 301 of the proposed Florida Building Code Appendix focuses on moisture control in buildings, addressing the harmful effects of moisture migration into and through the building envelope which can degrade materials and negatively impact indoor air quality. The section provides guidance on designing and constructing resilient building envelope systems, with an emphasis on moisture control and additionally on improving energy efficiency, occupant health, and building longevity. It outlines the importance of adhering to the Florida Building Codes, Florida Product Approval (FPA) requirements, Notices of Acceptances (NOA's) in Miami-Dade and Broward Counties and stresses the need for clear and concise communication of detailed design intent and proper construction practices. Additionally, it highlights specific requirements for exterior walls, balconies, roofs, and terraces, including detailed drawing checklists and testing protocols.

RESOURCES -Water Efficiency and Conservation

With a growing population constantly increasing the need for water for both human habitation, industry, and agriculture, Florida is in a seemingly counterintuitive situation of running the risk of having an inadequate water supply for the State's needs. As the aquifer is increasingly drained, saltwater intrusion from the Atlantic Ocean and the Gulf of Mexico becomes an ever-greater risk. Water is a basic need of any human population and for the State to thrive and be resilient, without resorting to costly desalination plants and incurring water shortages, then we will need to ensure the population can live within its resources. Ensuring plentiful water is available to all will require greater efficiency in its usage and this Appendix provides the tools to achieve that.

FLOOD-RESISTANT CONSTRUCTION

The flood-resistant construction guidelines establish enhanced standards to protect public health, safety, and welfare by mitigating the impact of flood hazards. These guidelines aim to reduce flood-related damage, ensure continuous access to essential public services, and minimize economic loss. They apply to all new and existing construction in flood-prone areas, requiring the use of advanced construction practices that exceed the minimum standards set by the Florida Building Code and ASCE regulations. Critical facilities, such as hospitals, storm shelters, and essential infrastructure, are subject to stricter construction requirements to maintain functionality during and after flood events.

The guidelines also address flood resilience measures for existing buildings and design features below the flood elevation. Non-substantially improved buildings must incorporate flood-resistant retrofits, such as elevating essential equipment and employing dry or wet floodproofing techniques. The use of flood-damage-resistant materials is encouraged to

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reduce repair costs and minimize disruptions following a flood. Additionally, the design of building elements below the flood elevation must allow the free passage of water, limit the use of enclosed spaces, and restrict the size and function of accessory structures in high-risk flood zones. These measures collectively aim to reduce the long-term costs of flood recovery, ensure public safety, and support community resilience.

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Fuel Gas

2

P11787

Date Submitted	01/18/2025	**Section**	101.2	**Proponent**	Greg Burke
Chapter	1	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Summary of Modification

Correlation for addition of three- and four- family dwellings to the scope.

Rationale

Housing and skilled labor is at a crisis point in the United States. Demand is outpacing supply in a critical way. To entice development and local authorities in providing more options for first time buyers or those who are wishing to down-size, the scope change will enable an opportunity for choice, Moving these two dwelling types into the FBC,R allows construction in an equivalent manner to single-, two-family, and townhouses buildings. More cost savings can come in the form of reduced egress requirements. Single exits could be required that would have stairs meet the riser/tread dimensions reduced from the commercial maximum requirement to the residential requirements for treads and risers. In Occupancy Group R2, under the FBC,B live load will be reduced to 40 psf from the commercial requirement of 100 psf. Other sections of the FBC,R may allow for potential for smaller HVAC units. Financial institutions finance these two types of dwelling units as single-family homes. It is not until a building has five or more residential units that the financing is a commercial loan. For this reason alone, three-family, and four-family dwelling units should be included in the FBC,R. It is possible to purchase these dwellings with an FHA Loan. Realtors in Florida are also permitted to sell up to four units on a residential license. With proper zoning, three-family and four-family dwelling units can be designed and constructed to be compatible in single-family neighborhoods. Most can be constructed within a 35-foot height limit, common in many parts of the state. Normally, three-family, and four-family dwellings are two, two and one-half or three stories above the grade plane making them compatible with a single-family or two-family home. The footprint of either a three- or a four-family building could be designed and constructed in dimensions of forty feet by sixty feet.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

The less restrictive application of a residential code souldlessen the burden on enforcement.

Impact to building and property owners relative to cost of compliance with code

Less expensive construction and sales cost.

Impact to industry relative to the cost of compliance with code

None

Impact to small business relative to the cost of compliance with code

None

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The design of three- and four-family dwelligs are similar in nature to a duplex. As such the dgree of health, safety and elfare is enhanced by admitting these two dwelling types to the residential code.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

The modification is in line with industry standards for financing and sales.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No.

Does not degrade the effectiveness of the code

No.

P11787Text Modification

Exceptions:

1. Detached one,- and two-, three-, and four- family *dwellings* and multiple single-family *dwellings (townhouses)* not more than three *stories* above *grade plane* in height with a separate *means of egress,* their accessory structures not more than three *stories* above *grade plane* in height, shall comply with the *Florida Building Code, Residential*.

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Mod11787_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Fuel Gas

3

P11740

Date Submitted	01/13/2025	**Section**	304	**Proponent**	Mo Madani
Chapter	3	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

This includes changes to Chapters 2, 3, 4 and 6.

Summary of Modification

Correlation with NFPA 54

Rationale

Proposed revisions to chapters 2, 3, 4 and 6 necessary to update the FBC-Fuel Gas for consistency with NFPA 54 as codified in the 2024 IFG.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
Correlation with NFPA 54.
Impact to building and property owners relative to cost of compliance with code
Correlation with NFPA 54.
Impact to industry relative to the cost of compliance with code
Correlation with NFPA 54.
Impact to small business relative to the cost of compliance with code
Correlation with NFPA 54.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Correlation with NFPA 54.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Correlation with NFPA 54.
Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Does not degrade the effectiveness of the code
Correlation with NFPA 54.

P11740Text Modification

See attached.

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Mod11740_TextOfModification.pdf

P11740Text Modification

CHAPTER 2 DEFINITIONS

APPROVED AGENCY. An established and recognized ~~agency~~ organization that is regularly engaged in conducting tests, furnishing inspection services or furnishing evaluation or certification, where such ~~agency~~ organization has been approved by the code official.

[A] PEER REVIEW. An independent and objective technical review conducted by an *approved* third party.

CHAPTER 3 GENERAL REGULATIONS

SECTION 304 (IFGS) COMBUSTION, VENTILATION AND DILUTION AIR

304.1 General. ~~Air for combustion, ventilation and dilution of flue gases for *appliances* installed in buildings shall be provided by application of one of the methods prescribed in Sections 304.5 through 304.9. Where the requirements of Section 304.5 are not met, outdoor air shall be introduced in accordance with one of the methods prescribed in Sections 304.6 through 304.9. *Direct vent appliances*, gas *appliances* of other than natural draft design, vented gas appliances not designated as Category I and appliances equipped with power burners shall be provided with combustion, ventilation and dilution air in accordance with the *appliance* manufacturer's instructions.~~

~~Exception:~~ ~~Type 1 clothes dryers that are provided with makeup air in accordance with Section 614.7.~~

Where chemicals that generate corrosive or flammable products such as aerosol sprays are routinely used, one of the following shall apply to fired appliances where these chemicals can enter combustion air:

1. Fired appliances shall be located in a mechanical room separate or partitioned off from other areas with provisions for combustion and dilution air from outdoors.
2. The appliances shall be direct vent and installed in accordance with the appliance manufacturer's installation instructions.

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Mod_11740_Text_FBC Fuel Gas correlation issues.pdf

P11740Text Modification

304.12 Protection from fumes and gases. ~~Where corrosive or flammable process fumes or gases, other than products of combustion, are present, means for the disposal of such fumes or gases shall be provided. Such fumes or gases include carbon monoxide, hydrogen sulfide, ammonia, chlorine and halogenated hydrocarbons. In barbershops, beauty shops and other facilities where chemicals that generate corrosive or flammable products, such as aerosol sprays, are routinely used, nondirect vent type *appliances* shall be located in a mechanical room separated or partitioned off from other areas with provisions for *combustion air* and dilution air from the outdoors. *Direct vent appliances* shall be installed in accordance with the appliance manufacturer's instructions.~~ Where chemicals that generate corrosive or flammable products such as aerosol sprays are routinely used, one of the following shall apply to fired *appliances* where these chemicals can enter combustion air:

1. Fired appliances shall be located in a mechanical room separate or partitioned off from other areas with provisions for combustion and dilution air from outdoors.
2. The appliances shall be direct vent and installed in accordance with the appliance manufacturer's installation instructions.

310.1 Pipe and tubing other than CSST. Each aboveground portion of a gas *piping* system other than corrugated stainless steel tubing (CSST) that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas *piping* other than CSST shall be considered to be bonded where it is connected to ~~an~~ one or more *appliances* that is Page 87 of 376 are connected to the *equipment* grounding conductor of the circuit that supplies that *appliance(s).*

310.3 Arc-resistant CSST. ~~This section applies to c~~ Corrugated stainless steel tubing (CSST) ~~that is *listed*~~ with an arc-resistant jacket or coating system ~~in accordance~~ shall be *listed* as arc resistant in accordance with **ANSI LC 1/CSA 6.26**. ~~The~~ Arc-resistant-jacketed CSST shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST used in ~~component of~~ a *piping* system

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Mod_11740_Text_FBC Fuel Gas correlation issues.pdf

P11740Text Modification

does not have an arc-resistant jacket or coating system, the bonding requirements of **Section 310.2** shall apply. Arc-resistant-jacketed CSST shall be considered to be bonded where it is connected to ~~an~~ one or more *appliances* that ~~is~~ are connected to the equipment ~~*appliance*~~ grounding conductor of the circuit that supplies that *appliance(s)*.

CHAPTER 4 GAS PIPING INSTALLATIONS

403.7 Workmanship and defects. Gas ~~P~~pipe, tubing and fittings at the time of installation shall meet the following requirements:

1. Gas pipe, tubing and fittings shall be clear and free from cutting burrs and visible defects in structure or threading.

2. Gas pipe, tubing and fittings shall be thoroughly cleaned to remove chip, scale and debris.

3. Visible defects in pipe, tubing and fittings shall not be repaired.

4. Pipe, tubing and fittings with visible defects shall be replaced.

~~be clear and free from cutting burrs and defects in structure or threading, and shall be thoroughly brushed, and chip and scale blown. Defects in pipe, tubing and fittings shall not be repaired. Defective pipe, tubing and fittings shall be replaced.~~

403.10 Metallic piping joints and fittings. The type of piping joint used shall conform to the following:

1. It shall be suitable for the pressure-temperature conditions.

2. It shall be ~~and shall be~~ selected giving consideration to joint tightness and mechanical strength under the service conditions.

3. It shall be ~~The joint shall be~~ able to sustain the maximum ~~end force caused by the internal pressure and any additional forces caused by~~ forces inclusive of temperature expansion or contraction, vibration, fatigue, internal pressure or the weight of the pipe and its contents.

403.12.3 Nonferrous. Nonferrous flanges shall be in accordance with ASME B16.24 except listed components using aluminum flange connections constructed in accordance with the dimensional specifications of ANSI/ASME B16.5.

406.1.2 Repairs and additions. In the event repairs or additions are made after the pressure test, the affected piping shall be tested. Minor repairs and additions ~~are not~~ shall not be required to be pressure tested provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other approved leak-detecting methods.

406.4.1 Test pressure. The test pressure to be used shall be not less than 11 /2 times the proposed maximum working pressure, but not less than 3 psig (20 kPa gauge~~), irrespective of design pressure~~.

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Mod_11740_Text_FBC Fuel Gas correlation issues.pdf

P11740Text Modification

Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe.

406.5.1 Detection methods. The leakage shall be located by means of ~~an approved~~ a listed combustible gas detector, a noncorrosive leak detection fluid or other approved leak detection methods.

416.3.6 Size of fittings, pipe and openings. The fittings, pipe and openings located between the system to be protected and the pressure-relieving device shall be sized to prevent hammering of the valve and to prevent ~~impairment~~ reduction of relief capacity.

CHAPTER 6 SPECIFIC APPLIANCES

602.1 General. Decorative appliances for installation in approved solid fuel-burning fireplaces shall be listed in accordance with ~~ANSI Z21.60/CSA 6.26~~ ANSI Z21.60/CSA 2.26 and shall be installed in accordance with the manufacturer's instructions. Manually lighted natural gas decorative appliances shall be listed in accordance with ANSI Z21.84.

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Mod_11740_Text_FBC Fuel Gas correlation issues.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Fuel Gas

4

SP12020

Date Submitted	02/13/2025	**Section**	301.11	**Proponent**	Rebecca Quinn obo FL Div Emerg Mgnt
Chapter	3	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

12018, 12019

Summary of Modification

For clarity, carry into other codes the change made in 8th to require elevation of exterior equipment and exterior appliances that are damaged by flood (see FBC EB Sec. 701.3 and FBCR Sec. R322.1.6).

Rationale

Many buildings in floodplains were built before communities started regulating and requiring buildings to be elevated and constructed to minimize exposure to flooding. During floods, exterior equipment that serves those buildings gets damaged, even when the building itself is not substantially damaged. When buildings are flooded and elevated exterior equipment remains functional, clean up and drying out are easier and faster. This means dangerous mold conditions are less likely to develop and buildings can more quickly be reoccupied. The code change clarifies the existing requirement in FBCEB Sec. 701.3 and FBCR Sec. R322.1.6) by adding it to FBCEB Repairs, FBC Mechanical, and FBC Fuel Gas so that it is clear that the requirement that is already in the code applies, whether it is called an alteration or repair, and whether a permit is issued under only the Mechanical or Fuel Gas codes. Methods used to raise the replacement exterior equipment are the same as the methods used when equipment is installed to serve new construction (pedestal, platforms, platforms that are cantilevered from or knee braced to the structure; wall brackets for mini-splits). FEMA's Mitigation Assessment Team reports prepared after some significant flood events document widespread damage to non-elevated exterior equipment. Elevating equipment at the time of replacement also saves building owners from having to pay for replacement equipment after the subsequent flood event.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

None; the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Impact to building and property owners relative to cost of compliance with code

None; the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Impact to industry relative to the cost of compliance with code

None; the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Impact to small business relative to the cost of compliance with code

None; the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

No change because the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

No change because the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No change because the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

Does not degrade the effectiveness of the code

No change because the 8th Ed requirements already apply to exterior equipment/appliances replaced because of flood damage.

SP12020Text Modification

301.11 Flood hazard. For structures located in flood hazard areas, the appliance, equipment and system installations regulated by this code shall be located at or above the elevation required by Section 1612 of the International Building Code for utilities and attendant equipment. Replacement of exterior equipment and exterior appliances damaged by flood shall meet the requirements of this section.

Exception: The *appliance*, *equipment* and system installations regulated by this code are permitted to be located below the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to such elevation.

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Mod12020_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Fuel Gas

5

P11719

Date Submitted	01/10/2025	**Section**	407.2	**Proponent**	Jonathan Sargeant
Chapter	4	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Summary of Modification

The proposed modification is to reverse the commission's action to permit plastic hangers for fuel gas piping.

Rationale

the 2024 IFGC made the change to omit the requirement for metal hangers for fuel gas piping. The consent agenda for the 2027 IFGC includes a proposed change from the PMGCAC to reverse this change (See FG-6 in support file). I am submitting this proposal to avoid making a change in Florida that will be reversed in three years when we come together again to look at the 2027 changes.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposal will greatly reduce confusion in localities throughout the state by not making a change that will will be reversed in three years.

Impact to building and property owners relative to cost of compliance with code

Metal hangers are slightly more expensive than plastic hangers so the proposal will marginally increase the cost of installing fuel gas piping in Florida. However, since the code currently requires metal hangers, the cost will not change from the cost of current practices.

Impact to industry relative to the cost of compliance with code

Metal hangers are slightly more expensive than plastic hangers so the proposal will marginally increase the cost of installing fuel gas piping in Florida. However, since the code currently requires metal hangers, the cost will not change from the cost of current practices.

Impact to small business relative to the cost of compliance with code

Metal hangers are slightly more expensive than plastic hangers so the proposal will marginally increase the cost of installing fuel gas piping in Florida. However, since the code currently requires metal hangers, the cost will not change from the cost of current practices.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The metal hanger requirement in the IFGC was added to prevent gas piping from falling during building fires potentially breaking and contributing to the fire and endangering first responders. The proposal contributes to the health, safety and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Hangers that do not melt in a building fire are better products than plastic hangers that do.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

The proposal absolutely discriminates against plastic hangers that could be used to support fuel gas piping but it does so in the interest of public safety.

Does not degrade the effectiveness of the code

The proposal enhances the effectiveness of the code.

P11719Text Modification

407.2 Design and installation. Piping shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers or building structural components, suitable for the size of piping, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. Piping shall be anchored to prevent undue strains on connected appliances and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of MSS SP-58 and shall be spaced in accordance with Section 415. Supports, hangers and anchors shall be installed so as not to interfere with the free expansion and contraction of the piping between anchors. All parts of the supporting equipment shall be designed and installed so that they will not be disengaged by movement of the supported piping.

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IFGC

2024 GROUP A PROPOSED CHANGES TO THE I-CODES

April 7 – 16, 2024
Doubletree by Hilton
Universal Orlando - Orlando, FL

ICC INTERNATIONAL CODE COUNCIL

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2024 GROUP A – PROPOSED CHANGES TO THE INTERNATIONAL FUEL GAS CODE

FUEL GAS CODE COMMITTEE

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TENTATIVE ORDER OF DISCUSSION
2024 PROPOSED CHANGES TO THE INTERNATIONAL FUEL GAS CODE

The following is the tentative order in which the proposed changes to the code will be discussed at the public hearings. Proposed changes which impact the same subject have been grouped to permit consideration in consecutive changes.

Proposed change numbers that are indented are those which are being heard out of numerical order. Indentation does not necessarily indicate that one change is related to another. Proposed changes may be grouped for purposes of discussion at the hearing at the discretion of the chair. Note that some FG code change proposals may not be included on this list, as they are being heard by another committee.

FG1-24
FG2-24
FG3-24
FG4-24
FG5-24
FG6-24
FG7-24
FG8-24
FG10-24
FG11-24 Part I
    ADM1-24

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FG1-24

IFGC: 303.3

Proponents: Guy McMann, Jefferson County Colorado, Colorado Association of Plumbing and Mechanical Officials (CAPMO) (gmcmann@jeffco.us)

2024 International Fuel Gas Code

Revise as follows:

303.3 Prohibited locations.

Appliances shall not be located in ~~sleeping rooms~~, bedrooms, bathrooms, toilet rooms, storage closets or surgical rooms, or in a space that opens only into such rooms or spaces, except where the installation complies with one of the following:

1. The *appliance* is a direct-vent *appliance* installed in accordance with the conditions of the listing and the manufacturer's instructions.
2. Vented room heaters, wall furnaces, vented decorative *appliances*, vented gas fireplaces, vented gas *fireplace* heaters and decorative *appliances* for installation in vented solid fuel-burning fireplaces are installed in rooms that meet the required volume criteria of Section 304.5.
3. A single wall-mounted unvented room heater is installed in a bathroom and such unvented room heater is equipped as specified in Section 621.6 and has an input rating not greater than 6,000 Btu/h (1.76 kW). The bathroom shall meet the required volume criteria of Section 304.5.
4. A single wall-mounted unvented room heater is installed in a bedroom and such unvented room heater is equipped as specified in Section 621.6 and has an input rating not greater than 10,000 Btu/h (2.93 kW). The bedroom shall meet the required volume criteria of Section 304.5.
5. The *appliance* is installed in a room or space that opens only into a bedroom or bathroom, and such room or space is used for no other purpose and is provided with a solid weather-stripped door equipped with an *approved* self-closing device. *Combustion air* shall be taken directly from the outdoors in accordance with Section 304.6.
6. A clothes dryer is installed in a residential bathroom or toilet room having a permanent opening with an area of not less than 100 square inches (0.06 m^2) that communicates with a space outside of a bedroom, bathroom, toilet room or storage closet.

Reason: 1. Replacing the words sleeping room with bedroom in the first paragraph of the code will align it with the exceptions. Nowhere in the exceptions is sleeping room used.

2. The question is, what is the difference between a sleeping room and a bedroom? The Miriam Webster dictionary defines a bedroom as: a room furnished with a bed and intended primarily for sleeping. There is no definition in Miriam Webster for sleeping room. A definition of sleeping area can be found in the Collins dictionary where a sleeping area is defined as: an area in a room or house where people can sleep but there is no definition of sleeping room. Law Insider has multiple citations for sleeping room from many different municipalities across the country. Most of the citations have differing opinions of what a sleeping room is or is not. In Chapter 2 of the IFGC, IMC, IBC or IRC sleeping room is not defined so anyone using the International Codes is left to figure out on their own what the term sleeping room encompasses. In summation, the words sleeping room are too vague for proper interpretation of what the code is trying to describe.

3. Sleeping room is a holdover from the 2003 IFGC Section 303.3 Prohibited locations code. There is no definition for sleeping room in Chapter 2 of the 2003 IFGC.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

There is no cost as this is editorial in nature.

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P11719Text Modification

P11719Text Modification

FG2-24

IFGC: 303.3

Proponents: Guy McMann, Jefferson County Colorado, Colorado Association of Plumbing and Mechanical Officials (CAPMO) (gmcmann@jeffco.us)

2024 International Fuel Gas Code

Revise as follows:

303.3 Prohibited locations.
Appliances shall not be located in sleeping rooms, bathrooms, toilet rooms, storage closets or surgical rooms, or in a space that opens only into such rooms or spaces, except where the installation complies with one of the following:

1. The *appliance* is a direct-vent *appliance* installed in accordance with the conditions of the listing and the manufacturer's instructions.
2. Vented room heaters, wall furnaces, vented decorative *appliances*, vented gas fireplaces, vented gas *fireplace* heaters and decorative *appliances* for installation in vented solid fuel-burning fireplaces are installed in rooms that meet the required volume criteria of Section 304.5.
3. A single wall-mounted unvented room heater is installed in a bathroom and such unvented room heater is equipped as specified in Section 621.6 and has an input rating not greater than 6,000 Btu/h (1.76 kW). The bathroom shall meet the required volume criteria of Section 304.5.
4. A single wall-mounted unvented room heater is installed in a bedroom and such unvented room heater is equipped as specified in Section 621.6 and has an input rating not greater than 10,000 Btu/h (2.93 kW). The bedroom shall meet the required volume criteria of Section 304.5.
5. The *appliance* is installed in a room or space that opens only into a bedroom or bathroom, and such room or space is used for no other purpose and is provided with a solid weather-stripped door equipped with an *approved* self-closing device. *Combustion air* shall be taken directly from the outdoors in accordance with Section 304.6, or obtained from any adjacent space or spaces outside of a bedroom, bathroom, toilet room, storage closet or surgical room. Sizing for indoor combustion air volume shall be in accordance with Section 304.5. Sizing and location of the openings used to connect the indoor spaces shall be in accordance with Section 304.5.3.
6. A clothes dryer is installed in a residential bathroom or toilet room having a permanent opening with an area of not less than 100 square inches (0.06 m^2) that communicates with a space outside of a sleeping room, bathroom, toilet room or storage closet.

Reason: As written, when appliances are located in a room or space that opens only in a bedroom or bathroom there is only one option for obtaining combustion air for the appliances located in the space, bring it into the room or space from the outside. There are situations where this is not a feasible or a cost effective solution. For example, the room may not be located near an outside wall making it difficult to get the combustion air duct/ducts into the room or space. The total BTU load in the room may require very large combustion air duct/ducts to be installed. Bringing outside combustion air into a room located within the building envelope does not consider all the insulation requirements of IECC R402.4.4 (Rooms containing fuel-burning appliances).

benefits

1. Having this second option for obtaining combustion air for appliances located in a room or space accessed through a bedroom will allow the homeowner or contractor to safely provide combustion air to the appliance using IFGC 304.5 (Indoor combustion air) and 304.5.3 (Indoor opening size and location).

2. Combustion air requirements for the appliances can be met even if the room or space is not located on an outside wall.

3. Using indoor combustion air is more energy efficient than bringing in cold or hot outside combustion air into the room or space located within the building envelope.

4. Combustion air ducts can be, and sometimes are, plugged by the homeowner to prevent cold air from entering into the mechanical room during the winter months. High/low grilles are rarely intentionally blocked off.

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P11719Text Modification

5. Installing grilles is more cost effective than installing combustion air duct/ducts especially when the prohibited location is not adjacent to an outside wall.

Cost Impact: Decrease

Estimated Immediate Cost Impact:

There will be no added cost to industry. There could be savings to the industry. Grilles are relatively inexpensive to purchase especially when compared to the price of sheet metal and fabrication of ducts. Cutting holes in an interior wall and installing grilles is less labor intensive than cutting a hole/holes in an outside wall and installing combustion air duct/ducts.

Estimated Immediate Cost Impact Justification (methodology and variables):

The savings could range from $0 to $500 based on not having to spend labor dollars drilling holes and by not having to insulate the room to meet Energy code requirements.

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P11719Text Modification

FG3-24

IFGC: 303.7

Proponents: Guy McMann, Jefferson County Colorado, CAPMO (gmcmann@jeffco.us)

2024 International Fuel Gas Code

Revise as follows:

303.7 Pit locations. *Appliances* installed in pits or excavations shall not come in direct contact with the surrounding soil. The sides of the pit or excavation shall be held back not less than 12 inches (305 mm) from the *appliance*. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry, such concrete or masonry shall extend not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. Excavation on the control side of the appliance shall extend horizontally not less than 30 inches (762 mm). The *appliance* shall be protected from flooding in an *approved* manner.

Reason: This text is extracted from IRC Section1305.1.3.2 and makes the IFGC consistent with the IRC.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

It is important to the installer to have this information in order to make adjustments if necessary to the install thus saving time at a later date.

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FG4-24

IFGC: SECTION 202, SECTION 315 (New), 315.1 (New), 315.1.2 (New)

Proponents: Marcelo Hirschler, GBH International, GBH International (mmh@gbhint.com)

2024 International Fuel Gas Code

Delete without substitution:

~~**[M] NONCOMBUSTIBLE MATERIALS.** Materials that, where tested in accordance with ASTM E136, have not fewer than three of four specimens tested meeting all of the following criteria:~~

1. ~~The recorded temperature of the surface and interior thermocouples shall not at any time during the test rise more than 54°F (30°C) above the furnace temperature at the beginning of the test.~~
2. ~~There shall not be flaming from the specimen after the first 30 seconds.~~
3. ~~If the weight loss of the specimen during testing exceeds 50 percent, the recorded temperature of the surface and interior thermocouples shall not at any time during the test rise above the furnace air temperature at the beginning of the test, and there shall not be flaming of the specimen.~~

Add new text as follows:

SECTION 315
NONCOMBUSTIBLE MATERIALS

315.1 Testing. Noncombustible materials shall be those materials that comply with Section 703.3.1 of the International Building Code.

315.1.2 Inherently noncombustible materials. Inherently noncombustible materials, such as concrete and steel, shall not be required to be tested to be acceptable as noncombustible materials.

Reason: The so-called definition contained in the 2024 IFGC is said to be under the jurisdiction of the IMC (in accordance with the [M] in front of it). In fact it is not identical to the definition in the IMC, which reads: "Noncombustible material: a material that passes ASTM E136." Furthermore, the present definition in the IFGC is no longer consistent with the language contained in ASTM E136 and also addresses only one of the two options included in ASTM E136 for a material to be considered noncombustible. Finally, the "definition" in the IFGC is actually a "requirement" since it requires materials to meet certain criteria to be classified as a noncombustible material. ICC definitions should not contain requirements.

In the area of material regulation, materials that pass ASTM E136 have long been considered to be those that are noncombustible materials, and that concept is consistent with the flawed "definition" in the IFGC.

This proposal recommends including a correct requirement for what materials shall be considered noncombustible materials and it is to comply with the IBC section 703.3.1. A second proposed section states that a requirement for what is a noncombustible material does not mean that clearly noncombustible materials, such as steel, concrete, or masonry, need to be tested, for example to ASTM E136.

Note that ASTM E136 is one of the very few ASTM fire test standards that has acceptance criteria. The acceptance criteria are different from the theoretical definition of a noncombustible material.

If no requirement exists for what is a noncombustible material, experience indicates that some material manufacturers have claimed that their material is noncombustible when it simply exhibits improved fire performance. When searching the internet, multiple web sites offer materials or products that are alleged to be noncombustible when that claim is incorrect. There is often confusion in the public mind between how to consider a material that performs better than typical combustible materials, but is not enough for the material to be considered noncombustible.

This proposal recommends including a correct requirement for what materials shall be considered noncombustible materials and that is that they need to comply with the IBC section 703.3.1. A second section states that a requirement for what is a noncombustible material

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does not mean that clearly noncombustible materials, such as steel, concrete, or masonry, need to be tested, for example to ASTM E136.

Equivalent proposals are being submitted to the IFC (by FCAC), the IPC, and the IMC, all of which use noncombustible materials.

Another proposal revises the definitions of "combustible material" in the IMC and IFGC to clarify that the whether a material is or is not noncombustible is the result of a classification. The IBC does not "define" a noncombustible material but contains requirements for such materials.

The language in section 703.3.1 of the IBC reads as follows:*703.3.1 Noncombustible materials. Materials required to be noncombustible shall be tested in accordance with ASTM E136. Alternately, materials required to be noncombustible shall be tested in accordance with ASTM E2652 using the acceptance criteria prescribed by ASTM E136.*

Exception: Materials having a structural base of noncombustible material as determined in accordance with ASTM E136, or with ASTM E2652 using the acceptance criteria prescribed by ASTM E136, with a surfacing of not more than 0.125 inch (3.18 mm) in thickness having a flame spread index not greater than 50 when tested in accordance with ASTM E84 or UL 723 shall be acceptable as noncombustible.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

This proposal simply moves a requirement (that is not consistent with the present edition of ASTM E136) into a place where the requirement can be enforced.

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FG5-24

IFGC: 404.11.2

Proponents: Jonathan Sargeant, OmegaFlex, OmegaFlex (jonathan.sargeant@omegaflex.com)

2024 International Fuel Gas Code

Revise as follows:

404.11.2 Protection methods.

Underground *piping* shall comply with one or more of the following:

1. The *piping* shall be made of corrosion-resistant material that is suitable for the environment in which it will be installed.
2. Pipe shall have a factory-applied, electrically-insulating coating. Fittings and joints between sections of coated pipe shall be coated in accordance with the coating manufacturer's instructions.
3. The *piping* shall have a cathodic protection system installed and the system shall be monitored and maintained in accordance with an *approved* program.
4. The piping shall employ an encasement system listed for underground installation.

Reason: The proposal adds listed encasement systems currently permitted in 404.14 for installation underground beneath buildings. Listed encasement systems have a long history of successful use below grade both within and outside of the building footprint.

Cost Impact: Decrease

Estimated Immediate Cost Impact:

The material cost for a 20 foot run of 1" piping installed below grade:

Polyethylene with tracer wire and two risers: $217.44

Listed encasement system with two end fittings: $178.84

Savings for listed encasement system: $38.60

Estimated Immediate Cost Impact Justification (methodology and variables):

The proposal permits a manufactured listed encasement system for gas lines below grade outside the building. The most common, and least expensive, material used for this application is polyethylene. Polyethylene on a per foot material is less expensive than a listed encasement system but polyethylene requires a tracer wire and risers where they penetrate grade which is not required for a metallic listed encasement system. Because of the additional requirements, a metallic listed encasement system is often less expensive for shorter piping runs. This estimate assumes a twenty foot run of 1" piping. For longer runs, polyethylene, with the added requirements, would be less expensive to install and the proposal leaves that option intact for the contractor should he choose that alternative.

Estimated Life Cycle Cost Impact:

The proposal has no additional impact on the life cycle of the project.

Estimated Life Cycle Cost Impact Justification (methodology and variables):

The only protection method that would have life cycle costs would be cathodic protection. However, the anode replacement schedule is highly variable (dependent on the corrosiveness of the environment). The length of the replacement schedule coupled with the minimal cost of replacement anodes would make the life cycle cost of the activity trivial.

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FG6-24

IFGC: 407.2

Proponents: Andrew Bevis, Chair, Plumbing, Mechanical and Fuel Gas Code Action Committee (pmgcac@iccsafe.org)

2024 International Fuel Gas Code

Revise as follows:

407.2 Design and installation.
Piping shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, hangers or building structural components, suitable for the size of *piping*, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. *Piping* shall be anchored to prevent undue strains on connected *appliances* and shall not be supported by other *piping*. Pipe hangers and supports shall conform to the requirements of MSS SP-58 and shall be spaced in accordance with Section 415. Supports, hangers and anchors shall be installed so as not to interfere with the free expansion and contraction of the *piping* between anchors. The components of the supporting *equipment* shall be designed and installed so that they will not be disengaged by movement of the supported *piping*.

Reason: The standards ANSI Z223 and NFPA 54 require metal support hardware. This proposal reverses the action of FG3-21 and aligns with IFGC with those standards.

This proposal is submitted by the ICC Plumbing Mechanical Gas Code Action Committee (PMGCAC)

PMGCAC was established by the ICC Board of Directors in July 2011 to pursue opportunities to improve and enhance assigned International Codes or portions thereof. In 2023 PMGCAC has held 26 virtual meetings open to any interested party. In addition, there were several virtual Working Group meetings for the current code development cycle, which included members of the committee as well as interested parties. Related documents and reports are posted on the PMGCAC website at PMGCAC.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

Support hardware for any gas piping project is a minimal cost as compared to the entire job. The difference between lowest cost support hardware and metal hardware is insignificant in the big picture.

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P11719Text Modification

FG7-24

IFGC: 410.2

Proponents: Jonathan Sargeant, OmegaFlex, OmegaFlex (jonathan.sargeant@omegaflex.com)

2024 International Fuel Gas Code

Revise as follows:

410.2 MP regulators.

MP *pressure regulators* shall comply with the following:

1. The MP regulator shall be *approved* and shall be suitable for the inlet and outlet gas pressures for the application.
2. The MP regulator shall maintain a reduced outlet pressure under lock-up (no-flow) conditions.
3. The capacity of the MP regulator, determined by published ratings of its manufacturer, shall be adequate to supply the *appliances* served.
4. The MP *pressure regulator* shall be provided with *access*. Where located indoors, the regulator shall be vented to the outdoors or shall be equipped with a leak-limiting device, in either case complying with Section 410.3.
5. A tee fitting with one opening capped or plugged shall be installed between the MP regulator and its upstream shutoff valve. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument and to serve as a sediment trap.
6. ~~A tee fitting with one opening capped or plugged shall be installed not less than 10 pipe diameters downstream of the MP regulator outlet. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument. The tee fitting is not required where the MP regulator serves an *appliance* that has a pressure test port on the gas control inlet side and the *appliance* is located in the same room as the MP regulator.~~ Means shall be provided downstream of, and in the same room as, the MP regulator for the connection of a pressure measuring instrument. Such means shall be a dedicated test port on a regulator, appliance gas control, or manifold, a plugged tee fitting or a plugged manifold port.
7. Where connected to rigid *piping*, a union shall be installed within 1 foot (304 mm) of either side of the MP regulator.

Reason: This proposal expands the list of acceptable pressure test ports beyond a simple tee fitting by recognizing that regulator, appliance gas control, and pre-fabricated manifold manufacturers often provide integral test ports in their devices that meet the intent of the code. The proposal eliminates the requirement that the test port be 10 pipe diameters downstream of the MP regulator because this requirement is overly restrictive and provides no real world advantage. Bench testing reveals that, at maximum flow, the pressure differential between the regulator test port and a test port located 10 pipe diameters downstream of the regulator is within 1/4 inch water column of each other. This proposal eliminates unnecessary fittings, joints, and potential leak paths in the gas piping system and, in so doing, reduces installation cost while also increasing safety.

Cost Impact: Decrease

Estimated Immediate Cost Impact:

This proposal reduces costs by eliminating the requirement that the plumber install additional fittings to fabricate a test port downstream of the regulator. The eliminated test port assembly is estimated to save roughly $49.46 - $50.77 for a typical installation.

Estimated Immediate Cost Impact Justification (methodology and variables):

Estimated savings reflects the cost of a Tee fitting, pipe nipple and end cap needed to fabricate a test port in from malleable iron but does not reflect the cost of pipe dope or thread tape. A labor rate of $100 per hour was used and assembly time was estimated at 20 minutes. The cost for fabricating the test port out of 1/2" malleable iron is estimated to be $49.46 and the cost of fabricating it out of 3/4 malleable iron is estimated to be $50.77. Variables include fluctuations in material costs and differential labor rates.

Estimated Life Cycle Cost Impact:

There would be no life cycle cost impact.

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Estimated Life Cycle Cost Impact Justification (methodology and variables):

N/A

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FG8-24

IFGC: 502.1

2024 International Fuel Gas Code

Revise as follows:

502.1 General.

Vents, except as provided in Section 503.7, shall be *listed* and *labeled*. Type B and BW vents shall be tested in accordance with UL 441. Type L vents shall be tested in accordance with UL 641. Vents for Category II ~~and,~~III, and IV *appliances* shall be tested in accordance with UL 1738. ~~Plastic vents for Category IV *appliances* shall not be required to be *listed* and *labeled* where such vents are as specified by the *appliance* manufacturer and are installed in accordance with the *appliance* manufacturer's instructions~~.

Reason: The current venting standard, UL 1738, should be designated as the exclusive standard for listing and labeling combustion gas venting products within the International Fuel Gas Code (IFGC). The current language allows appliance manufacturers to determine what materials can be used for the venting of their appliances, as long as said materials are listed to a testing standard. This has led to the common practice of using PVCs listed to ASTM D1785. The problem associated with this is that this standard is a plumbing standard without provisions for the application of flue gas venting. The first page of ASTM D1785 states:

"NOTE 2: This standard specifies dimensional, performance and test requirements for plumbing and fluid handling applications only. It does not include provisions for the use of these products for venting of combustion gases. UL 1738 is a standard that does include specific testing and marking requirements for flue gas venting products, including PVC."

The current code is both allowing the application of a plumbing standard to the venting of combustion gases and also allowing the application of a standard to be used for a purpose which it explicitly states it is not to be used for. ASTM even goes as far as citing the correct standard (UL 1738) to use in these applications. CPVC, which is also commonly used in these applications, suffers from the same issue with its plumbing standard, ASTM F441. The misapplication of materials and testing standards poses a significant safety hazard, necessitating urgent attention and rectification within the code.

Additionally, the ASTM plumbing standards do not test several critical conditions that venting materials experience, such as elevated and low-temperatures, UV exposure, and elbow load. These conditions, commonplace in vent systems, demand a standard that comprehensively evaluates them.

UL 1738 also incorporates provisions to ensure uniformity in material throughout the entire venting system, emphasizing the need for consistency in properties like expansion/contraction rates. Such considerations as these are unique to flue gas venting systems, further emphasizing the importance of specifying a universal venting standard for these applications.

Numerous countries and municipalities have already established a single standard to which venting products must adhere, such as Canada requiring the ULC S636 standard nationwide in 2007, and NYC recently accepting UL 1738 listing for the venting of Category IV appliances.

The IFGC commentary even supports a robust stance, clarifying that un-listed plastic pipes like PVC, ABS, and CPVC are not included in the definition of "vent" and should not be used for the venting of appliances; see below excerpt from section 503.4.1 of the 2018 IFGC Code Commentary:

"… The definition of 'Vent' does not include plastic pipe, such as PVC, ABS, and CPVC, because such pipes are not currently listed as factory-built venting systems… The PVC, ABS, and CPVC pipe manufacturers do not recommend that their pipes be used for appliance venting because such products are not currently listed for such applications. There are polypropylene and possibly other types of plastic venting systems on the market that are listed to UL 1738 as appliance venting systems, and they would fall under the definition of 'Vent'."

Considering all these factors, it is evident that UL 1738 should be mandated as the required testing standard for any material used in the venting of combustion gases. This is paramount for enhancing installation safety and mitigating the potential risks associated with improper installations that can ultimately jeopardize lives.

Bibliography: 1. ASTM D1785-21a, Scope Section, NOTE 2.
2. 2018 IFGC Code Commentary, Section 503.4.1.
3. Canadian adds 2007 Supplement to Natural Gas & Propane Installation Code (CSA B149-1S1-07), requiring all plastic vent piping to

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be certified to ULC S636. https://www.achrnews.com/articles/topic/2670-canada?page=32

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

UL systems are already installed on a daily occurrence, these edits clarify the listing standards that flue gas venting fall under.

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P11719Text Modification

FG9-24

IFGC: [M] 614.9.6

Proponents: Jonathan Roberts, UL Solutions, UL Solutions (jonathan.roberts@ul.com)

THIS PROPOSAL WILL BE HEARD BY THE MECHANICAL CODE COMMITTEE. SEE THE TENTATIVE HEARING ORDER FOR THIS COMMITTEE.

2024 International Fuel Gas Code

Revise as follows:

[M] 614.9.6 Exhaust duct required. Where space for a gas-fired clothes dryer is provided, an exhaust duct system shall be installed. Where the clothes dryer is not installed at the time of occupancy, the exhaust duct shall be capped at the location of the future dryer.

~~**Exception:** Where a *listed* condensing clothes dryer is installed prior to occupancy of the structure.~~

Reason: Clarifies that these provisions in the IFGC and Fuel Gas Chapter 24 of the IRC only apply to cases where provisions for a gas clothes dryer have been provided. These provisions would be identified by the presence of a gas outlet in the laundry area. Because condensing-type and heat pump clothes dryers (which do not require exhaust ducts) would not coincide with provisions for a gas outlet in new construction, then the exception is not needed.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

These comments are editorial clarifications for code usability and do not change the substantive requirements.

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FG10-24

IFGC: 704.1.2.4

Proponents: Christopher Adam Smith, Viega, LLC, Codes and Standards Manager for Viega, LLC

2024 International Fuel Gas Code

Revise as follows:

704.1.2.4 Joints.
Joints in *piping* and tubing in hydrogen service shall be *listed* as complying with ASME B31.3 to include the use of welded, brazed, flared, socket, press-connect, and slip and compression fittings. Gaskets and sealants used in hydrogen service shall be *listed* as complying with ASME B31.12. Threaded and flanged connections shall not be used in areas other than hydrogen cutoff rooms and outdoors.

Reason: When approved by the manufacturer and meeting all of the required standards, press-connect technology is an acceptable joining method for hydrogen piping that provides a joint that is equal to or better than traditional pipe joining methods. The addition of this joining method to the list of approved joints will allow for more options available to the installer.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

The addition of joint type does not increase the cost of construction. The additional joint type allows for a wider selection of materials but does not make their use mandatory. By including this additional joint type in the code, the options for installers will increase while the cost of construction should stay the same or even decrease.

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FG11-24 Part I

IFGC: SECTION 202, SECTION 202 (New), 301.3.1 (New), 301.3.2 (New), 301.5, 634.1, 701.1, 705.5.4

Proponents: Andrew Bevis, Chair, Plumbing, Mechanical and Fuel Gas Code Action Committee (pmgcac@iccsafe.org)

THIS IS A 2 PART CODE CHANGE. PART I WILL BE HEARD BY THE FUEL GAS CODE COMMITTEE. PART II WILL BE HEARD BY THE IFC CODE COMMITTEE. SEE THE TENTATIVE HEARING ORDER FOR THESE COMMITTEES.

2024 International Fuel Gas Code

Revise as follows:

FUEL GAS. A natural gas, manufactured gas, liquefied petroleum gas or mixtures of these gases including up to 5-percent hydrogen gas by volume.

Add new definition as follows:

HYDROGEN ADMIXTURE.
Fuel gas to which hydrogen is blended or mixed by the fuel supplier or at the point of delivery greater than 5% and less than 95%.

Add new text as follows:

301.3.1 Appliances and equipment listed and labeled for use with hydrogen admixture. Appliances and equipment operating on hydrogen admixtures shall be listed and labeled for operation on the hydrogen admixture limits defined under Section 101.2.1.1.

301.3.2 Piping systems listed and labeled for use with hydrogen admixture. Piping systems and fuel gas system components shall be listed and labeled for the applicable hydrogen admixture limits.

Revise as follows:

301.5 Label information. A permanent factory-applied nameplate(s) shall be affixed to *appliances* on which shall appear in legible lettering, the manufacturer's name or trademark, the model number, serial number and, for *listed appliances*, the seal or mark of the testing agency. A label shall include the hourly rating in British thermal units per hour (Btu/h) (W); the type of fuel gas *approved* for use with the *appliance*; and the minimum *clearance* requirements.

634.1 Installation.
The installation of gaseous hydrogen systems shall be in accordance with ~~the applicable requirements~~ Chapter 7 of this code, the *International Fire Code* ~~and~~ the *International Building Code* and NFPA 2.

701.1 Scope.
The installation of *gaseous hydrogen systems* shall comply with this chapter~~, and~~ Chapters 53 and 58 of the International Fire Code and NFPA 2. Compressed gases shall also comply with Chapter 50 of the International Fire Code for general requirements.

705.5.4 Placing equipment in operation.
After the *piping* has been placed in operation, all *equipment* shall be purged in accordance with ~~Section 707.2~~ NFPA 2 and then placed in operation, as necessary.

Reason: FUEL GAS

Natural gas utilities are implementing projects to blend gaseous hydrogen into natural gas to reduce their systems and consumers' "carbon footprints." Hydrogen admixtures have raised questions of compatibility of these blends with existing appliances, equipment, and piping systems and components.

Following the submission of a request for interpretation, CSA Group standards Technical Committees were provided access to a range of test data from a variety of sources, and upon careful review and analysis, agree that natural gas containing up to and including 5% of

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Hydrogen is covered by testing with Test Gas A. The Request for Interpretation (RFI), and the position of the Technical Committees, have been published here:https://www.csagroup.org/documents/Formal_Interpretations.pdf

As a result, PMG CAC sees no reason to add specifications for such blends in ANSI accredited standards. However, code officials using the ICC Codes would be aided in understanding through the definition of 'fuel gas' that such blends are covered through the revised definition.

HYDROGEN ADMIXTURE

The proposed definition is to address Hydrogen Admixtures in the IFGC. Currently provisions do not exist to address Hydrogen Admixtures and their ranges when introduced to natural gas. Chapter 7 of the IFGC regulates Gaseous Hydrogen Systems which are defined as being 95% or higher GH2. This definition will help address ranges of hydrogen admixtures from 6%-94%.

Section 301.3.1

This is one of several proposals that address the potential for hydrogen admixtures. This specific proposal is designed to clarify that Appliances which operate on hydrogen admixtures are treated the same way all other fuel burning appliances are considered. They need to be listed and labeled for the specific fuel mixture that is supplied. This section is applicable to the IRC Chapter 24 as well as the IFGC.

Section 301.3.2

This is one of several proposals that address the potential for hydrogen admixtures. This specific proposal is designed to clarify that all piping and components which are intended to carry hydrogen admixtures are treated the same way all other piping and system components are considered. They need to be listed and labeled for the specific fuel mixture that is being transported. This section is applicable to the IRC Chapter 24 as well as the IFGC.

Section 301.5This proposal updates the current word fuel to fuel gas to ensure correlation to the revised definition for fuel gas that includes up to 5% hydrogen admixture by volume. All other fuels in accordance with Section 301.1.1 shall be regulated by the International Mechanical Code.

Section [A]101.2.1 scopes gaseous hydrogen systems directly to Chapter 7 which is complete for the for the piping system. A direct link to NFPA 2 has been provided for additional provisions that standard provides for.

Section 701.1

Once the user gets to the IFC references they find pointers to NFPA 2. This provides for a direct linkage which is important for those jurisdictions that do not use the IFC for construction purposes.Section 705.5.4

The IFC relies on NFPA 2 for this requirement and this change provides for consistency, Section 707.2 is proposed to be modified to point to NFPA 2.

This proposal is submitted by the ICC Plumbing Mechanical Gas Code Action Committee (PMGCAC)

PMGCAC was established by the ICC Board of Directors in July 2011 to pursue opportunities to improve and enhance assigned International Codes or portions thereof. In 2023 PMGCAC has held 26 virtual meetings open to any interested party. In addition, there were several virtual Working Group meetings for the current code development cycle, which included members of the committee as well as interested parties. Related documents and reports are posted on the PMGCAC website at PMGCAC.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

This proposal is a clarification of different fuel types to address the trend towards blended fuels.

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FG11-24 Part II

IFGC: [F] 633.1, [F] 703.4, [F] 706.1, [F] 707.1, [F] 707.2, [F] 708.1

Proponents: Andrew Bevis, Chair, Plumbing, Mechanical and Fuel Gas Code Action Committee (pmgcac@iccsafe.org)

2024 International Fuel Gas Code

Revise as follows:

[F] 633.1 General. Stationary fuel-cell power systems having a power output not exceeding 10 MW shall be ~~tested~~ listed in accordance with ANSI/CSA FC 1 and shall be installed in accordance with the manufacturer's instructions, NFPA 853, the *International Building Code* and the *International Fire Code* . Hydrogen fuel cell power systems shall also comply with Chapter 7 of this code and NFPA 2.

[F] 703.4 Venting.
Relief device vents shall be terminated in an *approved* location in accordance with ~~Section 2309 of the International Fire Code~~ NFPA 2.

[F] 706.1 General.
The location and installation of *gaseous hydrogen systems* shall be in accordance with Sections 706.2 and 706.3.

~~Exception:~~ ~~Stationary fuel-cell power plants in accordance with Section 633.~~

[F] 707.1 Maintenance.
Gaseous hydrogen systems and detection devices shall be maintained in accordance with the *International Fire Code*, ~~and~~ the manufacturer's installation instructions and NFPA 2.

[F] 707.2 Purging.
Purging of *gaseous hydrogen systems*, other than *piping* systems purged in accordance with Section 705.5, shall be in accordance ~~with Sections 2309.6 and 2309.6.1 of the International Fire Code or in accordance~~ with the system manufacturer's instructions and NFPA 2.

[F] 708.1 General.
The design of liquefied hydrogen systems shall comply with Chapters 55 and 58 of the International Fire Code and NFPA 2.

Reason: .

Section [F] 633.1

The word "tested" has been changed to "listed", FC1 is a listing standard. A general reference to NFPA 2 has been added for linkage without having to traverse through the IFC.

Section [F] 703.4

The IFC does not contain the vent termination requirements, that is contained in NFPA 2. Plus, the IFC section pointed to only applies to motor vehicle fueling and repair activities.

Section [F] 706.1

The exception should be deleted, gaseous hydrogen piping systems associated with fuel cell power plants need to be installed in accordance with Chapter 7.

Section [F] 706.2

The IFC has requirements and should be linked here, the "or "should be a "and".

Section [F] 706.3

Section 2309.3.1.1 is the incorrect reference; it only applies to motor fueling. The correct references are Chapters 55 and 58 of the IFC

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along with NFPA 2.

Section [F] 707.1

NFPA 2 is an important reference, particularly where the IFC is not utilized.

Section [F] 707.2

The IFC relies on NFPA 2 for purging and the IFC sections referenced are limited to motor vehicle fueling.

Section [F]708.1Chapter 58 of the IFC should have been included as the flammable gas chapter. The bulk of the requirements for these systems are found in NFPA 2.

This proposal is submitted by the ICC Plumbing Mechanical Gas Code Action Committee (PMGCAC)

PMGCAC was established by the ICC Board of Directors in July 2011 to pursue opportunities to improve and enhance assigned International Codes or portions thereof. In 2023 PMGCAC has held 26 virtual meetings open to any interested party. In addition, there were several virtual Working Group meetings for the current code development cycle, which included members of the committee as well as interested parties. Related documents and reports are posted on the PMGCAC website at PMGCAC.

Cost Impact: The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification for no cost impact:

This proposal is a clarification of different fuel types to address the trend towards blended fuels.

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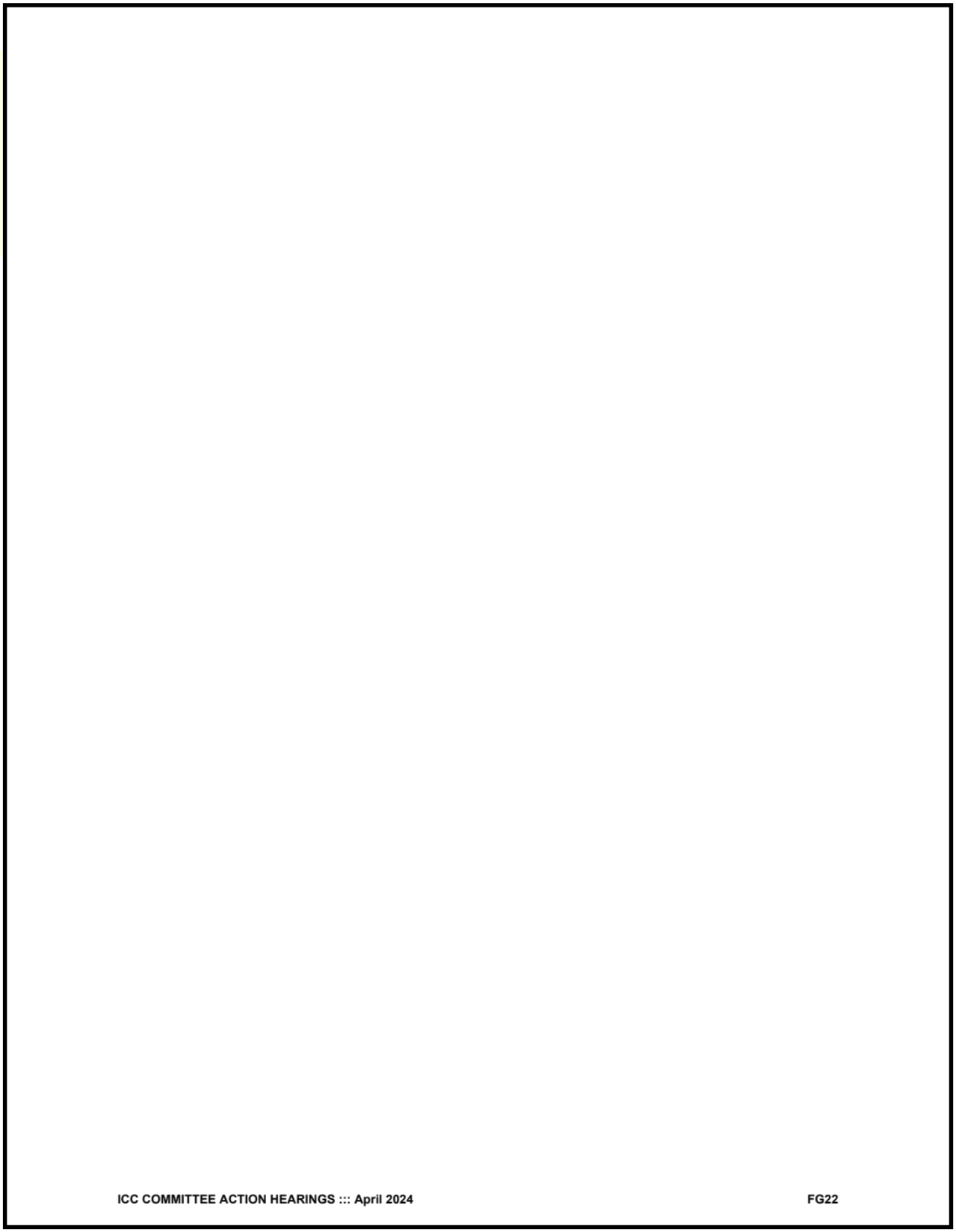

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Fuel Gas

6

P12028

Date Submitted	02/11/2025	**Section**	102.4	**Proponent**	Bryan Holland
Chapter	8	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

A related modification has been submitted to the FBC-B, FBC-R, FBC-EC, FBC-EB, and FBC-M to update the reference to NFPA 70-23, including all published TIAs.

Summary of Modification

This proposed modification recommends adoption of NFPA 70-23, including all published Tentative Interim Amendments (TIAs).

Rationale

This proposed modification recommends updating the adopted edition of NFPA 70 to the 2023 edition, including all published TIAs (TIA 23-1 through TIA 23-16). Tentative Interim Amendments (TIAs) are important revisions to the code that have been issued by the NFPA Standards Council after publication of the document. All issued TIAs have been reviewed and approved through consensus voting on the basis of "technical merit" and "emergency nature" by the corresponding Code Making Panel, without creating a correlation issue with any other sections of the code. For the 2023 edition of NFPA 70, TIAs 23-1 through 23-6 were issued prior to publication of the code and incorporated into the first printing. This proposed modification recommends all TIAs, 23-1 through 23-16 be officially adopted and incorporated into the code. This will help reduce conflicts in the field and improve consistent enforcement across all Florida jurisdictions.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
This proposed modification will improve the consistent enforcement of the code by the local entity.
Impact to building and property owners relative to cost of compliance with code
This proposed modification will not change the cost of compliance with code.
Impact to industry relative to the cost of compliance with code
This proposed modification will not change the cost of compliance with code.
Impact to small business relative to the cost of compliance with code
This proposed modification will not change the cost of compliance with code.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The changes made to the 2023 NEC along with all issued TIAs represent important improvements and corrections to the published code. All (16) TIAs have been deemed to have both technical merit and emergency in nature, thus increasing the health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by updating to the most current edition of the NEC and by incorporating corrections made after initial publication.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification improves the effectiveness of the code.

P12028Text Modification

Chapter 8 Referenced Standards

NFPA

70 - ~~20~~ 23 National Electrical Code (NEC), including all published Tentative Interim Amendments (TIAs) published until December 4, 2024

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Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: Definition of Pool, and 680.26
TIA 23-9
(SC 23-3-8 / TIA Log #1687)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 17 and the NEC Correlating Committee, and was issued by the Standards Council on March 21, 2023, with an effective date of April 10, 2023.

1. Revise the definition of "Pool" to read as follows:

Pool. Manufactured or field-constructed equipment designed to contain water on a permanent or semipermanent basis and used by persons for swimming, wading, immersion, or therapeutic purposes, but not including bodies of water incorporated as part of an industrial process or lakes, lagoons, surf parks, or other natural and man-made bodies of water that may incorporate swimming and swimming areas. (680) (CMP-17)

Informational Note: Natural and man-made bodies of water, which includes lakes, lagoons, surf parks, or other similar bodies of water, are addressed in Article 682.

2. Revise section paragraph 680.26 to read as follows:

680.26 Equipotential Bonding.

(A) Performance. The equipotential bonding required by 680.26(B) and (C) to reduce voltage gradients in the pool area shall be installed for pools with or without associated electrical equipment related to the pool.

Informational Note No. 1: Some causes of voltage gradients originate outside the premises wiring system and are not within the scope of the *NEC*. Measures identified in Rule 097D2 of ANSI C2, *National Electrical Safety Code,* can also serve to address voltage gradients originating on the utility side of the service point.

Informational Note No. 2: By its nature, equipotential bonding of swimming pools and perimeter surfaces involves contact between various metallic materials and the earth. This can, in some cases, expose various specific metals to a corrosive environment, depending on factors such as the type and chemical content of the soil and the specific metal. Corrosive environments are also addressed in 680.14.

(B) Bonded Parts. …

(1) Conductive Pool Shells. …

(2) Perimeter Surfaces. The perimeter surface to be bonded shall be considered to extend for ~~1 m~~ 900 mm (3 ft) horizontally beyond the inside walls of the pool ~~and~~ while also at a height between 900 mm (3 ft) above and 600 mm (2 ft) below the maximum water level. The perimeter surface shall include unpaved surfaces, concrete, and other types of paving. Perimeter surfaces separated from the pool by a permanent wall or building 1.5 m (5 ft) in height or more shall

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P12028Text Modification

require equipotential bonding only on the pool side of the permanent wall or building. Bonding to perimeter surfaces shall be provided as specified in 680.26(B)(2)(a), (B)(2)(b), ~~or~~ (B)(2)(c), and (B)(2)(d). ~~and~~ For conductive pool shells where bonding to perimeter surfaces is required, it shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four points uniformly spaced around the perimeter of the pool, or if the bonded perimeter surface does not surround the entire pool, it shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four uniformly spaced points along the bonded perimeter surface. For nonconductive pool shells where bonding to the perimeter surfaces is required, bonding at four points shall not be required, and the perimeter bonding shall be attached to the 8 AWG copper equipotential bonding conductor and, if present, to any conductive support structure for the pool.

Informational Note: Because the perimeter surface can incorporate various types of materials at various locations and elevations above and below maximum water level, the perimeter surface required to be bonded might not surround the entire pool. The 8 AWG copper equipotential bonding conductor can encircle the entire pool to facilitate connection of bonded parts.

(a) ~~*Structural Reinforcing Steel.* Structural reinforcing steel shall be bonded in accordance with 680.26(B)(1)(a).~~ *Conductive Paved Portions of Perimeter Surfaces.* Conductive paved portions of perimeter surfaces, including masonry pavers, if used, shall be bonded with unencapsulated structural reinforcing steel in accordance with 680.26(B)(1)(a), or with unencapsulated steel structural welded wire reinforcement (welded wire mesh, welded wire fabric), bonded together by steel tie wires or the equivalent. Steel welded wire reinforcement shall be fully embedded within the pavement unless the pavement will not allow for embedding. If the reinforcing steel is absent, or is encapsulated in a nonconductive compound, or embedding is not possible, unencapsulated welded wire steel reinforcement or a copper conductor grid shall be provided and shall be secured directly under the paving, and not more than 150 mm (6 in.) below finished grade.

Unencapsulated steel welded wire reinforcement that is not fully embedded in concrete, and copper grid regardless of location, where used for equipotential bonding, shall be listed for corrosion resistance and mechanical performance. This listing requirement shall become effective January 1, 2025. The copper grid or unencapsulated steel welded wire reinforcement shall also meet the following:

(1) Copper grid is constructed of 8 AWG solid bare copper and arranged in accordance with 680.26(B)(1)(b)(3).
(2) Steel welded wire reinforcement is minimum ASTM 6x6-W2.0 x W2.0 or minimum No. 3 rebar constructed in a 300 mm (12 in.) grid.
(3) Copper grid and steel welded wire reinforcement follow the contour of the perimeter surface extending not less than 900 mm (3 ft) horizontally beyond the inside walls of the pool.
(4) Only listed splicing devices or exothermic welding are used.

Informational Note No. 1: Performance of the equipotential bonding system at the perimeter surface is improved as the distance between the bonding means and finished grade is minimized, either by embedding within, or by direct contact with the underside of, the finished pavement.

Informational Note No. 2: See ASTM A615/A615M, *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement;* A1064/A1064M, *Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete;* A1022/A1022M, *Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement;* A1060A/A1060M, *Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete;* and ACI Standard ACI 318, *Building Code Requirements for Structural Concrete,* for examples of standards currently used in the listing of reinforcing steel bars and steel welded wire reinforcement.

(b) *Unpaved Portions of Perimeter Surfaces.* Unpaved portions of perimeter surfaces shall be bonded with any of the following methods:
(1) ~~*Copper Ring.* Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound, a c~~Copper conductor(s) shall ~~be utilized where the following requirements are met~~ meet the following:
~~(1)~~a. At least one minimum 8 AWG bare solid copper conductor, including the 8 AWG copper equipotential bonding conductor if available ~~shall be provided~~.
~~(2)~~b. The conductors ~~shall~~ follow the contour of the perimeter surface.
~~(3)~~c. Only listed splicing devices or exothermic welding are used. ~~shall be permitted.~~
~~(4)~~d. The ~~required~~ conductor(s) is ~~shall be~~ 450 mm to 600 mm (18 in. to 24 in.) from the inside walls of the pool.
~~(5)~~e. The ~~required~~ conductor(s) ~~shall be secured within or~~ is under the unpaved portion of the perimeter surface 100 mm to 150 mm (4 in. to 6 in.) below ~~the subgrade~~finished grade.
f. Be installed only in perimeter surfaces not intended to have direct access to swimmers in the pool.

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(e2) ~~*Copper Grid.* Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound,~~ ~~e~~Copper grid or unencapsulated steel welded wire reinforcement used for equipotential bonding of unpaved portions of perimeter surfaces shall ~~be utilized where the following requirements are met~~ meet the following:
~~(1)~~a. ~~The copper grid shall be constructed of 8 AG solid bare copper and be arranged~~ Be installed in accordance with 680.26~~(B)(1)(b)(3)~~(B)(2)(a).
~~(2) The copper grid shall follow the contour of the perimeter surface extending 1 m (3 ft) horizontally beyond the inside walls of the pool.~~
~~(3) Only listed splicing devices or exothermic welding shall be permitted.~~
~~(4)~~b. ~~The copper grid shall be secured~~ Be located within ~~or under~~ the ~~deck or~~ unpaved surface(s) between 100 mm to 150 mm (4 in. to 6 in.) below ~~the subgrade~~finished grade.

(c) *Nonconductive Perimeter Surfaces.* Equipotential bonding shall not be required for nonconductive portions of perimeter surfaces that are separated from earth or raised on nonconducting supports, and it shall not be required for any perimeter surface that is electrically separated from the pool structure and raised on nonconductive supports above an equipotentially bonded surface.

Informational Note: Nonconductive materials include, but are not limited to, wood, plastic, wood-plastic composites, fiberglass, and fiberglass composites.

(d) *Interconnection of Bonded Portions of Perimeter Surfaces.* All surfaces where equipotential bonding is required shall be interconnected using listed splicing devices or exothermic welding. Where copper wire is used for this purpose, it shall be solid copper, not smaller than 8 AWG. The conductor shall be permitted to encircle the pool to facilitate bonding connections to portions of the perimeter covered in 680.26(B)(2)(a) and (B)(2)(b) that are not contiguous.

Issue Date: March 21, 2023

Effective Date: April 10, 2023

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Tentative Interim Amendment

NFPA® 70®

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2023 Edition

Reference: 300.26
TIA 23-8
(SC 23-3-9 / TIA Log #1688)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 3 and the NEC Correlating Committee, and was issued by the Standards Council on March 21, 2023, with an effective date of April 10, 2023.

1. Revise paragraph 300.26 to read as follows:

300.26 Remote-Control and Signaling Circuits Classification.

Remote-control and signaling circuits shall be classified as either power-limited or non-power-limited and comply with ~~the following~~300.26(A) through (C).

(~~1~~A) **Class 1 Power-Limited Remote-Control and Signaling Circuits.** Class 1 power-limited remote-control and signaling circuits shall comply with 724.3.

(~~2~~B) **Class 2 and Class 3 Power-Limited Remote-Control and Signaling Circuits.** Class 2 and Class 3 power-limited remote-control and signaling circuits shall comply with 725.3.

(~~3~~C) **Non-Power-Limited Remote-Control and Signaling Circuits.** Non-power-limited remote-control and signaling circuits shall be installed in accordance with 300.2 through 300.25 and comply with 300.26(C)(1) through (C)(3).

(1) Sizes and Use.

(a) Conductors that are 18 AWG and 16 AWG copper shall be permitted to be used if they supply loads that do not exceed the ampacities specified in 402.5 and are installed in a raceway, an approved enclosure, or a listed cable.

(b) Conductors that are 14 AWG copper-clad aluminum shall be permitted to be used in Type MC cable and Type TC cable. The continuous load shall not exceed 8 amperes.

(c) Conductors larger than 16 AWG copper or 14 AWG copper-clad aluminum shall not supply loads greater than the ampacities specified in 310.14.

(d) Flexible cords shall comply with the applicable general requirements, applications, and construction specifications for flexible cords and flexible cables in accordance with Article 400 Parts I and II.

(2) Insulation.

(a) Insulation on conductors shall be rated for the system voltage and not less than 600 volts.

(b) Conductors larger than 16 AWG copper or 14 AWG copper-clad aluminum shall comply with the applicable general requirements for conductors rated up to and including 2000 volt for type designations, insulations, markings, ampacity ratings, and uses in accordance with 310.3, 310.4, 310.6, 310.8, 310.10, and 310.14.

(c) Conductors that are 18 AWG copper, 16 AWG copper, or 14 AWG copper-clad aluminum shall be Type FFH-2, Type KF-2, Type KFF-2, Type PAF, Type PAFF, Type PF, Type PFF, Type PGF, Type PGFF, Type PTF, Type PTFF, Type RFH-2, Type RFHH-2, Type RFHH-3, Type SF-2, SFF-2, Type TF, Type TFF, Type TFFN, Type TFN, Type ZF, or Type ZFF.

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(d) Conductors with other types and thicknesses of insulation shall be permitted if listed for Class 1 circuit use.

(3) Overcurrent Protection.

(a) Overcurrent protection for conductors 14 AWG copper and larger shall be provided in accordance with the conductor ampacity, without applying the ampacity adjustment and correction factors specified in 310.15 to the ampacity calculation.

(b) Overcurrent protection shall not exceed 7 amperes for 18 AWG copper conductors and 10 amperes for 16 AWG copper and 14 AWG copper-clad aluminum.

Exception: The overcurrent protection specified in 300.26(C)(3)(1) and 300.26(C)(3)(2) shall not be required where this Code requires or permits other overcurrent protection ratings.

Issue Date: March 21, 2023

Effective Date: April 10, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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2023 Edition

Reference: Table C.18, Table C.19 and Table C.20
TIA 23-7
(SC 22-12-7 / TIA Log #1678)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 8, and the NEC Correlating Committee, and was issued by the Standards Council on December 8, 2022, with an effective date of December 28, 2022.

*1. Revise Table Headers **only** for Table C.18, Table, C.19 and Table C.20 to read as follows:*

Table C.18 Number of Single Conductor Cables Permitted in Cable Tray
(Based on fill in accordance with 392.22, Table 392.22~~(A)~~(B)(1), column 1, ampacity in accordance with 392.80)

Table C.19 Number of Single Conductor Cables Permitted in Cable Tray
(Based on fill in accordance with 392.22, Table 392.22~~(A)~~(B)(1), column 1, ampacity in accordance with 392.80)

Table C.20 Number of Single Conductor Cables Permitted in Cable Tray
(Based on fill in accordance with 392.22, Table 392.22~~(A)~~(B)(1), column 1, ampacity in accordance with 392.80)

Issue Date: December 8, 2022

Effective Date: December 28, 2022

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
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Reference: 555.35
TIA 23-6
(SC 22-8-23 / TIA Log #1660)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 555.35 to read as follows:

555.35 Ground-Fault Protection of Equipment (GFPE) and Ground-Fault Circuit Interrupter. For other than floating buildings, ground-fault protection for docking facilities shall be provided in accordance with 555.35(A) through (~~F~~D).

~~**(A) Sources Directly Supplying Docking Facilities or Wharfs.** Listed GFPE, rated not more than 100 milliamperes, shall be provided for sources directly supplying all docking facilities or wharfs. Coordination with downstream GFPE shall be permitted.~~

(~~B~~A) Feeder. …

Exception: Transformer secondary conductors of a separately derived system that do not exceed 3 m (10 ft) and are installed in a raceway shall be permitted to be installed without ground-fault protection.
This exception shall also apply to the supply terminals of the equipment supplied by the transformer secondary conductors.

(~~C~~B) Branch-Circuits.
(1) Receptacles Providing Shore Power. …
(2) Outlets for Other than Shore Power. Outlets supplied by branch circuits not exceeding 150 volts to ground and 60 amperes, single phase, and 150 volts or less to ground, 100 amperes or less, three phase, shall be provided with GFCI protection for personnel.

Exception to (~~C~~B): Low-voltage circuits not requiring grounding, not exceeding the low-voltage contact limit and supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall be permitted to be installed without ground-fault protection.

(~~D~~C) Boat Hoists. …
(~~E~~D) Leakage Current Measurement Device. …
Informational Note No. 1: …
Informational Note No. 2: …

Exception: Where the shore power equipment includes a leakage indicator and leakage alarm, a separate leakage test device shall not be required.

Issue Date: August 12, 2022

Effective Date: September 1, 2022

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Reference: 555.30
TIA 23-5
(SC 22-8-22 / TIA Log #1659)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 555.30 to read as follows:

555.30 Electrical Equipment and Connections.

(A) General. All electrical components within electrical equipment (excluding wiring methods) and connections not intended for operation while submerged shall be located at least 305 mm (12 in.) above the deck of a fixed or floating structure, but not below the electrical datum plane. Conductor splices, within junction boxes identified for wet locations, utilizing sealed wire connector systems listed and identified for submersion shall be required for floating structures where located above the waterline but below the electrical datum plane.

(B) Replacements. …

Issue Date: August 12, 2022

Effective Date: September 1, 2022

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Reference: 215.15
TIA 23-4
(SC 22-8-18 / TIA Log #1655)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 215.15 to read as follows:

215.15 Barriers. Barriers shall be placed such that no energized, uninsulated, ungrounded busbar or terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations in panelboards, switchboards, switchgear, or motor control centers supplied by feeder taps in 240.21(B) or transformer secondary conductors in 240.21(C) when the disconnecting device, to which the tap conductors are terminated, is in the open position.

Issue Date: August 12, 2022

Effective Date: September 1, 2022

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Reference: 210.8(F) and Exception No. 2(new)
TIA 23-3
(SC 22-8-17 / TIA Log #1654)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 210.8(F) to read as follows:

210.8(F) Outdoor Outlets.

For dwellings, all outdoor outlets, other than those covered in 210.8(A), Exception No. 1, including outlets installed in the following locations, and supplied by single-phase branch circuits rated 150 volts or less to ground, 50 amperes or less, shall be provided with GFCI protection:

(1) Garages that have floors located at or below grade level
(2) Accessory buildings
(3) Boathouses

If equipment supplied by an outlet covered under the requirements of this section is replaced, the outlet shall be supplied with GFCI protection.

Exception No. 1: GFCI protection shall not be required on lighting outlets other than those covered in 210.8(C).
Exception No. 2: GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026.

Issue Date: August 12, 2022

Effective Date: September 1, 2022

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Tentative Interim Amendment

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2023 Edition

Reference: Article 100 (Ignitible Fibers/Flyings), 506.5, and 506.9(B)
TIA 23-2
(SC 22-4-8 / TIA Log #1617)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise Article 100 Ignitible Fibers/Flyings to read as follows:

Ignitible Fibers/Flyings. Fibers/flyings where any dimension is greater than 500 µm in nominal size, which are not likely to be in suspension in quantities to produce an explosible mixture, but could produce an ignitible layer fire hazard. [**499:**3.3.4.2]

Informational Note No.1: This definition and Informational Note No. 2 have been extracted from NFPA 499-2021, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. The NFPA 499 reference is in brackets. Only editorial changes were made to the extracted text to make it consistent with this *Code*.

Informational Note No. 2: Section 500.5 of this *Code* prescribes a Class III location as one where ignitible fibers/flyings are present, but not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. This description addresses fibers/flyings that do not present a flash-fire hazard or explosion hazard by test. This could be because those fibers/flyings are too large or too agglomerated to be suspended in air in sufficient concentration, or at all, under typical test conditions. Alternatively, this could be because they burn so slowly that, when suspended in air, they do not propagate combustion at any concentration. In this document the zone classification system includes ignitible fibers/flyings as a fire hazard in a layer, which is not addressed in the IEC zone system (see IEC 60079-10-2, *Explosive atmospheres — Part 10-2: Classification of areas — Explosive dust atmospheres*). Where these are present, the user could also consider installation in accordance with Article 503 of this *Code*. [**499:**A.3.3.4.2]

2. Revise Section 506.5 to read as follows:

506.5 Classification of Locations.
(A) Classifications of Locations. …
(B) Zone 20, Zone 21, and Zone 22 Locations. …
(1) Zone 20. A Zone 20 location is a location where one of the following apply:
(1) Ignitible concentrations of combustible dust, ~~or~~ combustible fibers/flyings, or ignitible fibers/flyings are present continuously or for long periods of time.
…
(2) Zone 21. …
(3) Zone 22. A Zone 22 location is a location where one of the following apply:
(1) …
(2) Combustible dust, combustible fibers/flyings, or ignitible fibers/flyings are handled, processed, or used…
(3) …

3. Revise Section 506.9(B) to read as follows:

506.9 Equipment Requirements.
…

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(B) Listing. Equipment that is listed for Zone 20 shall be permitted in a Zone 21 or Zone 22 location of the same combustible dust, combustible fiber/flying, or ignitible fiber/flying. Equipment that is listed for Zone 21 ~~can be used~~ shall be permitted in a Zone 22 location of the same combustible dust, combustible fiber/flying, or ignitible fiber/flying.

Issue Date: April 12, 2022

Effective Date: May 2, 2022

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Reference: 680.43, Exception No. 3
TIA 23-16
(SC 24-12-6 / TIA Log #1800)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 17, and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on December 4, 2024, with an effective date of December 24, 2024.

1. Delete Exception No. 3 of 680.43 as follows:

680.43 Indoor Installations. A spa or hot tub installed indoors shall comply with the provisions of Parts I and II of this article except as modified by this section and shall be connected by the wiring methods of Chapter 3.
Exception No. 1: Listed spa and hot tub …
Exception No. 2: The equipotential bonding …
~~*Exception No. 3: For a dwelling unit(s) only, where a listed spa or hot tub is installed indoors, the wiring method requirements of 680.42(C) shall also apply.*~~

Issue Date: December 4, 2024

Effective Date: December 24, 2024

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
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Mod_12028_Text_TIA 23-16.pdf

P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 210.70
TIA 23-15
(SC 23-11-10/ TIA Log #1753)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 2, and the Correlating Committee on National Electrical Code and was issued by the Standards Council on November 30, 2023, with an effective date of December 20, 2023.

1. Revise section 210.70 to read as follows:

210.70 Lighting Outlets Required. Lighting outlets shall be installed where specified in 210.70(A), (B), and (C). The switch or listed wall-mounted control device shall not rely exclusively on ~~a~~ battery power unless ~~a~~ it incorporates a positive means of notification of impending battery depletion. ~~is provided for automatically energizing the lighting outlets upon battery failure.~~

Issue Date: November 30, 2023

Effective Date: December 20, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 517.30(B)(3)(a)
TIA 23-14
(SC 23-11-9 / TIA Log #1752)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 15, and the Correlating Committee on National Electrical Code and was issued by the Standards Council on November 30, 2023, with an effective date of December 20, 2023.

1. Revise section 517.30(B)(3)(a) to read as follows:

517.30(B)(3) Fuel Cell Systems. Fuel cell systems shall be permitted to serve as the alternate power source for all or part of an EES. [**99:**6.7.1.5.1]

(a) Installation of fuel cells shall comply with the requirements in Parts I through VI ~~VII~~ of Article 692 ~~for 1000 volts or less and Part VIII for over 1000 volts~~.

Issue Date: November 30, 2023

Effective Date: December 20, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Mod_12028_Text_TIA 23-14.pdf

P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 400.47
TIA 23-13
(SC 23-8-57 / TIA Log #1731)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 6 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise section 400.47 to read as follows:

400.47. ~~Minimum~~ Conductor Bending ~~Radii~~ Radius. ~~The minimum bending radii for~~ Pportable power feeder cables rated from 2000 volts to 5000 volts shall not ~~exceed~~ be bent to a radius less than six times the overall cable outer diameter. ~~The minimum bending radii for~~ Pportable power feeder cables rated from 5001 volts to 25,000 volts shall not ~~exceed~~ be bent to a radius less than eight-times the overall cable outer diameter.

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Mod_12028_Text_TIA 23-13.pdf

P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 408.6
TIA 23-12
(SC 23-8-56 / TIA Log #1699)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 9 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise 408.6 to read as follows:

408.6 Short-Circuit Current Rating. Switchboards, switchgear, and panelboards shall have a short-circuit current rating not less than the available fault current. In other than one- and two-family dwelling units, the available fault current and the date the calculation was performed shall be field marked on the enclosure at the point of supply. The marking shall be of sufficient durability to withstand the environment involved. ~~comply with 110.21(B)(3).~~

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Mod_12028_Text_TIA 23-12.pdf

P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 700.32(C), 701.32(C), and 708.54(C)
TIA 23-11
(SC 23-8-54 / TIA Log #1692)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 13 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise 700.32(C) Informational Note and title of Figure for the Informational Note to read as follows:

700.32 Selective Coordination.

700.32(A) General. Emergency system(s) overcurrent protective devices (OCPDs) shall be selectively coordinated with all supply-side and load-side OCPDs.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

700.32(B) Replacements. Where emergency system(s) OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.

700.32(C) Modifications. If modifications, additions, or deletions to the emergency system(s) occur, selective coordination of the emergency system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 700.32~~(C)~~ for an example of how emergency system OCPDs selectively coordinate with all supply-side OCPDs.

~~OCPD D selectively coordinates with OCPDs C, F, E, B, and A.~~
~~OCPD C selectively coordinates with OCPDs F, E, B, and A.~~
~~OCPD F selectively coordinates with OCPD E.~~
~~OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not an emergency system OCPD.~~

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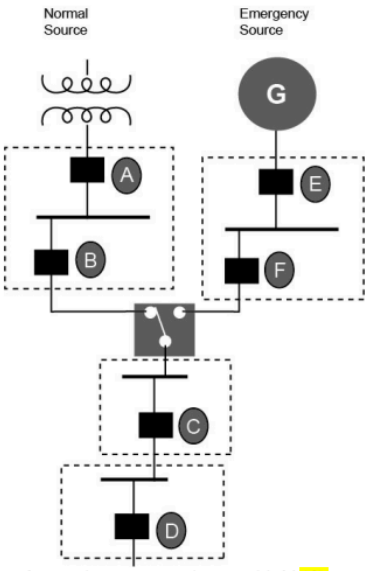
P12028Text Modification



Informational Note Figure 700.32~~(C)~~ Emergency System Selective Coordination.
OCPD D selectively coordinates with OCPDs C, F, E, B, and A.
OCPD C selectively coordinates with OCPDs F, E, B, and A.
OCPD F selectively coordinates with OCPD E.
OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not an emergency system OCPD.

2. Revise 701.32(C) Informational Note and title of Figure for the Informational Note to read as follows:

701.32 Selective Coordination.

701.32(A) General. Legally required standby system(s) overcurrent protective devices (OCPDs shall be selectively coordinated with all supply-side and load-side OCPDs.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

701.32(B) Replacements. Where legally required standby OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.

701.32(C) Modifications. If modifications, additions, or deletions to the legally required standby system(s) occur, selective coordination of the legally required system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 701.32~~(C)~~ for an example of how legally required standby system OCPDs selectively coordinate with all supply-side OCPDs.

~~OCPD D selectively coordinates with OCPDs C, F, E, B, and A.~~
~~OCPD C selectively coordinates with OCPDs F, E, B, and A.~~
~~OCPD F selectively coordinates with OCPD E.~~
~~OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a legally required standby system OCPD.~~

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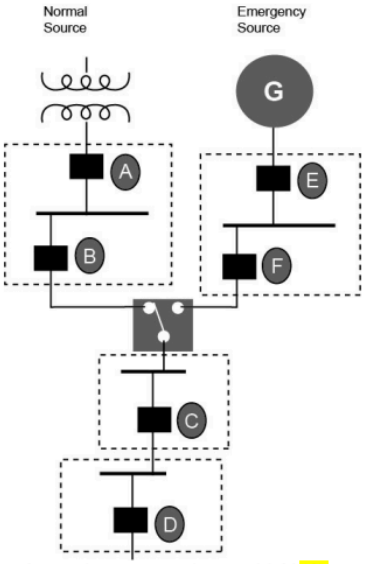
Mod_12028_Text_TIA 23-11.pdf

P12028Text Modification



Informational Note Figure 701.32~~(C)~~ Legally Required Standby System Selective Coordination.
OCPD D selectively coordinates with OCPDs C, F, E, B, and A.
OCPD C selectively coordinates with OCPDs F, E, B, and A.
OCPD F selectively coordinates with OCPD E.
OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a legally required standby system OCPD.

3. Revise 708.54(C) Informational Note and title of Figure for the Informational Note to read as follows:

708.54(A) General. Critical operations power system(s) overcurrent protective devices (OCPDs) shall be selectively coordinated with all supply-side and load-side OCPDs.
Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.
708.54(B) Replacements. Where critical operations power system(s) OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.
708.54(C) Modifications. If modifications, additions, or deletions to the critical operations power system(s) occur, selective coordination of the critical operations power system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.
Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.
Informational Note: See Informational Note Figure 708.54~~(C)~~ for an example of how critical operations power system OCPDs selectively coordinate with all supply-side OCPDs.
~~OCPD D selectively coordinates with OCPDs C, F, E, B, and A.~~
~~OCPD C selectively coordinates with OCPDs F, E, B, and A.~~
~~OCPD F selectively coordinates with OCPD E.~~
~~OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a critical operations power system OCPD.~~

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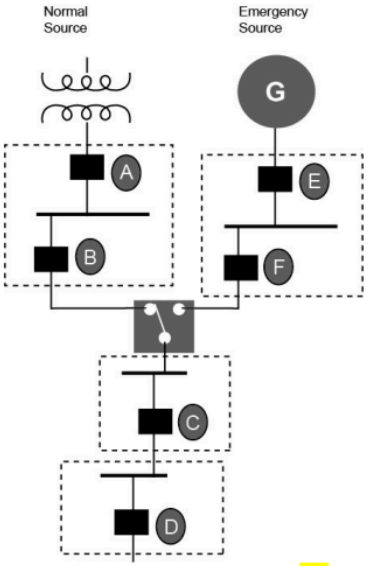
P12028Text Modification



Informational Note Figure 708.54~~(C)~~ Critical Operations Power System Selective Coordination.
OCPD D selectively coordinates with OCPDs C, F, E, B, and A.
OCPD C selectively coordinates with OCPDs F, E, B, and A.
OCPD F selectively coordinates with OCPD E.
OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a critical operations power system OCPD.

Issue Date: August 25, 2023

Effective Date: September 14, 2023

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Mod_12028_Text_TIA 23-11.pdf

P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 314.29(A)
TIA 23-10
(SC 23-3-10 / TIA Log #1690)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 9 and the NEC Correlating Committee, and was issued by the Standards Council on March 21, 2023, with an effective date of April 10, 2023.

1. Revise paragraph 314.29(A) to read as follows:

314.29 Boxes, Conduit Bodies, and Handhole Enclosures to Be Accessible. Boxes, conduit bodies, and handhole enclosures shall be installed so that wiring and devices contained in the boxes, conduit bodies, or handhole enclosures can be rendered accessible in accordance with 314.29(A) and (B).

(A) In Buildings and Other Structures. Boxes and conduit bodies shall be installed so the contained wiring and devices are accessible. Boxes and conduit bodies that are recessed into or behind finished surfaces of buildings shall have access to their internal contents maintained by openings in their covers and in the building finish that comply with 314.29(A)(1), (A)(2), or (A)(3) as applicable. Removable finished covers and faceplates that maintain this access shall be permitted.

(1) Boxes 1650 cm³ (100 in.³) or Less in Size. The openings in the building surfaces, if reduced from the outer walls of the box, shall be centered not more than 25 mm (1 in.) from the centerline of the box, and shall not extend beyond the walls of the box. If rectangular, the opening shall be not less than 73 mm (2 7/8 in.) by 45 mm (1 3/4 in.) in size. If circular, the opening shall not be less than 90 mm (3½ in.) in diameter.

Exception: Smaller openings in building surfaces that accommodate one or more individual devices shall be permitted if all of the following conditions are met:

(1) The outlet box that supplies the device(s) is nonmetallic.
(2) The branch circuit wiring that supplies each device consists of a separate nonmetallic cable assembly originating outside the box, or individual sets of conductors in a single nonmetallic raceway, all of which originate outside the box. Other than the connections to a single device, these conductors are not spliced in the box or continued to another device, and no other wiring or raceways enter the box.
(3) Each device is capable of removal from the building surface opening without being damaged. If a special tool is required for this purpose, the applicable circuit directory for the device records the location of the tool, together with a product code/QR code for acquiring a replacement if necessary.
(4) All connections for each device to the branch circuit wiring are made with listed clamping-type wire connectors, which are supplied with the devices. The branch-circuit conductors are arranged to permit the connector(s) to be exposed after the device has been fully removed.
(5) The device assemblies are listed for this application.

(2) Boxes Larger Than 1650 cm³ (100 in.³) in Size. The openings shall not be smaller than the outer walls of the box.

(3) Conduit Bodies. The openings shall not be smaller than outer walls of the conduit body.

(B) Underground. Underground boxes and handhole enclosures shall be installed …

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Mod_12028_Text_TIA 23-10.pdf

P12028Text Modification

Issue Date: March 21, 2023

Effective Date: April 10, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Mod_12028_Text_TIA 23-10.pdf

P12028Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 250.114(3)e and 250.114(4)e
TIA 23-1
(SC 21-12-13 / TIA Log #1608)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise 250.114(3)e and (4)e to read as follows:

250.114 Equipment Connected by Cord and Plug. Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

…

(3) In residential occupancies:

…

e. Portable handlamps ~~and portable luminaires~~

(4) In other than residential occupancies:

…

e. Portable handlamps ~~and portable luminaires~~

…

Issue Date: December 8, 2021

Effective Date: December 28, 2021

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
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Mod_12028_Text_TIA 23-1.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Fuel Gas

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P12116

Date Submitted	02/14/2025	**Section**	0.0	**Proponent**	Joseph Eysie
Chapter	3004	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Residential Companion

Summary of Modification

A minor code change replaces the term brass with “copper alloy in Appendix D.3 regarding gas piping and connection inspections.

Rationale

To remain consistent with other sections where this change has already been made.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
No impact
Impact to building and property owners relative to cost of compliance with code
No Impact
Impact to industry relative to the cost of compliance with code
No Impact
Impact to small business relative to the cost of compliance with code
No Impact

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
This change ensures uniformity throughout the code
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Maintains uniformity throughout the code.
Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Does not degrade the effectiveness of the code
Promotes consistency throughout the code.

P12116Text Modification

A minor code change replaces the term “brass” with “copper alloy” in **Appendix D, Recommended Procedure for Safety Inspection of an Existing Appliance Installation**, regarding gas piping and connection inspections. This revision ensures consistency between the Florida Fuel Gas Code and the International Fuel Gas Code. This amendment serves as a companion to a similar proposal affecting Appendix D of Chapter 24 of the Residential Code.

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Mod12116_TextOfModification.pdf

P12116Text Modification

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Mod_12116_Text_FBC FG Appendix D_ Recommended Procedure for Safety Inspection .pdf

Appendix D: Recommended Procedure for Safety Inspection of an Existing Appliance Installation

SECTION D103 GAS PIPING AND CONNECTIONS INSPECTIONS.

1. *Leak Checks.* Conduct a test for gas leakage using either a non-corrosive leak detection solution or a CGD confirmed with a leak detection solution.

   The preferred method for leak checking is by use of gas leak detection solution applied to all joints. This method provides a reliable visual indication of significant leaks.

   The use of a CGD in its audio sensing mode can quickly locate suspect leaks but can be overly sensitive indicating insignificant and false leaks. All suspect leaks found through the use of a CGD should be confirmed using a leak detection solution.

   Where gas leakage is confirmed, the owner should be notified that repairs must be made. The inspection should include the following components:

   a. All gas *piping* fittings located within the *appliance* space.

   b. *Appliance* connector fittings.

   c. *Appliance* gas valve/regulator housing and connections.

2. *Appliance Connector.* Verify that the *appliance* connection type is compliant with Section 411 of the International Fuel Gas Code. Inspect flexible *appliance* connections to determine if they are free of cracks, corrosion and signs of damage. Verify that there are no uncoated ~~brass~~ copper alloy connectors. Where connectors are determined to be unsafe or where an uncoated~~brass~~ copper alloy connector is found, the appliance shutoff valve should be placed in the off position and the owner notified that the connector must be replaced.

3. *Piping Support.* Inspect *piping* to determine that it is adequately supported, that there is no undue stress on the *piping,* and if there are any improperly capped pipe openings.

4. *Bonding.* Verify that the electrical bonding of gas *piping* is compliant with Section 310 of the International Fuel Gas Code.

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P12029

Date Submitted	02/11/2025	**Section**	102.4	**Proponent**	Bryan Holland
Chapter	1	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

A related modification has been submitted to the FBC-B, FBC-R, FBC-EC, FBC-EB, FBC-M, and FBC-FG to update the reference to NFPA 70-23, including all published TIAs.

Summary of Modification

This proposed modification recommends adoption of NFPA 70-23, including all published Tentative Interim Amendments (TIAs) in Chapter 15. (Chapter 15 is not in the drop box above)

Rationale

This proposed modification recommends updating the adopted edition of NFPA 70 to the 2023 edition, including all published TIAs (TIA 23-1 through TIA 23-16). Tentative Interim Amendments (TIAs) are important revisions to the code that have been issued by the NFPA Standards Council after publication of the document. All issued TIAs have been reviewed and approved through consensus voting on the basis of "technical merit" and "emergency nature" by the corresponding Code Making Panel, without creating a correlation issue with any other sections of the code. For the 2023 edition of NFPA 70, TIAs 23-1 through 23-6 were issued prior to publication of the code and incorporated into the first printing. This proposed modification recommends all TIAs, 23-1 through 23-16 be officially adopted and incorporated into the code. This will help reduce conflicts in the field and improve consistent enforcement across all Florida jurisdictions.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
This proposed modification will improve the consistent enforcement of the code by the local entity.
Impact to building and property owners relative to cost of compliance with code
This proposed modification will not change the cost of compliance with code.
Impact to industry relative to the cost of compliance with code
This proposed modification will not change the cost of compliance with code.
Impact to small business relative to the cost of compliance with code
This proposed modification will not change the cost of compliance with code.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The changes made to the 2023 NEC along with all issued TIAs represent important improvements and corrections to the published code. All (16) TIAs have been deemed to have both technical merit and emergency in nature, thus increasing the health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by updating to the most current edition of the NEC and by incorporating corrections made after initial publication.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification improves the effectiveness of the code.

P12029Text Modification

Chapter 15 Referenced Standards

NFPA

70 - ~~20~~ 23 National Electrical Code (NEC), including all published Tentative Interim Amendments (TIAs) published until December 4, 2024

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Mod12029_TextOfModification.pdf

P12029Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: Definition of Pool, and 680.26
TIA 23-9
(SC 23-3-8 / TIA Log #1687)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 17 and the NEC Correlating Committee, and was issued by the Standards Council on March 21, 2023, with an effective date of April 10, 2023.

1. Revise the definition of "Pool" to read as follows:

Pool. Manufactured or field-constructed equipment designed to contain water on a permanent or semipermanent basis and used by persons for swimming, wading, immersion, or therapeutic purposes, but not including bodies of water incorporated as part of an industrial process or lakes, lagoons, surf parks, or other natural and man-made bodies of water that may incorporate swimming and swimming areas. (680) (CMP-17)

Informational Note: Natural and man-made bodies of water, which includes lakes, lagoons, surf parks, or other similar bodies of water, are addressed in Article 682.

2. Revise section paragraph 680.26 to read as follows:

680.26 Equipotential Bonding.

(A) Performance. The equipotential bonding required by 680.26(B) and (C) to reduce voltage gradients in the pool area shall be installed for pools with or without associated electrical equipment related to the pool.

Informational Note No. 1: Some causes of voltage gradients originate outside the premises wiring system and are not within the scope of the *NEC*. Measures identified in Rule 097D2 of ANSI C2, *National Electrical Safety Code,* can also serve to address voltage gradients originating on the utility side of the service point.

Informational Note No. 2: By its nature, equipotential bonding of swimming pools and perimeter surfaces involves contact between various metallic materials and the earth. This can, in some cases, expose various specific metals to a corrosive environment, depending on factors such as the type and chemical content of the soil and the specific metal. Corrosive environments are also addressed in 680.14.

(B) Bonded Parts. …

(1) Conductive Pool Shells. …

(2) Perimeter Surfaces. The perimeter surface to be bonded shall be considered to extend for ~~1 m~~ 900 mm (3 ft) horizontally beyond the inside walls of the pool ~~and~~ while also at a height between 900 mm (3 ft) above and 600 mm (2 ft) below the maximum water level. The perimeter surface shall include unpaved surfaces, concrete, and other types of paving. Perimeter surfaces separated from the pool by a permanent wall or building 1.5 m (5 ft) in height or more shall

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require equipotential bonding only on the pool side of the permanent wall or building. Bonding to perimeter surfaces shall be provided as specified in 680.26(B)(2)(a), (B)(2)(b), ~~or~~ (B)(2)(c), and (B)(2)(d). ~~and~~ For conductive pool shells where bonding to perimeter surfaces is required, it shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four points uniformly spaced around the perimeter of the pool, or if the bonded perimeter surface does not surround the entire pool, it shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four uniformly spaced points along the bonded perimeter surface. For nonconductive pool shells where bonding to the perimeter surfaces is required, bonding at four points shall not be required, and the perimeter bonding shall be attached to the 8 AWG copper equipotential bonding conductor and, if present, to any conductive support structure for the pool.

Informational Note: Because the perimeter surface can incorporate various types of materials at various locations and elevations above and below maximum water level, the perimeter surface required to be bonded might not surround the entire pool. The 8 AWG copper equipotential bonding conductor can encircle the entire pool to facilitate connection of bonded parts.

(a) ~~*Structural Reinforcing Steel.* Structural reinforcing steel shall be bonded in accordance with 680.26(B)(1)(a).~~ *Conductive Paved Portions of Perimeter Surfaces.* Conductive paved portions of perimeter surfaces, including masonry pavers, if used, shall be bonded with unencapsulated structural reinforcing steel in accordance with 680.26(B)(1)(a), or with unencapsulated steel structural welded wire reinforcement (welded wire mesh, welded wire fabric), bonded together by steel tie wires or the equivalent. Steel welded wire reinforcement shall be fully embedded within the pavement unless the pavement will not allow for embedding. If the reinforcing steel is absent, or is encapsulated in a nonconductive compound, or embedding is not possible, unencapsulated welded wire steel reinforcement or a copper conductor grid shall be provided and shall be secured directly under the paving, and not more than 150 mm (6 in.) below finished grade.

Unencapsulated steel welded wire reinforcement that is not fully embedded in concrete, and copper grid regardless of location, where used for equipotential bonding, shall be listed for corrosion resistance and mechanical performance. This listing requirement shall become effective January 1, 2025. The copper grid or unencapsulated steel welded wire reinforcement shall also meet the following:

(1) Copper grid is constructed of 8 AWG solid bare copper and arranged in accordance with 680.26(B)(1)(b)(3).
(2) Steel welded wire reinforcement is minimum ASTM 6x6-W2.0 x W2.0 or minimum No. 3 rebar constructed in a 300 mm (12 in.) grid.
(3) Copper grid and steel welded wire reinforcement follow the contour of the perimeter surface extending not less than 900 mm (3 ft) horizontally beyond the inside walls of the pool.
(4) Only listed splicing devices or exothermic welding are used.

Informational Note No. 1: Performance of the equipotential bonding system at the perimeter surface is improved as the distance between the bonding means and finished grade is minimized, either by embedding within, or by direct contact with the underside of, the finished pavement.

Informational Note No. 2: See ASTM A615/A615M, *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement;* A1064/A1064M, *Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete;* A1022/A1022M, *Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement;* A1060A/A1060M, *Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete;* and ACI Standard ACI 318, *Building Code Requirements for Structural Concrete,* for examples of standards currently used in the listing of reinforcing steel bars and steel welded wire reinforcement.

(b) *Unpaved Portions of Perimeter Surfaces.* Unpaved portions of perimeter surfaces shall be bonded with any of the following methods:
(1) ~~*Copper Ring.* Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound, a c~~Copper conductor(s) shall ~~be utilized where the following requirements are met~~ meet the following:
~~(1)~~a. At least one minimum 8 AWG bare solid copper conductor, including the 8 AWG copper equipotential bonding conductor if available ~~shall be provided~~.
~~(2)~~b. The conductors ~~shall~~ follow the contour of the perimeter surface.
~~(3)~~c. Only listed splicing devices or exothermic welding are used. ~~shall be permitted.~~
~~(4)~~d. The ~~required~~ conductor(s) is ~~shall be~~ 450 mm to 600 mm (18 in. to 24 in.) from the inside walls of the pool.
~~(5)~~e. The ~~required~~ conductor(s) ~~shall be secured within or~~ is under the unpaved portion of the perimeter surface 100 mm to 150 mm (4 in. to 6 in.) below ~~the subgrade~~finished grade.
f. Be installed only in perimeter surfaces not intended to have direct access to swimmers in the pool.

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(e2) ~~*Copper Grid.* Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound,~~ ~~e~~Copper grid or unencapsulated steel welded wire reinforcement used for equipotential bonding of unpaved portions of perimeter surfaces shall ~~be utilized where the following requirements are met~~ meet the following:
~~(1)~~a. ~~The copper grid shall be constructed of 8 AG solid bare copper and be arranged~~ Be installed in accordance with 680.26~~(B)(1)(b)(3)~~(B)(2)(a).
~~(2) The copper grid shall follow the contour of the perimeter surface extending 1 m (3 ft) horizontally beyond the inside walls of the pool.~~
~~(3) Only listed splicing devices or exothermic welding shall be permitted.~~
~~(4)~~b. ~~The copper grid shall be secured~~ Be located within ~~or under~~ the ~~deck or~~ unpaved surface(s) between 100 mm to 150 mm (4 in. to 6 in.) below ~~the subgrade~~finished grade.

(c) *Nonconductive Perimeter Surfaces.* Equipotential bonding shall not be required for nonconductive portions of perimeter surfaces that are separated from earth or raised on nonconducting supports, and it shall not be required for any perimeter surface that is electrically separated from the pool structure and raised on nonconductive supports above an equipotentially bonded surface.

Informational Note: Nonconductive materials include, but are not limited to, wood, plastic, wood-plastic composites, fiberglass, and fiberglass composites.

(d) *Interconnection of Bonded Portions of Perimeter Surfaces.* All surfaces where equipotential bonding is required shall be interconnected using listed splicing devices or exothermic welding. Where copper wire is used for this purpose, it shall be solid copper, not smaller than 8 AWG. The conductor shall be permitted to encircle the pool to facilitate bonding connections to portions of the perimeter covered in 680.26(B)(2)(a) and (B)(2)(b) that are not contiguous.

Issue Date: March 21, 2023

Effective Date: April 10, 2023

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Tentative Interim Amendment

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Reference: 300.26
TIA 23-8
(SC 23-3-9 / TIA Log #1688)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 3 and the NEC Correlating Committee, and was issued by the Standards Council on March 21, 2023, with an effective date of April 10, 2023.

1. Revise paragraph 300.26 to read as follows:

300.26 Remote-Control and Signaling Circuits Classification.

Remote-control and signaling circuits shall be classified as either power-limited or non-power-limited and comply with ~~the following~~300.26(A) through (C).

(~~1~~A) **Class 1 Power-Limited Remote-Control and Signaling Circuits.** Class 1 power-limited remote-control and signaling circuits shall comply with 724.3.

(~~2~~B) **Class 2 and Class 3 Power-Limited Remote-Control and Signaling Circuits.** Class 2 and Class 3 power-limited remote-control and signaling circuits shall comply with 725.3.

(~~3~~C) **Non-Power-Limited Remote-Control and Signaling Circuits.** Non-power-limited remote-control and signaling circuits shall be installed in accordance with 300.2 through 300.25 and comply with 300.26(C)(1) through (C)(3).

(1) Sizes and Use.

(a) Conductors that are 18 AWG and 16 AWG copper shall be permitted to be used if they supply loads that do not exceed the ampacities specified in 402.5 and are installed in a raceway, an approved enclosure, or a listed cable.

(b) Conductors that are 14 AWG copper-clad aluminum shall be permitted to be used in Type MC cable and Type TC cable. The continuous load shall not exceed 8 amperes.

(c) Conductors larger than 16 AWG copper or 14 AWG copper-clad aluminum shall not supply loads greater than the ampacities specified in 310.14.

(d) Flexible cords shall comply with the applicable general requirements, applications, and construction specifications for flexible cords and flexible cables in accordance with Article 400 Parts I and II.

(2) Insulation.

(a) Insulation on conductors shall be rated for the system voltage and not less than 600 volts.

(b) Conductors larger than 16 AWG copper or 14 AWG copper-clad aluminum shall comply with the applicable general requirements for conductors rated up to and including 2000 volt for type designations, insulations, markings, ampacity ratings, and uses in accordance with 310.3, 310.4, 310.6, 310.8, 310.10, and 310.14.

(c) Conductors that are 18 AWG copper, 16 AWG copper, or 14 AWG copper-clad aluminum shall be Type FFH-2, Type KF-2, Type KFF-2, Type PAF, Type PAFF, Type PF, Type PFF, Type PGF, Type PGFF, Type PTF, Type PTFF, Type RFH-2, Type RFHH-2, Type RFHH-3, Type SF-2, SFF-2, Type TF, Type TFF, Type TFFN, Type TFN, Type ZF, or Type ZFF.

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(d) Conductors with other types and thicknesses of insulation shall be permitted if listed for Class 1 circuit use.

(3) Overcurrent Protection.

(a) Overcurrent protection for conductors 14 AWG copper and larger shall be provided in accordance with the conductor ampacity, without applying the ampacity adjustment and correction factors specified in 310.15 to the ampacity calculation.

(b) Overcurrent protection shall not exceed 7 amperes for 18 AWG copper conductors and 10 amperes for 16 AWG copper and 14 AWG copper-clad aluminum.

Exception: The overcurrent protection specified in 300.26(C)(3)(1) and 300.26(C)(3)(2) shall not be required where this Code requires or permits other overcurrent protection ratings.

Issue Date: March 21, 2023

Effective Date: April 10, 2023

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Reference: Table C.18, Table C.19 and Table C.20
TIA 23-7
(SC 22-12-7 / TIA Log #1678)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 8, and the NEC Correlating Committee, and was issued by the Standards Council on December 8, 2022, with an effective date of December 28, 2022.

*1. Revise Table Headers **only** for Table C.18, Table, C.19 and Table C.20 to read as follows:*

Table C.18 Number of Single Conductor Cables Permitted in Cable Tray
(Based on fill in accordance with 392.22, Table 392.22~~(A)~~(B)(1), column 1, ampacity in accordance with 392.80)

Table C.19 Number of Single Conductor Cables Permitted in Cable Tray
(Based on fill in accordance with 392.22, Table 392.22~~(A)~~(B)(1), column 1, ampacity in accordance with 392.80)

Table C.20 Number of Single Conductor Cables Permitted in Cable Tray
(Based on fill in accordance with 392.22, Table 392.22~~(A)~~(B)(1), column 1, ampacity in accordance with 392.80)

Issue Date: December 8, 2022

Effective Date: December 28, 2022

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Reference: 555.35
TIA 23-6
(SC 22-8-23 / TIA Log #1660)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 555.35 to read as follows:

555.35 Ground-Fault Protection of Equipment (GFPE) and Ground-Fault Circuit Interrupter. For other than floating buildings, ground-fault protection for docking facilities shall be provided in accordance with 555.35(A) through (~~F~~D).

~~**(A) Sources Directly Supplying Docking Facilities or Wharfs.** Listed GFPE, rated not more than 100 milliamperes, shall be provided for sources directly supplying all docking facilities or wharfs. Coordination with downstream GFPE shall be permitted.~~

(~~B~~A) Feeder. …

Exception: Transformer secondary conductors of a separately derived system that do not exceed 3 m (10 ft) and are installed in a raceway shall be permitted to be installed without ground-fault protection.
This exception shall also apply to the supply terminals of the equipment supplied by the transformer secondary conductors.

(~~C~~B) Branch-Circuits.
(1) Receptacles Providing Shore Power. …
(2) Outlets for Other than Shore Power. Outlets supplied by branch circuits not exceeding 150 volts to ground and 60 amperes, single phase, and 150 volts or less to ground, 100 amperes or less, three phase, shall be provided with GFCI protection for personnel.

Exception to (~~C~~B): Low-voltage circuits not requiring grounding, not exceeding the low-voltage contact limit and supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall be permitted to be installed without ground-fault protection.

(~~D~~C) Boat Hoists. …
(~~E~~D) Leakage Current Measurement Device. …
Informational Note No. 1: …
Informational Note No. 2: …

Exception: Where the shore power equipment includes a leakage indicator and leakage alarm, a separate leakage test device shall not be required.

Issue Date: August 12, 2022

Effective Date: September 1, 2022

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Reference: 555.30
TIA 23-5
(SC 22-8-22 / TIA Log #1659)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 555.30 to read as follows:

555.30 Electrical Equipment and Connections.

(A) General. All electrical components within electrical equipment (excluding wiring methods) and connections not intended for operation while submerged shall be located at least 305 mm (12 in.) above the deck of a fixed or floating structure, but not below the electrical datum plane. Conductor splices, within junction boxes identified for wet locations, utilizing sealed wire connector systems listed and identified for submersion shall be required for floating structures where located above the waterline but below the electrical datum plane.

(B) Replacements. …

Issue Date: August 12, 2022

Effective Date: September 1, 2022

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Reference: 215.15
TIA 23-4
(SC 22-8-18 / TIA Log #1655)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 215.15 to read as follows:

215.15 Barriers. Barriers shall be placed such that no energized, uninsulated, ungrounded busbar or terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations in panelboards, switchboards, switchgear, or motor control centers supplied by feeder taps in 240.21(B) or transformer secondary conductors in 240.21(C) when the disconnecting device, to which the tap conductors are terminated, is in the open position.

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(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Reference: 210.8(F) and Exception No. 2(new)
TIA 23-3
(SC 22-8-17 / TIA Log #1654)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise paragraph 210.8(F) to read as follows:

210.8(F) Outdoor Outlets.

For dwellings, all outdoor outlets, other than those covered in 210.8(A), Exception No. 1, including outlets installed in the following locations, and supplied by single-phase branch circuits rated 150 volts or less to ground, 50 amperes or less, shall be provided with GFCI protection:

(1) Garages that have floors located at or below grade level
(2) Accessory buildings
(3) Boathouses

If equipment supplied by an outlet covered under the requirements of this section is replaced, the outlet shall be supplied with GFCI protection.

Exception No. 1: GFCI protection shall not be required on lighting outlets other than those covered in 210.8(C).
Exception No. 2: GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026.

Issue Date: August 12, 2022

Effective Date: September 1, 2022

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Reference: Article 100 (Ignitible Fibers/Flyings), 506.5, and 506.9(B)
TIA 23-2
(SC 22-4-8 / TIA Log #1617)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise Article 100 Ignitible Fibers/Flyings to read as follows:

Ignitible Fibers/Flyings. Fibers/flyings where any dimension is greater than 500 µm in nominal size, which are not likely to be in suspension in quantities to produce an explosible mixture, but could produce an ignitible layer fire hazard. [**499:**3.3.4.2]

Informational Note No.1: This definition and Informational Note No. 2 have been extracted from NFPA 499-2021, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. The NFPA 499 reference is in brackets. Only editorial changes were made to the extracted text to make it consistent with this *Code*.

Informational Note No. 2: Section 500.5 of this *Code* prescribes a Class III location as one where ignitible fibers/flyings are present, but not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. This description addresses fibers/flyings that do not present a flash-fire hazard or explosion hazard by test. This could be because those fibers/flyings are too large or too agglomerated to be suspended in air in sufficient concentration, or at all, under typical test conditions. Alternatively, this could be because they burn so slowly that, when suspended in air, they do not propagate combustion at any concentration. In this document the zone classification system includes ignitible fibers/flyings as a fire hazard in a layer, which is not addressed in the IEC zone system (see IEC 60079-10-2, *Explosive atmospheres — Part 10-2: Classification of areas — Explosive dust atmospheres*). Where these are present, the user could also consider installation in accordance with Article 503 of this *Code*. [**499:**A.3.3.4.2]

2. Revise Section 506.5 to read as follows:

506.5 Classification of Locations.
(A) Classifications of Locations. …
(B) Zone 20, Zone 21, and Zone 22 Locations. …
(1) Zone 20. A Zone 20 location is a location where one of the following apply:
(1) Ignitible concentrations of combustible dust, ~~or~~ combustible fibers/flyings, or ignitible fibers/flyings are present continuously or for long periods of time.
…
(2) Zone 21. …
(3) Zone 22. A Zone 22 location is a location where one of the following apply:
(1) …
(2) Combustible dust, combustible fibers/flyings, or ignitible fibers/flyings are handled, processed, or used…
(3) …

3. Revise Section 506.9(B) to read as follows:

506.9 Equipment Requirements.
…

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(B) Listing. Equipment that is listed for Zone 20 shall be permitted in a Zone 21 or Zone 22 location of the same combustible dust, combustible fiber/flying, or ignitible fiber/flying. Equipment that is listed for Zone 21 ~~can be used~~ shall be permitted in a Zone 22 location of the same combustible dust, combustible fiber/flying, or ignitible fiber/flying.

Issue Date: April 12, 2022

Effective Date: May 2, 2022

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Reference: 680.43, Exception No. 3
TIA 23-16
(SC 24-12-6 / TIA Log #1800)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 17, and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on December 4, 2024, with an effective date of December 24, 2024.

1. Delete Exception No. 3 of 680.43 as follows:

680.43 Indoor Installations. A spa or hot tub installed indoors shall comply with the provisions of Parts I and II of this article except as modified by this section and shall be connected by the wiring methods of Chapter 3.
Exception No. 1: Listed spa and hot tub …
Exception No. 2: The equipotential bonding …
~~*Exception No. 3: For a dwelling unit(s) only, where a listed spa or hot tub is installed indoors, the wiring method requirements of 680.42(C) shall also apply.*~~

Issue Date: December 4, 2024

Effective Date: December 24, 2024

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Reference: 210.70
TIA 23-15
(SC 23-11-10/ TIA Log #1753)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 2, and the Correlating Committee on National Electrical Code and was issued by the Standards Council on November 30, 2023, with an effective date of December 20, 2023.

1. Revise section 210.70 to read as follows:

210.70 Lighting Outlets Required. Lighting outlets shall be installed where specified in 210.70(A), (B), and (C). The switch or listed wall-mounted control device shall not rely exclusively on ~~a~~ battery power unless ~~a~~ it incorporates a positive means of notification of impending battery depletion. ~~is provided for automatically energizing the lighting outlets upon battery failure.~~

Issue Date: November 30, 2023

Effective Date: December 20, 2023

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Reference: 517.30(B)(3)(a)
TIA 23-14
(SC 23-11-9 / TIA Log #1752)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 15, and the Correlating Committee on National Electrical Code and was issued by the Standards Council on November 30, 2023, with an effective date of December 20, 2023.

1. Revise section 517.30(B)(3)(a) to read as follows:

517.30(B)(3) Fuel Cell Systems. Fuel cell systems shall be permitted to serve as the alternate power source for all or part of an EES. [**99:**6.7.1.5.1]

(a) Installation of fuel cells shall comply with the requirements in Parts I through VI ~~VII~~ of Article 692 ~~for 1000 volts or less and Part VIII for over 1000 volts~~.

Issue Date: November 30, 2023

Effective Date: December 20, 2023

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Reference: 400.47
TIA 23-13
(SC 23-8-57 / TIA Log #1731)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 6 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise section 400.47 to read as follows:

400.47. ~~Minimum~~ Conductor Bending ~~Radii~~ Radius. ~~The minimum bending radii for~~ Pportable power feeder cables rated from 2000 volts to 5000 volts shall not ~~exceed~~ be bent to a radius less than six times the overall cable outer diameter. ~~The minimum bending radii for~~ Pportable power feeder cables rated from 5001 volts to 25,000 volts shall not ~~exceed~~ be bent to a radius less than eight-times the overall cable outer diameter.

Issue Date: August 25, 2023

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Reference: 408.6
TIA 23-12
(SC 23-8-56 / TIA Log #1699)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 9 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise 408.6 to read as follows:

408.6 Short-Circuit Current Rating. Switchboards, switchgear, and panelboards shall have a short-circuit current rating not less than the available fault current. In other than one- and two-family dwelling units, the available fault current and the date the calculation was performed shall be field marked on the enclosure at the point of supply. The marking shall be of sufficient durability to withstand the environment involved. ~~comply with 110.21(B)(3).~~

Issue Date: August 25, 2023

Effective Date: September 14, 2023

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Reference: 700.32(C), 701.32(C), and 708.54(C)
TIA 23-11
(SC 23-8-54 / TIA Log #1692)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 13 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise 700.32(C) Informational Note and title of Figure for the Informational Note to read as follows:

700.32 Selective Coordination.

700.32(A) General. Emergency system(s) overcurrent protective devices (OCPDs) shall be selectively coordinated with all supply-side and load-side OCPDs.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

700.32(B) Replacements. Where emergency system(s) OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.

700.32(C) Modifications. If modifications, additions, or deletions to the emergency system(s) occur, selective coordination of the emergency system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 700.32~~(C)~~ for an example of how emergency system OCPDs selectively coordinate with all supply-side OCPDs.

~~OCPD D selectively coordinates with OCPDs C, F, E, B, and A.~~
~~OCPD C selectively coordinates with OCPDs F, E, B, and A.~~
~~OCPD F selectively coordinates with OCPD E.~~
~~OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not an emergency system OCPD.~~

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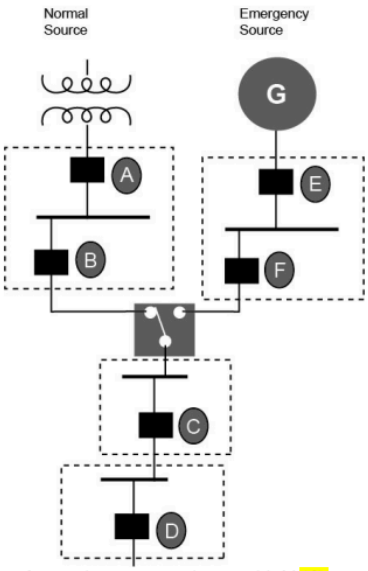
Mod_12029_Text_TIA 23-11.pdf

P12029Text Modification



Informational Note Figure 700.32~~(C)~~ Emergency System Selective Coordination.
OCPD D selectively coordinates with OCPDs C, F, E, B, and A.
OCPD C selectively coordinates with OCPDs F, E, B, and A.
OCPD F selectively coordinates with OCPD E.
OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not an emergency system OCPD.

2. Revise 701.32(C) Informational Note and title of Figure for the Informational Note to read as follows:

701.32 Selective Coordination.

701.32(A) General. Legally required standby system(s) overcurrent protective devices (OCPDs shall be selectively coordinated with all supply-side and load-side OCPDs.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

701.32(B) Replacements. Where legally required standby OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.

701.32(C) Modifications. If modifications, additions, or deletions to the legally required standby system(s) occur, selective coordination of the legally required system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.

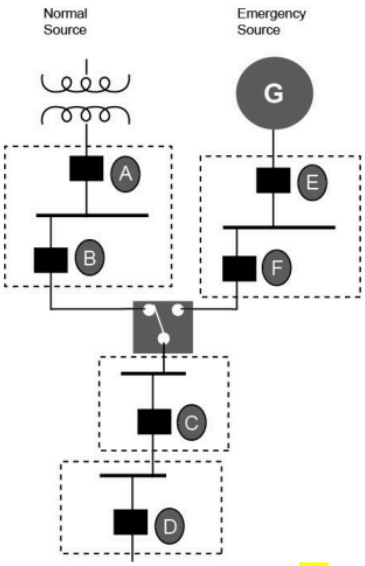
Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 701.32~~(C)~~ for an example of how legally required standby system OCPDs selectively coordinate with all supply-side OCPDs.

~~OCPD D selectively coordinates with OCPDs C, F, E, B, and A.~~
~~OCPD C selectively coordinates with OCPDs F, E, B, and A.~~
~~OCPD F selectively coordinates with OCPD E.~~
~~OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a legally required standby system OCPD.~~

Mod_12029_Text_TIA 23-11.pdf

P12029Text Modification



Informational Note Figure 701.32~~(C)~~ Legally Required Standby System Selective Coordination.
OCPD D selectively coordinates with OCPDs C, F, E, B, and A.
OCPD C selectively coordinates with OCPDs F, E, B, and A.
OCPD F selectively coordinates with OCPD E.
OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a legally required standby system OCPD.

3. Revise 708.54(C) Informational Note and title of Figure for the Informational Note to read as follows:

708.54(A) General. Critical operations power system(s) overcurrent protective devices (OCPDs) shall be selectively coordinated with all supply-side and load-side OCPDs.
Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.
708.54(B) Replacements. Where critical operations power system(s) OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.
708.54(C) Modifications. If modifications, additions, or deletions to the critical operations power system(s) occur, selective coordination of the critical operations power system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.
Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.
Informational Note: See Informational Note Figure 708.54~~(C)~~ for an example of how critical operations power system OCPDs selectively coordinate with all supply-side OCPDs.
~~OCPD D selectively coordinates with OCPDs C, F, E, B, and A.~~
~~OCPD C selectively coordinates with OCPDs F, E, B, and A.~~
~~OCPD F selectively coordinates with OCPD E.~~
~~OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a critical operations power system OCPD.~~

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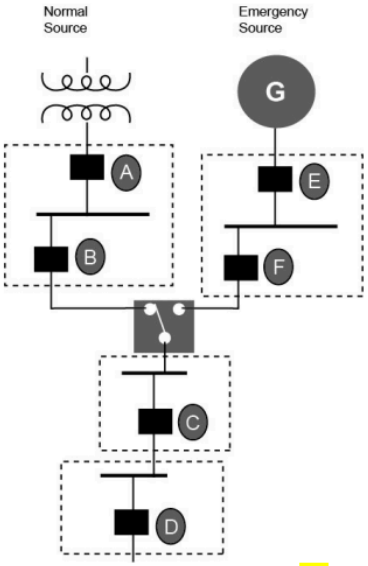
Mod_12029_Text_TIA 23-11.pdf

P12029Text Modification



Informational Note Figure 708.54~~(C)~~ Critical Operations Power System Selective Coordination.
OCPD D selectively coordinates with OCPDs C, F, E, B, and A.
OCPD C selectively coordinates with OCPDs F, E, B, and A.
OCPD F selectively coordinates with OCPD E.
OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a critical operations power system OCPD.

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
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Mod_12029_Text_TIA 23-11.pdf

P12029Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 314.29(A)
TIA 23-10
(SC 23-3-10 / TIA Log #1690)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by the NEC Code-Making Panel 9 and the NEC Correlating Committee, and was issued by the Standards Council on March 21, 2023, with an effective date of April 10, 2023.

1. Revise paragraph 314.29(A) to read as follows:

314.29 Boxes, Conduit Bodies, and Handhole Enclosures to Be Accessible. Boxes, conduit bodies, and handhole enclosures shall be installed so that wiring and devices contained in the boxes, conduit bodies, or handhole enclosures can be rendered accessible in accordance with 314.29(A) and (B).

(A) In Buildings and Other Structures. Boxes and conduit bodies shall be installed so the contained wiring and devices are accessible. Boxes and conduit bodies that are recessed into or behind finished surfaces of buildings shall have access to their internal contents maintained by openings in their covers and in the building finish that comply with 314.29(A)(1), (A)(2), or (A)(3) as applicable. Removable finished covers and faceplates that maintain this access shall be permitted.

(1) Boxes 1650 cm³ (100 in.³) or Less in Size. The openings in the building surfaces, if reduced from the outer walls of the box, shall be centered not more than 25 mm (1 in.) from the centerline of the box, and shall not extend beyond the walls of the box. If rectangular, the opening shall be not less than 73 mm (2 7/8 in.) by 45 mm (1 3/4 in.) in size. If circular, the opening shall not be less than 90 mm (3½ in.) in diameter.

Exception: Smaller openings in building surfaces that accommodate one or more individual devices shall be permitted if all of the following conditions are met:

(1) The outlet box that supplies the device(s) is nonmetallic.

(2) The branch circuit wiring that supplies each device consists of a separate nonmetallic cable assembly originating outside the box, or individual sets of conductors in a single nonmetallic raceway, all of which originate outside the box. Other than the connections to a single device, these conductors are not spliced in the box or continued to another device, and no other wiring or raceways enter the box.

(3) Each device is capable of removal from the building surface opening without being damaged. If a special tool is required for this purpose, the applicable circuit directory for the device records the location of the tool, together with a product code/QR code for acquiring a replacement if necessary.

(4) All connections for each device to the branch circuit wiring are made with listed clamping-type wire connectors, which are supplied with the devices. The branch-circuit conductors are arranged to permit the connector(s) to be exposed after the device has been fully removed.

(5) The device assemblies are listed for this application.

(2) Boxes Larger Than 1650 cm³ (100 in.³) in Size. The openings shall not be smaller than the outer walls of the box.

(3) Conduit Bodies. The openings shall not be smaller than outer walls of the conduit body.

(B) Underground. Underground boxes and handhole enclosures shall be installed …

Page: 1

Mod_12029_Text_TIA 23-10.pdf

P12029Text Modification

Issue Date: March 21, 2023

Effective Date: April 10, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

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Mod_12029_Text_TIA 23-10.pdf

P12029Text Modification

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 250.114(3)e and 250.114(4)e
TIA 23-1
(SC 21-12-13 / TIA Log #1608)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise 250.114(3)e and (4)e to read as follows:

250.114 Equipment Connected by Cord and Plug. Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

…

(3) In residential occupancies:

…

e. Portable handlamps ~~and portable luminaires~~

(4) In other than residential occupancies:

…

e. Portable handlamps ~~and portable luminaires~~

…

Issue Date: December 8, 2021

Effective Date: December 28, 2021

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
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Mod_12029_Text_TIA 23-1.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P11715

Date Submitted	01/08/2025	**Section**	607.2	**Proponent**	Timothy deCarion
Chapter	6	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments Yes **Alternate Language No**

Related Modifications

C404.5 of FECC

Summary of Modification

This is a conflict in the code. 50 feet is not the actual minimum length of piping allowed. The energy code is more stringent and uses charts. The real minimum length is in the energy code based on two possible methods of calculating water loss waiting on hot water.

Rationale

This is a conflict in the code. The plumbing code lists 50 feet in this section and the energy code is more restrictive. Any conflict in the code means the more restrictive stringent applies. Many plumbing code officials do not know the energy code is more restrictive.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
Clarifies the code and gives the code official the code reference to where to find the minimum lengths.
Impact to building and property owners relative to cost of compliance with code
This change fixes conflict and confusion.
Impact to industry relative to the cost of compliance with code
No impact, Energy code already applies.
Impact to small business relative to the cost of compliance with code
No impact, only better clarity.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
No impact, Energy code already applies.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No discrimination of materials, products, methods, and systems

Does not degrade the effectiveness of the code

Makes the code more effective

1st Comment Period History

P11715-G1

Proponent Gary Kozan Submitted 3/23/2025 12:19:21 PM Attachments No

Comment:

This proposal is rendered moot because of the Commission’s acceptance of P10985 during the first phase of this code change cycle: "607.2.1 Commercial energy provisions. In occupancies that are required to comply with the Commercial provisions of the Florida Energy Conservation Code, the developed length of hot or tempered water piping shall be limited in accordance with Sections C404.5.1 through C404.5.2.1 of that code."

P11715Text Modification

607.2 Hot or tempered water supply to fixtures.

The developed length of hot or tempered water piping, from the source of hot water to the fixtures that require hot or tempered water, shall not exceed ~~50 feet (15 240 mm).~~ the maximum allowable pipe length found in C404.5 of the *Florida Building Code Energy Conservation.* Recirculating system piping and heat-traced piping shall be considered to be sources of hot or tempered water.

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Mod11715_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P11747

Date Submitted	02/08/2025	**Section**	607.2	**Proponent**	Gary Kozan
Chapter	6	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments Yes **Alternate Language No**

Related Modifications

EN11746 is a companion change to P11747, and should be heard by both the Plumbing and Energy TACs.

Summary of Modification

Adds a new requirement limiting the hot water distance for public lavatory faucets to 10 feet maximum

Rationale

Public handwashing lavatory faucets have a much lower flow rate than other plumbing fixtures, which can result in an excessive wait for hot water. By reducing the maximum distance from 50 feet to 10 feet, hot water will arrive much sooner. The 10 feet distance is restrictive, yet provides sufficient length to allow hot water circulating loops to be run in the ceiling space. This is a companion change to EN11746, which proposes deleting the entire Section C404.5, and replacing it with this one simple plumbing code change.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
No cost impact
Impact to building and property owners relative to cost of compliance with code
No cost impact
Impact to industry relative to the cost of compliance with code
No cost impact
Impact to small business relative to the cost of compliance with code
No cost impact

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Provides quicker hot water delivery to public handwashing lavatories
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Does not discriminate against any materials, products, or other methods

Does not degrade the effectiveness of the code

Improves the effectiveness of the code by making it easier to understand

1st Comment Period History

P11747-G1

Proponent Jennifer Hatfield Submitted 4/16/2025 6:42:50 PM Attachments No

Comment:

On behalf of the Building Officials Association of Florida (BOAF), we support both this proposal and the corresponding modification EN11746. This approach provides simplicity, which better ensures compliance and makes it easier for enforcement. By way of better enforcement, the intent of the national requirement to meet the model code for energy efficiency will be maintained. Whereas time constraints make it difficult to near impossible to enforce the current energy language.

P11747Text Modification

Revise as follows:

607.2 Hot or tempered water supply to fixtures.

The *developed length* of *hot* or *tempered water* piping, from the source of hot water to the fixtures that require *hot* or *tempered water*, shall not exceed 50 feet (15 240 mm). Recirculating system piping and heat-traced piping shall be considered to be sources of *hot* or *tempered water*.

Exception: For public lavatory faucets, the developed length of hot or tempered water from the source of hot water shall not exceed 10 feet (3048 mm).

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Mod11747_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P11832

Date Submitted	02/12/2025	**Section**	717	**Proponent**	Michael Wilson
Chapter	7	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Summary of Modification

Complete removal of Section 717

Rationale

Remove 717.1 through 717.10 because " Fold and Form is not relevant to the Florida Building Code. 717.2 Applicability states, "The relining of existing building and sewer building drainage piping... 717.6 Relining materials states "The relining material shall be manufactured in compliance with the applicable standards and certified as required in Section 303". Section 303 references materials in: 303.1 "utilized in plumbing system." 303.4 "All plumbing products and materials." the Fold and Form material and installation process is intended to be installed by traditional licensed Underground Utility Contractors for relining Mainline Municipal sewer and storm culvert pipes. It is not used in "building sewers and building drainage piping" or "utilized in a plumbing system".

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
There would be no impact.
Impact to building and property owners relative to cost of compliance with code
There would be no impact.
Impact to industry relative to the cost of compliance with code
There would be no impact.
Impact to small business relative to the cost of compliance with code
There would be no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
The removal of the inaccurate code is a crucial step forward towards ensuring health, safety and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

The elimination of Section 717 will improve the codes overall.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

The removal of Section 717 does not in anyway discriminate against materials, products methods or systems of construction.

Does not degrade the effectiveness of the code

No it does not degrade the effectiveness of the code.

P11832Text Modification

~~717.1 General~~

~~This section shall govern the relining of existing building sewers and building drainage piping.~~

~~717.2 Applicability~~

~~The relining of existing building sewers and building drainage piping shall be limited to gravity drainage piping 4 inches (102 mm) in diameter and larger. The relined piping shall be of the same nominal size as the existing piping.~~

~~717.3 Preinstallation requirements~~

~~Prior to commencement of the relining installation, the existing piping sections to be relined shall be descaled and cleaned. After the cleaning process has occurred and water has been flushed through the system, the piping shall be inspected internally by a recorded video camera survey.~~

~~717.3.1 Preinstallation recorded video camera survey.~~

~~The video survey shall include verification of the project address location. The video shall include notations of the cleanout and fitting locations, and the approximate depth of the existing piping. The video shall also include notations of the length of piping at intervals not greater than 25 feet (7620 mm).~~

-

~~717.4 Permitting.~~

~~Prior to permit issuance, the code official shall review and evaluate the preinstallation recorded video camera survey to determine if the piping system is able to be relined in accordance with the proposed lining system manufacturer's installation requirements and applicable referenced standards.~~

-

~~717.5 Prohibited applications.~~

~~Where review of the preinstallation recorded video camera survey reveals that piping systems are not installed correctly or defects exist, relining shall not be permitted. The defective portions of piping shall be exposed and repaired with pipe and fittings in accordance with this code. Defects include, but are not limited to, backgrade or insufficient slope, complete pipe wall deterioration or complete separations such as from tree root invasion or improper support.~~

~~717.6 Relining materials.~~

~~The relining materials shall be manufactured in compliance with applicable standards and certified as required in Section 303. Fold-and-form pipe reline material shall be manufactured in compliance with ASTM F1504 or ASTM F1871.~~

~~717.7 Installation.~~

~~The installation of the relining material shall be performed in accordance with the manufacturer's installation instructions, applicable referenced standards and this code.~~

~~717.7.1 material data report.~~

~~The installer shall record the data as required by the relining material manufacturer and applicable standards. The recorded data shall include but is not limited to location of the project, relining material type, amount of product installed and conditions of the installation. A copy of the data report shall be provided to the code official prior to final approval.~~

~~717.8 Post-installation recorded video camera survey.~~

~~The completed, relined piping system shall be inspected internally by a recorded video camera survey after the system has been flushed and flow tested with water. The video survey shall be submitted to the code official prior to finalization of the permit. The video survey shall be reviewed and evaluated to provide verification that no defects exist. Any defect identified shall be repaired and replaced in accordance with this code.~~

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Mod11832_TextOfModification.pdf

P11832Text Modification

-

~~717.9 Certification.~~

~~A certification shall be provided in writing to the code official, from the permit holder, thawt the relining materials have been installed in accordance with the manufacturer's installation instructions, the applicable standards and this code.~~

-

~~717.10 Approval.~~

~~Upon verification of compliance with the requirements of Sections 717.1 through 717.9, the code official shall approve the installation.~~

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Mod11832_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P11834

Date Submitted	02/12/2025	**Section**	718	**Proponent**	Michael Wilson
Chapter	7	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments Yes **Alternate Language Yes**

Related Modifications

Summary of Modification

The finished resin-impregnated tube shall be continuous over the entire length of the installation or inversion run, with no gaps in coverage at branch or service connections.

Rationale

The proposed modification reflects the changes in the glitch flix, this is to better clarify the standard. Support File Attached.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
There is no impact.
Impact to building and property owners relative to cost of compliance with code
There is no impact.
Impact to industry relative to the cost of compliance with code
There is no impact.
Impact to small business relative to the cost of compliance with code
There is no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
This proposed modification has reasonable and substantial connection with the health, safety and welfare of the general public.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
The proposed modification improves and strengthens the clarity of the code, provides equivalent, with better, products, methods and systems.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No; this proposed change does not discriminate against any products, methods, systems of constructions.

Does not degrade the effectiveness of the code

No, this proposed change does not degrade the effectiveness of the code.

Alternate Language

1st Comment Period History

P11834-A6

Proponent Mark Miller **Submitted** 4/14/2025 7:19:18 PM **Attachments** Yes

Rationale:

The proposed language to which this alternate modification is submitted in response imposes unnecessary confusion, inconsistency, and constraints on practical and effective CIPP rehabilitation methods. The term “continuous,” as used in ASTM F1216, ASTM F1743, and ASTM F3541 does not require that a CIPP liner extend uninterrupted through the entire piping system. Instead, ASTM F1743 emphasizes the structural integrity and uniformity of each installed segment. It requires each CIPP segment to be free of seams, dry spots, or discontinuities, ensuring that where a liner is installed, it is installed completely and performs as intended. It does not mandate that the entire piping network be lined in a single run. Requiring a single continuous liner from the building vent to the city main is not only impracticable in many existing buildings, but it is also not necessary to ensure system performance. The proposed clarification aligns with ASTM F1743’s actual requirements and intent, allowing installers to rehabilitate pipelines efficiently and effectively while maintaining compliance with established performance and safety standards. Still, to eliminate further confusion as to the plain meaning of the code, the incorporation of ASTM F3541 into Section 718.1 is the ideal option. ASTM F3541 specifically addresses sectional repairs for gravity flow, non-pressure pipelines, and conduits, and likewise emphasized the structural integrity and proper installation of each installation length without mandating a single continuous application. This approach aligns more closely with industry best practices, promotes flexibility, and ensures that each installed length is free of gaps, seams, dry spots, lifts, or delaminations, thereby achieving the intended performance and safety standards. Incorporating ASTM F3541 not only mitigates confusion but also supports more efficient and reliable rehabilitation processes.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

None noted.

Impact to building and property owners relative to cost of compliance with code

None noted.

Impact to industry relative to the cost of compliance with code

None noted.

Impact to small business relative to the cost of compliance with code

There is no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The change links directly to public health by ensuring leak-free, safe pipelines. Incorporating ASTM F3541 reduces hazards and supports effective rehabilitation, thereby protecting the community’s health, safety, and welfare.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Including ASTM F3541 strengthens the code by aligning with proven, flexible repair methods. It enables sectional repairs that meet or exceed current standards without enforcing impractical continuous lining, ensuring better construction.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Adding ASTM F3541 alongside existing standards is technology-neutral. It does not favor any specific method, material, or product, ensuring all proven approaches remain acceptable and encouraging fair competition.

Does not degrade the effectiveness of the code

The modification preserves the code’s effectiveness by clarifying acceptable repair methods without lowering performance standards. It maintains rigorous safety and quality, avoiding ambiguities that could compromise system integrity.

1st Comment Period History

P11834-A5

Proponent Steve Medley **Submitted** 4/14/2025 5:56:18 PM **Attachments** Yes

Rationale:

ASTM F3541 is for segmental relining by CIPP and closely reflects the actual installation practices utilized within Building Sewer and Building Drain applications. ASTM F3541 includes by reference the same performance property requirements of ASTM F1743.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

Change is editorial in nature and as such has no impact.

Impact to building and property owners relative to cost of compliance with code

Change is editorial in nature and as such has no impact.

Impact to industry relative to the cost of compliance with code

Change is editorial in nature and as such has no impact.

Impact to small business relative to the cost of compliance with code

There is no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

Exhumation and replacement can have environmental and health impacts such as disruption of encapsulated asbestos, lead paint or other hazardous materials, requiring high remediation and disposal costs, as well as subjecting workers and facility occupants to unnecessary risks.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

ASTM F3541 is for segmental relining by CIPP and closely reflects the actual installation practices utilized within Building Sewer and Building Drain applications.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Does not discriminate.

Does not degrade the effectiveness of the code

Does not degrade the effectiveness of the code.

1st Comment Period History

P11834-G1

Proponent Michael Wilson Submitted 4/16/2025 6:33:51 PM Attachments Yes

Comment:

P11834-A5 – The recommendation to add ASTM F3541 into 718.1 is not consistent with the intent of 718.1 to “rehabilitate” building sewers and drainage piping. ASTM F3541 applies to a “Sectional Repair” using one “liner wrapped around a carrier device” to repair one defect in the host pipe. According to 5.1 “the liner will extend 1ft in all directions beyond the host pipe defect.” It is not “segmental” with multiple liner “segments” creating “Gaps” over branch fittings. The words “segment” and “segmental” do not appear in ASTM F3541, but “continuous” 6.7.1 and “reinstated with a remote control cutting device” 6.7.2 are required within ASTM F3541.

1st Comment Period History

P11834-G2

Proponent Michael Wilson Submitted 4/16/2025 6:55:20 PM Attachments Yes

Comment:

P11834-A6 – Petitioner has “preferences”, “personal knowledge”, and “experience” with the CIPP “Gapping” installation method that conflicts with ASTM F1216, CIPP Inversion, and ASTM F1743, CIPP Pull-in-Place. Petitioner feels the ASTM Standards are “impractical” and “not necessary”, although both ASTMs establish industry required Standards, supported by valid third-party certification for “Continuous” CIPP material installation methods as required by the Florida Building Code, ICC, and IPC. (See attached Illustration) There is NO ASTM that recognizes or references a CIPP material “Gapping” installation method. (See attached full General Comment Rationale)

P11834-A6Text Modification

718.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216, ~~or~~ ASTM F1743, or ASTM F3541.

718.1.1 The finished CIPP shall be continuous throughout each installation length, extending from service connection to service connection. Each continuous installation length shall be free of gaps, seams, dry spots, lifts, and delaminations.

Page: 1

Mod11834_A6_TextOfModification.pdf

P11834-A6Text Modification

718.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216, ~~or~~ ASTM F1743, or ASTM F3541.

718.1.1 The finished CIPP shall be continuous throughout each installation length, extending from service connection to service connection. Each continuous installation length shall be free of gaps, seams, dry spots, lifts, and delaminations.

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Mod_11834_A6_Text_PROPOSED MODIFICATION 718.1.pdf

P11834-A5Text Modification

718.1 Cured-in-place~~.~~ pipe. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216~~, 2022 or~~ ASTM F1743~~ 2022.~~ or ASTM F3541.

Page: 1

Mod11834_A5_TextOfModification.pdf

P11834Text Modification

718.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743. The finished resin-impregnated tube shall be continuous over the entire length of the installation or inversion run, with no gaps in coverage at branch or service connections.

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Mod11834_TextOfModification.pdf

P11834-G2General Comment

POLSINELLI

7676 Forsyth Boulevard, Suite 800, St. Louis, MO 63105 · (314) 889-8000

February 11, 2025

Ryan J. McCarty
(314) 622-6698
(314) 754-9186 Fax
rmccarty@polsinelli.com

Mr. Jeffrey D. Green, Esq.
Kaye Bender Rembaum, PL.
1200 Park Central Blvd. South
Pompano Beach, FL 33064

Re: Highland Towers, Inc. Warranty Demand

Dear Mr. Green:

My firm represents Perma-Liner Industries, LLC ("**PLI**"). I am in receipt of your letter to Jerry S. D'Hulster dated January 10, 2025, regarding my client's product installed at Highland Towers, Inc.'s ("**Highland**") property located at 2921 S. Ocean Blvd., Highland Beach, FL 33404 (the "**Property**"). PLI rejects Highland's purported warranty claim because the materials cited in your letter clearly demonstrate that any alleged problems with the cured-in-place pipe materials ("**CIPP**") at the Property were caused by improper installation, not defective product, thereby negating the warranty.

PLI's warranty clearly states: "[PLI] warrants that the cured-in-place pipe materials (the "Materials"), ***when properly maintained and installed***, will be free from defects in material and workmanship for ten (10) years from the date of delivery to PLI's customer.... PLI warrants to Customer that, ***when installed in accordance with applicable PLI standard operating procedures***, the Materials are manufactured and supplied to the requirements of ASTMF1216...."

As you noted in your letter, which is also confirmed by the Crain Atlantis Engineering report ("**Crain Report**"), the installer, [redacted], improperly used the "non-code compliant, GAP method" to install the product. The GAP method violates code, is not consistent with industry standard for installation of CIPP, violates PLI's standard operating procedures provided to installers (see enclosure) and, consequently, negates any warranty. The Crain Report also clearly indicates that the "Plumbing Contractor" improperly installed the CIPP and the deficient installation is the source of the current problems:

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Mod_11834_G2_General_Redacted Warranty Demand Perma-Liner.pdf

P11834-G2General Comment

POLSINELLI.

The Highland Towers sanitary piping system is failing and the non FBC CODE COMPLIANT Pull in Place GAP method utilized by [redacted] Plumbing Contractor does not meet the Highland Towers expectations for the sanitary systems extended useful life.
The installed GAP method has resulted in liner deterioration, bulges, subsequent blockage and non-lined branch connections.

The video inspections revealed that the GAP repair method used by [redacted] evidenced failing of the liner at the terminations within the piping and liner "blow outs" bulges creating flow restrictions in the piping with the potential for complete blockage of the affected sanitary system.

On Wednesday, October 16, 2024, a section of the pipe riser located in the laundry room was cut and sampled to evaluate the liner condition. The assessment indicated that the liner installation was deficient.

It is apparent that the Pull in Place, GAP, start and start method is failing. The GAP method also allows the unlined locations of the existing piping at the branch connections to remain a candidate for future probable failures. The gaps occur at the branch connections of the sanitary piping systems.

See Crain Report at pages 3 & 8.

Furthermore, the fourth image of Exhibit A to the Crain Report identifies debris on the edge of the gapped liner which appears to extend behind the liner as inferred by the liner "bulges" apparent at the identified locations. Such debris should have been cleaned prior to liner installation, resulting in a smooth, continuous repair with no discontinuities in its circularity. Failure to properly clean the pipe prior to installing CIPP also negates the warranty because subsequent failures are caused by installation and not defective product. Failure to sufficiently clean the pipes prior to installation is also likely a demonstrable breach of [redacted] contract with Highland. *See* Section II.

For the foregoing reasons, PLI firmly rejects Highland's warranty demand and suggests that Highland look to the installer for any remedy to address the issues it is experiencing at the Property.

Please direct all future communication on this issue to me.

Sincerely

Ryan J. McCarty

RJM:da

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Mod_11834_G2_General_Redacted Warranty Demand Perma-Liner.pdf

P11834-G2General Comment

SPECIFICATIONS FOR INSTALLING CURED-IN-PLACE-PIPE (CIPP) DRAIN, WASTE, AND VENT PIPE LINING USING THE PULL-IN-PLACE METHOD FOR REHABILITATION OF EXISTING PIPELINES

1.00 ***Intent***

The intent of this cured-in-place lateral lining specification is to provide reconstruction of sewer collection drain, waste and vent pipelines without excavating the entire existing pipeline.

2.00 ***General***

The existing pipe reconstruction will be accomplished using a liner tube measured to exact length and inside diameter utilizing a thermosetting resin that meets required physical and chemical resistance properties. The liner will be impregnated with resin then dropped into the pipe opening. A pre-strung cable or winch line will be used to pull the liner and bladder into place. Once in place, an internal rubber bladder will be inflated to allow the liner to hold its shape against the host pipe as the resin cures. At no time during the cure will the bladder lose air pressure and be re-pressurized. Once the liner is fully cured, the bladder is removed. The sewer lateral collection pipe will be immediately televised for the inspector's approval. A copy of the televised inspection must be recorded on VHS or DVD format for future reference.

3.1 ***Materials***

The liner tube will consist of a needled felt. The liner tube will be fabricated together using a butt stitched seam sealing process with a heat welded sealing tape to ensure airtight seal. The liner tube is to be manufactured in the United States by Perma-Liner Industries, LLC. The liner tube will be capable of carrying resin and withstanding installation pressures and curing temperatures. The liner tube will be lined on one side with a translucent impermeable chemically resistant polyurethane (PU) waterproof coating. An internal bladder must come inside of the liner material. This bladder may consist of a rubber or vinyl calibration hose material.

The resin will be a two-part, 100% solids epoxy containing no styrene. No styrene based resin will be accepted due to its change in volume during polymerization. The epoxy resin shall be formulated to have a gel (pot) life of approximately 30 minutes with a set cure time of three (3) hours. The epoxy shall ambient cure by internal exothermic chemical reaction. External heat processes using hot water or steam to lower cure times will be accepted.

The seam stitched / heat welded seam tape / felt liner tube and resin will upon installation meet and/or exceed minimum testing standards as required by ASTM, IAPMO and ANSI/NSF International. All materials must have 3rd party testing provided by an independent a2La accredited laboratory completed within one year of the bid completion date.

3.2

Required Cured-In-Place Lateral Lining Standards		Minimum(ASTM F 1216/ 1743)
Flexural Strength	(ASTM D-790)	4,500 PSI
Flexural Modulus	(ASTM D-790)	250,000 PSI
Tensile Strength	(ASTM D-638)	3,000 PSI
Tensile Elongation	(ASTM D-638)	5 PSI
Compressive Strength	(ASTM D-695)	4,000 PSI
Chemical Resistance	(ASTM D-543)	> 20% loss
Leakage Test*	(NSF Standard 14)	0/gal/in/day

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P11834-G2General Comment

Manufacturer must have United States based manufacturing head quarters. The manufacturer must have at least 10 years of manufacturing / supplying C.I.P.P. Air Inversion or Pull In Place Liner Tube and Materials. The manufacturing plant has a Quality Assurance / Quality Control program in place and audited a minimum of once per year by NSF International, IAPMO R&T Laboratories, and the International Code Council.

4.1 ***Pull-In-Place Process***

Standard Practice for Rehabilitation of Existing Drain, Waste, Vent Pipelines and Conduits by Pulled-In-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

4.2 The owner shall be notified 24 hours in advance of project start time. No building utilities, such as toilets, sinks, dishwasher, laundry washer, bath tubs or sump pumps will be used during the installation and curing process. It is up to the contractor to determine if water supply should be temporarily shut down. Generally no by-pass pumping is needed.

4.3 Lateral sewer collection pipe must be cleaned thoroughly prior to installation of liner. All sand, rocks, gravel, grease, mud, sludge, and other debris must be removed from the invert to permit proper installation. Roots will need to be removed to the extent necessary to effectively line the entire pipe.

4.4 The existing lateral sewer collection pipe will be inspected using a mini-televising color camera system capable of viewing the interior condition of the host pipe by a trained technician. The TV inspection must be performed within 5 hours prior to installation of liner tube. All obstacles should be noted.

4.5 The resin and liner material will not be contaminated and/or diluted prior to installation.

4.6 Resin impregnation must be performed on site prior to installation into the pipe or conduit. Visual inspection must yield no dry spots in the liner. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material at nominal thickness and diameter. The volume should be adjusted by adding 3-15% excess resin to allow for migration through the perforations of the fabric tube out onto the host pipe.

4.7 The liner tube will be lubricated with vegetable oil, this is done to help the liner slide into the host pipe, and to aid in preventing epoxy loss during movement. The liner tube will be pulled into place using a pre-strung winch or cable line. The liner tube will be open and not sealed off. The liner tube will be designed to fit tightly against the host pipe annular space and gaps. The bladder tube inside the liner will be inflated to ensure the liner is tight against the host pipe until fully cured. The resin-impregnated liner tube will cure within 4 hours without external heat sources.

4.8 External heat sources such as hot water and steam may be used to speed the cure of the liner. If either of these is used, a proper initial cure, post cure, and cool down process must be implemented to the resin manufacturer's specifications.

4.9 Once the curing process is finished, the internal bladder is removed and the lateral sewer collection pipe is immediately inspected for final acceptance. The new lined pipe will be free of any foreign objects providing a smooth, seamless and continuous lined pipe from entry point to main sewer connection pipe.

4.10 Any liner tube protruding from the lateral sewer collection pipe into the main sewer pipeline will be removed by remote robotic cutting equipment.

4.11 A final TV Inspection of the lined lateral collection sewer pipe will be recorded and provided to the owner for final approval.

5.1 ***Final Acceptance***

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P11834-G2General Comment

In addition to any specific acceptance criteria specified in the contract, the following standards shall be satisfied before final acceptance of the liner installation:

5.2 Finish

The finished pipe shall be continuous over the length of a run and be free from defects.

5.3 Defects

Any defects, which will affect the integrity of the installed pipe, will be repaired as directed by the owner.

5.4 Leakage

No visible leakage through the liner will be allowed.

5.5 Lateral Branch Pipe Reinstatement

In Vertical Pipe Applications, if the CIPP lined pipe requires reinstatement of lateral branch connections, Perma-Liner™ offers robotic equipment and training for the reinstatements.

In the absence of industry standards regarding the reinstatement of lateral branch connections in vertical pipelining applications, Perma-Liner™ does not publish guidelines or offer training on alternative reinstatement methods not offered by Perma-Liner™.

Perma-Liner™ is aware of alternative methods for reinstating lateral branch connections in vertical pipelining applications, such as "Start & Stop", "Gapping" and "Spin-Casting" methods. However, performing such methods could potentially void any warranty Perma-Liner supplies to our certified installers.

6.00 *Payment*

Payment for the work included in this section will be in accordance with the prices set forth in the contract for the quantity of work performed. Progress payments will be made monthly based on the work performed during that month.

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P11834-G2General Comment

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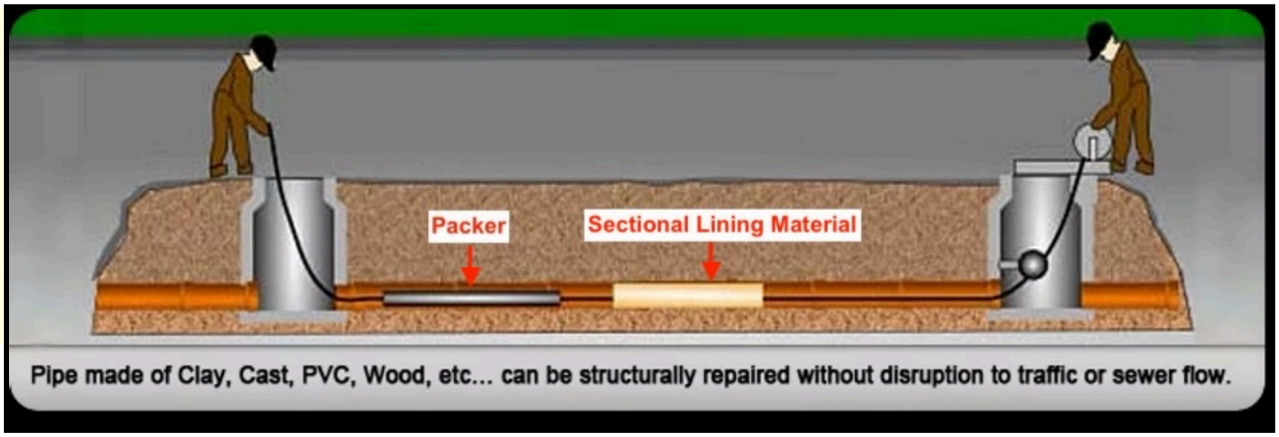

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Mod_11834_G2_General_Packer image for ASTM F3541.pdf

P11834-G2General Comment

General Comment

Rebuttal to P11834 - A6

Respondent has "preferences", "personal knowledge" and "experience" with the CIPP "Gapping" installation method that conflicts with ASTM F1216, CIPP Inversion, and ASTM F1743, CIPP Pull-in-Place. Respondent feels the ASTM Standards are "impractical" and "not necessary", although both ASTMs establish industry required Standards, supported by valid third-party certification for "Continuous" CIPP material installation methods as required by the Florida Building Code, ICC, and IPC. (See attached Illustration) **There is NO ASTM that recognizes or references a CIPP material "Gapping" installation method.**

"Continuous" CIPP material installation is a required "Standard" in all three ASTMs referenced by the Respondent:

*****ASTM F1216:**

7.8 Workmanship

*"The finished pipe shall be (**B) continuous over the entire length** of an inversion run and be free of dry spots, lifts, and delamination."*

*****ASTM F1743:**

6.8 Workmanship

*"The finished CIPP should be (**B) continuous over the entire length** of an installation and be free of dry spots, lifts, and delamination."*

*****ASTM F3541:**

6.7 Workmanship

*"The finished CIPP shall be **continuous over its entire length** and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations."*

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Mod_11834_G2_General_General Comment Rebuttal P11834-G2 to P11834 - A6.pdf

P11834-G2General Comment

***** See attached Illustration - "CONTINUOUS MATERIAL INSTALLATION"**

The Respondent disagrees with the dictionary definition and common understanding of the word "continuous": *"unbroken and uninterrupted*" and finds the ASTM Standard of "continuous over the entire length", as "impractical" and "not necessary", despite the clear language and requirement mandated by ASTM F1216 and ASTM F1743.

The Respondent's "preferences", "personal knowledge" and "experience" with the CIPP "Gapping" material installation method conflicts with the Florida Building Code **"Glitch Fix":**
2024 Supplement to the 8th Edition (2023) Florida Building Code
Effective date – April 16, 2024, 8th Edition (2023) Florida Building Code:

> **Chapter 7 -Sanitary Drainage**
> **718.1 Cured-in-place**. Cured-in-place rehabilitation of building sewers and building drainage piping ***shall be in accordance with ASTM F1216 or ASTM F1743.***
>
> **Chapter 30 – Sanitary Drainage**
> **P3012.1** Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping ***shall be in accordance with ASTM F1216 or ASTM F1743.***

The Respondent's recommendation to add ASTM F3541 into 718.1 is not consistent with the intent of 718.1 to **"rehabilitate"** building sewers and drainage piping.

ASTM F3541 – 1.1 applies to a single "Sectional **Repair**" using one "liner wrapped around a carrier device" to **repair one defect in the host pipe**.

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P11834-G2General Comment

ASTM F3541 - 1.1 is approved for pipe sizes "3 in. to 60 in.", and **does NOT allow** for use in 2" pipe as stated in Respondent's statement **"i. Capability to install 2" liners"**

ASTM F3541 - 5.1 states "the liner will extend 1ft in all directions beyond the host pipe **defect**." It is not "segmental" with multiple liner "segments" creating "Gaps" over branch fittings. The words "segment" and "segmental" do not appear in ASTM F3541. The ASTM F3541 liner is a single section of material installed to **repair one issue**, much like an external "Repair clamp"

ASTM F3541 6.6 **does not** support or approve "Gapped" or segmented CIPP lining material installation, instead it requires:
"6.6 Overlapping Installations—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end **with a minimum overlap to adjacent CIPP sections**".

ASTM F3541 - REQUIRES **CONTINUOUS** material installation
6.7 Workmanship:
6.7.1 The finished **CIPP shall be continuous over its entire length**

ASTM F3541 - DOES NOT promote "Gapping" the CIPP lining material on the "carrier device" in order to "Gap" fitting branches or service connections instead:
ASTM 3541 – 6.7.2 *Service Connections*—After the new CIPP has been

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Mod_11834_G2_General_General Comment Rebuttal P11834-G2 to P11834 - A6.pdf

P11834-G2General Comment

installed, any existing, active **service connections shall be <u>reinstated</u>**. This shall be performed……**by the means of….. a <u>remote control cutting device."</u>**

The Respondent's Page 1 Paragraph 3 comments: i. - viii. Reflect "preferences", "personal knowledge", and "experience" with CIPP material "Gapping" methods that conflict with industry accepted ASTM Standards and requirements established since the approval of ASTM F1216 in 1989. If the Respondent is determined to continue promoting CIPP "Gapping" material installation in the State of Florida he should petition the American Society for Testing and Materials for an ASTM that specifically addresses the CIPP "Gapping" installation methods that will allow for "third-party certification", FBC approvals, and a legitimate Manufacturer's material warranty*** in order to protect the Florida Consumer. Currently there are NO ASTM Standards that approve or endorse the CIPP "Gapping" material installation method.

*** See the attached recent Perma-Liner Industries WARRANTY DENIAL letter for the "Gapping" of their CIPP material. Perma-Liner Industries is the largest manufacturer of CIPP lining material in the State of Florida and their material is widely used in the State of Florida by small diameter pipe lining contractors.

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Mod_11834_G2_General_General Comment Rebuttal P11834-G2 to P11834 - A6.pdf

P11834-G2General Comment

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]

D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D4814 Specification for Automotive Spark-Ignition Engine Fuel

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

E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

Current edition approved Nov. 15, 2022. Published December 2022. Originally approved in 1996. Last previous edition approved in 2021 as F1743 – 21. DOI: 10.1520/F1743-22.

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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Mod_11834_G2_General_Exhibit B _ASTM F1743-22.pdf

P11834-G2General Comment

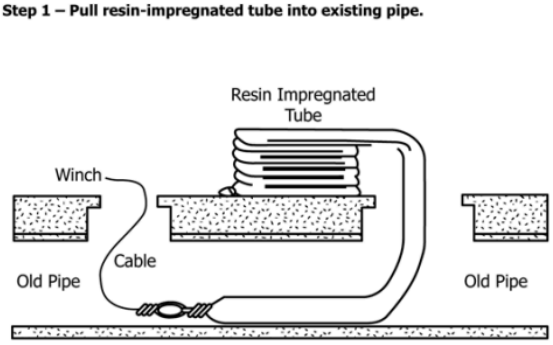

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F 6 3.6 °F (23 °C 6 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1216 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2]

This standard is issued under the fixed designation F1216; 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 reconstruction of pipelines and conduits (2 in. to 108 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water, introducing controlled steam within the tube, or by photoinitiated reaction. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process is used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe

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

E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standard:*[4]

M 28 Rehabilitation of Water Mains, Third Ed.

2.3 *NASSCO Standard:*[5]

Sewer Pipe Cleaning Specification Guideline

3. Terminology

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

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "*Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois*," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[3] 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.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] Available from the National Association of Sewer Service Companies, 5285 Westview Drive, Suite 202, Frederick, MD 21703. http://www.nassco.org/

***A Summary of Changes section appears at the end of this standard**

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3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—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.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.4 *photoinitiated reaction*—the polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube shall consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube and any non-structural plastic coating or flexible membrane included in the tube construction shall be compatible with the resin system used. The material shall be able to stretch to fit irregular pipe sections and negotiate bends. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance shall be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process shall be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The CIPP system shall be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties shall be determined in accordance with Section 8.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

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

7.1.2 *Cleaning of Pipeline*—All internal debris that will interfere with the installation or adversely affect the performance of the CIPP shall be removed from the original pipeline. Gravity pipes are cleaned with hydraulically powered equipment, high-velocity jet cleaners, mechanically powered equipment, or other applicable method(s) (see NASSCO Sewer Pipe Cleaning Specification Guideline). Pressure pipelines are cleaned with cable-attached devices, fluid-propelled devices, or other applicable method(s) (see Chapter 3 "Pipe Cleaning Methods" in AWWA, M 28 Rehabilitation of Water Mains, Third Ed.).

7.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or worker entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions shall be noted and corrected prior to installation of CIPP.

7.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % to ensure proper installation of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation shall be made to uncover and remove or repair the obstruction prior to the installation of the CIPP.

7.2 *Resin Impregnation*—The tube shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all the void space present in the tube material at nominal thickness and diameter. The volume shall be adjusted by adding excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

NOTE 1—In pipelines 8 in. diameter and less, 5 % to 10 % excess resin should be added.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the pump and bypass lines shall be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

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7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube shall be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head shall be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube shall be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube shall be turned inside out. The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions shall be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed.

NOTE 3—After inversion is completed, pressures can be adjusted to facilitate the safe installation of condensate removal equipment or other mechanisms required to transition to the curing process.

7.5 *Lubricant*—When lubricant is used to reduce friction during inversion, the lubricant shall be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used shall be a nontoxic product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.1.1 The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam-generating equipment is required and shall be capable of producing a sufficient amount of thermal energy throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The volume of air being sent through the pipe shall be sufficient to minimize condensation of the steam occurring during the curing. The temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.2.1 The steam-generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing steam. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the distribution of thermal energy via control of steam and air flow maintains the stated temperature. The curing of the CIPP must take into account the existing pipe material, the resin system, the current vertical alignment (that is, sags), and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.3 *Using Photoinitiated Reaction*—After the inversion is completed, while the tube is expanded under pressure, a light

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curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

7.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

7.6.3.2 *Processing*—Before the inversion begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

7.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

7.6.4 *Required Pressures*—The estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process shall be provided by the tube manufacturer and shall be increased to include consideration of the external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures shall be maintained until the cure has been completed. The pressure shall be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP shall be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 7.8 and Section 8.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113 °F (45 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care shall be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe shall be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes shall be sealed by an approved method using compatible materials, if required by the owner in contract documents.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the Contract documents or purchase order, the preparation of a CIPP sample is required, using one of the following two methods, depending on access and the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample shall be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 In medium and large-diameter applications and areas with limited access, the sample shall be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used. This method can also be used for sizes 18 in. or less, in situations where preparing samples in accordance with 8.1.1 can not be obtained due to physical constrains, if approved by the owner.

8.1.3 The samples for each of these cases shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures shall be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and shall meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength shall be measured for pressure pipe applications in accordance with Test Method D638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes shall be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test shall take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end shall not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe shall be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The

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leakage quantity shall be gauged by the water level in a temporary standpipe placed in the upstream plug. The test shall be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36-in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes shall be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test shall be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the owner in the contract documents or purchase order, a delamination test shall be performed on each inversion length specified. The CIPP samples shall be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample shall be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate shall be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchase and seller.

8.6.1 *Ultrasonic Testing of Wall Thickness*—An alternative method to 8.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797/E797M. A minimum of eight (8) evenly spaced measurements shall be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 in. to 18 in. from the end of the pipe. For pipe diameters of fifteen (15) in. or greater, a minimum of sixteen (16) evenly spaced measurements shall be recorded. The ultrasonic method to be used is the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of E797/E797M. A calibration block shall be manufactured from the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendations. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.7 *Inspection and Acceptance*—The installation shall be inspected visually if practical, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed through the CIPP itself. All service entrances shall be accounted for and be unobstructed.

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APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required.

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe*:

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N} \qquad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa), measured from the invert of the pipe
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
DR = dimension ratio of CIPP,
C = ovality reduction factor =

$$\left(\left[1-\frac{\Delta}{100}\right]/\left[1+\frac{\Delta}{100}\right]^2\right)^3$$

Δ = percentage ovality of original pipe equals

$$100 \times \frac{(Mean\ Inside\ Diameter - Minimum\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

or

$$100 \times \frac{(Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

and

N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum SDR of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\,\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR = \frac{\sigma_L}{PN} \qquad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter, in. (Inside Diameter of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, t, in.	Maximum Allowable Groundwater Load[A] (above invert)	
			ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A]Assumes K = 7.0, E = 125 000 psi (862 MPa) (50-year strength), ν = 0.30, C = 0.64 (5 % ovality), and N = 2.0

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$$q_t = \frac{1}{N}\left[32\,R_w\,B'\,E'_s \cdot C\left(E_L I/D^3\right)\right]^{1/2} \qquad \text{(X1.3)}$$

where:

q_t = total external pressure on pipe, psi (MPa),
= $0.433H_w + wHR_w/144 + W_s$, (English Units),
$0.00981H_w + wHR_w/1000 + W_s$, (Metric Units)
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
w = soil density, $lb.ft^3$ (KN/m^3),
W_s = live load, psi (Mpa),
H_w = height of water above top of pipe, ft (m)
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1 + 4e^{-0.065H})$ inch-pound units, $(1/(1 + 4e^{-0.213H})$ SI units
I = moment of inertia of CIPP, $in.^4/in.$ (mm^4/mm) = $t^3/12$,

t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long-term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm)

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093\ (inch - pound\ units), \qquad \text{(X1.4)}$$

or

$$\frac{E}{12(DR)^3} \geq 0.00064\ (SI\ units)$$

where:

E = initial modulus of elasticity, psi (MPa)

NOTE X1.3—For pipelines at depth not subject to construction disturbance, or if the pipeline was originally installed using tunneling method, the soil load may be calculated using a tunnel load analysis. Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eq X1.1 and X1.2.

X1.3 *Pressure Pipe*:

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eq X1.6 or Eq X1.7, as directed by Eq X1.5, and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eq X1.5-X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \qquad \text{(X1.5)}$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(DR-1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \qquad \text{(X1.6)}$$

where:

DR = dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eq X1.1, Eq X1.3, Eq X1.4, and Eq X1.7, and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(DR-2)\,N} \qquad \text{(X1.7)}$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
DR = dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of

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sizes from 2 in. to 108 in. diameter which would be impractical to list here.

X2. CHEMICAL-RESISTANCE TESTS

X2.1 *Scope*:

X2.1.1 This appendix covers the test procedures for chemical-resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical-Resistance Testing*:

X2.2.1 Chemical resistance tests should be completed in accordance with Practices D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical-resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical-resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–21) that may impact the use of this standard. (Approved August 15, 2022.)

(1) Changed non-mandatory wording to mandatory wording throughout the standard.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–16) that may impact the use of this standard. (Approved November 1, 2021.)

(1) Added 3.2.4 and 7.6.3.

(2) Section 7.6.4 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3541 – 22

Standard Practice for Sectional Repair of Existing Gravity Flow, Non-Pressure Pipelines and Conduits by Pushed or Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F3541; 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 sectional repair of gravity flow, non-pressure pipelines and conduits 3 in. to 60 in. (75 mm to 1500 mm) diameter by the installation of a resin-saturated liner which is placed onto or wrapped around a carrier device, pushed or pulled into an existing pipeline or conduit and expanded against the interior of the host pipe or conduit with air pressure. The resin is cured under ambient conditions, by photoinitiated reaction or with the application of heat. When cured, the finished sectional repair will be tight-fitting across its installed length. This repair process is used in a variety of gravity flow, non-pressure applications such as sanitary sewers, storm sewers, drains, electrical conduits and ventilation systems.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D578/D578M Specification for Glass Fiber Strands

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

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

F2019 Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method

2.2 *ASCE Standard:*[3]

Manual of Practice 145, Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

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2.3 *ISO Standard:*[4]

ISO 11296-4 , Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes

2.4 *NSF Standard:*[5]

NSF/ANSI-14 , SE10990 – Rehabilitation by Point Repair of Existing Pipe

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binding material, n*—A material utilized to secure the resin-saturated liner to the carrier device prior to placement into the pipeline.

3.2.1.1 *Discussion*—Examples include, but are not limited to, wire, nylon ties, adhesive tape or elastomeric bands.

3.2.2 *carrier device, n*—An apparatus utilized to deliver the resin-saturated liner to a section of host pipe identified for repair by pushing or pulling force.

3.2.3 *catalyst, n*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

3.2.4 *cured-in-place pipe (CIPP), n*—A hollow cylinder consisting of a liner cured (cross-linked) with a thermosetting resin. The CIPP is installed inside an existing pipe and pressed against the pipe interior to form a tight fit.

3.2.5 *delamination, n*—Separation of layers of the CIPP.

3.2.6 *design reconciliation, n*—A process conducted post-construction to determine whether the original design objectives for the installation have been met.

3.2.6.1 *Discussion*—Design reconciliation is completed to assess the net impact of post-construction variations present including fit, finish, wall thickness and mechanical properties on the installed product's ability to conform to design requirements as established by the owner or engineer.

3.2.7 *dry spot, n*—An area of the installed CIPP which is deficient or void of resin.

3.2.8 *lift, n*—A portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.9 *photoinitiated reaction, n*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

3.2.10 *protective membrane, n*—An impermeable polymer sleeve or film that is used to prevent resin contact with the carrier device, resin contamination or washout, when required, is properly sized for the host pipe diameter, and is designed to accommodate the application, installation, resin system and curing process.

3.2.11 *release agent, n*—A non-reactive, sacrificial chemical applied to a surface to prevent bonding.

3.2.12 *tight-fitting, adj*—conformance of a lining system to the host pipe interior geometry whereas intimate contact is realized across the entire perimeter.

3.2.13 *wellpoint system, n*—A series of closely spaced, small diameter, shallow wells connected to a common header pipe and pumped with a high-efficiency vacuum dewatering pump.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of gravity flow, non-pressure pipes through the use of a resin-saturated liner installed within a section of damaged or leaking existing pipe. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Liner*—The liner utilized shall consist of one or more layers of fiberglass matting, reinforced composite, flexible needled felt or an equivalent nonwoven or woven material, or a combination thereof. The liner shall be capable of carrying resin, withstanding installation pressures and curing temperatures, bridging pipe defects, conforming to irregular shapes and negotiating bends as applicable. The liner shall be a manufactured tube or an overlapping flat sheet, with or without a plastic coating, that is compatible with the resin system used, and fabricated to a size that, when installed, will be tight-fitting across the entire length identified for sectional repair. The liner shall be appropriately sized to extend at least 1 ft (0.30 m) in all directions beyond the limits of the host pipe defect when installed.

5.1.1 *Fiberglass Matting*—Chemically resistant E-CR fiberglass meeting Specification D578/D578M or similar material meeting the requirements herein; consisting of single or multiple layers of woven or nonwoven material, with or without chopped strand mat.

5.1.2 *Reinforced Composite*—Needled felt, or an equivalent woven or non-woven material, with E-CR fiberglass meeting Specification D578/D578M or similar reinforcement material meeting the requirements herein.

5.1.3 *Overlapping Flat Sheet*—Liners designed as overlapping flat sheets having a minimum circumference = $\pi \times D_i \times 1.1$, where D_i = inside diameter of the host pipe. When multiple layers of liner are required to achieve the desired thickness, the ends of the liner are tapered as required to obtain a smooth transition to the host pipe by adding additional layers in a stepwise fashion in accordance with the manufacturer's guidelines such that each subsequent layer is slightly longer than the adjacent, underlying layer.

5.1.4 *Manufactured Tubes*—Liners manufactured as tubes shall be sized per the manufacturer's recommendations relative to the host pipe inside diameter to permit radial expansion and a tight fit against the host pipe during installation and cure.

5.1.5 *Resin*—A chemically resistant, thermosetting resin and catalyst system that is cured under ambient conditions, by

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

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photoinitiated reaction or with the application of heat and is compatible with the installation process shall be used. Resin systems that are heat cured shall have an initiating temperature less than 180 °F (82 °C).

5.2 *CIPP System:*

5.2.1 *Mechanical Properties*—The CIPP system shall have as a minimum the initial mechanical properties given in Table 1. These mechanical properties shall be determined in accordance with Section 7.

6. Installation

6.1 *Cleaning and Pre-Inspection:*

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

6.1.2 *Cleaning of Pipeline*—To the extent practical, all internal debris shall be removed from the original pipeline using hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television (CCTV) or worker-entry techniques. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that will prevent proper installation of the resin-saturated liner. The manufacturer shall provide guidance as needed to determine whether existing conditions will prohibit a successful installation or if additional measures are necessary in advance of lining. This includes addressing points of infiltration that will cause resin wash out or adversely impact the cure and finished quality of the CIPP sectional repair. Corrective actions include, but are not limited to, injecting chemical grout, dewatering using a wellpoint system, or utilizing a protective membrane as defined in 3.2.10 and described in 6.4.4.

6.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions that will hinder or prevent the installation of the resin-saturated liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, a point repair excavation shall be made to uncover and remove or repair the obstruction.

6.2 *Resin Saturation*—The liner shall be fully saturated with resin (wet out) under controlled conditions and free of any dry spots or resin lean areas. The resin system shall be proportionally mixed, handled and applied in accordance with manufacturer's recommendations. The volume of resin used shall be sufficient to fully saturate the liner material and shall be adjusted by adding excess resin to account for the change in resin volume due to polymerization, to allow for migration of resin into the cracks and joints in the original pipe, and to account for any resin loss expected during the liner insertion process. For each CIPP installation, wet out data shall be recorded and retained by the user for quality assurance and record keeping purposes, and submitted to the purchaser as required.

TABLE 1 CIPP Initial Mechanical Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural Strength[B]	D790	Declared value, but not less than 4 500	Declared value, but not less than 31
Flexural Modulus[B]	D790	Declared value, but not less than 250 000	Declared value, but not less than 1 724

[A] The values in Table 1 are for test results on field specimens. The purchaser shall consult the manufacturer for the long-term mechanical properties.
[B] The value indicates minimum strength in the circumferential direction.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass shall be made by capturing flow from all contributing points upstream of the pipe to be reconstructed and discharging the flow to a downstream point or adjacent system. The bypass pumping and piping system shall be of adequate capacity and size to handle the flow. Prior to cleaning and pre-inspection and during installation, all upstream contributing flows impacting the repair area shall be isolated and bypassed around the repair area. Bypassing shall be coordinated between all parties involved.

6.3.1 Public advisory services shall be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the pipeline is back in service.

6.4 *Liner Insertion:*

6.4.1 The carrier device shall be able to navigate the host pipe alignment and geometry to the point of installation without compromise to the host pipe, installation process or finished quality of the CIPP; shall be designed to expand with air pressure to press the resin-saturated liner tightly against the interior of the host pipe for the duration of cure; shall be compatible with the curing process; and, when required, shall have flow-thru capabilities for flow control.

6.4.2 When required, a protective membrane shall be secured to the carrier device and a compatible release agent shall be liberally applied to its entire surface area as required.

6.4.3 The resin-saturated liner shall be centered and rolled tightly against the carrier device and secured with binding material. The binding material shall be placed approximately 1 in. (25 mm) from each end of the liner and spaced along the remaining length of the repair, typically 1.5 ft to 2.0 ft (0.46 m to 0.61 m) apart; shall be used to secure the leading edge of the liner to the front of the carrier device as required to ensure the liner's position is maintained as it is pushed or pulled into the host pipe; and shall be designed to release or break under tension when the carrier device is pressurized and the resin-saturated liner is expanded against the host pipe.

6.4.4 When required, to prevent resin contamination or washout and as directed by the manufacturer, a protective membrane shall be attached to the resin-saturated liner across the affected area.

6.4.5 The resin-saturated liner shall be positioned into the host pipe using push rods or a winching process. Prior to insertion and as directed by the manufacturer, the carrier device shall be inflated to a low pressure to increase rigidity and reduce material drag along the pipe invert. The carrier device

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shall be equipped with adequate air supply for proper inflation and full expansion of the liner against the host pipe interior for the duration of cure.

6.4.6 CCTV inspection shall be conducted concurrently with the placement of the resin-saturated liner to verify proper positioning and the host pipe condition and resin saturation in accordance with 6.2 prior to inflation and cure.

6.5 *Curing*—The resin-saturated liner shall be cured in accordance with manufacturer's recommendations, and the curing process shall be documented and submitted to the purchaser as required. The estimated minimum and maximum pressures recommended to form a tight-fitting liner against the existing pipe during the curing process shall be provided by the manufacturer.

6.5.1 *Using Air or Air/Steam*—Curing of the resin-saturated liner shall be accomplished without pressure interruption with air or a mixture of air and steam for the duration of time in accordance with the manufacturer's recommendations for a complete cure. For CIPP cured under ambient conditions, to the extent practical, a representative coupon of the resin impregnated liner suspended at the access point shall be used to confirm curing time as required.

6.5.2 *Using Photoinitiated Reaction*—While the liner is expanded under pressure against the host pipe, a CCTV inspection shall be performed to verify that the liner is properly positioned and tight-fitting. Any anomalies shall be corrected prior to initiating the curing process.

6.5.2.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photoinitiators shall be optimized to the output of the curing lights.

6.5.2.2 For dynamic curing processes, the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific liner dimensions to initiate polymerization and facilitate the cure of the CIPP resin.

6.5.2.3 A full curing protocol shall be provided by the manufacturer and be recorded and maintained as documentation verifying the curing process. As a minimum, data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, and the power output of the light assembly.

6.6 *Overlapping Installations*—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end with a minimum overlap to adjacent CIPP sections in accordance with manufacturer's recommendations. To the extent practical, installations shall progress from the furthest point downstream towards the upstream end so that overlapping ends of the CIPP are streamlined with the flow.

6.7 *Workmanship:*

6.7.1 The finished CIPP shall be continuous over its entire length and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations. If these conditions are present, CIPP in these areas shall be removed and replaced. The CIPP shall be tight-fitting against the host pipe at its termination points with transitions at each end that do not create a ledge, a change in direction of flow, or a location where debris will accumulate during uniform flow conditions. In sections of pipe of constant internal diameter and straight alignment, the CIPP shall not introduce surface irregularities in addition to those of the host pipe which exceed 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater. Applications where surface irregularities exceeding 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater, are anticipated due to geometric features, condition or alignment of the host pipe shall be evaluated by the owner, engineer and manufacturer to determine feasibility and compliance of this practice. Examples include CIPP that is installed through bends, joint offsets, diameter transitions and other discontinuities in the host pipe which can result in localized radial or longitudinal fins or folds, or other surface irregularities in the CIPP.

6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active service connections shall be reinstated. This shall be performed without excavation and, in cases of non-worker-entry sized pipes, from the interior of the pipeline by the means of CCTV inspection and a remote-control cutting device. Reinstated service connections shall be cut smooth and free of burrs and rough edges. All laterals where a plug by the end of the lateral was not visible by the pre-inspection shall be reinstated if the purchase agreement does not specify it differently.

7. Inspection Practices

7.1 *Sampling*—CIPP samples for mechanical properties testing shall be prepared when required and as directed by the engineer or purchaser. Representative samples of the resin-saturated liner shall be restrained in a like diameter pipe or prepared in a clamped mold and cured in the same manner as the installed CIPP. Samples shall be prepared in a manhole or other point of access, or under simulated conditions above ground, and shall be of adequate size to perform flexural properties testing as described in 7.2.

7.2 *Short-Term Flexural (Bending) Properties*—For isotropic materials, the tangent flexural modulus of elasticity and flexural strength shall be measured in accordance with Test Method D790. For anisotropic composites, flexural testing shall be conducted in the hoop direction on specimens cut from plate samples in accordance with Test Method D790 or on curved beam specimens cut from restrained samples in accordance with the modified Test Method D790 method as described in Annex B of ISO 11296-4 and Practice F2019, Appendix X2. Flexural properties shall meet or exceed values listed in Table 1.

7.3 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 7.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and

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shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. If minimum wall thickness requirements are not met, a design reconciliation shall be performed. If it is determined through design reconciliation that the installed CIPP is non-compliant, the designer or purchaser shall determine whether corrective action is necessary.

7.4 *Inspection and Acceptance*—The CIPP installation shall be inspected visually if appropriate or by CCTV inspection if visual inspection cannot be accomplished. No infiltration of groundwater shall be observed. The CIPP shall comply with 6.7.

8. Keywords

8.1 ambient cure; binding material; CIPP; carrier device; cured-in-place pipe; design reconciliation; E-CR; fiberglass matting; photoinitiated reaction; protective membrane; reinforced composite; release agent; sealing mechanism; sectional repair; silicate resin; tight-fitting; wellpoint system

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 During the initial design phase, consideration should be given to anchoring mechanisms required to limit downstream movement or dislodging of the CIPP sectional repair once it is put into service, which is of particular importance on lines with steep slopes, high velocity flows, surcharge conditions or broad temperature swings. The selected CIPP sectional repair system should align with design objectives for each application (for example, thermal properties or minimum levels of adhesion), and should be demonstrated through proper host pipe preparation and installation practice in accordance with this standard and manufacturer's guidelines.

X1.2 For circular host pipes with up to 10% ovality, the CIPP system should be designed for minimum wall thickness in accordance with ASCE Manual of Practice 145 or, alternatively, Practice F1216, Appendix X1, with the exception that Eq. X1.2 and X1.4 be excluded from the calculations. For non-circular host pipes or circular host pipes with greater than 10 % ovality, the design method described in ASCE Manual of Practice 145 is recommended. The design of the CIPP shall take into consideration the type of deterioration or damage to the existing pipe as well as relevant hydrostatic, soil and live loads.

X1.3 Further, when Practice F1216 is used for design, note X1.2 of Practice F1216 suggesting a maximum SDR of 100 be used for liners installed in pipes where the groundwater is not above the pipe invert shall be ignored. Instead, the partially deteriorated design shall be determined by using F1216, Eq X1.1 with the actual groundwater load or, in the case of no groundwater being present, a virtual groundwater load equal to a minimum of 5.0 ft (1.5 m) above the pipe invert or at least 0.33 ft (0.10 m) above the crown of the liner – whichever is greater (but in no case should this height exceed the cover depth of the host pipe). The fully deteriorated design condition shall be determined using F1216, Eq X1.3 with H_w being the height of the groundwater above the invert of the pipe.

X2. CHEMICAL RESISTANCE TESTS

Scope:

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

Procedure for Chemical Resistance Testing:

X2.2.1 Chemical resistance tests should be completed in accordance with Practice D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with 7.2 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

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serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

X3. CERTIFICATIONS

X3.1 The CIPP system may comply with NSF/ANSI-14 and may be tested and certified to be in compliance with NSF SE 10990.

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CONTINUOUS MATERIAL INSTALLATION

EXHIBIT D
PG. 1 of 1

Inverted "Continuous" Liner
ASTM F1216

7.4.2 Using Air Pressure...

"The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from ***point of inversion to point of termination*** *and hold the tube tight to the pipe wall,* ***(A) producing dimples at side connections."***

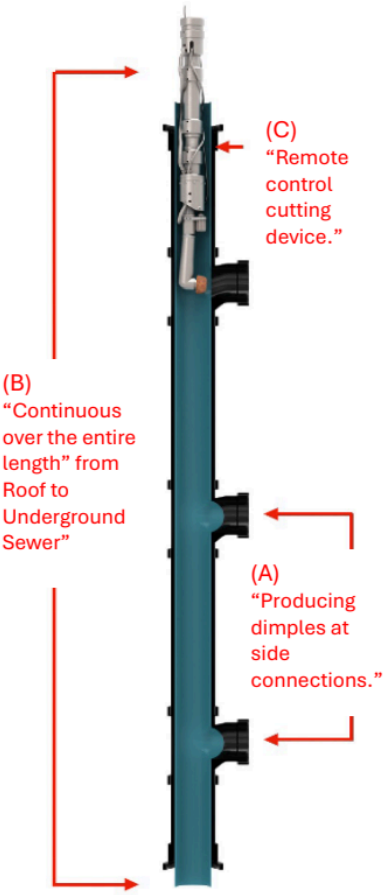
("Dimples" identify Branch Connections to be robotically reinstated not gapped.)

7.8 Workmanship

"The finished pipe shall be ***(B) continuous over the entire length*** *of an inversion run and be free of dry spots, lifts, and delamination."*

7.9 Service Connections

"After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a ***(C) remote-control cutting device."***



Pulled-in-Place "Continuous" Liner
ASTM F1743

6.4.2 Pulling Resin-Impregnated Tube into Position...

"The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point... ***(A) producing dimples at side connections."***

("Dimples" identify Branch Connections to be robotically reinstated not gapped.)

6.8 Workmanship

"The finished CIPP should be ***(B) continuous over the entire length*** *of an installation and be free of dry spots, lifts, and delamination."*

6.9 Service Connections

"After the new CIPP has been installed, the existing active (or inactive) service connection should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a ***(C) remote-control cutting device.*** *Service connections shall be reinstated to at least 90% of the original area as it enters the host pipe or conduit."*

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7676 Forsyth Boulevard, Suite 800, St. Louis, MO 63105 · (314) 889-8000

February 11, 2025

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Mr. Jeffrey D. Green, Esq.
Kaye Bender Rembaum, PL.
1200 Park Central Blvd. South
Pompano Beach, FL 33064

Re: Highland Towers, Inc. Warranty Demand

Dear Mr. Green:

My firm represents Perma-Liner Industries, LLC ("**PLI**"). I am in receipt of your letter to Jerry S. D'Hulster dated January 10, 2025, regarding my client's product installed at Highland Towers, Inc.'s ("**Highland**") property located at 2921 S. Ocean Blvd., Highland Beach, FL 33404 (the "**Property**"). PLI rejects Highland's purported warranty claim because the materials cited in your letter clearly demonstrate that any alleged problems with the cured-in-place pipe materials ("**CIPP**") at the Property were caused by improper installation, not defective product, thereby negating the warranty.

PLI's warranty clearly states: "[PLI] warrants that the cured-in-place pipe materials (the "Materials"), ***when properly maintained and installed***, will be free from defects in material and workmanship for ten (10) years from the date of delivery to PLI's customer.... PLI warrants to Customer that, ***when installed in accordance with applicable PLI standard operating procedures***, the Materials are manufactured and supplied to the requirements of ASTMF1216...."

As you noted in your letter, which is also confirmed by the Crain Atlantis Engineering report ("**Crain Report**"), the installer, [redacted], improperly used the "non-code compliant, GAP method" to install the product. The GAP method violates code, is not consistent with industry standard for installation of CIPP, violates PLI's standard operating procedures provided to installers (see enclosure) and, consequently, negates any warranty. The Crain Report also clearly indicates that the "Plumbing Contractor" improperly installed the CIPP and the deficient installation is the source of the current problems:

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POLSINELLI.

The Highland Towers sanitary piping system is failing and the non FBC CODE COMPLIANT Pull in Place GAP method utilized by [redacted] Plumbing Contractor does not meet the Highland Towers expectations for the sanitary systems extended useful life.
The installed GAP method has resulted in liner deterioration, bulges, subsequent blockage and non-lined branch connections.

The video inspections revealed that the GAP repair method used by [redacted] evidenced failing of the liner at the terminations within the piping and liner "blow outs" bulges creating flow restrictions in the piping with the potential for complete blockage of the affected sanitary system.

On Wednesday, October 16, 2024, a section of the pipe riser located in the laundry room was cut and sampled to evaluate the liner condition. The assessment indicated that the liner installation was deficient.

It is apparent that the Pull in Place, GAP, start and start method is failing. The GAP method also allows the unlined locations of the existing piping at the branch connections to remain a candidate for future probable failures. The gaps occur at the branch connections of the sanitary piping systems.

See Crain Report at pages 3 & 8.

Furthermore, the fourth image of Exhibit A to the Crain Report identifies debris on the edge of the gapped liner which appears to extend behind the liner as inferred by the liner "bulges" apparent at the identified locations. Such debris should have been cleaned prior to liner installation, resulting in a smooth, continuous repair with no discontinuities in its circularity. Failure to properly clean the pipe prior to installing CIPP also negates the warranty because subsequent failures are caused by installation and not defective product. Failure to sufficiently clean the pipes prior to installation is also likely a demonstrable breach of [redacted] contract with Highland. *See* Section II.

For the foregoing reasons, PLI firmly rejects Highland's warranty demand and suggests that Highland look to the installer for any remedy to address the issues it is experiencing at the Property.

Please direct all future communication on this issue to me.

Sincerely

Ryan J. McCarty

RJM:da

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SPECIFICATIONS FOR INSTALLING CURED-IN-PLACE-PIPE (CIPP) DRAIN, WASTE, AND VENT PIPE LINING USING THE PULL-IN-PLACE METHOD FOR REHABILITATION OF EXISTING PIPELINES

1.00 ***Intent***

The intent of this cured-in-place lateral lining specification is to provide reconstruction of sewer collection drain, waste and vent pipelines without excavating the entire existing pipeline.

2.00 ***General***

The existing pipe reconstruction will be accomplished using a liner tube measured to exact length and inside diameter utilizing a thermosetting resin that meets required physical and chemical resistance properties. The liner will be impregnated with resin then dropped into the pipe opening. A pre-strung cable or winch line will be used to pull the liner and bladder into place. Once in place, an internal rubber bladder will be inflated to allow the liner to hold its shape against the host pipe as the resin cures. At no time during the cure will the bladder lose air pressure and be re-pressurized. Once the liner is fully cured, the bladder is removed. The sewer lateral collection pipe will be immediately televised for the inspector's approval. A copy of the televised inspection must be recorded on VHS or DVD format for future reference.

3.1 ***Materials***

The liner tube will consist of a needled felt. The liner tube will be fabricated together using a butt stitched seam sealing process with a heat welded sealing tape to ensure airtight seal. The liner tube is to be manufactured in the United States by Perma-Liner Industries, LLC. The liner tube will be capable of carrying resin and withstanding installation pressures and curing temperatures. The liner tube will be lined on one side with a translucent impermeable chemically resistant polyurethane (PU) waterproof coating. An internal bladder must come inside of the liner material. This bladder may consist of a rubber or vinyl calibration hose material.

The resin will be a two-part, 100% solids epoxy containing no styrene. No styrene based resin will be accepted due to its change in volume during polymerization. The epoxy resin shall be formulated to have a gel (pot) life of approximately 30 minutes with a set cure time of three (3) hours. The epoxy shall ambient cure by internal exothermic chemical reaction. External heat processes using hot water or steam to lower cure times will be accepted.

The seam stitched / heat welded seam tape / felt liner tube and resin will upon installation meet and/or exceed minimum testing standards as required by ASTM, IAPMO and ANSI/NSF International. All materials must have 3rd party testing provided by an independent a2La accredited laboratory completed within one year of the bid completion date.

3.2

Required Cured-In-Place Lateral Lining Standards		Minimum(ASTM F 1216/ 1743)
Flexural Strength	(ASTM D-790)	4,500 PSI
Flexural Modulus	(ASTM D-790)	250,000 PSI
Tensile Strength	(ASTM D-638)	3,000 PSI
Tensile Elongation	(ASTM D-638)	5 PSI
Compressive Strength	(ASTM D-695)	4,000 PSI
Chemical Resistance	(ASTM D-543)	> 20% loss
Leakage Test*	(NSF Standard 14)	0/gal/in/day

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Manufacturer must have United States based manufacturing head quarters. The manufacturer must have at least 10 years of manufacturing / supplying C.I.P.P. Air Inversion or Pull In Place Liner Tube and Materials. The manufacturing plant has a Quality Assurance / Quality Control program in place and audited a minimum of once per year by NSF International, IAPMO R&T Laboratories, and the International Code Council.

4.1 ***Pull-In-Place Process***

Standard Practice for Rehabilitation of Existing Drain, Waste, Vent Pipelines and Conduits by Pulled-In-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

4.2 The owner shall be notified 24 hours in advance of project start time. No building utilities, such as toilets, sinks, dishwasher, laundry washer, bath tubs or sump pumps will be used during the installation and curing process. It is up to the contractor to determine if water supply should be temporarily shut down. Generally no by-pass pumping is needed.

4.3 Lateral sewer collection pipe must be cleaned thoroughly prior to installation of liner. All sand, rocks, gravel, grease, mud, sludge, and other debris must be removed from the invert to permit proper installation. Roots will need to be removed to the extent necessary to effectively line the entire pipe.

4.4 The existing lateral sewer collection pipe will be inspected using a mini-televising color camera system capable of viewing the interior condition of the host pipe by a trained technician. The TV inspection must be performed within 5 hours prior to installation of liner tube. All obstacles should be noted.

4.5 The resin and liner material will not be contaminated and/or diluted prior to installation.

4.6 Resin impregnation must be performed on site prior to installation into the pipe or conduit. Visual inspection must yield no dry spots in the liner. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material at nominal thickness and diameter. The volume should be adjusted by adding 3-15% excess resin to allow for migration through the perforations of the fabric tube out onto the host pipe.

4.7 The liner tube will be lubricated with vegetable oil, this is done to help the liner slide into the host pipe, and to aid in preventing epoxy loss during movement. The liner tube will be pulled into place using a pre-strung winch or cable line. The liner tube will be open and not sealed off. The liner tube will be designed to fit tightly against the host pipe annular space and gaps. The bladder tube inside the liner will be inflated to ensure the liner is tight against the host pipe until fully cured. The resin-impregnated liner tube will cure within 4 hours without external heat sources.

4.8 External heat sources such as hot water and steam may be used to speed the cure of the liner. If either of these is used, a proper initial cure, post cure, and cool down process must be implemented to the resin manufacturer's specifications.

4.9 Once the curing process is finished, the internal bladder is removed and the lateral sewer collection pipe is immediately inspected for final acceptance. The new lined pipe will be free of any foreign objects providing a smooth, seamless and continuous lined pipe from entry point to main sewer connection pipe.

4.10 Any liner tube protruding from the lateral sewer collection pipe into the main sewer pipeline will be removed by remote robotic cutting equipment.

4.11 A final TV Inspection of the lined lateral collection sewer pipe will be recorded and provided to the owner for final approval.

5.1 ***Final Acceptance***

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In addition to any specific acceptance criteria specified in the contract, the following standards shall be satisfied before final acceptance of the liner installation:

5.2 Finish

The finished pipe shall be continuous over the length of a run and be free from defects.

5.3 Defects

Any defects, which will affect the integrity of the installed pipe, will be repaired as directed by the owner.

5.4 Leakage

No visible leakage through the liner will be allowed.

5.5 Lateral Branch Pipe Reinstatement

In Vertical Pipe Applications, if the CIPP lined pipe requires reinstatement of lateral branch connections, Perma-Liner™ offers robotic equipment and training for the reinstatements.

In the absence of industry standards regarding the reinstatement of lateral branch connections in vertical pipelining applications, Perma-Liner™ does not publish guidelines or offer training on alternative reinstatement methods not offered by Perma-Liner™.

Perma-Liner™ is aware of alternative methods for reinstating lateral branch connections in vertical pipelining applications, such as "Start & Stop", "Gapping" and "Spin-Casting" methods. However, performing such methods could potentially void any warranty Perma-Liner supplies to our certified installers.

6.00 *Payment*

Payment for the work included in this section will be in accordance with the prices set forth in the contract for the quantity of work performed. Progress payments will be made monthly based on the work performed during that month.

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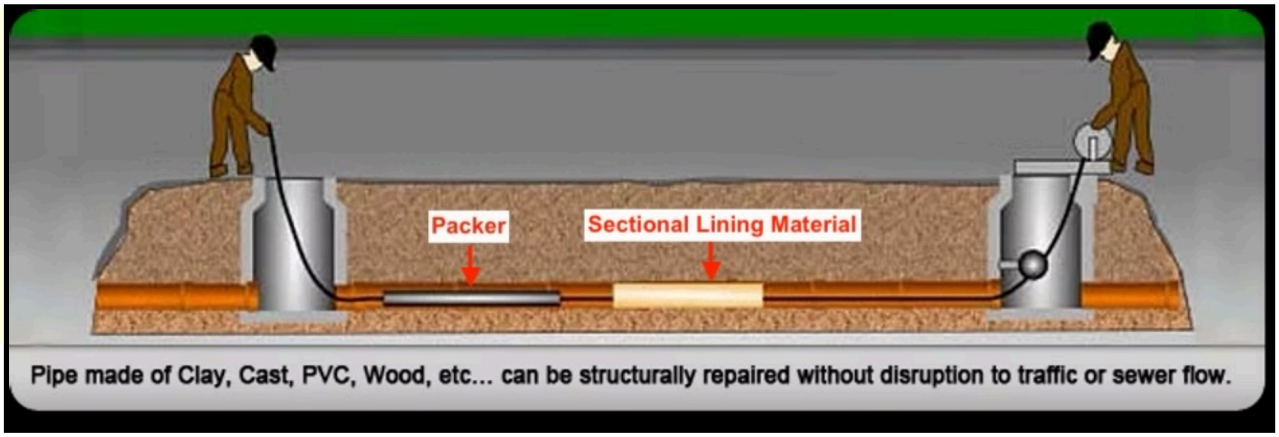

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General Comment

Rebuttal to P11834 – A5

The Respondent's recommendation to add ASTM F3541 to 718.1 is not consistent with the intent of 718.1 to **"rehabilitate"** building sewers and drainage piping.

ASTM F3541 – 1.1 applies to a single "Sectional **Repair**" using one "liner wrapped around a carrier device" to **repair one defect in the host pipe**.

ASTM F3541 - 1.1 is approved for pipe sizes "3 in. to 60 in.", and **does NOT allow** for use in 2" pipe as stated in Respondent's statement **"i. Capability to install 2" liners"**

ASTM F3541 - 5.1 states "the liner will extend 1ft in all directions beyond the host pipe **defect**." It is not "segmental" with multiple liner "segments" creating "Gaps" over branch fittings. The words "segment" and "segmental" do not appear in ASTM F3541. The ASTM F3541 liner is a single section of material installed to **repair one issue**, much like an external "Repair clamp"

ASTM F3541 6.6 **does not** support or approve "Gapped" or segmented CIPP lining material installation, instead it requires:

> **"6.6 Overlapping** Installations—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be

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accomplished by installing multiple repairs end-to-end **with a minimum overlap to adjacent CIPP sections**".

ASTM F3541 - REQUIRES **CONTINUOUS** material installation

6.7 Workmanship:

6.7.1 The finished **CIPP shall be <u>continuous</u> over its entire length**

ASTM F3541 - DOES NOT promote "Gapping" the CIPP lining material on the "carrier device" in order to "Gap" fitting branches or service connections instead:

ASTM 3541 – 6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active **service connections shall be <u>reinstated</u>**. This shall be performed……**by the means of….. a <u>remote control cutting device."</u>**

The Respondent's Page 1 Paragraph 3 comments: i. - viii. Reflect "preferences", "personal knowledge", and "experience" with CIPP material "Gapping" methods that conflict with industry accepted ASTM Standards and requirements established since the approval of ASTM F1216 in 1989. If the Respondent is determined to continue promoting CIPP "Gapping" material installation in the State of Florida he should petition the American Society for Testing and Materials for an ASTM that specifically addresses the CIPP material "Gapping" installation methods that will allow for "third-party certification", FBC approvals, and a legitimate Manufacturer's material warranty*** in order to protect the Florida Consumer. Currently there are NO ASTM Standards that approve or endorse the CIPP "Gapping" material installation method.

*** See the attached recent Perma-Liner Industries WARRANTY DENIAL letter for the "Gapping" of their CIPP material. Perma-Liner Industries is the largest

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manufacturer of CIPP lining material in the State of Florida and their material is widely used in the State of Florida by small diameter pipe lining contractors.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]

D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D4814 Specification for Automotive Spark-Ignition Engine Fuel

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

E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

Current edition approved Nov. 15, 2022. Published December 2022. Originally approved in 1996. Last previous edition approved in 2021 as F1743 – 21. DOI: 10.1520/F1743-22.

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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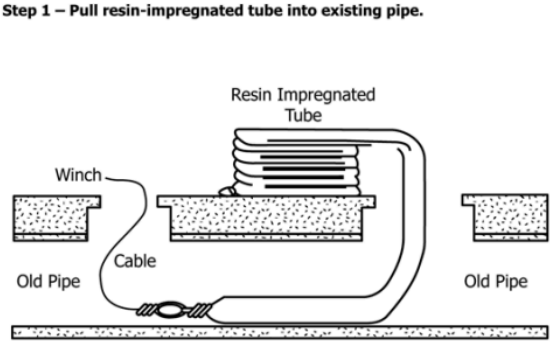

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F 6 3.6 °F (23 °C 6 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1216 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2]

This standard is issued under the fixed designation F1216; 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 reconstruction of pipelines and conduits (2 in. to 108 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water, introducing controlled steam within the tube, or by photoinitiated reaction. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process is used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe

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

E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standard:*[4]

M 28 Rehabilitation of Water Mains, Third Ed.

2.3 *NASSCO Standard:*[5]

Sewer Pipe Cleaning Specification Guideline

3. Terminology

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

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "*Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois*," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[3] 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.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] Available from the National Association of Sewer Service Companies, 5285 Westview Drive, Suite 202, Frederick, MD 21703. http://www.nassco.org/

***A Summary of Changes section appears at the end of this standard**

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3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—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.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.4 *photoinitiated reaction*—the polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube shall consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube and any non-structural plastic coating or flexible membrane included in the tube construction shall be compatible with the resin system used. The material shall be able to stretch to fit irregular pipe sections and negotiate bends. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance shall be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process shall be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The CIPP system shall be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties shall be determined in accordance with Section 8.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

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

7.1.2 *Cleaning of Pipeline*—All internal debris that will interfere with the installation or adversely affect the performance of the CIPP shall be removed from the original pipeline. Gravity pipes are cleaned with hydraulically powered equipment, high-velocity jet cleaners, mechanically powered equipment, or other applicable method(s) (see NASSCO Sewer Pipe Cleaning Specification Guideline). Pressure pipelines are cleaned with cable-attached devices, fluid-propelled devices, or other applicable method(s) (see Chapter 3 "Pipe Cleaning Methods" in AWWA, M 28 Rehabilitation of Water Mains, Third Ed.).

7.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or worker entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions shall be noted and corrected prior to installation of CIPP.

7.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % to ensure proper installation of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation shall be made to uncover and remove or repair the obstruction prior to the installation of the CIPP.

7.2 *Resin Impregnation*—The tube shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all the void space present in the tube material at nominal thickness and diameter. The volume shall be adjusted by adding excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

NOTE 1—In pipelines 8 in. diameter and less, 5 % to 10 % excess resin should be added.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the pump and bypass lines shall be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

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7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube shall be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head shall be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube shall be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube shall be turned inside out. The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions shall be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed.

NOTE 3—After inversion is completed, pressures can be adjusted to facilitate the safe installation of condensate removal equipment or other mechanisms required to transition to the curing process.

7.5 *Lubricant*—When lubricant is used to reduce friction during inversion, the lubricant shall be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used shall be a nontoxic product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.1.1 The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam-generating equipment is required and shall be capable of producing a sufficient amount of thermal energy throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The volume of air being sent through the pipe shall be sufficient to minimize condensation of the steam occurring during the curing. The temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.2.1 The steam-generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing steam. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the distribution of thermal energy via control of steam and air flow maintains the stated temperature. The curing of the CIPP must take into account the existing pipe material, the resin system, the current vertical alignment (that is, sags), and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.3 *Using Photoinitiated Reaction*—After the inversion is completed, while the tube is expanded under pressure, a light

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curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

7.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

7.6.3.2 *Processing*—Before the inversion begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

7.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

7.6.4 *Required Pressures*—The estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process shall be provided by the tube manufacturer and shall be increased to include consideration of the external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures shall be maintained until the cure has been completed. The pressure shall be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP shall be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 7.8 and Section 8.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113 °F (45 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care shall be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe shall be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes shall be sealed by an approved method using compatible materials, if required by the owner in contract documents.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the Contract documents or purchase order, the preparation of a CIPP sample is required, using one of the following two methods, depending on access and the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample shall be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 In medium and large-diameter applications and areas with limited access, the sample shall be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used. This method can also be used for sizes 18 in. or less, in situations where preparing samples in accordance with 8.1.1 can not be obtained due to physical constrains, if approved by the owner.

8.1.3 The samples for each of these cases shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures shall be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and shall meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength shall be measured for pressure pipe applications in accordance with Test Method D638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes shall be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test shall take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end shall not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe shall be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The

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leakage quantity shall be gauged by the water level in a temporary standpipe placed in the upstream plug. The test shall be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36-in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes shall be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test shall be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the owner in the contract documents or purchase order, a delamination test shall be performed on each inversion length specified. The CIPP samples shall be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample shall be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate shall be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchase and seller.

8.6.1 *Ultrasonic Testing of Wall Thickness*—An alternative method to 8.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797/E797M. A minimum of eight (8) evenly spaced measurements shall be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 in. to 18 in. from the end of the pipe. For pipe diameters of fifteen (15) in. or greater, a minimum of sixteen (16) evenly spaced measurements shall be recorded. The ultrasonic method to be used is the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of E797/E797M. A calibration block shall be manufactured from the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendations. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.7 *Inspection and Acceptance*—The installation shall be inspected visually if practical, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed through the CIPP itself. All service entrances shall be accounted for and be unobstructed.

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(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required.

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe*:

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N} \qquad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa), measured from the invert of the pipe
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
DR = dimension ratio of CIPP,
C = ovality reduction factor =

$$\left(\left[1-\frac{\Delta}{100}\right]/\left[1+\frac{\Delta}{100}\right]^2\right)^3$$

Δ = percentage ovality of original pipe equals

$$100 \times \frac{(Mean\ Inside\ Diameter - Minimum\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

or

$$100 \times \frac{(Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

and

N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum SDR of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\,\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR = \frac{\sigma_L}{PN} \qquad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter, in. (Inside Diameter of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, t, in.	Maximum Allowable Groundwater Load[A] (above invert)	
			ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A]Assumes K = 7.0, E = 125 000 psi (862 MPa) (50-year strength), ν = 0.30, C = 0.64 (5 % ovality), and N = 2.0

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$$q_t = \frac{1}{N}\left[32\,R_w\,B'\,E'_s \cdot C\left(E_L I/D^3\right)\right]^{1/2} \quad \text{(X1.3)}$$

where:

q_t = total external pressure on pipe, psi (MPa),
= $0.433H_w + wHR_w/144 + W_s$, (English Units),
$0.00981H_w + wHR_w/1000 + W_s$, (Metric Units)
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
w = soil density, $lb.ft^3$ (KN/m^3),
W_s = live load, psi (Mpa),
H_w = height of water above top of pipe, ft (m)
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1 + 4e^{-0.065H})$ inch-pound units, $(1/(1 + 4e^{-0.213H})$ SI units
I = moment of inertia of CIPP, $in.^4/in.$ (mm^4/mm) = $t^3/12$,

t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long-term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm)

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093\ (inch - pound\ units), \quad \text{(X1.4)}$$

or

$$\frac{E}{12(DR)^3} \geq 0.00064\ (SI\ units)$$

where:

E = initial modulus of elasticity, psi (MPa)

NOTE X1.3—For pipelines at depth not subject to construction disturbance, or if the pipeline was originally installed using tunneling method, the soil load may be calculated using a tunnel load analysis. Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eq X1.1 and X1.2.

X1.3 *Pressure Pipe*:

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eq X1.6 or Eq X1.7, as directed by Eq X1.5, and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eq X1.5-X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \quad \text{(X1.5)}$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(DR-1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \quad \text{(X1.6)}$$

where:

DR = dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eq X1.1, Eq X1.3, Eq X1.4, and Eq X1.7, and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(DR-2)\,N} \quad \text{(X1.7)}$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
DR = dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of

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sizes from 2 in. to 108 in. diameter which would be impractical to list here.

X2. CHEMICAL-RESISTANCE TESTS

X2.1 *Scope*:

X2.1.1 This appendix covers the test procedures for chemical-resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical-Resistance Testing*:

X2.2.1 Chemical resistance tests should be completed in accordance with Practices D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical-resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical-resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–21) that may impact the use of this standard. (Approved August 15, 2022.)

(1) Changed non-mandatory wording to mandatory wording throughout the standard.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–16) that may impact the use of this standard. (Approved November 1, 2021.)

(1) Added 3.2.4 and 7.6.3.

(2) Section 7.6.4 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3541 – 22

Standard Practice for Sectional Repair of Existing Gravity Flow, Non-Pressure Pipelines and Conduits by Pushed or Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F3541; 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 sectional repair of gravity flow, non-pressure pipelines and conduits 3 in. to 60 in. (75 mm to 1500 mm) diameter by the installation of a resin-saturated liner which is placed onto or wrapped around a carrier device, pushed or pulled into an existing pipeline or conduit and expanded against the interior of the host pipe or conduit with air pressure. The resin is cured under ambient conditions, by photoinitiated reaction or with the application of heat. When cured, the finished sectional repair will be tight-fitting across its installed length. This repair process is used in a variety of gravity flow, non-pressure applications such as sanitary sewers, storm sewers, drains, electrical conduits and ventilation systems.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D578/D578M Specification for Glass Fiber Strands

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

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

F2019 Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method

2.2 *ASCE Standard:*[3]

Manual of Practice 145, Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

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2.3 *ISO Standard:*[4]

ISO 11296-4 , Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes

2.4 *NSF Standard:*[5]

NSF/ANSI-14 , SE10990 – Rehabilitation by Point Repair of Existing Pipe

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binding material, n*—A material utilized to secure the resin-saturated liner to the carrier device prior to placement into the pipeline.

3.2.1.1 *Discussion*—Examples include, but are not limited to, wire, nylon ties, adhesive tape or elastomeric bands.

3.2.2 *carrier device, n*—An apparatus utilized to deliver the resin-saturated liner to a section of host pipe identified for repair by pushing or pulling force.

3.2.3 *catalyst, n*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

3.2.4 *cured-in-place pipe (CIPP), n*—A hollow cylinder consisting of a liner cured (cross-linked) with a thermosetting resin. The CIPP is installed inside an existing pipe and pressed against the pipe interior to form a tight fit.

3.2.5 *delamination, n*—Separation of layers of the CIPP.

3.2.6 *design reconciliation, n*—A process conducted post-construction to determine whether the original design objectives for the installation have been met.

3.2.6.1 *Discussion*—Design reconciliation is completed to assess the net impact of post-construction variations present including fit, finish, wall thickness and mechanical properties on the installed product's ability to conform to design requirements as established by the owner or engineer.

3.2.7 *dry spot, n*—An area of the installed CIPP which is deficient or void of resin.

3.2.8 *lift, n*—A portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.9 *photoinitiated reaction, n*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

3.2.10 *protective membrane, n*—An impermeable polymer sleeve or film that is used to prevent resin contact with the carrier device, resin contamination or washout, when required, is properly sized for the host pipe diameter, and is designed to accommodate the application, installation, resin system and curing process.

3.2.11 *release agent, n*—A non-reactive, sacrificial chemical applied to a surface to prevent bonding.

3.2.12 *tight-fitting, adj*—conformance of a lining system to the host pipe interior geometry whereas intimate contact is realized across the entire perimeter.

3.2.13 *wellpoint system, n*—A series of closely spaced, small diameter, shallow wells connected to a common header pipe and pumped with a high-efficiency vacuum dewatering pump.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of gravity flow, non-pressure pipes through the use of a resin-saturated liner installed within a section of damaged or leaking existing pipe. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Liner*—The liner utilized shall consist of one or more layers of fiberglass matting, reinforced composite, flexible needled felt or an equivalent nonwoven or woven material, or a combination thereof. The liner shall be capable of carrying resin, withstanding installation pressures and curing temperatures, bridging pipe defects, conforming to irregular shapes and negotiating bends as applicable. The liner shall be a manufactured tube or an overlapping flat sheet, with or without a plastic coating, that is compatible with the resin system used, and fabricated to a size that, when installed, will be tight-fitting across the entire length identified for sectional repair. The liner shall be appropriately sized to extend at least 1 ft (0.30 m) in all directions beyond the limits of the host pipe defect when installed.

5.1.1 *Fiberglass Matting*—Chemically resistant E-CR fiberglass meeting Specification D578/D578M or similar material meeting the requirements herein; consisting of single or multiple layers of woven or nonwoven material, with or without chopped strand mat.

5.1.2 *Reinforced Composite*—Needled felt, or an equivalent woven or non-woven material, with E-CR fiberglass meeting Specification D578/D578M or similar reinforcement material meeting the requirements herein.

5.1.3 *Overlapping Flat Sheet*—Liners designed as overlapping flat sheets having a minimum circumference = $\pi \times D_i \times 1.1$, where D_i = inside diameter of the host pipe. When multiple layers of liner are required to achieve the desired thickness, the ends of the liner are tapered as required to obtain a smooth transition to the host pipe by adding additional layers in a stepwise fashion in accordance with the manufacturer's guidelines such that each subsequent layer is slightly longer than the adjacent, underlying layer.

5.1.4 *Manufactured Tubes*—Liners manufactured as tubes shall be sized per the manufacturer's recommendations relative to the host pipe inside diameter to permit radial expansion and a tight fit against the host pipe during installation and cure.

5.1.5 *Resin*—A chemically resistant, thermosetting resin and catalyst system that is cured under ambient conditions, by

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

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photoinitiated reaction or with the application of heat and is compatible with the installation process shall be used. Resin systems that are heat cured shall have an initiating temperature less than 180 °F (82 °C).

5.2 *CIPP System:*

5.2.1 *Mechanical Properties*—The CIPP system shall have as a minimum the initial mechanical properties given in Table 1. These mechanical properties shall be determined in accordance with Section 7.

6. Installation

6.1 *Cleaning and Pre-Inspection:*

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

6.1.2 *Cleaning of Pipeline*—To the extent practical, all internal debris shall be removed from the original pipeline using hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television (CCTV) or worker-entry techniques. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that will prevent proper installation of the resin-saturated liner. The manufacturer shall provide guidance as needed to determine whether existing conditions will prohibit a successful installation or if additional measures are necessary in advance of lining. This includes addressing points of infiltration that will cause resin wash out or adversely impact the cure and finished quality of the CIPP sectional repair. Corrective actions include, but are not limited to, injecting chemical grout, dewatering using a wellpoint system, or utilizing a protective membrane as defined in 3.2.10 and described in 6.4.4.

6.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions that will hinder or prevent the installation of the resin-saturated liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, a point repair excavation shall be made to uncover and remove or repair the obstruction.

6.2 *Resin Saturation*—The liner shall be fully saturated with resin (wet out) under controlled conditions and free of any dry spots or resin lean areas. The resin system shall be proportionally mixed, handled and applied in accordance with manufacturer's recommendations. The volume of resin used shall be sufficient to fully saturate the liner material and shall be adjusted by adding excess resin to account for the change in resin volume due to polymerization, to allow for migration of resin into the cracks and joints in the original pipe, and to account for any resin loss expected during the liner insertion process. For each CIPP installation, wet out data shall be recorded and retained by the user for quality assurance and record keeping purposes, and submitted to the purchaser as required.

TABLE 1 CIPP Initial Mechanical Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural Strength[B]	D790	Declared value, but not less than 4 500	Declared value, but not less than 31
Flexural Modulus[B]	D790	Declared value, but not less than 250 000	Declared value, but not less than 1 724

[A] The values in Table 1 are for test results on field specimens. The purchaser shall consult the manufacturer for the long-term mechanical properties.
[B] The value indicates minimum strength in the circumferential direction.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass shall be made by capturing flow from all contributing points upstream of the pipe to be reconstructed and discharging the flow to a downstream point or adjacent system. The bypass pumping and piping system shall be of adequate capacity and size to handle the flow. Prior to cleaning and pre-inspection and during installation, all upstream contributing flows impacting the repair area shall be isolated and bypassed around the repair area. Bypassing shall be coordinated between all parties involved.

6.3.1 Public advisory services shall be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the pipeline is back in service.

6.4 *Liner Insertion:*

6.4.1 The carrier device shall be able to navigate the host pipe alignment and geometry to the point of installation without compromise to the host pipe, installation process or finished quality of the CIPP; shall be designed to expand with air pressure to press the resin-saturated liner tightly against the interior of the host pipe for the duration of cure; shall be compatible with the curing process; and, when required, shall have flow-thru capabilities for flow control.

6.4.2 When required, a protective membrane shall be secured to the carrier device and a compatible release agent shall be liberally applied to its entire surface area as required.

6.4.3 The resin-saturated liner shall be centered and rolled tightly against the carrier device and secured with binding material. The binding material shall be placed approximately 1 in. (25 mm) from each end of the liner and spaced along the remaining length of the repair, typically 1.5 ft to 2.0 ft (0.46 m to 0.61 m) apart; shall be used to secure the leading edge of the liner to the front of the carrier device as required to ensure the liner's position is maintained as it is pushed or pulled into the host pipe; and shall be designed to release or break under tension when the carrier device is pressurized and the resin-saturated liner is expanded against the host pipe.

6.4.4 When required, to prevent resin contamination or washout and as directed by the manufacturer, a protective membrane shall be attached to the resin-saturated liner across the affected area.

6.4.5 The resin-saturated liner shall be positioned into the host pipe using push rods or a winching process. Prior to insertion and as directed by the manufacturer, the carrier device shall be inflated to a low pressure to increase rigidity and reduce material drag along the pipe invert. The carrier device

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shall be equipped with adequate air supply for proper inflation and full expansion of the liner against the host pipe interior for the duration of cure.

6.4.6 CCTV inspection shall be conducted concurrently with the placement of the resin-saturated liner to verify proper positioning and the host pipe condition and resin saturation in accordance with 6.2 prior to inflation and cure.

6.5 *Curing*—The resin-saturated liner shall be cured in accordance with manufacturer's recommendations, and the curing process shall be documented and submitted to the purchaser as required. The estimated minimum and maximum pressures recommended to form a tight-fitting liner against the existing pipe during the curing process shall be provided by the manufacturer.

6.5.1 *Using Air or Air/Steam*—Curing of the resin-saturated liner shall be accomplished without pressure interruption with air or a mixture of air and steam for the duration of time in accordance with the manufacturer's recommendations for a complete cure. For CIPP cured under ambient conditions, to the extent practical, a representative coupon of the resin impregnated liner suspended at the access point shall be used to confirm curing time as required.

6.5.2 *Using Photoinitiated Reaction*—While the liner is expanded under pressure against the host pipe, a CCTV inspection shall be performed to verify that the liner is properly positioned and tight-fitting. Any anomalies shall be corrected prior to initiating the curing process.

6.5.2.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photoinitiators shall be optimized to the output of the curing lights.

6.5.2.2 For dynamic curing processes, the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific liner dimensions to initiate polymerization and facilitate the cure of the CIPP resin.

6.5.2.3 A full curing protocol shall be provided by the manufacturer and be recorded and maintained as documentation verifying the curing process. As a minimum, data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, and the power output of the light assembly.

6.6 *Overlapping Installations*—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end with a minimum overlap to adjacent CIPP sections in accordance with manufacturer's recommendations. To the extent practical, installations shall progress from the furthest point downstream towards the upstream end so that overlapping ends of the CIPP are streamlined with the flow.

6.7 *Workmanship:*

6.7.1 The finished CIPP shall be continuous over its entire length and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations. If these conditions are present, CIPP in these areas shall be removed and replaced. The CIPP shall be tight-fitting against the host pipe at its termination points with transitions at each end that do not create a ledge, a change in direction of flow, or a location where debris will accumulate during uniform flow conditions. In sections of pipe of constant internal diameter and straight alignment, the CIPP shall not introduce surface irregularities in addition to those of the host pipe which exceed 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater. Applications where surface irregularities exceeding 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater, are anticipated due to geometric features, condition or alignment of the host pipe shall be evaluated by the owner, engineer and manufacturer to determine feasibility and compliance of this practice. Examples include CIPP that is installed through bends, joint offsets, diameter transitions and other discontinuities in the host pipe which can result in localized radial or longitudinal fins or folds, or other surface irregularities in the CIPP.

6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active service connections shall be reinstated. This shall be performed without excavation and, in cases of non-worker-entry sized pipes, from the interior of the pipeline by the means of CCTV inspection and a remote-control cutting device. Reinstated service connections shall be cut smooth and free of burrs and rough edges. All laterals where a plug by the end of the lateral was not visible by the pre-inspection shall be reinstated if the purchase agreement does not specify it differently.

7. Inspection Practices

7.1 *Sampling*—CIPP samples for mechanical properties testing shall be prepared when required and as directed by the engineer or purchaser. Representative samples of the resin-saturated liner shall be restrained in a like diameter pipe or prepared in a clamped mold and cured in the same manner as the installed CIPP. Samples shall be prepared in a manhole or other point of access, or under simulated conditions above ground, and shall be of adequate size to perform flexural properties testing as described in 7.2.

7.2 *Short-Term Flexural (Bending) Properties*—For isotropic materials, the tangent flexural modulus of elasticity and flexural strength shall be measured in accordance with Test Method D790. For anisotropic composites, flexural testing shall be conducted in the hoop direction on specimens cut from plate samples in accordance with Test Method D790 or on curved beam specimens cut from restrained samples in accordance with the modified Test Method D790 method as described in Annex B of ISO 11296-4 and Practice F2019, Appendix X2. Flexural properties shall meet or exceed values listed in Table 1.

7.3 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 7.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and

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shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. If minimum wall thickness requirements are not met, a design reconciliation shall be performed. If it is determined through design reconciliation that the installed CIPP is non-compliant, the designer or purchaser shall determine whether corrective action is necessary.

7.4 *Inspection and Acceptance*—The CIPP installation shall be inspected visually if appropriate or by CCTV inspection if visual inspection cannot be accomplished. No infiltration of groundwater shall be observed. The CIPP shall comply with 6.7.

8. Keywords

8.1 ambient cure; binding material; CIPP; carrier device; cured-in-place pipe; design reconciliation; E-CR; fiberglass matting; photoinitiated reaction; protective membrane; reinforced composite; release agent; sealing mechanism; sectional repair; silicate resin; tight-fitting; wellpoint system

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 During the initial design phase, consideration should be given to anchoring mechanisms required to limit downstream movement or dislodging of the CIPP sectional repair once it is put into service, which is of particular importance on lines with steep slopes, high velocity flows, surcharge conditions or broad temperature swings. The selected CIPP sectional repair system should align with design objectives for each application (for example, thermal properties or minimum levels of adhesion), and should be demonstrated through proper host pipe preparation and installation practice in accordance with this standard and manufacturer's guidelines.

X1.2 For circular host pipes with up to 10% ovality, the CIPP system should be designed for minimum wall thickness in accordance with ASCE Manual of Practice 145 or, alternatively, Practice F1216, Appendix X1, with the exception that Eq. X1.2 and X1.4 be excluded from the calculations. For non-circular host pipes or circular host pipes with greater than 10 % ovality, the design method described in ASCE Manual of Practice 145 is recommended. The design of the CIPP shall take into consideration the type of deterioration or damage to the existing pipe as well as relevant hydrostatic, soil and live loads.

X1.3 Further, when Practice F1216 is used for design, note X1.2 of Practice F1216 suggesting a maximum SDR of 100 be used for liners installed in pipes where the groundwater is not above the pipe invert shall be ignored. Instead, the partially deteriorated design shall be determined by using F1216, Eq X1.1 with the actual groundwater load or, in the case of no groundwater being present, a virtual groundwater load equal to a minimum of 5.0 ft (1.5 m) above the pipe invert or at least 0.33 ft (0.10 m) above the crown of the liner – whichever is greater (but in no case should this height exceed the cover depth of the host pipe). The fully deteriorated design condition shall be determined using F1216, Eq X1.3 with H_w being the height of the groundwater above the invert of the pipe.

X2. CHEMICAL RESISTANCE TESTS

Scope:

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

Procedure for Chemical Resistance Testing:

X2.2.1 Chemical resistance tests should be completed in accordance with Practice D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with 7.2 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

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serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

X3. CERTIFICATIONS

X3.1 The CIPP system may comply with NSF/ANSI-14 and may be tested and certified to be in compliance with NSF SE 10990.

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Rationale:

The proposed language imposes unnecessary confusion, inconsistency, and constraints on practical and effective CIPP rehabilitation methods.

The term “continuous,” as used in ASTM F1216, ASTM F1743, **and** ASTM F3541 does not require that a CIPP liner extend uninterrupted through the entire piping system.

Instead, ASTM F1743 emphasizes the structural integrity and uniformity of each installed segment. It requires each CIPP segment to be free of seams, dry spots, or discontinuities, ensuring that where a liner is installed, it is installed completely and performs as intended. It does not mandate that the entire piping network be lined in a single run.

Requiring a single continuous liner from the building vent to the city main is not only impracticable in many existing buildings, but it is also not necessary to ensure system performance. The proposed clarification aligns with ASTM F1743’s actual requirements and intent, allowing installers to rehabilitate pipelines efficiently and effectively while maintaining compliance with established performance and safety standards.

Still, to eliminate further confusion as to the plain meaning of the code, the incorporation of ASTM F3541 into Section 718.1 is the ideal option. ASTM F3541 specifically addresses sectional repairs for gravity flow, non-pressure pipelines, and conduits, and likewise emphasized the structural integrity and proper installation of each installation length without mandating a single continuous application. This approach aligns more closely with industry best practices, promotes flexibility, and ensures that each installed length is free of gaps, seams, dry spots, lifts, or delaminations, thereby achieving the intended performance and safety standards. Incorporating ASTM F3541 not only mitigates confusion but also supports more efficient and reliable rehabilitation processes.

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February 27, 2025

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Re: Declaration of Rudy Rudisill in Support of Petition for Declaratory Statement

Dear Mr. Madani,

Please take notice that I, Rudy Rudisill, President of Pipe Restoration Solutions, Inc., declare that the following is true and correct based on my personal knowledge and professional experience:

1. I am the President of Pipe Restoration Solutions, Inc., a company specializing in trenchless pipeline rehabilitation services, including cured-in-place pipe (CIPP) lining. With over 20 years of experience in the pipeline restoration industry, I am well-versed in various methods of performing service connections following CIPP installations. My company regularly performs CIPP lining using both the "gapping" and "reinstatement" methods.

2. Based on extensive experience and industry best practices, I strongly favor the gapping method over traditional robotic reinstatement for service connections following CIPP lining for smaller diameter pipe (2" thru 4") installed inside the building. My company's goal is to provide the best end-product for our customers, and we often favor the gapping method to accomplish this. We do not prefer the gapping method over the "cutting" reinstatement method simply because of the additional cost and time required for installation (although these are relevant factors that we respectfully believe the Committee should consider). Instead, Petitioner prefers the gapping method to the "cutting" reinstatement method because Petitioner wishes to deliver the best product to its customers, including 100% watertight pipelines, which the "cutting" reinstatement method does not allow for.

3. Our preference for gapping is due to the significant advantages that the gapping method provides in terms of efficiency, reliability, and long-term performance. The gapping method offers numerous benefits, including but not limited to:

   i. <u>Capability to Install 2" Liners</u>: Unlike traditional reinstatement methods, the gapping method allows for the installation of 2" liners, expanding service capabilities for smaller diameter pipes.

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ii. Installation of Fitting Liners: Gapping enables the efficient lining of pipe fittings, which is not achievable through standard reinstatement techniques.

iii. Preservation of Flow Capacity: Unlike robotic reinstatement, which can reduce flow capacity due to uneven cuts or lips, the gapping method maintains the full flow capacity of the pipe.

iv. Reduced Downtime for Unit Owners: This method eliminates the need for overnight curing, significantly reducing downtime and inconvenience for residents or tenants.

v. Ability to Perform Emergency Point Repairs: Gapping allows for rapid and efficient point repairs, making it ideal for emergency situations.

vi. No Lips on 90% of Reinstatements: The gapping method prevents the formation of protruding lips, which are a common issue with robotic reinstatement.

vii. Elimination of Delamination Risk: By removing the risk of water infiltration behind reinstatement lips, the gapping method prevents delamination and ensures liner integrity.

viii. Prevention of Damage to Fittings: Robotic reinstatement can often cause damage to fittings during the cutting process, whereas the gapping method avoids this issue entirely.

4. My personal knowledge and experience have convinced me that the gapping method represents a superior solution for service connections following CIPP installations. It offers enhanced performance, reduced risk, and greater customer satisfaction compared to traditional robotic reinstatement methods. As such, I strongly advocate for its adoption as the preferred industry standard for service connection restorations.

Executed on February 27, 2024 at Sarasota, Florida.

Rudy Rudisill
Rudy Rudisill
President, Pipe Restoration Solutions, Inc.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3541 – 22

Standard Practice for Sectional Repair of Existing Gravity Flow, Non-Pressure Pipelines and Conduits by Pushed or Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F3541; 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 sectional repair of gravity flow, non-pressure pipelines and conduits 3 in. to 60 in. (75 mm to 1500 mm) diameter by the installation of a resin-saturated liner which is placed onto or wrapped around a carrier device, pushed or pulled into an existing pipeline or conduit and expanded against the interior of the host pipe or conduit with air pressure. The resin is cured under ambient conditions, by photoinitiated reaction or with the application of heat. When cured, the finished sectional repair will be tight-fitting across its installed length. This repair process is used in a variety of gravity flow, non-pressure applications such as sanitary sewers, storm sewers, drains, electrical conduits and ventilation systems.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D578/D578M Specification for Glass Fiber Strands

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

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

F2019 Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method

2.2 *ASCE Standard:*[3]

Manual of Practice 145, Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

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2.3 *ISO Standard:*[4]
ISO 11296-4 , Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes
2.4 *NSF Standard:*[5]
NSF/ANSI-14 , SE10990 – Rehabilitation by Point Repair of Existing Pipe

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binding material, n*—A material utilized to secure the resin-saturated liner to the carrier device prior to placement into the pipeline.

3.2.1.1 *Discussion*—Examples include, but are not limited to, wire, nylon ties, adhesive tape or elastomeric bands.

3.2.2 *carrier device, n*—An apparatus utilized to deliver the resin-saturated liner to a section of host pipe identified for repair by pushing or pulling force.

3.2.3 *catalyst, n*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

3.2.4 *cured-in-place pipe (CIPP), n*—A hollow cylinder consisting of a liner cured (cross-linked) with a thermosetting resin. The CIPP is installed inside an existing pipe and pressed against the pipe interior to form a tight fit.

3.2.5 *delamination, n*—Separation of layers of the CIPP.

3.2.6 *design reconciliation, n*—A process conducted post-construction to determine whether the original design objectives for the installation have been met.

3.2.6.1 *Discussion*—Design reconciliation is completed to assess the net impact of post-construction variations present including fit, finish, wall thickness and mechanical properties on the installed product's ability to conform to design requirements as established by the owner or engineer.

3.2.7 *dry spot, n*—An area of the installed CIPP which is deficient or void of resin.

3.2.8 *lift, n*—A portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.9 *photoinitiated reaction, n*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

3.2.10 *protective membrane, n*—An impermeable polymer sleeve or film that is used to prevent resin contact with the carrier device, resin contamination or washout, when required, is properly sized for the host pipe diameter, and is designed to accommodate the application, installation, resin system and curing process.

3.2.11 *release agent, n*—A non-reactive, sacrificial chemical applied to a surface to prevent bonding.

3.2.12 *tight-fitting, adj*—conformance of a lining system to the host pipe interior geometry whereas intimate contact is realized across the entire perimeter.

3.2.13 *wellpoint system, n*—A series of closely spaced, small diameter, shallow wells connected to a common header pipe and pumped with a high-efficiency vacuum dewatering pump.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of gravity flow, non-pressure pipes through the use of a resin-saturated liner installed within a section of damaged or leaking existing pipe. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Liner*—The liner utilized shall consist of one or more layers of fiberglass matting, reinforced composite, flexible needled felt or an equivalent nonwoven or woven material, or a combination thereof. The liner shall be capable of carrying resin, withstanding installation pressures and curing temperatures, bridging pipe defects, conforming to irregular shapes and negotiating bends as applicable. The liner shall be a manufactured tube or an overlapping flat sheet, with or without a plastic coating, that is compatible with the resin system used, and fabricated to a size that, when installed, will be tight-fitting across the entire length identified for sectional repair. The liner shall be appropriately sized to extend at least 1 ft (0.30 m) in all directions beyond the limits of the host pipe defect when installed.

5.1.1 *Fiberglass Matting*—Chemically resistant E-CR fiberglass meeting Specification D578/D578M or similar material meeting the requirements herein; consisting of single or multiple layers of woven or nonwoven material, with or without chopped strand mat.

5.1.2 *Reinforced Composite*—Needled felt, or an equivalent woven or non-woven material, with E-CR fiberglass meeting Specification D578/D578M or similar reinforcement material meeting the requirements herein.

5.1.3 *Overlapping Flat Sheet*—Liners designed as overlapping flat sheets having a minimum circumference = $\pi \times D_i \times 1.1$, where D_i = inside diameter of the host pipe. When multiple layers of liner are required to achieve the desired thickness, the ends of the liner are tapered as required to obtain a smooth transition to the host pipe by adding additional layers in a stepwise fashion in accordance with the manufacturer's guidelines such that each subsequent layer is slightly longer than the adjacent, underlying layer.

5.1.4 *Manufactured Tubes*—Liners manufactured as tubes shall be sized per the manufacturer's recommendations relative to the host pipe inside diameter to permit radial expansion and a tight fit against the host pipe during installation and cure.

5.1.5 *Resin*—A chemically resistant, thermosetting resin and catalyst system that is cured under ambient conditions, by

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.
[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

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photoinitiated reaction or with the application of heat and is compatible with the installation process shall be used. Resin systems that are heat cured shall have an initiating temperature less than 180 °F (82 °C).

5.2 *CIPP System:*

5.2.1 *Mechanical Properties*—The CIPP system shall have as a minimum the initial mechanical properties given in Table 1. These mechanical properties shall be determined in accordance with Section 7.

6. Installation

6.1 *Cleaning and Pre-Inspection:*

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

6.1.2 *Cleaning of Pipeline*—To the extent practical, all internal debris shall be removed from the original pipeline using hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television (CCTV) or worker-entry techniques. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that will prevent proper installation of the resin-saturated liner. The manufacturer shall provide guidance as needed to determine whether existing conditions will prohibit a successful installation or if additional measures are necessary in advance of lining. This includes addressing points of infiltration that will cause resin wash out or adversely impact the cure and finished quality of the CIPP sectional repair. Corrective actions include, but are not limited to, injecting chemical grout, dewatering using a wellpoint system, or utilizing a protective membrane as defined in 3.2.10 and described in 6.4.4.

6.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions that will hinder or prevent the installation of the resin-saturated liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, a point repair excavation shall be made to uncover and remove or repair the obstruction.

6.2 *Resin Saturation*—The liner shall be fully saturated with resin (wet out) under controlled conditions and free of any dry spots or resin lean areas. The resin system shall be proportionally mixed, handled and applied in accordance with manufacturer's recommendations. The volume of resin used shall be sufficient to fully saturate the liner material and shall be adjusted by adding excess resin to account for the change in resin volume due to polymerization, to allow for migration of resin into the cracks and joints in the original pipe, and to account for any resin loss expected during the liner insertion process. For each CIPP installation, wet out data shall be recorded and retained by the user for quality assurance and record keeping purposes, and submitted to the purchaser as required.

TABLE 1 CIPP Initial Mechanical Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural Strength[B]	D790	Declared value, but not less than 4 500	Declared value, but not less than 31
Flexural Modulus[B]	D790	Declared value, but not less than 250 000	Declared value, but not less than 1 724

[A] The values in Table 1 are for test results on field specimens. The purchaser shall consult the manufacturer for the long-term mechanical properties.
[B] The value indicates minimum strength in the circumferential direction.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass shall be made by capturing flow from all contributing points upstream of the pipe to be reconstructed and discharging the flow to a downstream point or adjacent system. The bypass pumping and piping system shall be of adequate capacity and size to handle the flow. Prior to cleaning and pre-inspection and during installation, all upstream contributing flows impacting the repair area shall be isolated and bypassed around the repair area. Bypassing shall be coordinated between all parties involved.

6.3.1 Public advisory services shall be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the pipeline is back in service.

6.4 *Liner Insertion:*

6.4.1 The carrier device shall be able to navigate the host pipe alignment and geometry to the point of installation without compromise to the host pipe, installation process or finished quality of the CIPP; shall be designed to expand with air pressure to press the resin-saturated liner tightly against the interior of the host pipe for the duration of cure; shall be compatible with the curing process; and, when required, shall have flow-thru capabilities for flow control.

6.4.2 When required, a protective membrane shall be secured to the carrier device and a compatible release agent shall be liberally applied to its entire surface area as required.

6.4.3 The resin-saturated liner shall be centered and rolled tightly against the carrier device and secured with binding material. The binding material shall be placed approximately 1 in. (25 mm) from each end of the liner and spaced along the remaining length of the repair, typically 1.5 ft to 2.0 ft (0.46 m to 0.61 m) apart; shall be used to secure the leading edge of the liner to the front of the carrier device as required to ensure the liner's position is maintained as it is pushed or pulled into the host pipe; and shall be designed to release or break under tension when the carrier device is pressurized and the resin-saturated liner is expanded against the host pipe.

6.4.4 When required, to prevent resin contamination or washout and as directed by the manufacturer, a protective membrane shall be attached to the resin-saturated liner across the affected area.

6.4.5 The resin-saturated liner shall be positioned into the host pipe using push rods or a winching process. Prior to insertion and as directed by the manufacturer, the carrier device shall be inflated to a low pressure to increase rigidity and reduce material drag along the pipe invert. The carrier device

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shall be equipped with adequate air supply for proper inflation and full expansion of the liner against the host pipe interior for the duration of cure.

6.4.6 CCTV inspection shall be conducted concurrently with the placement of the resin-saturated liner to verify proper positioning and the host pipe condition and resin saturation in accordance with 6.2 prior to inflation and cure.

6.5 *Curing*—The resin-saturated liner shall be cured in accordance with manufacturer's recommendations, and the curing process shall be documented and submitted to the purchaser as required. The estimated minimum and maximum pressures recommended to form a tight-fitting liner against the existing pipe during the curing process shall be provided by the manufacturer.

6.5.1 *Using Air or Air/Steam*—Curing of the resin-saturated liner shall be accomplished without pressure interruption with air or a mixture of air and steam for the duration of time in accordance with the manufacturer's recommendations for a complete cure. For CIPP cured under ambient conditions, to the extent practical, a representative coupon of the resin impregnated liner suspended at the access point shall be used to confirm curing time as required.

6.5.2 *Using Photoinitiated Reaction*—While the liner is expanded under pressure against the host pipe, a CCTV inspection shall be performed to verify that the liner is properly positioned and tight-fitting. Any anomalies shall be corrected prior to initiating the curing process.

6.5.2.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photoinitiators shall be optimized to the output of the curing lights.

6.5.2.2 For dynamic curing processes, the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific liner dimensions to initiate polymerization and facilitate the cure of the CIPP resin.

6.5.2.3 A full curing protocol shall be provided by the manufacturer and be recorded and maintained as documentation verifying the curing process. As a minimum, data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, and the power output of the light assembly.

6.6 *Overlapping Installations*—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end with a minimum overlap to adjacent CIPP sections in accordance with manufacturer's recommendations. To the extent practical, installations shall progress from the furthest point downstream towards the upstream end so that overlapping ends of the CIPP are streamlined with the flow.

6.7 *Workmanship:*

6.7.1 The finished CIPP shall be continuous over its entire length and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations. If these conditions are present, CIPP in these areas shall be removed and replaced. The CIPP shall be tight-fitting against the host pipe at its termination points with transitions at each end that do not create a ledge, a change in direction of flow, or a location where debris will accumulate during uniform flow conditions. In sections of pipe of constant internal diameter and straight alignment, the CIPP shall not introduce surface irregularities in addition to those of the host pipe which exceed 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater. Applications where surface irregularities exceeding 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater, are anticipated due to geometric features, condition or alignment of the host pipe shall be evaluated by the owner, engineer and manufacturer to determine feasibility and compliance of this practice. Examples include CIPP that is installed through bends, joint offsets, diameter transitions and other discontinuities in the host pipe which can result in localized radial or longitudinal fins or folds, or other surface irregularities in the CIPP.

6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active service connections shall be reinstated. This shall be performed without excavation and, in cases of non-worker-entry sized pipes, from the interior of the pipeline by the means of CCTV inspection and a remote-control cutting device. Reinstated service connections shall be cut smooth and free of burrs and rough edges. All laterals where a plug by the end of the lateral was not visible by the pre-inspection shall be reinstated if the purchase agreement does not specify it differently.

7. Inspection Practices

7.1 *Sampling*—CIPP samples for mechanical properties testing shall be prepared when required and as directed by the engineer or purchaser. Representative samples of the resin-saturated liner shall be restrained in a like diameter pipe or prepared in a clamped mold and cured in the same manner as the installed CIPP. Samples shall be prepared in a manhole or other point of access, or under simulated conditions above ground, and shall be of adequate size to perform flexural properties testing as described in 7.2.

7.2 *Short-Term Flexural (Bending) Properties*—For isotropic materials, the tangent flexural modulus of elasticity and flexural strength shall be measured in accordance with Test Method D790. For anisotropic composites, flexural testing shall be conducted in the hoop direction on specimens cut from plate samples in accordance with Test Method D790 or on curved beam specimens cut from restrained samples in accordance with the modified Test Method D790 method as described in Annex B of ISO 11296-4 and Practice F2019, Appendix X2. Flexural properties shall meet or exceed values listed in Table 1.

7.3 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 7.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and

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shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. If minimum wall thickness requirements are not met, a design reconciliation shall be performed. If it is determined through design reconciliation that the installed CIPP is non-compliant, the designer or purchaser shall determine whether corrective action is necessary.

7.4 *Inspection and Acceptance*—The CIPP installation shall be inspected visually if appropriate or by CCTV inspection if visual inspection cannot be accomplished. No infiltration of groundwater shall be observed. The CIPP shall comply with 6.7.

8. Keywords

8.1 ambient cure; binding material; CIPP; carrier device; cured-in-place pipe; design reconciliation; E-CR; fiberglass matting; photoinitiated reaction; protective membrane; reinforced composite; release agent; sealing mechanism; sectional repair; silicate resin; tight-fitting; wellpoint system

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 During the initial design phase, consideration should be given to anchoring mechanisms required to limit downstream movement or dislodging of the CIPP sectional repair once it is put into service, which is of particular importance on lines with steep slopes, high velocity flows, surcharge conditions or broad temperature swings. The selected CIPP sectional repair system should align with design objectives for each application (for example, thermal properties or minimum levels of adhesion), and should be demonstrated through proper host pipe preparation and installation practice in accordance with this standard and manufacturer's guidelines.

X1.2 For circular host pipes with up to 10% ovality, the CIPP system should be designed for minimum wall thickness in accordance with ASCE Manual of Practice 145 or, alternatively, Practice F1216, Appendix X1, with the exception that Eq. X1.2 and X1.4 be excluded from the calculations. For non-circular host pipes or circular host pipes with greater than 10 % ovality, the design method described in ASCE Manual of Practice 145 is recommended. The design of the CIPP shall take into consideration the type of deterioration or damage to the existing pipe as well as relevant hydrostatic, soil and live loads.

X1.3 Further, when Practice F1216 is used for design, note X1.2 of Practice F1216 suggesting a maximum SDR of 100 be used for liners installed in pipes where the groundwater is not above the pipe invert shall be ignored. Instead, the partially deteriorated design shall be determined by using F1216, Eq X1.1 with the actual groundwater load or, in the case of no groundwater being present, a virtual groundwater load equal to a minimum of 5.0 ft (1.5 m) above the pipe invert or at least 0.33 ft (0.10 m) above the crown of the liner – whichever is greater (but in no case should this height exceed the cover depth of the host pipe). The fully deteriorated design condition shall be determined using F1216, Eq X1.3 with H_w being the height of the groundwater above the invert of the pipe.

X2. CHEMICAL RESISTANCE TESTS

Scope:

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

Procedure for Chemical Resistance Testing:

X2.2.1 Chemical resistance tests should be completed in accordance with Practice D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with 7.2 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

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serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

X3. CERTIFICATIONS

X3.1 The CIPP system may comply with NSF/ANSI-14 and may be tested and certified to be in compliance with NSF SE 10990.

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EXHIBIT D

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines
D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D903 Test Method for Peel or Stripping Strength of Adhesive Bonds
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]
D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
D4814 Specification for Automotive Spark-Ignition Engine Fuel
D5813 Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method
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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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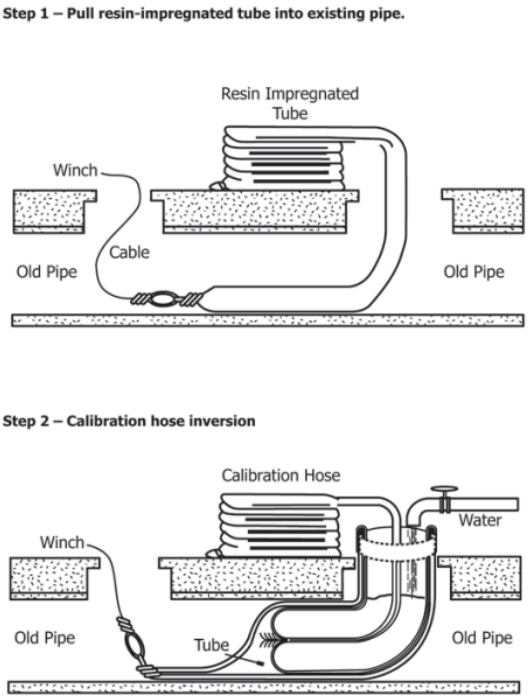

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F ± 3.6 °F (23 °C ± 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3541 – 22

Standard Practice for Sectional Repair of Existing Gravity Flow, Non-Pressure Pipelines and Conduits by Pushed or Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F3541; 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 sectional repair of gravity flow, non-pressure pipelines and conduits 3 in. to 60 in. (75 mm to 1500 mm) diameter by the installation of a resin-saturated liner which is placed onto or wrapped around a carrier device, pushed or pulled into an existing pipeline or conduit and expanded against the interior of the host pipe or conduit with air pressure. The resin is cured under ambient conditions, by photoinitiated reaction or with the application of heat. When cured, the finished sectional repair will be tight-fitting across its installed length. This repair process is used in a variety of gravity flow, non-pressure applications such as sanitary sewers, storm sewers, drains, electrical conduits and ventilation systems.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D578/D578M Specification for Glass Fiber Strands

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

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

F2019 Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method

2.2 *ASCE Standard:*[3]

Manual of Practice 145, Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

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2.3 *ISO Standard:*[4]
ISO 11296-4 , Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes
2.4 *NSF Standard:*[5]
NSF/ANSI-14 , SE10990 – Rehabilitation by Point Repair of Existing Pipe

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binding material, n*—A material utilized to secure the resin-saturated liner to the carrier device prior to placement into the pipeline.

3.2.1.1 *Discussion*—Examples include, but are not limited to, wire, nylon ties, adhesive tape or elastomeric bands.

3.2.2 *carrier device, n*—An apparatus utilized to deliver the resin-saturated liner to a section of host pipe identified for repair by pushing or pulling force.

3.2.3 *catalyst, n*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

3.2.4 *cured-in-place pipe (CIPP), n*—A hollow cylinder consisting of a liner cured (cross-linked) with a thermosetting resin. The CIPP is installed inside an existing pipe and pressed against the pipe interior to form a tight fit.

3.2.5 *delamination, n*—Separation of layers of the CIPP.

3.2.6 *design reconciliation, n*—A process conducted post-construction to determine whether the original design objectives for the installation have been met.

3.2.6.1 *Discussion*—Design reconciliation is completed to assess the net impact of post-construction variations present including fit, finish, wall thickness and mechanical properties on the installed product's ability to conform to design requirements as established by the owner or engineer.

3.2.7 *dry spot, n*—An area of the installed CIPP which is deficient or void of resin.

3.2.8 *lift, n*—A portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.9 *photoinitiated reaction, n*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

3.2.10 *protective membrane, n*—An impermeable polymer sleeve or film that is used to prevent resin contact with the carrier device, resin contamination or washout, when required, is properly sized for the host pipe diameter, and is designed to accommodate the application, installation, resin system and curing process.

3.2.11 *release agent, n*—A non-reactive, sacrificial chemical applied to a surface to prevent bonding.

3.2.12 *tight-fitting, adj*—conformance of a lining system to the host pipe interior geometry whereas intimate contact is realized across the entire perimeter.

3.2.13 *wellpoint system, n*—A series of closely spaced, small diameter, shallow wells connected to a common header pipe and pumped with a high-efficiency vacuum dewatering pump.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of gravity flow, non-pressure pipes through the use of a resin-saturated liner installed within a section of damaged or leaking existing pipe. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Liner*—The liner utilized shall consist of one or more layers of fiberglass matting, reinforced composite, flexible needled felt or an equivalent nonwoven or woven material, or a combination thereof. The liner shall be capable of carrying resin, withstanding installation pressures and curing temperatures, bridging pipe defects, conforming to irregular shapes and negotiating bends as applicable. The liner shall be a manufactured tube or an overlapping flat sheet, with or without a plastic coating, that is compatible with the resin system used, and fabricated to a size that, when installed, will be tight-fitting across the entire length identified for sectional repair. The liner shall be appropriately sized to extend at least 1 ft (0.30 m) in all directions beyond the limits of the host pipe defect when installed.

5.1.1 *Fiberglass Matting*—Chemically resistant E-CR fiberglass meeting Specification D578/D578M or similar material meeting the requirements herein; consisting of single or multiple layers of woven or nonwoven material, with or without chopped strand mat.

5.1.2 *Reinforced Composite*—Needled felt, or an equivalent woven or non-woven material, with E-CR fiberglass meeting Specification D578/D578M or similar reinforcement material meeting the requirements herein.

5.1.3 *Overlapping Flat Sheet*—Liners designed as overlapping flat sheets having a minimum circumference = $\pi \times D_i \times 1.1$, where D_i = inside diameter of the host pipe. When multiple layers of liner are required to achieve the desired thickness, the ends of the liner are tapered as required to obtain a smooth transition to the host pipe by adding additional layers in a stepwise fashion in accordance with the manufacturer's guidelines such that each subsequent layer is slightly longer than the adjacent, underlying layer.

5.1.4 *Manufactured Tubes*—Liners manufactured as tubes shall be sized per the manufacturer's recommendations relative to the host pipe inside diameter to permit radial expansion and a tight fit against the host pipe during installation and cure.

5.1.5 *Resin*—A chemically resistant, thermosetting resin and catalyst system that is cured under ambient conditions, by

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.
[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

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photoinitiated reaction or with the application of heat and is compatible with the installation process shall be used. Resin systems that are heat cured shall have an initiating temperature less than 180 °F (82 °C).

5.2 *CIPP System:*

5.2.1 *Mechanical Properties*—The CIPP system shall have as a minimum the initial mechanical properties given in Table 1. These mechanical properties shall be determined in accordance with Section 7.

6. Installation

6.1 *Cleaning and Pre-Inspection:*

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

6.1.2 *Cleaning of Pipeline*—To the extent practical, all internal debris shall be removed from the original pipeline using hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television (CCTV) or worker-entry techniques. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that will prevent proper installation of the resin-saturated liner. The manufacturer shall provide guidance as needed to determine whether existing conditions will prohibit a successful installation or if additional measures are necessary in advance of lining. This includes addressing points of infiltration that will cause resin wash out or adversely impact the cure and finished quality of the CIPP sectional repair. Corrective actions include, but are not limited to, injecting chemical grout, dewatering using a wellpoint system, or utilizing a protective membrane as defined in 3.2.10 and described in 6.4.4.

6.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions that will hinder or prevent the installation of the resin-saturated liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, a point repair excavation shall be made to uncover and remove or repair the obstruction.

6.2 *Resin Saturation*—The liner shall be fully saturated with resin (wet out) under controlled conditions and free of any dry spots or resin lean areas. The resin system shall be proportionally mixed, handled and applied in accordance with manufacturer's recommendations. The volume of resin used shall be sufficient to fully saturate the liner material and shall be adjusted by adding excess resin to account for the change in resin volume due to polymerization, to allow for migration of resin into the cracks and joints in the original pipe, and to account for any resin loss expected during the liner insertion process. For each CIPP installation, wet out data shall be recorded and retained by the user for quality assurance and record keeping purposes, and submitted to the purchaser as required.

TABLE 1 CIPP Initial Mechanical Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural Strength[B]	D790	Declared value, but not less than 4 500	Declared value, but not less than 31
Flexural Modulus[B]	D790	Declared value, but not less than 250 000	Declared value, but not less than 1 724

[A] The values in Table 1 are for test results on field specimens. The purchaser shall consult the manufacturer for the long-term mechanical properties.
[B] The value indicates minimum strength in the circumferential direction.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass shall be made by capturing flow from all contributing points upstream of the pipe to be reconstructed and discharging the flow to a downstream point or adjacent system. The bypass pumping and piping system shall be of adequate capacity and size to handle the flow. Prior to cleaning and pre-inspection and during installation, all upstream contributing flows impacting the repair area shall be isolated and bypassed around the repair area. Bypassing shall be coordinated between all parties involved.

6.3.1 Public advisory services shall be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the pipeline is back in service.

6.4 *Liner Insertion:*

6.4.1 The carrier device shall be able to navigate the host pipe alignment and geometry to the point of installation without compromise to the host pipe, installation process or finished quality of the CIPP; shall be designed to expand with air pressure to press the resin-saturated liner tightly against the interior of the host pipe for the duration of cure; shall be compatible with the curing process; and, when required, shall have flow-thru capabilities for flow control.

6.4.2 When required, a protective membrane shall be secured to the carrier device and a compatible release agent shall be liberally applied to its entire surface area as required.

6.4.3 The resin-saturated liner shall be centered and rolled tightly against the carrier device and secured with binding material. The binding material shall be placed approximately 1 in. (25 mm) from each end of the liner and spaced along the remaining length of the repair, typically 1.5 ft to 2.0 ft (0.46 m to 0.61 m) apart; shall be used to secure the leading edge of the liner to the front of the carrier device as required to ensure the liner's position is maintained as it is pushed or pulled into the host pipe; and shall be designed to release or break under tension when the carrier device is pressurized and the resin-saturated liner is expanded against the host pipe.

6.4.4 When required, to prevent resin contamination or washout and as directed by the manufacturer, a protective membrane shall be attached to the resin-saturated liner across the affected area.

6.4.5 The resin-saturated liner shall be positioned into the host pipe using push rods or a winching process. Prior to insertion and as directed by the manufacturer, the carrier device shall be inflated to a low pressure to increase rigidity and reduce material drag along the pipe invert. The carrier device

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shall be equipped with adequate air supply for proper inflation and full expansion of the liner against the host pipe interior for the duration of cure.

6.4.6 CCTV inspection shall be conducted concurrently with the placement of the resin-saturated liner to verify proper positioning and the host pipe condition and resin saturation in accordance with 6.2 prior to inflation and cure.

6.5 *Curing*—The resin-saturated liner shall be cured in accordance with manufacturer's recommendations, and the curing process shall be documented and submitted to the purchaser as required. The estimated minimum and maximum pressures recommended to form a tight-fitting liner against the existing pipe during the curing process shall be provided by the manufacturer.

6.5.1 *Using Air or Air/Steam*—Curing of the resin-saturated liner shall be accomplished without pressure interruption with air or a mixture of air and steam for the duration of time in accordance with the manufacturer's recommendations for a complete cure. For CIPP cured under ambient conditions, to the extent practical, a representative coupon of the resin impregnated liner suspended at the access point shall be used to confirm curing time as required.

6.5.2 *Using Photoinitiated Reaction*—While the liner is expanded under pressure against the host pipe, a CCTV inspection shall be performed to verify that the liner is properly positioned and tight-fitting. Any anomalies shall be corrected prior to initiating the curing process.

6.5.2.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photoinitiators shall be optimized to the output of the curing lights.

6.5.2.2 For dynamic curing processes, the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific liner dimensions to initiate polymerization and facilitate the cure of the CIPP resin.

6.5.2.3 A full curing protocol shall be provided by the manufacturer and be recorded and maintained as documentation verifying the curing process. As a minimum, data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, and the power output of the light assembly.

6.6 *Overlapping Installations*—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end with a minimum overlap to adjacent CIPP sections in accordance with manufacturer's recommendations. To the extent practical, installations shall progress from the furthest point downstream towards the upstream end so that overlapping ends of the CIPP are streamlined with the flow.

6.7 *Workmanship:*

6.7.1 The finished CIPP shall be continuous over its entire length and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations. If these conditions are present, CIPP in these areas shall be removed and replaced. The CIPP shall be tight-fitting against the host pipe at its termination points with transitions at each end that do not create a ledge, a change in direction of flow, or a location where debris will accumulate during uniform flow conditions. In sections of pipe of constant internal diameter and straight alignment, the CIPP shall not introduce surface irregularities in addition to those of the host pipe which exceed 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater. Applications where surface irregularities exceeding 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater, are anticipated due to geometric features, condition or alignment of the host pipe shall be evaluated by the owner, engineer and manufacturer to determine feasibility and compliance of this practice. Examples include CIPP that is installed through bends, joint offsets, diameter transitions and other discontinuities in the host pipe which can result in localized radial or longitudinal fins or folds, or other surface irregularities in the CIPP.

6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active service connections shall be reinstated. This shall be performed without excavation and, in cases of non-worker-entry sized pipes, from the interior of the pipeline by the means of CCTV inspection and a remote-control cutting device. Reinstated service connections shall be cut smooth and free of burrs and rough edges. All laterals where a plug by the end of the lateral was not visible by the pre-inspection shall be reinstated if the purchase agreement does not specify it differently.

7. Inspection Practices

7.1 *Sampling*—CIPP samples for mechanical properties testing shall be prepared when required and as directed by the engineer or purchaser. Representative samples of the resin-saturated liner shall be restrained in a like diameter pipe or prepared in a clamped mold and cured in the same manner as the installed CIPP. Samples shall be prepared in a manhole or other point of access, or under simulated conditions above ground, and shall be of adequate size to perform flexural properties testing as described in 7.2.

7.2 *Short-Term Flexural (Bending) Properties*—For isotropic materials, the tangent flexural modulus of elasticity and flexural strength shall be measured in accordance with Test Method D790. For anisotropic composites, flexural testing shall be conducted in the hoop direction on specimens cut from plate samples in accordance with Test Method D790 or on curved beam specimens cut from restrained samples in accordance with the modified Test Method D790 method as described in Annex B of ISO 11296-4 and Practice F2019, Appendix X2. Flexural properties shall meet or exceed values listed in Table 1.

7.3 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 7.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and

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shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. If minimum wall thickness requirements are not met, a design reconciliation shall be performed. If it is determined through design reconciliation that the installed CIPP is non-compliant, the designer or purchaser shall determine whether corrective action is necessary.

7.4 *Inspection and Acceptance*—The CIPP installation shall be inspected visually if appropriate or by CCTV inspection if visual inspection cannot be accomplished. No infiltration of groundwater shall be observed. The CIPP shall comply with 6.7.

8. Keywords

8.1 ambient cure; binding material; CIPP; carrier device; cured-in-place pipe; design reconciliation; E-CR; fiberglass matting; photoinitiated reaction; protective membrane; reinforced composite; release agent; sealing mechanism; sectional repair; silicate resin; tight-fitting; wellpoint system

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 During the initial design phase, consideration should be given to anchoring mechanisms required to limit downstream movement or dislodging of the CIPP sectional repair once it is put into service, which is of particular importance on lines with steep slopes, high velocity flows, surcharge conditions or broad temperature swings. The selected CIPP sectional repair system should align with design objectives for each application (for example, thermal properties or minimum levels of adhesion), and should be demonstrated through proper host pipe preparation and installation practice in accordance with this standard and manufacturer's guidelines.

X1.2 For circular host pipes with up to 10% ovality, the CIPP system should be designed for minimum wall thickness in accordance with ASCE Manual of Practice 145 or, alternatively, Practice F1216, Appendix X1, with the exception that Eq. X1.2 and X1.4 be excluded from the calculations. For non-circular host pipes or circular host pipes with greater than 10 % ovality, the design method described in ASCE Manual of Practice 145 is recommended. The design of the CIPP shall take into consideration the type of deterioration or damage to the existing pipe as well as relevant hydrostatic, soil and live loads.

X1.3 Further, when Practice F1216 is used for design, note X1.2 of Practice F1216 suggesting a maximum SDR of 100 be used for liners installed in pipes where the groundwater is not above the pipe invert shall be ignored. Instead, the partially deteriorated design shall be determined by using F1216, Eq X1.1 with the actual groundwater load or, in the case of no groundwater being present, a virtual groundwater load equal to a minimum of 5.0 ft (1.5 m) above the pipe invert or at least 0.33 ft (0.10 m) above the crown of the liner – whichever is greater (but in no case should this height exceed the cover depth of the host pipe). The fully deteriorated design condition shall be determined using F1216, Eq X1.3 with H_w being the height of the groundwater above the invert of the pipe.

X2. CHEMICAL RESISTANCE TESTS

Scope:

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

Procedure for Chemical Resistance Testing:

X2.2.1 Chemical resistance tests should be completed in accordance with Practice D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with 7.2 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

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serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

X3. CERTIFICATIONS

X3.1 The CIPP system may comply with NSF/ANSI-14 and may be tested and certified to be in compliance with NSF SE 10990.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]

D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D4814 Specification for Automotive Spark-Ignition Engine Fuel

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

E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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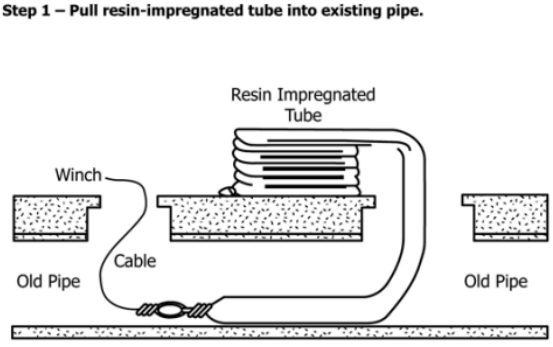

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F 6 3.6 °F (23 °C 6 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1216 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2]

This standard is issued under the fixed designation F1216; 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 reconstruction of pipelines and conduits (2 in. to 108 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water, introducing controlled steam within the tube, or by photoinitiated reaction. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process is used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe

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

E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standard:*[4]

M 28 Rehabilitation of Water Mains, Third Ed.

2.3 *NASSCO Standard:*[5]

Sewer Pipe Cleaning Specification Guideline

3. Terminology

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

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "*Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois*," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[3] 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.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] Available from the National Association of Sewer Service Companies, 5285 Westview Drive, Suite 202, Frederick, MD 21703. http://www.nassco.org/

***A Summary of Changes section appears at the end of this standard**

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3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—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.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.4 *photoinitiated reaction*—the polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube shall consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube and any non-structural plastic coating or flexible membrane included in the tube construction shall be compatible with the resin system used. The material shall be able to stretch to fit irregular pipe sections and negotiate bends. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance shall be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process shall be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The CIPP system shall be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties shall be determined in accordance with Section 8.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

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

7.1.2 *Cleaning of Pipeline*—All internal debris that will interfere with the installation or adversely affect the performance of the CIPP shall be removed from the original pipeline. Gravity pipes are cleaned with hydraulically powered equipment, high-velocity jet cleaners, mechanically powered equipment, or other applicable method(s) (see NASSCO Sewer Pipe Cleaning Specification Guideline). Pressure pipelines are cleaned with cable-attached devices, fluid-propelled devices, or other applicable method(s) (see Chapter 3 "Pipe Cleaning Methods" in AWWA, M 28 Rehabilitation of Water Mains, Third Ed.).

7.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or worker entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions shall be noted and corrected prior to installation of CIPP.

7.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % to ensure proper installation of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation shall be made to uncover and remove or repair the obstruction prior to the installation of the CIPP.

7.2 *Resin Impregnation*—The tube shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all the void space present in the tube material at nominal thickness and diameter. The volume shall be adjusted by adding excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

NOTE 1—In pipelines 8 in. diameter and less, 5 % to 10 % excess resin should be added.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the pump and bypass lines shall be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

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7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube shall be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head shall be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube shall be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube shall be turned inside out. The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions shall be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed.

NOTE 3—After inversion is completed, pressures can be adjusted to facilitate the safe installation of condensate removal equipment or other mechanisms required to transition to the curing process.

7.5 *Lubricant*—When lubricant is used to reduce friction during inversion, the lubricant shall be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used shall be a nontoxic product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.1.1 The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam-generating equipment is required and shall be capable of producing a sufficient amount of thermal energy throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The volume of air being sent through the pipe shall be sufficient to minimize condensation of the steam occurring during the curing. The temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.2.1 The steam-generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing steam. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the distribution of thermal energy via control of steam and air flow maintains the stated temperature. The curing of the CIPP must take into account the existing pipe material, the resin system, the current vertical alignment (that is, sags), and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.3 *Using Photoinitiated Reaction*—After the inversion is completed, while the tube is expanded under pressure, a light

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curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

7.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

7.6.3.2 *Processing*—Before the inversion begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

7.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

7.6.4 *Required Pressures*—The estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process shall be provided by the tube manufacturer and shall be increased to include consideration of the external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures shall be maintained until the cure has been completed. The pressure shall be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP shall be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 7.8 and Section 8.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113 °F (45 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care shall be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe shall be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes shall be sealed by an approved method using compatible materials, if required by the owner in contract documents.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the Contract documents or purchase order, the preparation of a CIPP sample is required, using one of the following two methods, depending on access and the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample shall be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 In medium and large-diameter applications and areas with limited access, the sample shall be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used. This method can also be used for sizes 18 in. or less, in situations where preparing samples in accordance with 8.1.1 can not be obtained due to physical constrains, if approved by the owner.

8.1.3 The samples for each of these cases shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures shall be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and shall meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength shall be measured for pressure pipe applications in accordance with Test Method D638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes shall be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test shall take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end shall not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe shall be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The

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leakage quantity shall be gauged by the water level in a temporary standpipe placed in the upstream plug. The test shall be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36-in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes shall be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test shall be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the owner in the contract documents or purchase order, a delamination test shall be performed on each inversion length specified. The CIPP samples shall be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample shall be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate shall be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchase and seller.

8.6.1 *Ultrasonic Testing of Wall Thickness*—An alternative method to 8.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797/E797M. A minimum of eight (8) evenly spaced measurements shall be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 in. to 18 in. from the end of the pipe. For pipe diameters of fifteen (15) in. or greater, a minimum of sixteen (16) evenly spaced measurements shall be recorded. The ultrasonic method to be used is the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of E797/E797M. A calibration block shall be manufactured from the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendations. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.7 *Inspection and Acceptance*—The installation shall be inspected visually if practical, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed through the CIPP itself. All service entrances shall be accounted for and be unobstructed.

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APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required.

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe*:

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N} \qquad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa), measured from the invert of the pipe
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
DR = dimension ratio of CIPP,
C = ovality reduction factor =

$$\left(\left[1-\frac{\Delta}{100}\right]/\left[1+\frac{\Delta}{100}\right]^2\right)^3$$

Δ = percentage ovality of original pipe equals

$$100 \times \frac{(Mean\ Inside\ Diameter - Minimum\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

or

$$100 \times \frac{(Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

and

N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum SDR of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\,\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR = \frac{\sigma_L}{PN} \qquad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter, in. (Inside Diameter of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, t, in.	Maximum Allowable Groundwater Load[A] (above invert)	
			ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A]Assumes K = 7.0, E = 125 000 psi (862 MPa) (50-year strength), ν = 0.30, C = 0.64 (5 % ovality), and N = 2.0

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$$q_t = \frac{1}{N}\left[32\,R_w\,B'\,E'_s \cdot C\,(E_L I/D^3)\right]^{1/2} \qquad (X1.3)$$

where:

q_t = total external pressure on pipe, psi (MPa),
= $0.433H_w + wHR_w/144 + W_s$, (English Units),
$0.00981H_w + wHR_w/1000 + W_s$, (Metric Units)
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
w = soil density, lb.ft^3 (KN/m^3),
W_s = live load, psi (Mpa),
H_w = height of water above top of pipe, ft (m)
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1 + 4e^{-0.065H})$ inch-pound units, $(1/(1 + 4e^{-0.213H})$ SI units
I = moment of inertia of CIPP, in.^{4}/in. (mm^4/mm) = $t^3/12$,

t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long-term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm)

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093\ (inch - pound\ units), \qquad (X1.4)$$

or

$$\frac{E}{12(DR)^3} \geq 0.00064\ (SI\ units)$$

where:

E = initial modulus of elasticity, psi (MPa)

NOTE X1.3—For pipelines at depth not subject to construction disturbance, or if the pipeline was originally installed using tunneling method, the soil load may be calculated using a tunnel load analysis. Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eq X1.1 and X1.2.

X1.3 *Pressure Pipe*:

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eq X1.6 or Eq X1.7, as directed by Eq X1.5, and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eq X1.5-X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \qquad (X1.5)$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(DR-1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \qquad (X1.6)$$

where:

DR = dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eq X1.1, Eq X1.3, Eq X1.4, and Eq X1.7, and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(DR-2)\,N} \qquad (X1.7)$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
DR = dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of

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sizes from 2 in. to 108 in. diameter which would be impractical to list here.

X2. CHEMICAL-RESISTANCE TESTS

X2.1 *Scope*:

X2.1.1 This appendix covers the test procedures for chemical-resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical-Resistance Testing*:

X2.2.1 Chemical resistance tests should be completed in accordance with Practices D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical-resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical-resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–21) that may impact the use of this standard. (Approved August 15, 2022.)

(1) Changed non-mandatory wording to mandatory wording throughout the standard.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–16) that may impact the use of this standard. (Approved November 1, 2021.)

(1) Added 3.2.4 and 7.6.3.

(2) Section 7.6.4 was revised.

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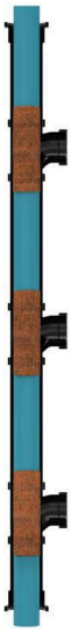
Continuous v. Gapped Cured-in-Place Pipe Repair Methodology Review

Engineering Evaluation Rev. 3



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This report has been digitally signed and sealed by M. James Aronsohn, PE, FRSE on August 23, 2024.

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M. James Aronsohn, PE, FRSE
(Civil/Structural Engineer)
Florida License Number 78248

Report: (20 Pages)
Representative Photographs:
(13 Photographs on 7 Pages)

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ARONSOHN ENGINEERING CO., LLC
Civil • Structural • Forensic Engineering
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August 23, 2024

Mr. Michael Wilson, President
Pipelining Technologies, Inc.
1500 North Mango Road, Suite #1
West Palm Beach, Florida 33409

Re: Engineering Evaluation Rev.3
Continuous v. Gapped
Cured-in-Place Pipe Repair Methodology Review
AEC Project Number: 2024.02-101

Report Revisions:

Rev.1: Reflects changes to the original Signed & Sealed Engineering Evaluation, dated 4/3/2024, made in accordance with redlines submitted by Melissa Delgado, Assistant, PTI in email correspondence dated 6/23/2024.

Rev.2: Reflects changes to Revision 1, dated 6/23/2024, as aligned with PTI during a workshop held on 7/2/2024. Revisions in toto include change of the header background color scheme used for Table 1 and Table 2, and incorporation of legends in same.

Rev.3: Reflects changes to Revision 2, dated 7/2/2024, based on a red-line version of that report received from PTI on 8/22/2024. Revisions in toto include the removal of references to complaints filed by PTI and the removal of the names of individuals associated with those complaints to facilitate PTI's Declaratory Statement Submittal.

Dear Mr. Wilson:

In accordance with your January 30, 2024 email notice of intent, Aronsohn Engineering Co., LLC (AEC) conducted an expert engineering review of the Continuous Cured-in-Place Pipe (CIPP) repair methodology developed by your team in contrast to Gapped CIPP methodology and prepared this report documenting findings under this research. Mr. M. James Aronsohn, PE, FRSE, MBA, Principal, performed this study in collaboration with key personnel from Pipelining Technologies, Inc. (PTI) during the months of February and March 2024.

AEC is a professional services firm whose principal brings more than four decades of civil/structural/forensic engineering experience to bear in providing expert consultation and testimony for its clients. Principally, AEC's mission as an engineering consultancy is to assist property owners, insurance carriers, and legal professionals in closing/resolving commercial and residential property-damage claims resulting from extreme weather events, soil subsidence, insect damage, and plumbing and construction defects.

Concerning this matter, during our January 30, 2024 Scoping Alignment call and our subsequent February 6, 2024 CIPP Methodology Review Workshop, AEC was specifically requested to contrast and evaluate Continuous and Gapped (where Gapped in some cases is referred to as Start and Stop) cured-in-place-pipe repair methodologies for conformance with governing industry-prescribed standards; specifically, ASTM International (formerly, American Society for Testing

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and Materials) Designation: F1216-22 and Designation: F1743-22, and the plumbing provisions of the Florida Building Code (FBC).

Beyond business ethics and professional canons, which dictate that we act as responsible stewards of our clients' finances and infrastructure, a clear and present need for these proceedings has been established through the passage of Florida Senate Bill SB 4D. This bill, which was passed by the Florida Legislature in May 2022, dictates that as of December 31, 2024, condominium and cooperative associations conduct milestone structural inspections, perform structural integrity reserve studies (SIRS), and adequately fund items identified as needing repair or replacement.

Failure to comply with SB 4D can result in personal liability on the part of board members. Further to the foregoing, once made public, these proceedings will provide board members with valuable insights to facilitate their work as responsible stewards of the communities they were elected to serve.

Holistically, a SIRS is comprised of eight (8) specific elements, which include plumbing systems, and which establishes the critical and time-sensitive business need to codify requirements governing pipelining repairs. To this end, this report provides a comparison study of the physical characteristics of each cured-in-place lining methodology and our evaluation and conclusions regarding the requested scope of work.

Evaluation Activities

AEC performed the following tasks to evaluate conformance with the above-cited ASTM specifications taken in concert with the applicable provisions of the FBC:

- Researched CIPP installation methodology and governing specifications;
- Studied exemplar mockups of actual Continuous and Gapped CIPP installations to understand the physical characteristics of each installation methodology;
- Conducted a background interview with Mr. Wilson and other PTI Staff to establish a timeline of the conditions and develop an understanding of the primary concerns;
- Held a project Scoping Alignment Meeting and a CIPP Methodology Review Workshop with the PTI team to define the business requirements for this report;
- Conducted interviews with the following stakeholders to obtain supplemental first-hand feedback concerning the design, installation, and in-service performance of Continuous and Gapped CIPP installations:
  - Mr. Michael Wilson, President, Pipelining Technologies, Inc.;
  - Mr. Sam Dosdourian, Principal, Pipelining Technologies, Inc.;
- Reviewed the documentation listed in the *Document Review* section of this report;
- Assimilated all information collected and performed an engineering evaluation to assess the observed conditions; and
- Prepared this report summarizing the results of the above-cited work along with the applied evaluation and ensuing conclusions.

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Background Information

At the onset of the work required to prepare this report, AEC scheduled a two-day-long project kick-off workshop with key PTI staff to define the scope of work and the business requirements for this project. These staff members included Mr. Michael Wilson, President; Mr. Sam Dosdourian, Principal; Mrs. Melissa Delgado, Assistant; and Mr. Wilson Crespo, Assistant.

To facilitate the engineering analysis presented herein, Mr. Wilson and his team provided full unrestricted access to PTI's shop and all relevant information in their possession. Furthermore, Mr. Wilson documented materially significant historical events that ultimately dictated the need for this report. Thus:

- **August 2005:** Incorporated Pipelining Technologies, Inc. (PTI) as a business entity to identify and service a Florida market for small diameter, 2"-12", Cured-in-Place drainage pipe rehabilitation in South Florida. Initially used NuFlow pull-in-place CIPP product.
- **September 2012:** PTI invested in Perma-Liner Industries CIPP inversion lining equipment and the Dancutter robotic tool, a critical tool (ASTM F1216-22, Article 7.9 – Service Connections); equipment required to complete the pipe repair.
- **November 2015:** Mr. Michael Wilson, President/Qualifier of PTI, is instrumental in implementing the Florida Declaratory Statement DS 2015-106, which requires licensed plumbing contractors to process a plumbing permit in order to perform small diameter CIPP installation work according to the manufacturer's written installation instructions, and in compliance with the applicable ASTM Standards and Florida Building/Plumbing Codes.
- **October 14, 2022:** PTI retained Mr. Kyle Rea with Adams Reese, LLP, to represent PTI in its complaints to the Florida Department of Business and Professional Regulation (DBPR), the Florida Construction Industry Licensing Board (CILB), and the Florida Board of Professional Engineers (FBPE), and further to facilitate any communication with the State of Florida Building Commission.
- **January 30, 2024:** PTI retained Mr. M. James Aronsohn, PE, FRSE, MBA, Principal, Aronsohn Engineering Co., LLC, to contrast, compare, and evaluate continuous and gapped CIPP repair methodologies with respect to the applicable ASTM specifications and provisions of the Florida Building Code, which, collectively, provide industry-standard guidelines and procedures governing the installation of the CIPP material. Mr. Aronsohn's evaluation includes a review of the manufacturer's installation instructions and the Florida Building/Plumbing Codes.

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Document Review

The following documentation was provided and reviewed as part of this assessment:

- *Pipelining Technologies, Inc. (PTI), Evaluation of Findings* – Prepared by Mr. Michael Wilson, President, Pipelining Technologies, Inc. and dated September 15, 2023; this document provides an evaluation of the conformance of the Gapped CIPP repair methodology with respect to the governing ASTM provisions on 10 pages. The document includes four illustrations and no photographs.

  The engineering analysis conducted and the conclusions derived therefrom, as presented within the framework of this expert review, undergird findings offered in the above-cited PTI report.

- *ASTM International Designation: F1216-22, Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of Resin-Impregnated Tube* – This international standard, presented on eight pages, was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

- *ASTM International Designation: F1743-22, Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)* – This international standard, presented on nine pages, was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

- *2024 International Plumbing Code*.

- *2023 Florida Building Code, Plumbing, Eighth Edition*.

- *2024 Supplement to the 8th Edition (2023) Florida Building Code*

  - **Chapter 7 SANITARY DRAINAGE**

    718.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743

  - **Chapter 30 SANITARY DRAINAGE**

    Section P3012 – REHABILITATION OF BUILDING SEWERS AND BUILDING DRAINS P3012.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743

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- *Perma-Liner Industries, LLC, Perma-Liner™ Pull-in-Place Installers Manual* – Dated January 1, 2015, this document provides guidelines for the installation of cure-in-place lining for the reconstruction of sewer drains and vent pipeline without excavation.
- *Florida Statue SB 4D* – A Senate Bill which establishes a statewide inspection program, requiring condominium and cooperative associations to conduct milestone structural inspections and perform structural integrity reserve studies to ensure that condominium and cooperative buildings are safe for continued use.

  The relevance of this bill to these proceedings is the statute-required evaluation of plumbing systems to facilitate repair/replacement decisions, the life-cycle costs for which can be significantly impacted by the selected repair methodology.

Analytical Approach – General

Objective contrasting/comparing and evaluation of the Continuous and the Gapped CIPP methodologies requires a comprehensive understanding of the physical characteristics of each cured-in-place pipe repair methodology and how those characteristic impact performance over time. The *Evaluation* section of this report that follows provides a detailed comparison study of the two pipe lining methodologies and illustrates conformance with critical industry-recognized performance-based standards. The results of this evaluation are then utilized to develop and substantiate the conclusions presented herein.

Cured-in-Place Pipe Repair Characteristics

PTI prepared actual mock-ups of a Continuous CIPP installation performed using the inversion methodology (ASTM F1216-22) and a Gapped CIPP installation performed using Pull-in-Place (PIP) methodology (ASTM F1743-22). In this regard, it bears mentioning that a Continuous liner may be installed using either the Inversion methodology or the PIP methodology. In furtherance of this, and by virtue of the gaps between the multiple discrete independent liner sections that collectively form a segmented-liner appliance run over the length of an installation, and the need to ensure that these independent sections of liner are accurately placed so as not to obstruct the branch fittings, installation of Gapped liners is limited to the PIP methodology.

Key differences between Continuous CIPP repairs and Gapped CIPP repairs are illustrated at the sanitary crosses depicted in Figure 1 and Figure 2, respectively, below. These key documented differences provide the basis for the detailed analysis that follows.

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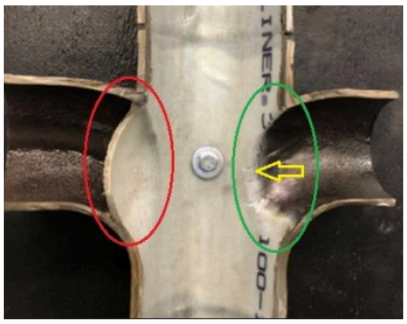

Figure 1: Section Cut Through a Mock-Up of a Continuous Liner Installation

With reference to Figure 1, above, the Continuous CIPP mock-up illustrates liner continuity and tight fit (ASTM F1216-22, Article 1.1 and 7.8); in essence, seamless coverage of the sanitary cross pipe joints and the pipe interior wall from the upstream pipe segment into and throughout the full length of the sanitary cross and continuing into the downstream pipe segment. Figure 1 further illustrates the required liner dimple protruding into a branch of the sanitary cross (circled red) (ASTM F1216-22, Article 7.4.2), competent liner reinstatement to the pipe substrate (yellow arrow), and the resulting faired condition of the finished unobstructed lining transition into the inlet of the sanitary-cross branch (circled green) (ASTM F1216-22, Article 7.9).

Figure 2, below, illustrates a mock-up of a Gapped CIPP installation. The light-blue arrow in the center of the sanitary cross indicates the direction of flow through the pipe for the purpose of defining hydraulic obstructions, whereby a hydraulic obstruction is a discontinuity in the surface of a fluid conveyance system that is in direct contact with the fluid contained within that system. The importance of this in terms of system longevity, is that these discontinuities introduce hydraulically-induced shear and axial forces which in turn act on the system components, thus adversely impacting system performance and reducing component life.

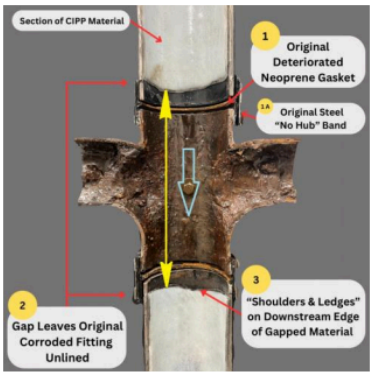

Figure 2: Section Cut Through a Mock-Up of a Gapped Liner Installation

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With further reference to Figure 2, Figure 3 that follows, and with the foregoing discussion in mind, note the bare section of pipe (gap) between the upstream and downstream liner segment termini that extends across the entire length of the sanitary cross and into the pipes to which it is connected (yellow arrow, Comment #2) thus leaving the original neoprene seals at the pipe joints exposed (Comment #1, Comment #1a, Figure 3).

Additionally, the liner terminus at the downstream end of the sanitary cross (the upstream end of the downstream liner segment) creates a condition where the liner shoulder/ledge created by that terminus (Comment #3) is subjected to hydraulically-induced loads as introduced above. These loads in turn cause the liner material to separate from the pipe host over time. This condition is documented in the *Observations* section of this report that follows and is discussed in greater detail under the subsection *Liner Separation* within the *Evaluation* section below.

Observations: Cured-in-Place Pipe Repair Performance

The following is a summary of in-service conditions observed by PTI through the pan-and-tilt sewer camera evaluation of pipe system repairs. Please reference the *Representative Photographs* section at the end of this report for the photographs cited below:

A view looking downstream toward a sanitary tee fitting with a side inlet branch inside of a pipe within which a Continuous CIPP repair was made illustrates the continuity and smoothness of the lined pipe walls across the joint, the competent reinstatement (faired finish) of the liner at the branch inlet, and the absence of obstructions at those inlets (Photograph 1). A close-up view of a side inlet branch illustrates robotically-produced liner reinstatement at a sanitary-tee branch, the absence of inlet obstructions, and the absence of gaps between the liner and the pipe substrate at the branch inlet. (Photograph 2)

A view looking downstream toward a sanitary tee inside of a pipe within which a Gapped CIPP repair was made illustrates the lack of continuity and the presence of hydraulic obstructions (blockages, ledges, and/or ridges and depressions that rise above or lie below the predominant plane of the pipe wall) that are present between any given two liner segments upstream and downstream of the sanitary tee. Noteworthy is the cured excess epoxy blocking a portion of a branch inlet (Photograph 3).

Sewer camera images looking downstream toward the upstream (top) edges of Gapped CIPP liner segments in three locations illustrate common conditions across all three repairs. The conditions include the presence of bare unlined pipe between the Gapped liner segments, and debris lodged between the bare pipe wall and the Shoulder/Ledge at the exposed upstream edge of the downstream liner segment (Photographs 4, 5, and 6).

A close-up view at a no-hub coupling illustrates cracks and pitting in the exposed neoprene gasket component of the pipe coupling (Photograph 7). The no-hub coupling depicted in Figure 3 below further illustrates the cracking and pitting observed in the in-service neoprene gasket, which, for the purpose of this discussion, works with Figure 2 above.

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Figure 3: No-Hub Band Connection used with a Gapped Liner Installation

Looking downstream toward the upstream edge of a liner segment below the bare unlined section of the host pipe within a Gapped CIPP lining repair illustrates fraying and delamination of the exposed upstream (leading) edge of the liner segment and the gap (space) between the liner Shoulder/Ledge and the bare pipe wall at the upstream edge of the liner segment (Photograph 8).

Looking downstream toward the upstream edges of a liner segment below the bare unlined section of the host pipe within a Gapped CIPP lining repair illustrates gaps (spaces) between the liner Shoulder/Ledge and the bare pipe wall at the upstream edge of the liner segment, debris lodged between the liner and the pipe wall at these gaps, and bulge-like deformations in the liner that extend along its length and originate at the gaps between the liner Shoulder/Ledge and the host pipe at the upstream edge of the liner segment (Photograph 9).

A sewer camera image looking downstream within a Gapped CIPP liner segment illustrates a longitudinal bulge within and along the length of a liner segment that extends along the visible length of the liner segment (Photograph 10).

A close-up image at a point along a liner bulge within a Gapped CIPP liner segment illustrates a burst in the liner material within the bulged portion of the liner. Liner material at the burst is frayed, delaminated, and protrudes outward from the predominant plane of the liner. Water is flowing out of the bulge through the burst in the liner material (Photographs 11 and 12). A close-up image at the downstream end of a bulge within a Gapped CIPP liner segment illustrates discharge of water flowing within the confines of the bulge (Photograph 13).

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Evaluation

Overview

The foregoing physical observations document observed in-service characteristics of Continuous and Gapped CIPP liner installations and provide the basis for the discussion that follows, which is premised on industry standards and codified requirements.

CIPP Repair Methodology Review

Figure 4, Figure 5, Table 1, Table 2, and Figure 8 that follow, respectively, work interdependently to illustrate conformance, or lack thereof, with industry-defined installation standards governing the use of Top-to-Bottom (Continuous) and Start and Stop (Gapped) Cured-in-Place Pipe repairs. Taken holistically, these four analytical tools provide a robust side-by-side comparison of the two pipe repair methodologies, and in that illustrate key differences between the two to facilitate an empirical evaluation of each methodology, void of bias, to ultimately enable a conformance assessment with respect to ASTM standards and the provision of the FBC.

It bears mentioning that cost, in this case, is not a conformance-defining driver and it has no bearing on these proceedings. Further to this point, cost comparisons between repair alternatives founded exclusively on initial cost do not provide insights into the total cost of ownership for these durable goods. In these cases, bias can only be mitigated through a net-present-value life-cycle cost comparison of code-compliant repair alternatives.

To these ends, the analytical approach utilized herein is objective, specification-based, unbiased, and levied in conformance with the scientific method. This analytical standard, in turn, allows us to render unbiased substantiated conclusions. Thus, please reference the above-cited figures and tables which follow below:

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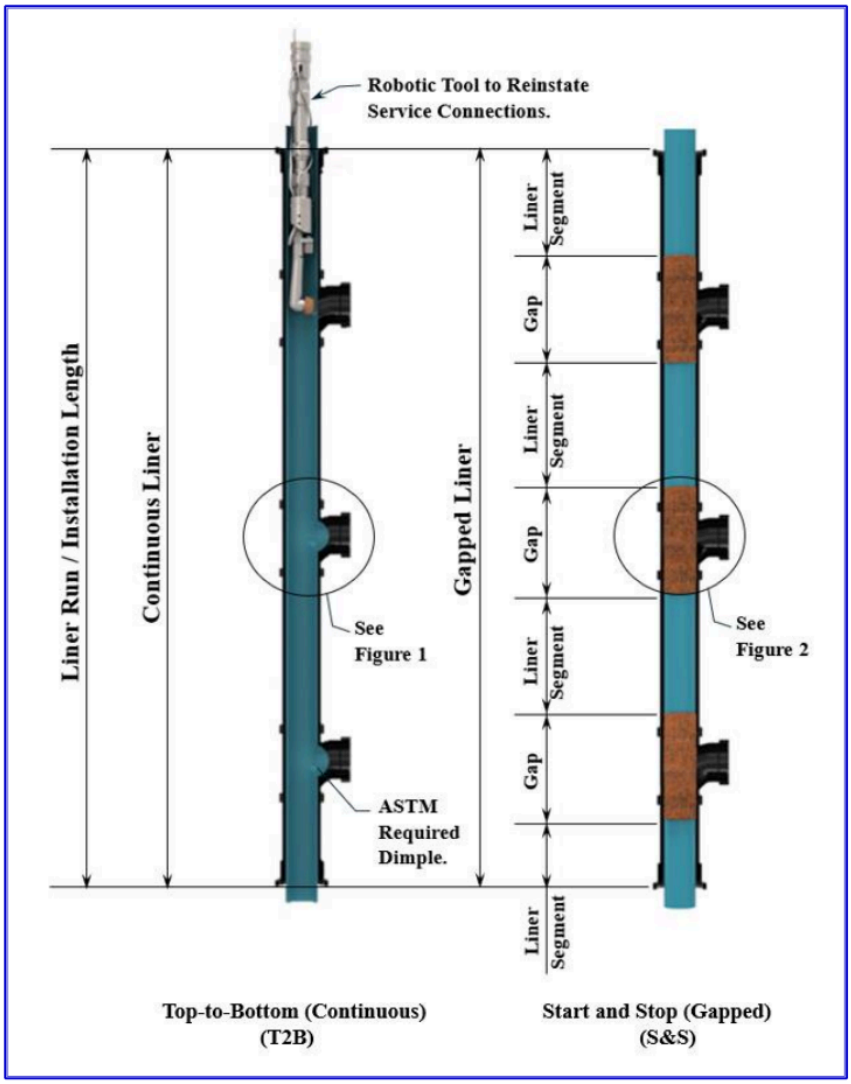

Figure 4: Physical Comparison of Cured -in-Place Pipe Repair Methods

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Continuity

The central question here is fundamentally centered on the definition of the word "Continuous" as it relates to ASTM F1216-22 for Inversion CIPP, and ASTM F1743-22 for Pull-in-Place CIPP. Both of these ASTM standards describe a "Continuous" installed tube with ***no*** gaps, which requires remote-controlled reinstatement of branch fittings. The single difference between the two ASTM specifications is the method of installing the "Continuous" material in the host pipe, which may be accomplished either by the Inversion method or by the Pull-In-Place method. Neither ASTM standard describes "Gapping" the branch fittings.

Further, with reference to Section 201, General, within the 2024 International Plumbing Code (IPC), the term" Continuous" is not defined. Thus, defaulting to IPC Section 201.4 – Terms not Defined, the code provides: *Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.*

To these ends, as it specifically concerns continuity, the underlying question is: Can a manufacturer, engineer, or installer reference ASTM F1743 and/or ASTM F1216 when promoting or approving the installation of multiple liner segments in a single delivery sleeve so as to leave a "Gap" in regions where branch connections or branch fittings occur, thus eliminating the need for a "remote-control cutting device" to reinstate branch connections in a vertical stack CIPP rehabilitation process?

We'll address this question using the Merriam-Webster and the Cambridge Dictionaries' definitions of "Continuous" and supplement those definitions with both narrative and graphic definitions of "Continuous" derived from mathematics. These are as follows:

Merriam-Webster: *marked by uninterrupted extension in space, time, or sequence;*

Cambridge: *without a pause or interruption;*

In mathematics: (RE: *https://en.wikipedia.org/wiki/Continuous_function | www.math.net/continuous*)

With reference to Figure 5 below, *a continuous line is a line that has no breaks or holes*. Intuitively, a mathematical function is continuous at a particular point if there is no break in its graph at that point; a function is continuous when its graph is a single unbroken curve. In contrast, a discontinuous function contains holes or jumps. In example:

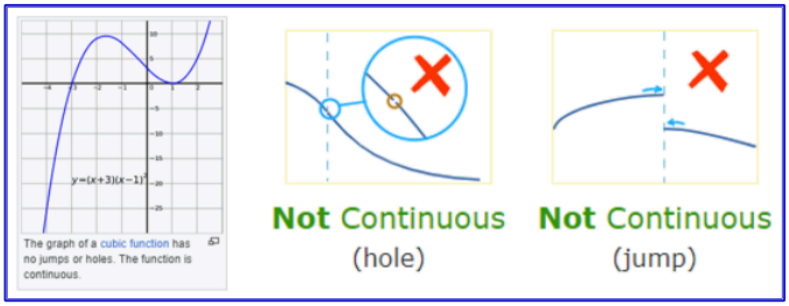

Figure 5: Functional Continuity

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Liner Separation

Collectively, the conditions sequentially reflected in Photographs 9 through 13 illustrate the importance of maintaining conformance with Sub-Section 706.2: Obstructions of both the 2024 International Plumbing Code and the 2023 Florida Building Code, Plumbing, Eighth Edition, and which reads: *The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping* (Table 2).

The bulge within the pipe liner, as it is described within the photographs, is essentially a conduit that formed between the liner and the host pipe due to the forces imparted on that liner by the fluids flowing within the lined pipe. These forces (shear and axial loads) are a result of obstructions created by the Gapped liner segments within the host pipe, which in turn disrupt the flow characteristics of the fluid moving through the pipe. In tangible terms facilitated by the application of basic principles of fluid mechanics (*Engineering Fluid Mechanics,* Robertson/Crowe):

Fluids flowing in a conduit void of obstructions exhibit laminar flow patterns, in contrast to turbulent flow patterns. Laminar flow has a smooth appearance throughout the flow field as characterized by the flow lines depicted in Figure 6 that follows. Intuitively, we can see that the forces acting on the conduit's interior surface under these conditions are shear (frictional) forces acting in the direction of flow at the interface between the fluid and the conduit surface.

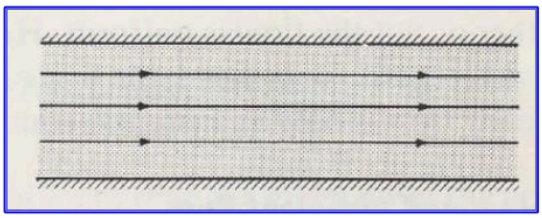

Figure 6: Laminar Flow within a Conduit

In contrast, fluids flowing in a conduit with internal obstructions exhibit turbulent flow within the influence zone of any given obstruction. The intensity of the turbulence is dictated by the geometry and attack angle of the obstruction. Flow patterns associated with turbulent flow are characterized by a mixing action throughout the flow field; this is illustrated in Figure 7 below.

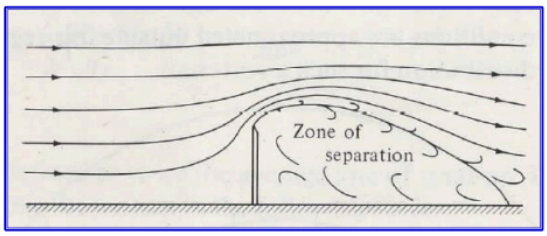

Figure 7: Flow Past an Obstruction

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Intuitively, these fluid models taken in concert with Newton's Third Law (*For every action there is an equal and opposite reaction*.) describe how obstructions influence fluid flow and how these obstructions in turn create the hydraulic forces that adversely impact liner performance. In consideration of the foregoing, and with further reference to Photographs 9 through 13:

The ledge at the upstream end of the liner obstructs flow and introduces hydraulic forces into the system that in turn act on the liner ledge. These forces then cause the exposed edge of the liner to separate from the pipe host, much like wind acting on the exposed leading edge of an asphalt roofing shingle, thus creating a gap between the liner and the host.

The gap in turn exacerbates the effects of the hydraulic forces by the ever-changing geometry of the gap. As the gap advances, prying action further separates the liner from the host and that separation propagates along the length of the liner thus forming a conduit between the liner and the host pipe.

These above-described conditions defeat the purpose of the liner installation itself through loss of protection for the host pipe and reduced hydraulic efficiency, which may be exacerbated by debris captured at these obstructions. Importantly, these understandings support the need for the plumbing code provisions that preclude *ledges, shoulders, or reductions capable of retarding or obstructing flow* from being present in the pipe system.

Discussion: Compliance with Industry Standards and Codified Requirements

Taking the above-provided narrative-form definitions of continuity in concert with the graphical definition of continuity presented in the Figure 5, and incorporating requirements mandated by the 2024 IPC Plumbing Code and the 2023 Florida Building Code, Plumbing, 706.2 Obstructions with further support provide by the foregoing discussion concerning liner separation: **Gapping in vertical stack liner installations is precluded and prohibited**.

The foregoing statement is further validated by comparing and contrasting the collective set of definitions for continuity to the physical characteristics of the CIPP repairs as illustrated in Figure 4. Doing so demonstrates that the Continuous CIPP repair methodology is in conformance with the holistic set of definitions for continuity; the liner is continuous and has no breaks or gaps over the entire installation run.

In contrast, the Gapped CIPP repair is not in conformance with the provisions of the 2024 IPC and the 2023 FBC, Plumbing, and does not meet either the grammatical or the mathematical standards for continuity as evidenced by the sections of bare pipe (gaps) that separate individual liner segments across the length of a liner run. A qualifying factor, in this case, is the length of a liner run, the termini for which encompass multiple sanitary branch fittings; *the installation, by definition, is non-continuous across the installation length*.

With the foregoing discussions specific to each CIPP repair methodology in mind, Table 1 and Table 2 that follow graphically illustrate the extent to which each CIPP repair methodology conforms with ASTM installation standards and Section 706.2 of the IPC and FBC, Plumbing, respectively. Please note the legends in these tables, which define the abbreviations used for the terms *Top-to-Bottom* and *Start and Stop* as introduced in Figure 4 above:

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Table 1: Compliance with ASTM Specifications

Legend: ☐ T2B: Top-to-Bottom ☐ S&S: Start and Stop

ASTM F1216-22 Inversion Installation Methodology			ASTM F1743-22 Pulled-in-Place Installation Methodology		
ASTM Specification	**Method**		**ASTM Specification**	**Method**	
	T2B	**S&S**		**T2B**	**S&S**
Article 1.1 – Scope When cured, the ***finished pipe will be continuous and tight-fitting***.	☑	☒	**Article 1.1 – Scope** When cured, the ***finished pipe will be continuous and tight-fitting***.	☑	☒
Article 5.1 – Materials, Tube The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit.	☑	☒	**Article 5.2.1 –Materials, Fabric Tube** The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit.	☑	☒
Article 7.4.1 – Installation, Inversion, Using Hydrostatic Head The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point.	☑	☒	**Article 6.4.2 – Installation, Methods, Pulling Resin-Impregnated Tube into Position** The wet-out fabric tube should be pulled into place using a power winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point.	☑	☒

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Table 1: Compliance with ASTM Specifications

Legend: ☐ T2B: Top-to-Bottom ☐ S&S: Start and Stop

ASTM F1216-22 Inversion Installation Methodology			ASTM F1743-22 Pulled-in-Place Installation Methodology		
ASTM Specification	**Method**		**ASTM Specification**	**Method**	
	T2B	**S&S**		**T2B**	**S&S**
Article 7.4.2 – Installation, Inversion, Using Air Pressure The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, ***producing dimples at side connections***.	☑	☒	**Article 6.4.4 – Installation, Methods, Using Air Pressure** The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, ***producing dimples at side connections***.	☑	☒
Article 7.8 – Workmanship ***The finished pipe shall be continuous over the entire length of an inversion run*** and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.	☑	☒	**Article 6.8 – Workmanship** ***The finished CIPP should be continuous over the entire length of an installation*** and be free of dry spots, lifts, and delaminations.	☑	☒
Article 7.9 – Service Connections After the new pipe has been cured in place, the ***existing active service connections shall be reconnected***. This should generally be done without excavation, and ***in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device***.	☑	☒	**Article 6.9 – Service Connections** After the new CIPP has been installed, the ***existing active (or inactive) service connections should be reinstated***. This should generally be done without excavation, and ***in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device***.	☑	☒

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Table 2: Compliance with Plumbing Code Provisions

Legend: ☐ **T2B: Top-to-Bottom** ☐ **S&S: Start and Stop**

Plumbing Code	Method	
	T2B	**S&S**
2024 International Plumbing Code **SECTION 706: Connections Between Drainage Piping and Fittings** **Sub-Section 706.2: Obstructions** The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping.	☑	☒
2023 Florida Building Code, Plumbing, Eighth Edition **SECTION 706: Connections Between Drainage Piping and Fittings** **Sub-Section 706.2: Obstructions** The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping.	☑	☒

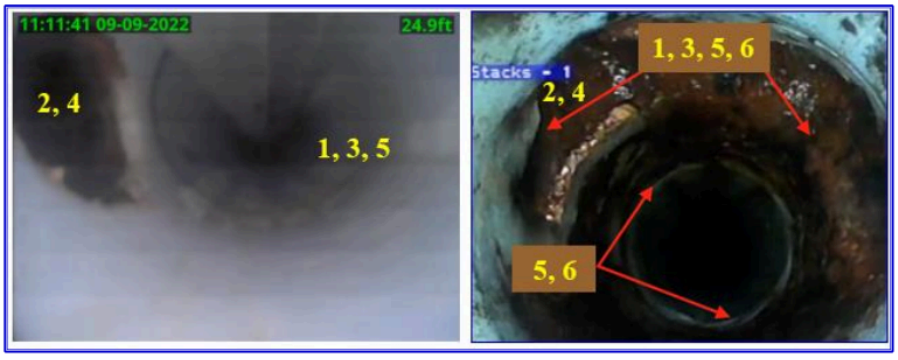

Figure 8: Comparison of Continuous CIPP (Left) and Gapped CIPP (Right)
(The numbers in each photograph correlate to the headers under *Findings* that follow.)

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Findings: Compliance with ASTM Standards and IPC/FBC Requirements

RE: Table 1, Table 2, and Figure 8 –

1. ASTM F1216-22, Article 1.1; ASTM F1743-22, Article 1.1 – CIPP Continuity and Tight Fit;

   Continuous CIPP: The repair depicted in Figure 8 illustrates liner continuity across the sanitary-tee branch inlets and tight fit against the interior pipe wall. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 illustrates liner discontinuity across the sanitary-tee branch inlets; this repair is not in compliance with the above-cited ASTM standards.

2. ASTM F1216-22, Article 7.4.2; ASTM F1743-22, Article 6.4.4 – Dimples;

   Continuous CIPP: The repair depicted in Figure 8 illustrates conditions where dimples were present and removed by a robotic cutting device as indicated by material reinstatement at the sanitary-tee branch inlets. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 illustrates liner discontinuity across the sanitary-tee branch inlets; by virtue of this liner discontinuity, no dimples were present at the branch inlets. The repair is not in compliance with the above-cited ASTM standards.

3. ASTM F1216-22, Article 7.8; ASTM F1743-22, Article 6.8 – CIPP Continuity;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates liner continuity across the visible length of the installation run with no apparent dry spots, lifts, or delaminations. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates liner discontinuity across the installation run; the repair is not in compliance with the above-cited ASTM standards.

4. ASTM F1216-22, Article 7.9; ASTM F1743-22, Article 6.9 – Branch Reinstatement;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates conditions where dimples were present and removed by a robotic cutter as indicated by material reinstatement at the sanitary-tee branch inlets. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates liner discontinuity across the sanitary-tee branches, and as such, no liner material is reinstated at the branch inlets. This installation is not in compliance with the above-cited ASTM standards.

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5. 2024 International Plumbing Code (IPC); Section 706.2 – Obstructions;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates liner continuity across the sanitary-tee; thus, no obstructions are present in the main trunk line or at the branch inlets; the installation meets the requirements of the above-cited IPC provision.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates ledges and obstructions in the main trunk line and in the branch inlets; this repair does not meet the requirements of the above-cited IPC provision.

6. 2023 Florida Building Code (FBC), Plumbing, 8th Ed.; Section 706.2 – Obstructions;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates liner continuity across the sanitary-tee; thus, no obstructions are present in the main trunk line or at the branch inlets; the installation meets the requirements of the above-cited FBC provision.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates ledges and obstructions in the main trunk line and in the branch inlets; this repair does not meet the requirements of the above-cited FBC provision.

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Conclusions

Conformity with ASTM Standards F1216-22 and F1743-22, the International Plumbing Code, and the Plumbing volume of the Florida Building Code is the basis for the quality and consistency of the final CIPP product delivered to the Consumer, and for the investigation and analysis conducted to facilitate Structural Integrity Reserve Studies as required by Florida Senate Bill SB 4D.

Based on the information collected and our subsequent engineering evaluation, it is AEC's professional opinion that:

- The Continuous CIPP repair methodology, whether installed using the Inversion methodology (ASTM F1216-22) or using the Pulled-in-Place method (ASTM F1743-22), is in strict compliance with the governing ASTM installation standards and with the requirements of the International Plumbing Code and the Florida Building Code.
- The Gapped CIPP repair methodology, which can only be installed using the Pulled-in-Place method (ASTM F1743-22), does not comply with the governing ASTM installation standards or with the requirements of either the International Plumbing Code or the Florida Building Code.

Further, this Engineering Evaluation reveals that licensed professionals and a manufacturer alike have collectively promoted, approved, and installed Gapped CIPP repairs that are not in conformance with The Florida Building/Plumbing Code or the Standards of the American Society for Testing and Materials (ASTM). With these considerations in mind, it stands to reason that Gapped CIPP liner installations will be identified as deficient and flawed in the SB 4D mandated statewide SIRS investigations.

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Limitations

The analyses and conclusions expressed herein have been prepared within a reasonable degree of professional certainty. They are based on the results and interpretations of the testing and/or data collection activities performed, the information made available to Aronsohn Engineering Co., LLC (AEC) at the time the report was issued, and the education, knowledge, and skill of the licensed professional noted.

The contents of this report are confidential and are intended for the express use of Pipelining Technologies, Inc. and its representatives or clients. AEC assumes no liability for the misuse of this information by others and reserves the right to update this report should additional information become available.

This document has been signed and sealed in accordance with applicable state statutes. If not signed and sealed by the licensed professional(s) named and shown as its author(s), the observations and conclusions cannot be relied upon, and in such cases, the document shall be construed as being for informational purposes only. This report was reviewed in accordance with AEC's standard quality control procedures.

Aronsohn Engineering Co., LLC appreciates this opportunity to be of service to you. Please do not hesitate to contact us if we can be of further assistance.

Sincerely,

Aronsohn Engineering Co., LLC
5254 SE Schooner Oaks Way, Stuart, Florida 34997
Florida Certificate of Authorization #32996

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Representative Photographs

ARONSOHN ENGINEERING CO., LLC

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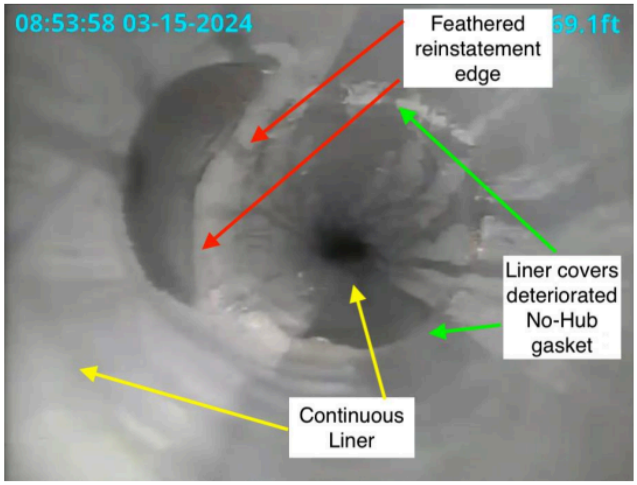
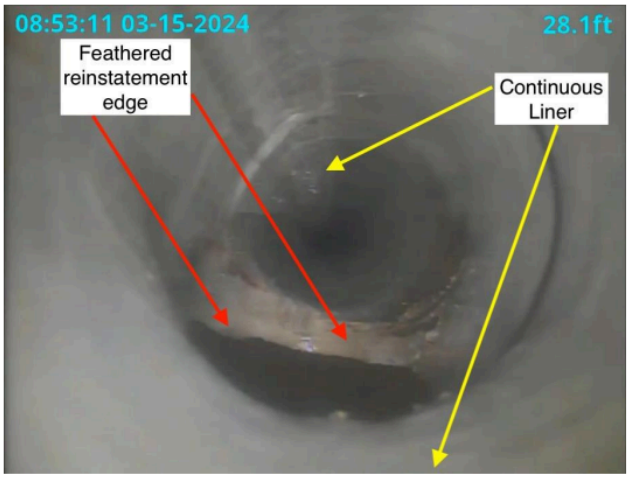


Photograph 1 - Sewer camera image of a Continuous CIPP repair at a sanitary tee. Note the liner continuity across the sanitary tee and at its branch inlet (yellow arrows). Also note the "faired" reinstated finish and the absence of obstructions at the branch inlet (red arrows), and the smooth liner coverage across the no-hub coupling neoprene gasket (green arrows).



Photograph 2 - Close-up sewer camera image of a Continuous CIPP repair illustrating robotically-produced liner reinstatement at the branch of a sanitary tee (yellow arrows). Note the "faired" reinstated finish on the branch opening (red arrows) and the absence of inlet obstructions and gaps between the liner and the pipe substrate at the branch inlet.

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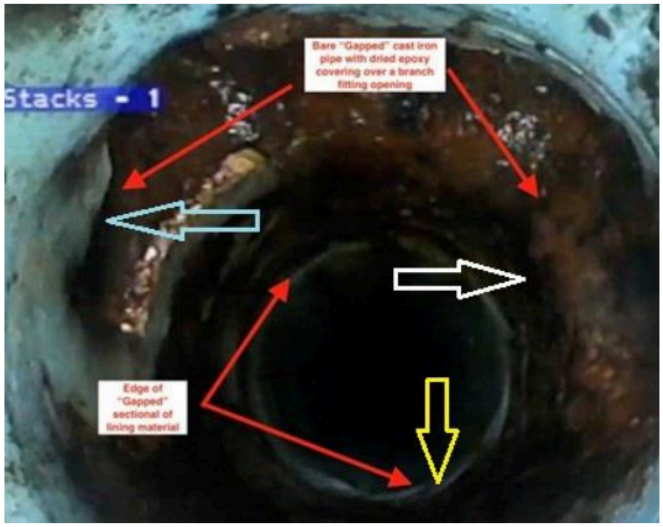
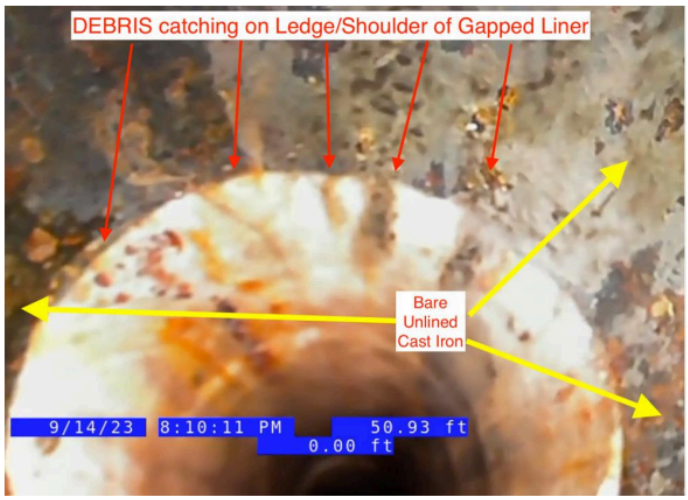


Photograph 3 - Sewer camera image of a Gapped CIPP repair at a sanitary tee. Note the exposed section of pipe (white arrow), the cured excess epoxy blocking a portion of a branch inlet (blue arrow), and the shoulder/ledge on the pipe interior wall formed by the upstream edge of the downstream liner segment (yellow arrow).



Photograph 4 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the bare unlined cast iron fitting within the gap between liner segments (yellow arrows), and the debris lodged between the pipe wall and the Shoulder/Ledge at the upstream edge of the liner segment (red arrows).

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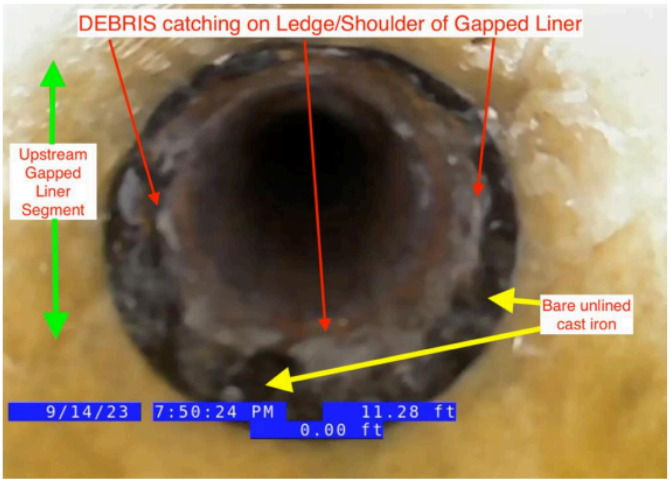
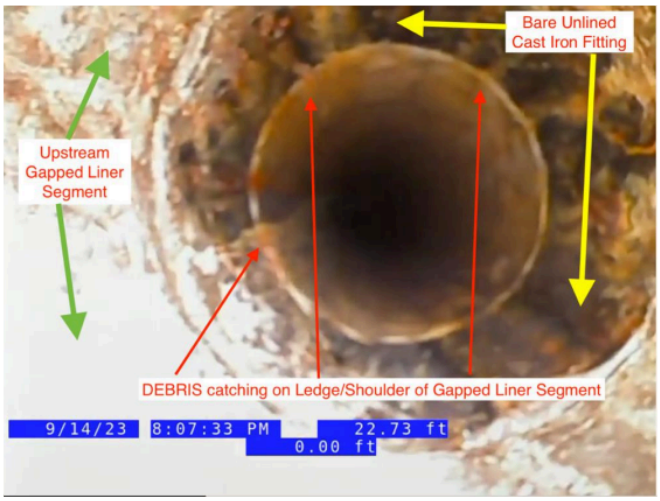


Photograph 5 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the upstream segment of liner (green arrows), the bare unlined cast iron fitting between liner segments (yellow arrows), and the debris lodged between the bare pipe wall and the Shoulder/Ledge at the exposed upstream edge of the downstream liner segment (red arrows).



Photograph 6 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the upstream Gapped liner segment (green arrows), the bare unlined cast iron fitting between Gapped liner segments (yellow arrows), and the debris lodged between the bare pipe wall and the Shoulder/Ledge at the exposed upstream edge of the downstream liner segment (red arrows).

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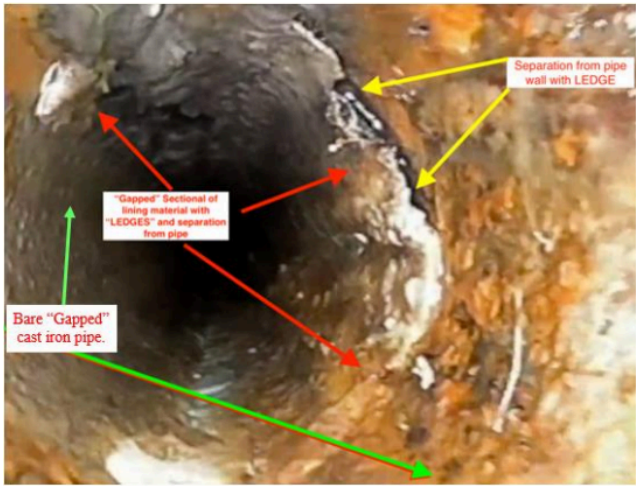
Photograph 7 - Pan-and-Tilt Sewer Camera close-up image of an exposed neoprene gasket in a no-hub pipe coupling illustrating cracks and pitting in the pipe-joint gasket between the liner segments of a Gapped CIPP repair (red arrow).



Photograph 8 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment (red arrows). Note the unlined section of the cast iron fitting above the Gapped liner segment (green arrows), the frayed delaminated upstream edge of the liner segment, and the gap between the liner Shoulder/Ledge and the pipe wall at the upstream edge of the liner segment (yellow arrows).

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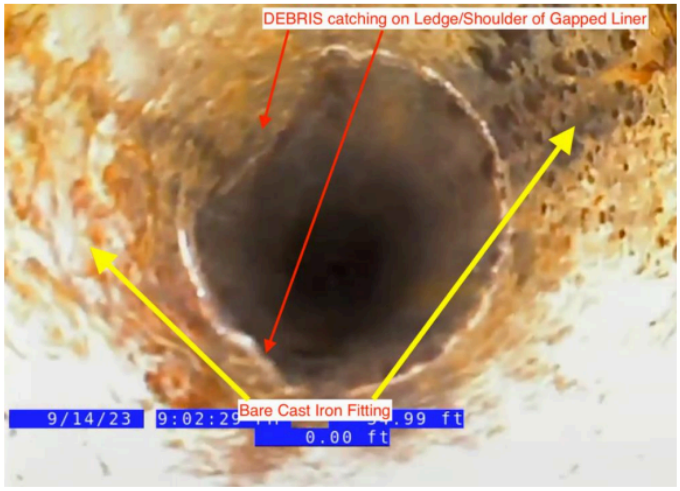

Photograph 9 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the unlined cast iron pipe above the Gapped liner segment (yellow arrows), the debris lodged between the bare pipe wall and the Shoulder/Ledge at the upstream edge of the liner segment, and the bulge-like deformations along the length of the lining, which originate at the gaps between the liner shoulder and the pipe wall (red arrows; works with Photographs 10, 11, 12, 13).

Photograph 10 - Sewer camera image of a Gapped CIPP liner segment illustrating a longitudinal bulge (red arrows) along the length of a liner segment (works with Photographs 9, 11, 12 and 13).

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Photograph 11 – Sewer camera close-up image of a burst in a liner bulge within a Gapped CIPP liner segment. Note the delamination of the liner material (red arrows; works with Photographs 9, 10, and 12).

Photograph 12 - Sewer camera close-up image of a burst in a liner bulge within a Gapped CIPP liner segment illustrating liner delamination, separation of the Gapped liner from the host pipe, and water penetration between liner and the pipe (red arrows; works with Photographs 9, 10, and 11).

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Photograph 13 - Sewer camera close-up image of a weep hole at the downstream end of a bulge within a Gapped CIPP liner segment illustrating the discharge of water flowing within the confines of the bulge (works with Photographs 9 and 10).

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P12192

Date Submitted	02/16/2025	**Section**	717.4	**Proponent**	Jennifer Hatfield
Chapter	7	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

P3011.4, Residential Code

Summary of Modification

On behalf of the Building Officials Association of Florida (BOAF), this modification addresses relining of the piping system when it comes to who evaluates the system.

Rationale

It is not the code official or the building official's responsibility to evaluate the existing piping system to determine if it is capable of being relined. This responsibility should be on the registered design professional to document that the piping system is capable to be relined per manufacturer installation requirements and applicable reference standards. This proposal makes that change.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
None
Impact to building and property owners relative to cost of compliance with code
None
Impact to industry relative to the cost of compliance with code
None
Impact to small business relative to the cost of compliance with code
None

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Yes, as it provides for appropriate evaluation by a design professional to ensure if a piping system is capable to be relined.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Yes, as it provides for appropriate evaluation by a design professional to ensure if a piping system is capable to be relined.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

It does not.

Does not degrade the effectiveness of the code

It does not.

P12192Text Modification

717.4 Permitting.

Prior to issuing a permit for relining, the building official shall review a report submitted by the registered design professional that documents ~~and evaluate the pre-installation recorded video camera survey to determine~~ whether the piping system is capable to be relined in accordance with the proposed lining system manufacturer's installation requirements and applicable referenced standards.

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Mod12192_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P11881

Date Submitted	01/31/2025	**Section**	1106.2	**Proponent**	Michael Weinbaum
Chapter	11	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

SW11878

Summary of Modification

Add row pertaining to 2.5" pipe to table 1106.2

Rationale

2.5" is a common pipe size, and interpolating between 2" and 3" will not give accurate figures. The other values on this table are based on the Manning Equation with inside diameters based on schedule 40 pipe, roughness equal to 0.01, with the pipe 85% full. The velocity of water in a sloped pipe is proportional to the diameter raised to the 2/3 power, while the area is proportional to the square of the diameter, therefore, the volumetric flow rate will be proportional to the diameter raised to the 4/3 power, and linear interpolation does not work. https://en.wikipedia.org/wiki/Manning_formula As for the vertical dropouts, in the other rows, the given values are 10% greater than the value for 1/4" slope, and the new row continues this pattern.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
none
Impact to building and property owners relative to cost of compliance with code
none
Impact to industry relative to the cost of compliance with code
none
Impact to small business relative to the cost of compliance with code
none

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
This will help this table be useful for the pool portion of the code.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

yes, 2.5" is a common pipe size, and this will allow it to be used at its appropriate capacity.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

no discrimination, no change to which pipe materials are acceptable.

Does not degrade the effectiveness of the code

increases the effectiveness because it will have accurate information about a common size selection.

P11881Text Modification

PIPE SIZE (inches)	CAPACITY (gpm)				
	VERTICAL DRAIN	SLOPE OF HORIZONTAL DRAIN			
		1/16 inch per foot	1/8 inch per foot	1/4 inch per foot	1/2 inch per foot
2	34	15	22	31	44
2.5	53	25	35	48	71

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Mod11881_TextOfModification.pdf

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P12198

Date Submitted	02/17/2025	**Section**	1	**Proponent**	Cheryl Harris
Chapter	3206	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Summary of Modification

Update definition for low volume irrigation and add new document for preconstruction submittals.

Rationale

Update the Appendix definition for low volume according to current thought and add "annual water use budget" to preconstruction submittal listing.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
None
Impact to building and property owners relative to cost of compliance with code
None
Impact to industry relative to the cost of compliance with code
None
Impact to small business relative to the cost of compliance with code
None

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Update to an Appendix that provides voluntary guidance to Installation of Irrigation System.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Update to an Appendix that provides voluntary guidance to Installation of Irrigation System.
Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities
No specific product, method or system of construction listed is discriminatory.
Does not degrade the effectiveness of the code

Upgrades rather than degrades the effectiveness of the code.

P12198Text Modification

Low Volume ~~Sprinklers~~ Irrigation. ~~Sprinkler heads that emit less than 0.5 gallons per minute~~ Refers to the use of devices specifically designed to both strictly limit the volume of water being applied and efficiently deliver the water within the root zone of the plant.

Preconstruction submittals.

Plans or drawings

Commercial, industrial, municipal and multiple-family. Provide professionally designed drawings prior to start of construction. Design drawings shall be clearly readable, to reasonable scale, show the entire site to be irrigated, including all improvements, and shall include but not be limited to: date, scale, revisions, legend, specifications which list all aspects of equipment and assembly there of, water source, water meter and/or point of connection, backflow prevention devices, pump station size, pump station location, design operating pressure and flow rate per zone, precipitation rate per zone, annual water use budget, locations of pipe, controllers, valves, sprinklers, sleeves, gate valves, etc. The plans and specifications shall be prepared in accordance with Section 107 of the Florida Building Code, Building

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Plumbing

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P12107

Date Submitted	02/17/2025	**Section**	1400	**Proponent**	Cheryl Harris
Chapter	14	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Summary of Modification

New code for commercial and residential installation of irrigation systems. Builders in some areas are not able to obtain water permits due to water shortages. Lack of code allowing poor installs is one of the reasons for shortages and needs immediate attention.

Rationale

Currently there is no state-wide standard for the installation of irrigation systems, only a patchwork of local ordinances or no standard at all. With the shortage in Florida's water supply causing severe water restrictions and denied water permits for new development, it is critical that this first step in bringing water usage under control be taken.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

Limited cost to those local entities who have local ordinances and already require plan review and permits with inspection. To those entities which do not have any installation requirements, there will be a cost to review plans and inspect that should be covered by permit fees.

Impact to building and property owners relative to cost of compliance with code

Sprinkler system install in most cases is voluntary. Installing systems per code may cost builders more money but a properly installed system will in the end the property owner money will save in water usage and ultimately reduce water demand allowing builders/developers to continue building

Impact to industry relative to the cost of compliance with code

Irrigation contractors will have a single standard to install systems and reduce their costs of researching and complying with multiple jurisdictions ordinances.

Impact to small business relative to the cost of compliance with code

Irrigation contractors will have a single standard to install systems and reduce their costs of researching and complying with multiple jurisdictions ordinances.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

Yes, water conservation quality.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Yes, provides code where none exists.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

Improves the effectiveness of the code.

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CHAPTER14

~~**SUBSURFACE GRAYWATER SOIL ABSORPTION SYSTEMS**~~

~~**RESERVED**~~

LANDSCAPE IRRIGATION SYSTEMS

Section 1400

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1401.1Scope.

The provisions of Chapter 14 shall govern the materials, design, construction and installation of turf and landscape irrigation systems connected to either potable or nonpotable water systems.

Exception: All Turf and Landscape irrigation systems serving as drainfields for onsite sewage treatment and disposal systems shall be regulated by Chapter 64E-6, Florida Administrative Code, Standards for Onsite Sewage Treatment and Disposal Systems.

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1401.2 This section shall apply to all irrigation systems used on residential and commercial landscape areas.

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1401.3 This section shall apply to all new irrigation systems and any new work to existing irrigation systems.

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Exception. This section shall not apply to irrigation systems for golf courses, nurseries, greenhouses, or agricultural production systems.

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1401.4 Nothing contained in this section shall be deemed to require any irrigation system or part thereof, which existed prior to the establishment of this code, to be changed altered or modified to meet the standards of this code.

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1402 Permits.

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1402.1 A permit shall be required for new installation of landscape irrigation systems and for repairs or modifications to the system design that exceed $1000.00 in labor and material based on invoice value.

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1402.2 No permit shall be required for general maintenance or repairs which do not change the structure or alter the system and the value of which does not exceed $1000.00 in labor and

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material based on invoice value. -

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1403 Preconstruction submittals.

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1403.1 Plans or drawings.

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1403.1.1 Single-family residence. Design drawings or shop drawings, where required, shall be provided for the installation of irrigation systems prior to start of construction. Design drawings shall be clearly readable, to reasonable scale, show the entire site to be irrigated, and include all improvements. Drawings shall be prepared by a licensed plumbing or irrigation contractor or licensed landscape architect.

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1403.1.2 Commercial, industrial, municipal and multiple-family. Professionally designed drawings prior to start of construction shall be provided for landscape irrigation systems. Design drawings shall be clearly readable, to reasonable scale, show the entire site to be irrigated, including all improvements, and shall include but not be limited to: date, scale, revisions, legend, specifications which list all aspects of equipment and assembly there of, water source, water meter and/or point of connection, backflow prevention devices, pump station size, pump station location, design operating pressure and flow rate per zone, precipitation rate per zone, locations of pipe, controllers, valves, sprinklers, sleeves, gate valves, sensors, etc. The plans and specifications shall be prepared in accordance with Section 107 of the Florida Building Code, Building.

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1404 Definitions. The following definitions are exclusive to this section of the code.

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ABS Pipe. Acrylonitrile-butadiene-styrene black, semi-rigid, plastic pipe extruded to IPS. ABS pipe is in limited use in present day irrigation systems. Solvent weld fittings are used with this pipe (see ASTM D 1788).

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Air Release Valve. A valve which will automatically release to the atmosphere accumulated small pockets of air from a pressurized pipeline. A small orifice is used to release air at low flow rates. Air release valves are normally required at all summits of mainline and submain pipelines in an irrigation system.

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Anti-Siphon Device. A safety device used to prevent back-flow of irrigation water to the water source by back-siphonage.

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Application Rate. The average rate at which water is applied by an irrigation system, sometimes also called precipitation rate. Units are typically inches/hr or mm/hr.

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Application uniformity. Irrigation application uniformity (also known as distribution uniformity) describes how evenly water is distributed within an irrigation zone.

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Arc. The angle of coverage of a sprinkler in degrees from one side of throw to the other. A 90-degree arc would be a quarter-circle sprinkler.

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Atmospheric Vacuum Breaker (AVB). An anti-siphon backflow device which uses a floating seat to allow an air break to interrupt the vacuum effect on water flow.

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Automatic Control Valve. A valve in a sprinkler system which is activated by an automatic controller by way of hydraulic or electrical control lines and controls a single device or multiple devices.

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Automatic System. An irrigation system which operates following a preset program entered into an automatic controller.

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Backflow Prevention Device. An approved safety device used to prevent pollution or contamination of the irrigation water supply due to backflow from the irrigation system.

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Belled (Pipe). Pipe which is enlarged at one end so that the spigot end of another length of pipe can be inserted into it during the assembly of a pipeline.

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Block (of sprinklers). A group of sprinklers controlled by one valve. Also called zones or subunits.

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Block System. An irrigation system in which several groups of sprinklers are controlled by one valve for each group.

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Bubbler Irrigation. The application of water to the soil surface or a container as a small stream or fountain. Bubbler emitter discharge rates generally range from 0.5 to 2 gpm but are generally less than 60 gph.

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Check Valve. A valve which permits water to flow in one direction only.

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Chemical Water Treatment. The addition of chemicals to water to make it acceptable for use in irrigation systems

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Chemigation. The application of water soluble chemicals by mixing or injecting with the water applied through an irrigation system.

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Contractor. Any person who engages in the fabrication and installation of any type of irrigation system on a contractual basis in accordance with all stipulations receiving compensation.

-

Control Lines. Hydraulic or electrical lines which carry signals to open and close the valves from the controller to the automatic valves.

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Controller. The timing mechanism and its mounting box. The controller signals the automatic valves to open and close on a pre-set program or based on sensor readings.

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Coverage. Refers to the way water is applied to an area.

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Cycle. Refers to one complete run of a controller through all programmed controller stations.

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Demand (or irrigation demand). Refers to the irrigation requirements of the irrigated area. Demand primarily depends on the type of crop, stage of growth, and climatic factors.

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Design Area. The specific land area to which water is to be applied by an irrigation system.

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Design Emission Uniformity. An estimate of the uniformity of water application with an irrigation system.

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Design Pressure. The pressure at which the irrigation system or certain components are designed to operate. The irrigation system design pressure is that measured at the pump discharge or entrance to the system if there is no pump, and a zone design pressure is the average operating pressure of all emitters within that zone.

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Direct Burial Wire. Plastic-coated single-strand copper wire for use as control line for electric valves.

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Discharge Rate. The instantaneous flow rate of an individual sprinkler, emitter, or other water emitting device, or a unit length of line-source micro irrigation tubing. Also, the flow rate from a pumping system or from a reduced pressure assembly or relief valve.

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Double Check Valve. An approved assembly of two single, independently-acting check valves with test ports to permit independent testing of each check valve.

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Drain Valve. A valve used to drain water from a line. The valve may be manually or automatically operated.

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Drip Irrigation. The precise low-rate application of water to or beneath the soil surface near or directly into the plant root zone. Applications normally occur as small streams, discrete or continuous drops, in the range of 0.5 to 2.0 gph.

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Effluent water. Also referred to as reclaimed ~~or gray water~~ is wastewater which has been treated per Florida Statute, §403.086 and is suitable for use as a water supply for irrigation systems.

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Emitters. Devices which are used to control the discharge of irrigation water from lateral pipes. This term is primarily used to refer to the low flow rate devices used in micro irrigation systems.

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Fertigation. The application of soluble fertilizers with the water applied through an irrigation system.

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Filtration System. The assembly of physical components used to remove suspended solids from irrigation water. These include both pressure and gravity type devices, such as settling basins, screens, media filters, and centrifugal force units (vortex sand separators).

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Flexible Swing Joint. A flexible connection between the lateral pipe and the sprinkler which allows the sprinkler to move when force is applied to it.

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Flow Meters. Devices used to measure the volume of flow of water (typically in gallons), or flow rates (typically in gpm), and to provide data on system usage.

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Gauge (Wire). Standard specification for wire size. The larger the gauge number, the smaller the wire diameter.

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Head. A sprinkler head. Sometimes used interchangeably with and in conjunction with "Sprinkler."

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Infiltration Rate. The rate of water flow across the surface of the soil and into the soil profile. Units are usually inches/hr.

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Irrigation. Application of water by artificial means, that is, means other than natural precipitation. Irrigation is practiced to supply crop water requirements, leach salts, apply chemicals, and for environmental control including crop cooling and freeze protection.

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Irrigation Water Requirement or Irrigation Requirement. The quantity of water that is required for crop production, exclusive of effective rainfall.

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Landscape. Refers to any and all areas which are ornamentally planted, including but not limited to turf, ground covers, flowers, shrubs, trees, and similar plant materials as opposed to agricultural crops grown and harvested for monetary return.

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Lateral. The water delivery pipeline that supplies water to the emitters or sprinklers from a manifold or header pipeline downstream of the control valve.

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Line-Source Emitters. Lateral pipelines which are porous or contain closely-spaced perforations so that water is discharged as a continuous band or in overlapping patterns rather than discrete widely-spaced points along the pipeline length.

-

Looped System. A piping system which allows more than one path for water to flow from the supply to the emitters or sprinklers.

-

Mainline. A pipeline which carries water from the control station to submains or to manifolds or header pipelines of the water distribution system.

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Manifold. The water delivery pipeline that conveys water from the main or submain pipelines to the laterals. Also sometimes called a header pipeline.

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Manual System. A system in which control valves are manually operated rather than operated by automatic controls.

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Matched Precipitation. An equal distribution of water over a given area or zone.

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Meter Box. A concrete or plastic box buried flush to grade which houses flow (water) meters or other components.

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Microirrigation. The frequent application of small quantities of water directly on or below the soil surface, usually as discrete drops, tiny streams, or miniature sprays through emitters with a

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flow rate of .5 gpm or less placed along the water delivery pipes (laterals). Microirrigation encompasses a number of methods or concepts, including drip, subsurface, bubbler, and spray irrigation. Previously known as trickle irrigation.

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Overlap. The amount one sprinkler pattern overlaps another one when installed in a pattern. Expressed as a percentage of the diameter of coverage.

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PE Pipe. Flexible polyethylene pipe for use in irrigation systems, normally manufactured with carbon black for resistance to degradation by ultraviolet radiation.

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Potable Water. Water which is suitable in quality for human consumption and meets the requirements of the Health Authority having jurisdiction.

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Pressure Relief Valve. A valve which will open and discharge to atmosphere when the pressure in a pipeline or pressure vessel exceeds a pre-set point to relieve the high-pressure condition.

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Pressure Vacuum Breaker. A backflow prevention device which includes a spring-loaded check valve and a spring-loaded vacuum breaker to prevent the backflow of irrigation system water to the water source.

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Pumping Station. The pump or pumps that provide water to an irrigation system, together with all of the necessary accessories such as bases or foundations, sumps, screens, valves, motor controls, safety devices, shelters and fences.

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PVC Pipe. Polyvinyl chloride plastic pipe made in standard thermoplastic pipe dimension ratios and pressure rated for water. Manufactured in accordance with AWWA C-900 or ASTM D-2241.

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Rain Shut off Device. A calibrated device that is designed to detect rainfall and override the irrigation cycle of the sprinkler system when a predetermined amount of rain fall has occurred.

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Reduced Pressure Principle Backflow Preventer also known as Reduced Pressure Zone Device (RPZD, RPZ or RPZ Valve). A type of backflow prevention device used to protect water supplies from contamination.

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Riser. A threaded pipe to which sprinklers or other emitters are attached for above-ground placement.

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Runoff. The result of excess water applied either naturally (precipitation) or mechanically (irrigation) that exceeds the absorption rate of the soil moving to an area of a lower elevation.

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Sleeve. A pipe used to enclose other pipes, wire, or tubing; usually under pavement, sidewalks, or planters.

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Spacing. The distance between sprinklers or other emitters.

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Spray Irrigation. The micro irrigation application of water to the soil or plant surface by low flow rate sprays or mists.

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Sprinkler. The sprinkler head. Sometimes called “Head.”

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Supply (Water Source). The origin of the water used in the irrigation system.

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Swing Joint. A ridged connection between the lateral pipe and the sprinkler, utilizing multiple elbows and nipples, which allows the sprinkler to move when force is applied to it.

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Tubing. Generally used to refer to flexible plastic hydraulic control lines which are usually constructed of PE or PVC.

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1404 DESIGN CRITERIA

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1404.1 Design defined. Within the scope of this code, irrigation system design is defined as the science and art of properly selecting and applying all components within the system

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1404.2 Water supply.

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1404.2.1 The water source shall be adequate from the stand-point of volume, flow rate, pressure, and quality to meet the irrigation requirements of the area to be irrigated, as well as

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other demands, if any, both at the time the system is designed and for the expected life of the system.

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1404.2.2 If the water source is effluent, it shall meet the advanced waste treatment standard as set forth in Florida Statute §403.086(4) as well as any other standard as set forth by the controlling governmental agency.

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1404.3 Application uniformity.

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1404.3.1 Sprinkler irrigation systems shall be designed with the appropriate uniformity for the type of plants being grown and the type of soil found in that area. The general watering of different types of plants as one group without regard to their individual water requirements shall be avoided.

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1404.3.2 Sprinkler head spacing, type and nozzle selection that achieves the highest application uniformity shall be utilized.

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1404.3.3 Application rates which avoid runoff and permit uniform water infiltration into the soil shall be utilized. Land slope, soil hydraulic properties, vegetative ground cover, and prevailing winds and sun exposure shall be considered when application rates are specified. Different types of sprinklers with different application rates, i.e., spray heads vs. rotor heads, bubbler heads vs rotor heads, shall not be combined on the same zone or circuit.

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1404.4 System zoning. The irrigation system shall be divided into zones based on consideration of the following hydrozoning practices.

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1404.4.1 Available flow rate.

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1404.4.2 Cultural use of the area.

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1404.4.3 Type of vegetation irrigated, i.e., turf, shrubs, native plants, etc.

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1404.4.4 Type of sprinkler, i.e., sprinklers with matching precipitation rates.

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1404.4.5 Soil characteristics and slope.

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1404.4.6 Sun exposure.

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1405 Sprinkler/emitter spacing and selection.

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1405.1 Sprinkler/Emitter spacing shall be determined considering the irrigation requirements, hydraulic characteristics of the soil and device, and water quality with its effect on plant growth, sidewalks, buildings, and public access areas.

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1405.2 All pop-up spray head bodies in turf areas shall be no less than 6" in height for St. Augustine, Zoysia and Bahia and no less than 4" in height for Bermuda, Centapede and Seashore Paspalum.

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1405.3 Sprinklers shall be located in accordance with manufacturer's specifications in each irrigated zone area for a matched precipitation rate objective.

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1405.4 Single row head spacing shall only occur when an additional row will cause saturated soils at the toe of a slope or other inefficiencies.

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1405.5 All heads shall not exceed 50% of manufacturer's specified diameters of coverage.

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1405.6 Water conservation shall be taken into consideration by minimizing irrigation of non-vegetated areas.

1405.7 Microirrigation systems shall be designed using the Emission Uniformity concept. Microirrigation emitters shall be spaced to wet 100 percent of the root zone in turf areas and 50 percent of the root zone for shrubs and trees.

1405.8 Microirrigation or low volume heads shall be required in all areas to be irrigated that are less than 4 feet in any direction from the emitter or nozzle.

1405.9 All microirrigation zones shall have adequate filtration installed at the zone valve or at the point where the drip tubing is attached to supply pipelines to protect the emission devices from contamination from a main or lateral break.

1405.10 Each plant shall have an adequate number and size (gph) of microirrigation devices, properly placed, to meet the plant water requirements for no rainfall.

1406 Pipelines. Pipelines shall be sized to limit pressure variations so that the working pressure at all points in the irrigation system will be in the range required for uniform water application. Velocities shall not exceed 5 feet (1524 mm) per second.

1407 Wells.

1407.1 Well diameters, depths and location shall correspond to the irrigation system demand and in compliance to all applicable state, regulatory agencies and local codes and regulations.

1408 Pumps.

1408.1 Pump and motor combinations shall be capable of satisfying the total system demand without invading the service factor of the motor except during start-up and between zones.

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1408.2 Pumps shall be positioned with respect to the water surface in order to ensure that the net positive suction head required (NPSHr) for proper pump operation is achieved.

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1408.3 The pumping system shall be protected against the effects of the interruption of water flow.

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1409 Control valves.

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1409.1 Control valve size shall be based on the flow rate through the valve. Friction loss through the valve, an approved air gap separation, or a reduced pressure assembly shall not exceed 10 percent of the static mainline head.

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1409.2 Control systems using hydraulic communication between controller and valve(s) shall comply with the manufacturer's recommendations for maximum distance between controller and valve, both horizontally and vertically (elevation change).

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1409.3 The size of the electrical control wire shall be in accordance with the valve manufacturer's specifications; based on the solenoid in-rush amperage and the circuit length, considering the number of solenoids operating on the circuit. Minimum of # 14 AWG single strand control wire shall be used on all systems, except individual, single lot residential systems.

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1409.4 Manually operated control valves shall be located so that they can be operated without wetting the operator.

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1409.5 In ground valves shall be located away from large tree and palm root zones.

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1409.6 A manual shut off valve shall be required to be installed close to the point of connection but downstream from any backflow device (or/unless included in the backflow

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device) to minimize water loss when the system is shut off for repairs or emergencies.

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1409.7 An automatic shut-off valve or master valve (normally closed) is required on all systems with a constantly pressurized mainline to confine the water loss from minor main line leaks, weeping valves, or stuck on valves to just the time the system is operating automatically.

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1410 Automatic irrigation controller. Automatic irrigation controllers shall conform to UL 1310 and have an adequate number of stations and power output per station to accommodate the irrigation system design. The controller shall be capable of incorporating a rain shut off device or other sensors to override the irrigation cycle when adequate rainfall has occurred, as required by Florida Statutes, Section 373.62.

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1411 Chemical injection.

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1411.1 Chemical injection systems for the injection of fertilizer, pesticides, rust inhibitors, or any other injected substance will be located and sized according to the manufacturers' recommendations.

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1411.2 Injection systems shall be located downstream of the applicable backflow prevention devices as required by Florida Statutes, Section 487.021 and 487.055; the Environmental Protection Agency (EPA); Pesticide Regulation Notice 87-1; or other applicable codes.

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1411.3 If an irrigation water supply is also used for human consumption, an air gap separation or an approved reduced pressure principal backflow prevention device shall be required in compliance with ASSE 1013 and Section 14031.12.

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1412 Backflow prevention methods. Backflow prevention assemblies at all cross connections with all water supplies shall be provided in accordance with county, municipal or other applicable codes. In the event of conflicting regulations the assembly type shall be provided which gives the highest degree of protection.

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1412.1 Irrigation systems into which chemicals are injected shall conform to Florida state law (Florida Statutes 487.021 and 487.055) and Environmental Protection Agency Pesticide Regulation Notice 87-1, which requires backflow prevention regulations to be printed on the chemical label.

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1412.1.1 For municipal water supplies, chemical injection equipment must be separated from the water supply by an approved air gap separation or a reduced pressure principle assembly that is approved by the Foundation for CCC and the Hydraulic Research Institute. The equipment shall comply with ASSE 1013 to protect the water supply from back-siphonage and back-pressure.

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1412.1.2 For other water supplies, Florida State law, EPA regulations, or other applicable local codes shall be followed. In the absence of legal guidelines, at minimum, a Pressure Vacuum Breaker shall be required.

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SECTION 1413 REFERENCED STANDARDS

The standards referenced below are exclusive to this section.

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1413.1 American Society of Agricultural Engineers (ASAE) Standards:

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ASAE S330.1: Procedure for sprinkler distribution testing for research purposes.

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ASAE S376.1: Design, installation, and performance of underground thermoplastic irrigation pipelines.

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ASAE S397.1: Electrical service and equipment for irrigation.

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ASAE S435: Drip/Trickle Polyethylene Pipe used for irrigation laterals.

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ASAE S398.1: Procedure for sprinkler testing and performance reporting.

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ASAE S339: Uniform classification for water hardness.

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ASAE S394: Specifications for irrigation hose and couplings used with self-propelled, hose-drag agricultural irrigation system.

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ASAE EP400.1: Designing and constructing irrigation wells.

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ASAE EP405: Design, installation, and performance of trickle irrigation systems.

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ASAE EP409: Safety devices for applying liquid chemicals through irrigation systems.

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1413.2 ASTM International Standards:

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ASTM D 2241-20: Poly (Vinyl Chloride) (PVC) Pressure-rated Pipe (SDR-Series).

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ASTM D 2239-12a: Specification for Polyethylene (PE) plastic pipe (SIDR Series).

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ASTM D 2466-21: Specification for Poly (Vinyl Chloride) (PVC) plastic pipe fittings, Schedule 40.

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ASTM D 2855-2020: Standard recommended practice for making solvent cemented joints with polyvinyl chloride pipe and fittings.

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ASTM D 3139-19: Specification for joints for plastic pressure pipes using flexible elastomeric seals.

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ASTM F 477-2021: Specification for elastomeric seals (gaskets) for joining plastic pipe).

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1413.3 American Water Works Association (AWWA) standards:

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AWWA C-900: PVC pipe standards and specifications

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1413.4 American Society of Sanitary Engineers (ASSE) Standards:

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ASSE 1001-2017: Performance Requirements for atmospheric type vacuum breakers.

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ASSE 1013-2011: Performance Requirements for Reduced pressure principle backflow preventers and Reduced Pressure Principle Fire Protection Backflow Preventers.

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ASSE 1015-2011: Pressure Performance Requirements for Double check backflow prevention assemblies.

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ASSE 1020-2020: Performance Requirements for Pressure Vacuum Breaker Assemblies

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ASSE 1024-2021: Performance Requirements for Dual check valve type backflow preventers. (for Residential Supply Service or Individual Outlets)

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1413.5 ANSI/Hydraulic Institute Standards

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1413.6 Standards and Specifications for Turf and Landscape Irrigation Systems Florida Irrigation Society (FIS) Standards

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1413.7 Natural Resources Conservation Service (NRCS) Field Office Technical Guide, Section IV-A — Cropland Codes:

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NRCS Code 430-DD: Irrigation water conveyance, underground, plastic pipeline.

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NRCS Code 430-EE: Irrigation water conveyance. Low pressure, underground, plastic pipeline.

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NRCS Code 430-FF: Irrigation water conveyance, steel pipeline.

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NRCS Code 441-1: Irrigation system, trickle.

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NRCS Code 442: Irrigation system sprinkler.

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NRCS Code 449: Irrigation water management.

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NRCS Code 533: Pumping plant for water control.

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NRCS Code 642: Well.

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1413.8. Underwriters Laboratories (UL) 333 Pfingsten Road, Northbrook, IL 60062-2096 Standards

UL 486C-1995 Splicing Wire Connectors

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UL 969-2013 Standard for Marking and Labeling Systems

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UL 1310-2011 Standard for Class 2 Power Units

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Section 1414 MATERIALS

The materials referenced below are exclusive to this section.

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1414.1 PVC pipe and fittings.

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1414.1.1 PVC pipe shall comply with one of the following standards ASTM D 1785-32a, ASTM D 2241-20, AWWA C-900, or AWWA C-905. SDR-PR pipe shall have a minimum wall thickness as required by SDR-26. All pipe used with effluent water systems shall be designated for nonpotable use by either label or by the industry standard color purple.

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1414.1.2 All solvent-weld PVC fittings shall, at a minimum, meet the requirements of Schedule 40 as set forth in ASTM D 2466-21.

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1414.1.3. Threaded PVC pipe firings shall meet the requirements of Schedule 40 as set forth in ASTM D 2464-15.

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1414.1.4. PVC gasketed fittings shall conform to ASTM D 3139-19. Gaskets shall conform to ASTM F 477-2021.

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1414.1.5. PVC flexible pipe shall be pressure rated as described in ASTM D 2740 with standard outside diameters compatible with PVC IPS solvent-weld fittings.

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1414.1.6. PVC cement shall meet ASTM D 2564-20. PVC cleaner-type should meet ASTM F 656-21.

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1414.2 Ductile iron pipe and fittings.

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1414.2.1 Gasket fittings for iron pipe shall be of materials and type compatible with the piping material being used.

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1414.3. Steel pipe and fittings.

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1414.3.1. All steel pipe shall be rated Schedule 40 or greater and be hot-dipped galvanized or black in accordance with ASTM A53/A53M-2020.

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1414.3.2 Threaded fittings for steel pipe shall be Schedule 40 Malleable Iron.

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1414.4 Polyethylene pipe.

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1414.4.1 Flexible swing joints shall be thick-walled with a minimum pressure rating of 75 psi (517 kPa) in accordance with ASTM D 2239-12a.

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1414.4.2 Low pressure polyethylene pipe for micro-irrigation systems shall conform with ASAE S-435.

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1414.4.3 Use fittings manufactured specifically for the type and dimensions of polyethylene pipe used.

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1414.5 Sprinklers, spray heads, and emitters.

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1414.5.1 Units and nozzles shall be selected in accordance with the size of the area and the type of plant material being irrigated. Sprinklers shall fit the area they are intended to water without excessive overspray. Intentional direct spray onto walkways, buildings, roadways, and driveways is prohibited.

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1414.5.2 Equipment shall be used that is protected from contamination and damage by use of seals, screens, and springs where site conditions present a potential for damage.

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1414.5.3 Riser-mounted sprinklers shall be supported to minimize movement of the riser resulting from the action of the sprinkler.

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1414.5.4 Swing joints, either flexible or rigid, shall be constructed to provide a leak-free connection between the sprinkler and lateral pipeline to allow movement in any direction and to prevent equipment damage.

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1414,5.5 Check valves shall be installed on any sprinkler where low point drainage occurs.

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1414.5.6 The pop-up height for sprays and rotator nozzles shall be adequate to prevent being obstructed by the turf grass blades: 6" height for St. Augustine, Zoysia and Bahia and 4" height for Bermuda, Centapede and Seashore Paspalum.

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1414.5.7 All microirrigation zones shall have adequate filtration installed at the zone valve or at the point where the drip tubing is attached to PVC pipe to protect the emission devices from contamination from a PVC main or lateral break.

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1414.5.8 All microirrigation zones shall have adequate pressure regulation installed at the zone valve or at the point where the drip tubing is attached to the PVC to ensure that all emission devices meet the manufacturer's performance standards.

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1414.5.9 Each plant shall have a adequate number and size(gph) of microirrigation devices, properly placed to meet the plant water requirements for no rainfall.

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1403.14.5.10 All tubing shall be secured to prevent movement in accordance with manufacturer's specification.

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1414.6 Valves.

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1414.6.1 Valves shall have a maximum working pressure rating equal to or greater than the maximum pressure of the system, but not less than 125 psi (861 kPa). This requirement shall be waived for low mainline pressure systems [30 psi (207 kPa) or less].

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1414.6.2 Only valves that are constructed of materials designed for use with the water and soil conditions of the installation shall be used. Valves that are constructed from materials that will not be deteriorated by chemicals injected into the system shall be used on all chemical injection systems.

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1414.7 Valve boxes.

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1414.7.1 Valve boxes shall be constructed to withstand traffic loads common to the area in which they are installed. They should be sized to allow manual operation of the enclosed valves without excavation.

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1414.7.2. Each valve box shall be permanently labeled in accordance with UL 969 to identify its contents.

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1414.8 Low voltage wiring.

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1414.8.1 All low voltage wire which is directly buried shall be labeled for direct burial wire. Wire not labeled for direct burial shall be installed in watertight conduits, and be listed TWN or THHN type wire as described in the NEC. All wire traveling under any hardscape or roadway must installed within a conduit and sleeve.

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1414.8.2 The size of the electrical control wire shall be in accordance with the valve manufacturer's specifications, based on the solenoid in-rush amperage and the circuit length, considering the number of solenoids operating, on the circuit. Minimum of # 14 AWG single strand control wire shall be used on all systems, except single lot individual residential systems.

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1414.8.3 Connections shall be made using devices conforming to UL 486 specifically designed for direct burial. All splices shall be enclosed within a valve box.

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1414.9 Irrigation controllers.

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1414.9.1 All irrigation controllers shall conform to UL 1310 and the provisions of the National Electric Code (NEC) and be grounded in accordance with the manufacturer's specifications.

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Solid state controls shall be equipped with surge suppressors on the primary and secondary wiring, except single lot residential systems.

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1414.9.2 The controller housing or enclosure shall protect the controller from the hazards of the environment in which it is installed.

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1414.9.3 The rain switch shall be placed on a stationary structure minimum of 5-foot (1524 mm) clearance from other outdoor equipment, free and clear of any tree canopy or other overhead obstructions, and above the height of the sprinkler coverage. Soil moisture sensors and ET sensors shall be installed in accordance with manufacturer's specifications and Florida Statutes, Section 373.62.

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1414.10 Pumps and wells.

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1414.10.1 Irrigation pump electrical control systems shall conform to the NEC and local building codes.

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1414.10.2 The pumping system shall be protected from the hazards of the environment in which it is installed.

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1414.10.3 Use electric motors with a nominal horsepower rating greater than the maximum horsepower requirement of the pump during normal operation. Motor shall have a service factor of at least 1.15.

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1414.10.4 Casings for drilled wells shall be steel, reinforced plastic mortar, plastic, or fiberglass pipe. Only steel pipe casings shall be used in driven wells. See NRCS code FL-642. Steel casings shall conform to ASTM A 589.

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1414.11 Chemical injection equipment.

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1414.11.1 Chemical injection equipment shall be constructed of materials capable of withstanding the potential corrosive effects of the chemicals being used. Equipment shall be used only for those chemicals for which it was intended as stated by the injection equipment manufacturer.

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1414.12 Filters and strainers.

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1414.12.1 Filtration equipment and strainers constructed of materials resistant to the potential corrosive and erosive effects of the water shall be used. They shall be sized to prevent the passage of foreign material that would obstruct the sprinkler/emitter outlets in accordance with the manufacturer's recommendations.

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Section 1415 INSTALLATION

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1415.1 Pipe installation.

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1415.1.1 Pipe shall be installed at sufficient depth below ground to protect it from hazards such as vehicular traffic or routine occurrences which occur in the normal use and maintenance of a property. Depths of cover shall meet or exceed NRCS Code 430-DD, Water Conveyance, as follows:

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1415.1.1.1 Vehicle traffic areas.

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Pipe Size (inches)

-

Depth of Cover (inches)

-

½ – 2 ½

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18 - 24

-

3 - 5

-

24 - 30

-

6 and larger

-

30 - 36

-

-

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1415.1.1.2 All areas except vehicle traffic:

-

-

Pipe Size (inches)

-

Depth of Cover (inches)

-

½ – 1 ½

-

6

-

2 - 3

-

12

-

4 - 6

-

18

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-

More than 6

-

24

-

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1415.1.2 All pipe joints and connections shall be made according to manufacturer's specifications. All solvent-weld connections shall be performed in accordance with ASTM D 2855-2020.

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1415.1.3 Minimum clearances shall be maintained between irrigation lines and other utilities. In no case shall one irrigation pipe rest upon another. For required minimum clearance to onsite sewage treatment and disposal systems, refer to Rule 64E-6.005(2)(b) of the Florida Administrative Code.

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1415.1.4 Thrust blocks shall be used on all gasketed PVC systems. They must be formed against a solid, hand-excavated trench wall undamaged by mechanical equipment. They shall be constructed of concrete, and the space between the pipe and trench shall be filled to the height of the outside diameter of the pipe. Thrust blocks shall be sized in accordance with ASAE S-376.1.

-

1415.1.5 The trench bottom shall be uniform, free of debris, and of sufficient width to properly place pipe and support it over its entire length. Native excavated material may be used to backfill the pipe trench. However, the initial backfill material shall be free from rocks or stones larger than 1-inch in diameter. At the time of placement, the moisture content of the material shall be such that the required degree of compaction can be obtained with the backfill method to be used. Blocking or mounding shall not be used to bring the pipe to final grade.

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1415.1.6. Pipe sleeves shall be used to protect pipes or wires installed under pavement or roadways. Pipe sleeves two pipe sizes larger than the carrier pipe or twice the diameter of the wire bundle shall be used under the paving or roadway and extending a minimum of 3 feet beyond the paved area or as required by the Florida Department of Transportation (FDOT). Pipe sleeves shall be Sch 40. Proper backfill and compaction procedures shall be followed.

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1415.2 Control valve installation.

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1415.2.1 Valve installation shall allow enough clearance for proper operation and maintenance. Where valves are installed underground, they shall be provided with a valve box with cover extending from grade to the body of the valve. The top of the valve body should have a minimum of 6 inches (152 mm) of cover in nontraffic and noncultivated areas and 18 inches (457 mm) of cover in traffic areas. The valve box shall be installed to minimize the effect of soil intrusion within the valve box with the use of filter fabric, pea gravel, or other approved material. If an automatic valve is installed under each sprinkler, then the valve box may be omitted.

-

1415.2.2 Valve boxes shall be installed so that they do not rest on the pipe and the box cover does not conflict with the valve stem or interfere with valve operation. They shall be flush with the ground surface and do not present a tripping hazard or interfere with routine maintenance of the landscape.

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1415.2.3. Quick coupling valves shall be installed on swing joints or flexible pipe with the top of the valve at ground level.

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1415.2.4 Any above-ground manually-operated valves on nonpotable water systems shall be adequately identified with distinctive purple colored paint. Hose bib connections on irrigation systems that utilize nonpotable water supplies shall not be permitted.

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1415.3 Sprinkler installation.

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1415.3.1. On flat landscaped areas, sprinklers shall be installed plumb. In areas where they are installed on slopes, sprinklers may be tilted as required to prevent erosion. Sprinklers shall be adjusted to avoid unnecessary discharge on roads, pavements and structures.

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1415.3.2. There shall be a minimum separation of 4 inches (102 mm) between sprinklers and pavement. There shall be a minimum separation of 12 inches (305 mm) between sprinklers and buildings and other vertical structures. Piping shall be thoroughly flushed before installation of sprinkler nozzles. Surface mounted and pop-up heads shall be installed on swing joints, polyethylene (PE) nipples or flexible pipe. Polyethylene (PE) nipples shall not be used in maintenance equipment traffic areas or alongside roadways and driveways. Above-ground (riser mounted) sprinklers shall be mounted on Schedule 40 PVC or steel pipe and be stabilized.

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1415.4 Pump installation.

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1415.4.1 Pumps shall be installed in accordance with the manufacturer's specifications. Pumps shall be set plumb and secure to a firm concrete base. There shall be no strain or distortion on the pipe and fittings. Pipe and fittings shall be supported to avoid placing undue strain on the pump. Steel pipe shall be used on pumps 5 horsepower (hp) or larger.

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1415.4.2 Pumps shall be installed in a manner to avoid loss of prime. Suction line shall be installed to prevent the accumulation of air pockets. All connections and reductions in suction pipe sizes shall be designed to avoid causing air pockets and cavitation.

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1415.4.3 Pumps shall be located to facilitate service and ease of removal. Appropriate fittings shall be provided to allow the pump to readily be primed, serviced, and disconnected. An enclosure shall be provide of adequate size and strength, with proper ventilation, to protect the pump from the elements (except residential systems).

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1415.5 Low voltage wire installation.

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1415.5.1 Install low voltage wire (less than 98 volts) with a minimum depth of cover of 12 inches (305 mm) where not installed directly under the mainline. A sufficient length of wire shall be provided at each connection to allow for thermal expansion/shrinkage. As a minimum, a 12-inch (305 mm) diameter loop shall be provided at all splices and connections. Terminations at valves shall have 24 inches (610 mm) minimum free wire.

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1415.5.2 All above-ground wire runs and wire entries into buildings shall be installed in electrical conduit. Common wires with a different color than the power wires (white shall be used for common wires) shall be provided. Connections shall be made using devices conforming to UL 486C specifically designed for direct burial. All splices shall be enclosed within a valve box.

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P12107Text Modification

Exception: When wiring above ground manifolds from the valve to the ground immediately beneath it, no conduit is required.

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1415.6 Hydraulic control tubing installation

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1415.6.1. For hydraulic control systems, a water supply shall be used that is filtered and free of deleterious materials, as defined by the hydraulic control system manufacturer's specifications. A backflow prevention device shall be installed where the hydraulic control system is connected to potable water supplies.

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1415.6.2 Tubing shall be installed in trenches and spaced so that it will not rub against pipe, fittings, or other objects that could score the tubing, and with a minimum 12-inch (305 mm) diameter loop at all turns and connections A minimum depth of cover of 12 inches (305 mm) shall be provided.

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1415.6.3 Tubing shall be connected with couplings and collars according to Manufacturer's specifications. All splices shall be made in valve boxes. Tubing shall be prefilled with water to expel entrapped air and tested for leaks prior to installation.

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1415.6.4 Exposed tubing shall be installed in a protective conduit manufactured from Schedule 40 UV protected PVC or electrical conduit.

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1416 As-Built Drawings.

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1416.1 An As-Built drawing shall be required of all irrigation systems installed on commercial and residential developments and shall contain the following information:

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1416.1.1 Location, type, pressure and maximum flow available of all water sources.

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1416.1.2 Location, type and size of all components including sprinklers, microirrigation, main and lateral piping, master valves, valves, moisture sensors, rain sensors, controllers, pump

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start relays, backflow devices, pumps, wells, etc.

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1416.3 The flow rate, application rate (inches per hour), and the operating pressure for the sprinklers and micro irrigation within each zone.

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1416.1.4 The name, address, phone, email, professional license or certification number of the installation contractor.

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1416.1.5 Date of installation.

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Residential

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CA11777

Date Submitted	01/18/2025	**Section**	101.1	**Proponent**	Greg Burke
Chapter	1	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

FBCR302 FBCB901.6.1 FBCB901.6.2 FBCB903.3.1.3 FBCB907.6.6 FBCEx505.2 FBCEx505.3 FBCEx702.4 FBCEx702.5 FBCFG101.2

Summary of Modification

Adds three- and four- family dwellings to the scope.

Rationale

Housing and skilled labor is at a crisis point in the United States. Demand is outpacing supply in a critical way. To entice development and local authorities in providing more options for first time buyers or those who are wishing to down-size, the scope change will enable an opportunity for choice, Moving these two dwelling types into the FBC,R allows construction in an equivalent manner to single-, two-family, and townhouses buildings. More cost savings can come in the form of reduced egress requirements. Single exits could be required that would have stairs meet the riser/tread dimensions reduced from the commercial maximum requirement to the residential requirements for treads and risers. In Occupancy Group R2, under the FBC,B live load will be reduced to 40 psf from the commercial requirement of 100 psf. Other sections of the FBC,R may allow for potential for smaller HVAC units. Financial institutions finance these two types of dwelling units as single-family homes. It is not until a building has five or more residential units that the financing is a commercial loan. For this reason alone, three-family, and four-family dwelling units should be included in the FBC,R. It is possible to purchase these dwellings with an FHA Loan. Realtors in Florida are also permitted to sell up to four units on a residential license. With proper zoning, three-family and four-family dwelling units can be designed and constructed to be compatible in single-family neighborhoods. Most can be constructed within a 35-foot height limit, common in many parts of the state. Normally, three-family, and four-family dwellings are two, two and one-half or three stories above the grade plane making them compatible with a single-family or two-family home. The footprint of either a three- or a four-family building could be designed and constructed in dimensions of forty feet by sixty feet.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

The less restrictive application of a residential code souldlessen the burden on enforcement.

Impact to building and property owners relative to cost of compliance with code

Less expensive construction and sales cost.

Impact to industry relative to the cost of compliance with code

None

Impact to small business relative to the cost of compliance with code

May provide more opportunity for small developers and contractors.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The design of three- and four-family dwelligs are similar in nature to a duplex. As such the dgree of health, safety and elfare is enhanced by admitting these two dwelling types to the residential code.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

The modification is in line with industry standards for financing and sales.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No.

Does not degrade the effectiveness of the code

No.

CA11777Text Modification

FBC,B 101.2 Scope.

The provisions of the *Florida Building Code, Residential* shall apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, removal, and demolition of detached one-, ~~and~~ two-, three- and four- family dwellings and *townhouses* not more than three stories above *grade plane* in height with a separate means of egress and their *accessory structures* not more than three stories above *grade plane* in height.

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Residential

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P11736

Date Submitted	01/13/2025	**Section**	2407	**Proponent**	Mo Madani
Chapter	24	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Summary of Modification

Correlation with NFPA 54 and the 2024 I-Code changes as approved by the Commission and as applicable.

Rationale

The proposed code changes are needed to update Chapter 24 Fuel Gas of the FBC - Residential for consistency with the 2024 NFPA 54 and the 2024 I - Codes changes as approved by the Commission.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
Provide correlation with NFPA 54
Impact to building and property owners relative to cost of compliance with code
Provide correlation with NFPA 54
Impact to industry relative to the cost of compliance with code
Provide correlation with NFPA 54
Impact to small business relative to the cost of compliance with code
Provide correlation with NFPA 54

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Provide correlation with NFPA 54
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Provide correlation with NFPA 54
Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities
Provide correlation with NFPA 54
Does not degrade the effectiveness of the code

Provide correlation with NFPA 54

P11736Text Modification

See attached

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P11736Text Modification

G2407.1(304.1) General. ~~Air for combustion, ventilation and dilution of flue gases for *appliances* installed in buildings shall be provided by application of one of the methods prescribed in Sections G2407.5 through G2407.9. Where the requirements of Section G2407.5 are not met, outdoor air shall be introduced in accordance with one of the methods prescribed in Sections 304.6 through 304.9. *Direct vent appliances*, gas *appliances* of other than natural draft design, vented gas appliances not designated as Category I and appliances equipped with power burners shall be provided with combustion, ventilation and dilution air in accordance with the *appliance* manufacturer's instructions.~~

~~Exception:~~ ~~Type 1 clothes dryers that are provided with makeup air in accordance with Section G2439.5.~~

Where chemicals that generate corrosive or flammable products such as aerosol sprays are routinely used, one of the following shall apply to fired appliances where these chemicals can enter combustion air:

1. Fired appliances shall be located in a mechanical room separate or partitioned off from other areas with provisions for combustion and dilution air from outdoors.
2. The appliances shall be direct vent and installed in accordance with the appliance manufacturer's installation instructions.

G2407.12 (304.12) Protection from fumes and gases. ~~Where corrosive or flammable process fumes or gases, other than products of combustion, are present, means for the disposal of such fumes or gases shall be provided. Such fumes or gases include carbon monoxide, hydrogen sulfide, ammonia, chlorine and halogenated hydrocarbons. In barbershops, beauty shops and other facilities where chemicals that generate corrosive or flammable products, such as aerosol sprays, are routinely used, nondirect vent type *appliances* shall be located in a mechanical room separated or partitioned off from other areas with provisions for *combustion air* and dilution air~~

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P11736Text Modification

~~from the outdoors. *Direct vent appliances* shall be installed in accordance with the appliance manufacturer's instructions.~~ Where chemicals that generate corrosive or flammable products such as aerosol sprays are routinely used, one of the following shall apply to fired *appliances* where these chemicals can enter combustion air:

1. Fired appliances shall be located in a mechanical room separate or partitioned off from other areas with provisions for combustion and dilution air from outdoors.
2. The appliances shall be direct vent and installed in accordance with the appliance manufacturer's installation instructions.

G2411.1 (310.1) Pipe and tubing other than CSST. Each aboveground portion of a gas *piping* system other than corrugated stainless steel tubing (CSST) that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas *piping* other than CSST shall be considered to be bonded where it is connected to ~~an~~ one or more *appliances* that ~~is~~ are connected to the *equipment* grounding conductor of the circuit that supplies that *appliance(s).*

G2411.3 (310.3) Arc-resistant CSST. ~~This section applies to c~~ Corrugated stainless steel tubing (CSST) ~~that is *listed*~~ with an arc-resistant jacket or coating system ~~in accordance~~ shall be *listed* as arc resistant in accordance with **ANSI LC 1/CSA 6.26**. ~~The~~ Arc-resistant-jacketed CSST shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST used in ~~component of~~ a *piping* system does not have an arc-resistant jacket or coating system, the bonding requirements of **Section**

G2411.2 shall apply. Arc-resistant-jacketed CSST shall be considered to be bonded where it is connected to ~~an~~ one or more *appliances* that is are connected to the equipment ~~*appliance*~~ grounding conductor of the circuit that supplies that *appliance(s).*

G2414.6 (403.7) Workmanship and defects. Gas ~~P~~pipe, tubing and fittings at the time of

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P11736Text Modification

installation shall meet the following requirements:

1. Gas pipe, tubing and fittings shall be clear and free from cutting burrs and visible defects in structure or threading.

2. Gas pipe, tubing and fittings shall be thoroughly cleaned to remove chip, scale and debris.

3. Visible defects in pipe, tubing and fittings shall not be repaired.

4. Pipe, tubing and fittings with visible defects shall be replaced.

~~be clear and free from cutting burrs and defects in structure or threading, and shall be thoroughly brushed, and chip and scale blown. Defects in pipe, tubing and fittings shall not be repaired. Defective pipe, tubing and fittings shall be replaced.~~

G2414.9 (403.9) Metallic piping joints and fittings. The type of piping joint used shall conform to the following:

1. It shall be suitable for the pressure-temperature conditions.

2. It shall be ~~and shall be~~ selected giving consideration to joint tightness and mechanical strength under the service conditions.

3. It shall be ~~The joint shall be~~ able to sustain the maximum ~~end force caused by the internal pressure and any additional forces caused by~~ forces inclusive of temperature expansion or contraction, vibration, fatigue, internal pressure or the weight of the pipe and its contents.

G2415.8.2 (404.8.2) Conduit with both ends terminating indoors. Where the conduit originates and terminates within the same building, the conduit shall originate and terminate in ~~an accessible~~ a portion of the building with access and shall not be sealed. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.

G2415.14.2 (404.14.2) Conduit with both ends terminating indoors. Where the conduit originates and terminates within the same building, the conduit shall originate and terminate in ~~an accessible~~ a portion of the building with access and shall not be sealed. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.

G2417.1.2 (406.1.2) Repairs and additions. In the event repairs or additions are made after the pressure test, the affected piping shall be tested. Minor repairs and additions ~~are not~~ shall not be required to be pressure tested provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other approved leak-detecting methods.

G2417.4.1 (406.4.1) Test pressure. The test pressure to be used shall be not less than 11 /2 times the proposed maximum working pressure, but not less than 3 psig (20 kPa gauge~~), irrespective of design pressure~~. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe.

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G2417.5.1 (406.5.1) Detection methods. The leakage shall be located by means of ~~an approved~~ a listed combustible gas detector, a noncorrosive leak detection fluid or other approved leak detection methods.

G2417.7.3.1 (406.7.3.1) Abandoned fuel gas piping. Where fuel gas piping is removed from service an indefinite time period, it shall be purged.

G2420.5.3 (409.5.3) Located at manifold. Where the appliance shutoff valve is installed at a manifold, such shutoff valve shall be located within 50 feet (15 240 mm) of the appliance served and shall ~~be readily accessible~~ have ready access and be permanently identified. The piping from the manifold to within 6 feet (1829 mm) of the appliance shall be designed, sized and installed in accordance with Sections G2412 through G2419.

G2422.1.4 (411.1.6) Unions. A union fitting shall be provided for appliances connected by rigid metallic pipe. Such unions shall ~~be accessible~~ have access and be located within 6 feet (1829 mm) of the appliance.

G2425.7.3 (501.7.3) Connection to masonry fireplace flue. A connector shall extend from the appliance to the flue serving a masonry fireplace such that the flue gases are exhausted directly into the flue. The connector shall ~~be accessible~~ have access or be removable for inspection and cleaning of both the connector and the flue. Listed direct connection devices shall be installed in accordance with their listing.

G2427.5.8 (503.5.9) Cleanouts. Where a chimney that formerly carried flue products from liquid or solid fuel-burning appliances is used with an appliance using fuel gas, ~~an accessible~~ a cleanout with access shall be provided. The cleanout shall have a tight-fitting cover and shall be installed so its upper edge is not less than 6 inches (152 mm) below the lower edge of the lowest chimney inlet opening.

G2427.14 (503.14) ~~Automatically operated~~ Automatic vent dampers. An ~~automatically operated~~ automatic vent damper shall be *listed* .

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Residential

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P12114

Date Submitted	02/14/2025	**Section**	0.0	**Proponent**	Joseph Eysie
Chapter	24	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

Fuel Gas Residential Companion

Summary of Modification

A minor code change to Appendix D, Recommended Procedure for Safety Inspection of an Existing Appliance Installation, replaces "brass" with "copper alloy" in Appendix D.3 for gas piping and connection inspections.

Rationale

To maintain consistency with the International Fuel Gas Code and ensure uniformity across chapters that refer to brass as copper alloy.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
No Impact
Impact to building and property owners relative to cost of compliance with code
No Impact
Impact to industry relative to the cost of compliance with code
No Impact
Impact to small business relative to the cost of compliance with code
No Impact

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Ensures consistency throughout the code
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Maintains uniformity throughout the code.

Uses the correct term "copper alloy" instead of "brass."

Does not degrade the effectiveness of the code

Ensures consistency across the code.

P12114Text Modification

A minor code change replaces the term “brass” with “copper alloy” in Appendix D.3 regarding gas piping and connection inspections. This revision, made to the 2024 International Fuel Gas Code, is being adopted to ensure consistency between the Florida Fuel Gas Code and the International Fuel Gas Code. This amendment serves as a companion to a similar proposal affecting Appendix D of the Fuel Gas Code.

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Mod_12114_Text_FBC FG Appendix D_ Recommended Procedure for Safety Inspection .pdf

Appendix D: Recommended Procedure for Safety Inspection of an Existing Appliance Installation

SECTION D103 GAS PIPING AND CONNECTIONS INSPECTIONS.

1. *Leak Checks.* Conduct a test for gas leakage using either a non-corrosive leak detection solution or a CGD confirmed with a leak detection solution.

   The preferred method for leak checking is by use of gas leak detection solution applied to all joints. This method provides a reliable visual indication of significant leaks.

   The use of a CGD in its audio sensing mode can quickly locate suspect leaks but can be overly sensitive indicating insignificant and false leaks. All suspect leaks found through the use of a CGD should be confirmed using a leak detection solution.

   Where gas leakage is confirmed, the owner should be notified that repairs must be made. The inspection should include the following components:

   a. All gas *piping* fittings located within the *appliance* space.

   b. *Appliance* connector fittings.

   c. *Appliance* gas valve/regulator housing and connections.

2. *Appliance Connector.* Verify that the *appliance* connection type is compliant with Section 411 of the International Fuel Gas Code. Inspect flexible *appliance* connections to determine if they are free of cracks, corrosion and signs of damage. Verify that there are no uncoated ~~brass~~ copper alloy connectors. Where connectors are determined to be unsafe or where an uncoated~~brass~~ copper alloy connector is found, the appliance shutoff valve should be placed in the off position and the owner notified that the connector must be replaced.

3. *Piping Support.* Inspect *piping* to determine that it is adequately supported, that there is no undue stress on the *piping,* and if there are any improperly capped pipe openings.

4. *Bonding.* Verify that the electrical bonding of gas *piping* is compliant with Section 310 of the International Fuel Gas Code.

TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Residential

20

P11851

Date Submitted	02/12/2025	**Section**	3012	**Proponent**	Michael Wilson
Chapter	30	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments Yes **Alternate Language Yes**

Related Modifications

None

Summary of Modification

The finished resin-impregnated tube shall be continuous over the entire length of the installation or inversion run, with no gaps in coverage at branch or service connections.

Rationale

See Attached Support Files The proposed modification reflects the changes in the glitch flix, this is to better clarify the standard.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
There is no impact.
Impact to building and property owners relative to cost of compliance with code
There is no impact.
Impact to industry relative to the cost of compliance with code
There is no impact.
Impact to small business relative to the cost of compliance with code
There is no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Yes.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction
Yes.

No it does not discriminate against materials, products, methods or systems of construction of demonstrated capabilities.

Does not degrade the effectiveness of the code

No it does not degrade the effectiveness of the code.

Alternate Language

1st Comment Period History

P11851-A2

Proponent Mark Miller **Submitted** 4/14/2025 7:27:25 PM **Attachments** Yes

Rationale:

The proposed language to which this alternate modification is submitted in response imposes unnecessary confusion, inconsistency, and constraints on practical and effective CIPP rehabilitation methods. The term "continuous," as used in ASTM F1216, ASTM F1743, and ASTM F3541 does not require that a CIPP liner extend uninterrupted through the entire piping system. Instead, ASTM F1743 emphasizes the structural integrity and uniformity of each installed segment. It requires each CIPP segment to be free of seams, dry spots, or discontinuities, ensuring that where a liner is installed, it is installed completely and performs as intended. It does not mandate that the entire piping network be lined in a single run. Requiring a single continuous liner from the building vent to the city main is not only impracticable in many existing buildings, but it is also not necessary to ensure system performance. The proposed clarification aligns with ASTM F1743's actual requirements and intent, allowing installers to rehabilitate pipelines efficiently and effectively while maintaining compliance with established performance and safety standards. Still, to eliminate further confusion as to the plain meaning of the code, the incorporation of ASTM F3541 into Section P3012.1 is the ideal option. ASTM F3541 specifically addresses sectional repairs for gravity flow, non-pressure pipelines, and conduits, and likewise emphasized the structural integrity and proper installation of each installation length without mandating a single continuous application. This approach aligns more closely with industry best practices, promotes flexibility, and ensures that each installed length is free of gaps, seams, dry spots, lifts, or delaminations, thereby achieving the intended performance and safety standards. Incorporating ASTM F3541 not only mitigates confusion but also supports more efficient and reliable rehabilitation processes.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

None noted.

Impact to building and property owners relative to cost of compliance with code

None noted.

Impact to industry relative to the cost of compliance with code

None noted.

Impact to small business relative to the cost of compliance with code

There is no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The change links directly to public health by ensuring leak-free, safe pipelines. Incorporating ASTM F3541 reduces hazards and supports effective rehabilitation, thereby protecting the community's health, safety, and welfare.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Including ASTM F3541 strengthens the code by aligning with proven, flexible repair methods. It enables sectional repairs that meet or exceed current standards without enforcing impractical continuous lining, ensuring better construction.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

Adding ASTM F3541 alongside existing standards is technology-neutral. It does not favor any specific method, material, or product, ensuring all proven approaches remain acceptable and encouraging fair competition.

Does not degrade the effectiveness of the code

The modification preserves the code's effectiveness by clarifying acceptable repair methods without lowering performance standards. It maintains rigorous safety and quality, avoiding ambiguities that could compromise system integrity.

1st Comment Period History

P11851-G1

Proponent Michael Wilson Submitted 4/16/2025 7:02:36 PM Attachments Yes

Comment:

P11851-A2 – Petitioner has “preferences”, “personal knowledge”, and “experience” with the CIPP “Gapping” installation method that conflicts with ASTM F1216, CIPP Inversion, and ASTM F1743, CIPP Pull-in-Place. Petitioner feels the ASTM Standards are “impractical” and “not necessary”, although both ASTMs establish industry required Standards, supported by valid third-party certification for “Continuous” CIPP material installation methods as required by the Florida Building Code, ICC, and IPC. (See attached Illustration) There is NO ASTM that recognizes or references a CIPP material “Gapping” installation method. (See attached full General Comment rationale)

P11851-A2Text Modification

P3012.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216, ~~or~~ ASTM F1743, or ASTM F3541.

P3012.1.1 The finished CIPP shall be continuous throughout each installation length, extending from service connection to service connection. Each continuous installation length shall be free of gaps, seams, dry spots, lifts, and delaminations.

Page: 1

Mod11851_A2_TextOfModification.pdf

P11851-A2Text Modification

P3012.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216, ~~or~~ ASTM F1743, or ASTM F3541.

P3012.1.1 The finished CIPP shall be continuous throughout each installation length, extending from service connection to service connection. Each continuous installation length shall be free of gaps, seams, dry spots, lifts, and delaminations.

Page: 1

Mod_11851_A2_Text_P3012 PROPOSED MODIFICATIONS.pdf

P11851Text Modification

P3012.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743. The finished resin-impregnated tube shall be continuous over the entire length of the installation or inversion run, with no gaps in coverage at branch or service connections.

Page: 1

Mod11851_TextOfModification.pdf

P11851-G1General Comment

POLSINELLI

7676 Forsyth Boulevard, Suite 800, St. Louis, MO 63105 · (314) 889-8000

February 11, 2025

Ryan J. McCarty
(314) 622-6698
(314) 754-9186 Fax
rmccarty@polsinelli.com

Mr. Jeffrey D. Green, Esq.
Kaye Bender Rembaum, PL.
1200 Park Central Blvd. South
Pompano Beach, FL 33064

Re: Highland Towers, Inc. Warranty Demand

Dear Mr. Green:

My firm represents Perma-Liner Industries, LLC ("**PLI**"). I am in receipt of your letter to Jerry S. D'Hulster dated January 10, 2025, regarding my client's product installed at Highland Towers, Inc.'s ("**Highland**") property located at 2921 S. Ocean Blvd., Highland Beach, FL 33404 (the "**Property**"). PLI rejects Highland's purported warranty claim because the materials cited in your letter clearly demonstrate that any alleged problems with the cured-in-place pipe materials ("**CIPP**") at the Property were caused by improper installation, not defective product, thereby negating the warranty.

PLI's warranty clearly states: "[PLI] warrants that the cured-in-place pipe materials (the "Materials"), ***when properly maintained and installed***, will be free from defects in material and workmanship for ten (10) years from the date of delivery to PLI's customer.... PLI warrants to Customer that, ***when installed in accordance with applicable PLI standard operating procedures***, the Materials are manufactured and supplied to the requirements of ASTMF1216...."

As you noted in your letter, which is also confirmed by the Crain Atlantis Engineering report ("**Crain Report**"), the installer, [redacted], improperly used the "non-code compliant, GAP method" to install the product. The GAP method violates code, is not consistent with industry standard for installation of CIPP, violates PLI's standard operating procedures provided to installers (see enclosure) and, consequently, negates any warranty. The Crain Report also clearly indicates that the "Plumbing Contractor" improperly installed the CIPP and the deficient installation is the source of the current problems:

Page: 1

Mod_11851_G1_General_Redacted Warranty Demand Perma-Liner.pdf

P11851-G1General Comment

POLSINELLI.

The Highland Towers sanitary piping system is failing and the non FBC CODE COMPLIANT Pull in Place GAP method utilized by [redacted] Plumbing Contractor does not meet the Highland Towers expectations for the sanitary systems extended useful life.
The installed GAP method has resulted in liner deterioration, bulges, subsequent blockage and non-lined branch connections.

The video inspections revealed that the GAP repair method used by [redacted] evidenced failing of the liner at the terminations within the piping and liner "blow outs" bulges creating flow restrictions in the piping with the potential for complete blockage of the affected sanitary system.

On Wednesday, October 16, 2024, a section of the pipe riser located in the laundry room was cut and sampled to evaluate the liner condition. The assessment indicated that the liner installation was deficient.

It is apparent that the Pull in Place, GAP, start and start method is failing. The GAP method also allows the unlined locations of the existing piping at the branch connections to remain a candidate for future probable failures. The gaps occur at the branch connections of the sanitary piping systems.

See Crain Report at pages 3 & 8.

Furthermore, the fourth image of Exhibit A to the Crain Report identifies debris on the edge of the gapped liner which appears to extend behind the liner as inferred by the liner "bulges" apparent at the identified locations. Such debris should have been cleaned prior to liner installation, resulting in a smooth, continuous repair with no discontinuities in its circularity. Failure to properly clean the pipe prior to installing CIPP also negates the warranty because subsequent failures are caused by installation and not defective product. Failure to sufficiently clean the pipes prior to installation is also likely a demonstrable breach of [redacted] contract with Highland. *See* Section II.

For the foregoing reasons, PLI firmly rejects Highland's warranty demand and suggests that Highland look to the installer for any remedy to address the issues it is experiencing at the Property.

Please direct all future communication on this issue to me.

Sincerely

Ryan J. McCarty

RJM:da

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Page: 2

Mod_11851_G1_General_Redacted Warranty Demand Perma-Liner.pdf

P11851-G1General Comment

SPECIFICATIONS FOR INSTALLING CURED-IN-PLACE-PIPE (CIPP) DRAIN, WASTE, AND VENT PIPE LINING USING THE PULL-IN-PLACE METHOD FOR REHABILITATION OF EXISTING PIPELINES

1.00 ***Intent***

The intent of this cured-in-place lateral lining specification is to provide reconstruction of sewer collection drain, waste and vent pipelines without excavating the entire existing pipeline.

2.00 ***General***

The existing pipe reconstruction will be accomplished using a liner tube measured to exact length and inside diameter utilizing a thermosetting resin that meets required physical and chemical resistance properties. The liner will be impregnated with resin then dropped into the pipe opening. A pre-strung cable or winch line will be used to pull the liner and bladder into place. Once in place, an internal rubber bladder will be inflated to allow the liner to hold its shape against the host pipe as the resin cures. At no time during the cure will the bladder lose air pressure and be re-pressurized. Once the liner is fully cured, the bladder is removed. The sewer lateral collection pipe will be immediately televised for the inspector's approval. A copy of the televised inspection must be recorded on VHS or DVD format for future reference.

3.1 ***Materials***

The liner tube will consist of a needled felt. The liner tube will be fabricated together using a butt stitched seam sealing process with a heat welded sealing tape to ensure airtight seal. The liner tube is to be manufactured in the United States by Perma-Liner Industries, LLC. The liner tube will be capable of carrying resin and withstanding installation pressures and curing temperatures. The liner tube will be lined on one side with a translucent impermeable chemically resistant polyurethane (PU) waterproof coating. An internal bladder must come inside of the liner material. This bladder may consist of a rubber or vinyl calibration hose material.

The resin will be a two-part, 100% solids epoxy containing no styrene. No styrene based resin will be accepted due to its change in volume during polymerization. The epoxy resin shall be formulated to have a gel (pot) life of approximately 30 minutes with a set cure time of three (3) hours. The epoxy shall ambient cure by internal exothermic chemical reaction. External heat processes using hot water or steam to lower cure times will be accepted.

The seam stitched / heat welded seam tape / felt liner tube and resin will upon installation meet and/or exceed minimum testing standards as required by ASTM, IAPMO and ANSI/NSF International. All materials must have 3rd party testing provided by an independent a2La accredited laboratory completed within one year of the bid completion date.

3.2

Required Cured-In-Place Lateral Lining Standards		Minimum(ASTM F 1216/ 1743)
Flexural Strength	(ASTM D-790)	4,500 PSI
Flexural Modulus	(ASTM D-790)	250,000 PSI
Tensile Strength	(ASTM D-638)	3,000 PSI
Tensile Elongation	(ASTM D-638)	5 PSI
Compressive Strength	(ASTM D-695)	4,000 PSI
Chemical Resistance	(ASTM D-543)	> 20% loss
Leakage Test*	(NSF Standard 14)	0/gal/in/day

Page: 3

Mod_11851_G1_General_Redacted Warranty Demand Perma-Liner.pdf

P11851-G1General Comment

Manufacturer must have United States based manufacturing head quarters. The manufacturer must have at least 10 years of manufacturing / supplying C.I.P.P. Air Inversion or Pull In Place Liner Tube and Materials. The manufacturing plant has a Quality Assurance / Quality Control program in place and audited a minimum of once per year by NSF International, IAPMO R&T Laboratories, and the International Code Council.

4.1 ***Pull-In-Place Process***

Standard Practice for Rehabilitation of Existing Drain, Waste, Vent Pipelines and Conduits by Pulled-In-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

4.2 The owner shall be notified 24 hours in advance of project start time. No building utilities, such as toilets, sinks, dishwasher, laundry washer, bath tubs or sump pumps will be used during the installation and curing process. It is up to the contractor to determine if water supply should be temporarily shut down. Generally no by-pass pumping is needed.

4.3 Lateral sewer collection pipe must be cleaned thoroughly prior to installation of liner. All sand, rocks, gravel, grease, mud, sludge, and other debris must be removed from the invert to permit proper installation. Roots will need to be removed to the extent necessary to effectively line the entire pipe.

4.4 The existing lateral sewer collection pipe will be inspected using a mini-televising color camera system capable of viewing the interior condition of the host pipe by a trained technician. The TV inspection must be performed within 5 hours prior to installation of liner tube. All obstacles should be noted.

4.5 The resin and liner material will not be contaminated and/or diluted prior to installation.

4.6 Resin impregnation must be performed on site prior to installation into the pipe or conduit. Visual inspection must yield no dry spots in the liner. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material at nominal thickness and diameter. The volume should be adjusted by adding 3-15% excess resin to allow for migration through the perforations of the fabric tube out onto the host pipe.

4.7 The liner tube will be lubricated with vegetable oil, this is done to help the liner slide into the host pipe, and to aid in preventing epoxy loss during movement. The liner tube will be pulled into place using a pre-strung winch or cable line. The liner tube will be open and not sealed off. The liner tube will be designed to fit tightly against the host pipe annular space and gaps. The bladder tube inside the liner will be inflated to ensure the liner is tight against the host pipe until fully cured. The resin-impregnated liner tube will cure within 4 hours without external heat sources.

4.8 External heat sources such as hot water and steam may be used to speed the cure of the liner. If either of these is used, a proper initial cure, post cure, and cool down process must be implemented to the resin manufacturer's specifications.

4.9 Once the curing process is finished, the internal bladder is removed and the lateral sewer collection pipe is immediately inspected for final acceptance. The new lined pipe will be free of any foreign objects providing a smooth, seamless and continuous lined pipe from entry point to main sewer connection pipe.

4.10 Any liner tube protruding from the lateral sewer collection pipe into the main sewer pipeline will be removed by remote robotic cutting equipment.

4.11 A final TV Inspection of the lined lateral collection sewer pipe will be recorded and provided to the owner for final approval.

5.1 ***Final Acceptance***

Page: 4

Mod_11851_G1_General_Redacted Warranty Demand Perma-Liner.pdf

P11851-G1General Comment

In addition to any specific acceptance criteria specified in the contract, the following standards shall be satisfied before final acceptance of the liner installation:

5.2 Finish

The finished pipe shall be continuous over the length of a run and be free from defects.

5.3 Defects

Any defects, which will affect the integrity of the installed pipe, will be repaired as directed by the owner.

5.4 Leakage

No visible leakage through the liner will be allowed.

5.5 Lateral Branch Pipe Reinstatement

In Vertical Pipe Applications, if the CIPP lined pipe requires reinstatement of lateral branch connections, Perma-Liner™ offers robotic equipment and training for the reinstatements.

In the absence of industry standards regarding the reinstatement of lateral branch connections in vertical pipelining applications, Perma-Liner™ does not publish guidelines or offer training on alternative reinstatement methods not offered by Perma-Liner™.

Perma-Liner™ is aware of alternative methods for reinstating lateral branch connections in vertical pipelining applications, such as "Start & Stop", "Gapping" and "Spin-Casting" methods. However, performing such methods could potentially void any warranty Perma-Liner supplies to our certified installers.

6.00 *Payment*

Payment for the work included in this section will be in accordance with the prices set forth in the contract for the quantity of work performed. Progress payments will be made monthly based on the work performed during that month.

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Mod_11851_G1_General_Redacted Warranty Demand Perma-Liner.pdf

P11851-G1General Comment

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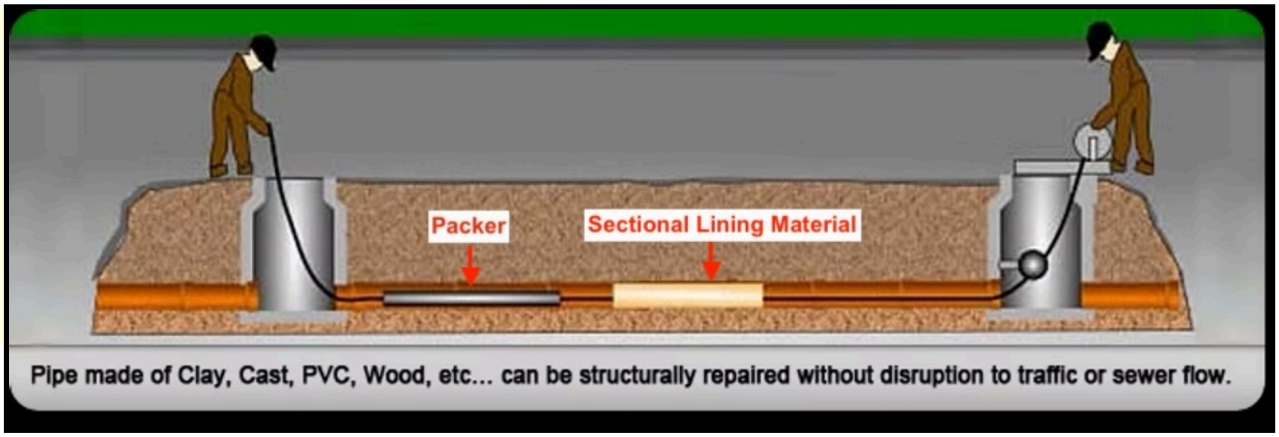
P11851-G1General Comment



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Mod_11851_G1_General_Packer image for ASTM F3541.pdf

P11851-G1General Comment

General Comment

Rebuttal to P11851 - A2

Respondent has "preferences", "personal knowledge" and "experience" with the CIPP "Gapping" installation method that conflicts with ASTM F1216, CIPP Inversion, and ASTM F1743, CIPP Pull-in-Place. Respondent feels the ASTM Standards are "impractical" and "not necessary", although both ASTMs establish industry required Standards, supported by valid third-party certification for "Continuous" CIPP material installation methods as required by the Florida Building Code, ICC, and IPC. (See attached Illustration) **There is NO ASTM that recognizes or references a CIPP material "Gapping" installation method.**

"Continuous" CIPP material installation is a required "Standard" in all three ASTMs referenced by the Respondent:

*****ASTM F1216:**

7.8 Workmanship

*"The finished pipe shall be **(B) continuous over the entire length** of an inversion run and be free of dry spots, lifts, and delamination."*

*****ASTM F1743:**

6.8 Workmanship

*"The finished CIPP should be **(B) continuous over the entire length** of an installation and be free of dry spots, lifts, and delamination."*

*****ASTM F3541:**

6.7 Workmanship

*"The finished CIPP shall be **continuous over its entire length** and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations."*

Page: 1

Mod_11851_G1_General_General Comment Rebuttal to P11851 - A2.pdf

P11851-G1General Comment

***** See attached Illustration - "CONTINUOUS MATERIAL INSTALLATION"**

The Respondent disagrees with the dictionary definition and common understanding of the word "continuous": *"unbroken and uninterrupted*" and finds the ASTM Standard of "continuous over the entire length", as "impractical" and "not necessary", despite the clear language and requirement mandated by ASTM F1216 and ASTM F1743.

The Respondent's "preferences", "personal knowledge" and "experience" with the CIPP "Gapping" material installation method conflicts with the Florida Building Code **"Glitch Fix":**
2024 Supplement to the 8th Edition (2023) Florida Building Code
Effective date – April 16, 2024, 8th Edition (2023) Florida Building Code,

> **Chapter 7 -Sanitary Drainage**
> **718.1 Cured-in-place**. Cured-in-place rehabilitation of building sewers and building drainage piping ***shall be in accordance with ASTM F1216 or ASTM F1743.***

> **Chapter 30 – Sanitary Drainage**
> **P3012.1** Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping ***shall be in accordance with ASTM F1216 or ASTM F1743.***

The Respondent's recommendation to add ASTM F3541 into 718.1 is not consistent with the intent of 718.1 to **"rehabilitate"** building sewers and drainage piping.

Page: 2

Mod_11851_G1_General_General Comment Rebuttal to P11851 - A2.pdf

P11851-G1General Comment

ASTM F3541 – 1.1 applies to a single "Sectional **Repair**" using one "liner wrapped around a carrier device" to **repair one defect in the host pipe**.

ASTM F3541 - 1.1 is approved for pipe sizes "3 in. to 60 in.", and **does NOT allow** for use in 2" pipe as stated in Respondent's statement **"i. Capability to install 2" liners"**

ASTM F3541 - 5.1 states "the liner will extend 1ft in all directions beyond the host pipe **defect**." It is not "segmental" with multiple liner "segments" creating "Gaps" over branch fittings. The words "segment" and "segmental" do not appear in ASTM F3541. The ASTM F3541 liner is a single section of material installed to **repair one issue**, much like an external "Repair clamp"

ASTM F3541 6.6 **does not** support or approve "Gapped" or segmented CIPP lining material installation, instead it requires:

> **"6.6 Overlapping** Installations—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end **with a minimum overlap to adjacent CIPP sections**".

ASTM F3541 - REQUIRES **CONTINUOUS** material installation

6.7 Workmanship:

> 6.7.1 The finished **CIPP shall be continuous over its entire length**

Page: 3

Mod_11851_G1_General_General Comment Rebuttal to P11851 - A2.pdf

P11851-G1General Comment

ASTM F3541 - DOES NOT promote "Gapping" the CIPP lining material on the "carrier device" in order to "Gap" fitting branches or service connections instead:

> **ASTM 3541** – 6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active **service connections shall be <u>reinstated</u>**. This shall be performed……**by the means of….. a <u>remote control cutting device."</u>**

The Respondent's Page 1 Paragraph 3 comments: i. - viii. Reflect "preferences", "personal knowledge", and "experience" with CIPP material "Gapping" methods that conflict with industry accepted ASTM Standards and requirements established since the approval of ASTM F1216 in 1989. If the Respondent is determined to continue promoting CIPP "Gapping" material installation in the State of Florida he should petition the American Society for Testing and Materials for an ASTM that specifically addresses the CIPP "Gapping" installation methods that will allow for "third-party certification", FBC approvals, and a legitimate Manufacturer's material warranty*** in order to protect the Florida Consumer. Currently there are NO ASTM Standards that approve or endorse the CIPP "Gapping" material installation method.

*** See the attached recent Perma-Liner Industries WARRANTY DENIAL letter for the "Gapping" of their CIPP material. Perma-Liner Industries is the largest manufacturer of CIPP lining material in the State of Florida and their material is widely used in the State of Florida by small diameter pipe lining contractors.

Page: 4

Mod_11851_G1_General_General Comment Rebuttal to P11851 - A2.pdf

P11851-G1General Comment

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]

D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D4814 Specification for Automotive Spark-Ignition Engine Fuel

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

E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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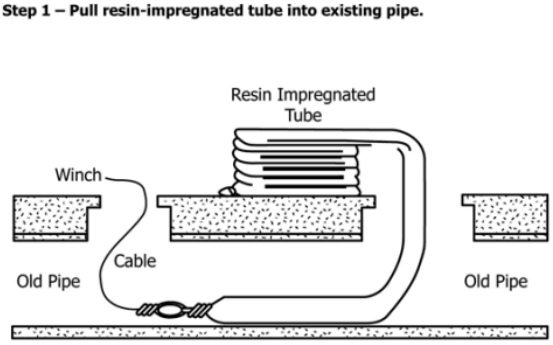

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F 6 3.6 °F (23 °C 6 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1216 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2]

This standard is issued under the fixed designation F1216; 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 reconstruction of pipelines and conduits (2 in. to 108 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water, introducing controlled steam within the tube, or by photoinitiated reaction. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process is used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe

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

E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standard:*[4]

M 28 Rehabilitation of Water Mains, Third Ed.

2.3 *NASSCO Standard:*[5]

Sewer Pipe Cleaning Specification Guideline

3. Terminology

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

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "*Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois*," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[3] 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.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] Available from the National Association of Sewer Service Companies, 5285 Westview Drive, Suite 202, Frederick, MD 21703. http://www.nassco.org/

***A Summary of Changes section appears at the end of this standard**

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3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—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.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.4 *photoinitiated reaction*—the polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube shall consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube and any non-structural plastic coating or flexible membrane included in the tube construction shall be compatible with the resin system used. The material shall be able to stretch to fit irregular pipe sections and negotiate bends. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance shall be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process shall be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The CIPP system shall be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties shall be determined in accordance with Section 8.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

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

7.1.2 *Cleaning of Pipeline*—All internal debris that will interfere with the installation or adversely affect the performance of the CIPP shall be removed from the original pipeline. Gravity pipes are cleaned with hydraulically powered equipment, high-velocity jet cleaners, mechanically powered equipment, or other applicable method(s) (see NASSCO Sewer Pipe Cleaning Specification Guideline). Pressure pipelines are cleaned with cable-attached devices, fluid-propelled devices, or other applicable method(s) (see Chapter 3 "Pipe Cleaning Methods" in AWWA, M 28 Rehabilitation of Water Mains, Third Ed.).

7.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or worker entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions shall be noted and corrected prior to installation of CIPP.

7.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % to ensure proper installation of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation shall be made to uncover and remove or repair the obstruction prior to the installation of the CIPP.

7.2 *Resin Impregnation*—The tube shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all the void space present in the tube material at nominal thickness and diameter. The volume shall be adjusted by adding excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

NOTE 1—In pipelines 8 in. diameter and less, 5 % to 10 % excess resin should be added.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the pump and bypass lines shall be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

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7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube shall be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head shall be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube shall be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube shall be turned inside out. The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions shall be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed.

NOTE 3—After inversion is completed, pressures can be adjusted to facilitate the safe installation of condensate removal equipment or other mechanisms required to transition to the curing process.

7.5 *Lubricant*—When lubricant is used to reduce friction during inversion, the lubricant shall be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used shall be a nontoxic product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.1.1 The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam-generating equipment is required and shall be capable of producing a sufficient amount of thermal energy throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The volume of air being sent through the pipe shall be sufficient to minimize condensation of the steam occurring during the curing. The temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.2.1 The steam-generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing steam. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the distribution of thermal energy via control of steam and air flow maintains the stated temperature. The curing of the CIPP must take into account the existing pipe material, the resin system, the current vertical alignment (that is, sags), and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.3 *Using Photoinitiated Reaction*—After the inversion is completed, while the tube is expanded under pressure, a light

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curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

7.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

7.6.3.2 *Processing*—Before the inversion begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

7.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

7.6.4 *Required Pressures*—The estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process shall be provided by the tube manufacturer and shall be increased to include consideration of the external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures shall be maintained until the cure has been completed. The pressure shall be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP shall be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 7.8 and Section 8.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113 °F (45 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care shall be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe shall be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes shall be sealed by an approved method using compatible materials, if required by the owner in contract documents.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the Contract documents or purchase order, the preparation of a CIPP sample is required, using one of the following two methods, depending on access and the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample shall be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 In medium and large-diameter applications and areas with limited access, the sample shall be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used. This method can also be used for sizes 18 in. or less, in situations where preparing samples in accordance with 8.1.1 can not be obtained due to physical constrains, if approved by the owner.

8.1.3 The samples for each of these cases shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures shall be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and shall meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength shall be measured for pressure pipe applications in accordance with Test Method D638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes shall be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test shall take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end shall not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe shall be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The

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leakage quantity shall be gauged by the water level in a temporary standpipe placed in the upstream plug. The test shall be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36-in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes shall be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test shall be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the owner in the contract documents or purchase order, a delamination test shall be performed on each inversion length specified. The CIPP samples shall be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample shall be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate shall be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchase and seller.

8.6.1 *Ultrasonic Testing of Wall Thickness*—An alternative method to 8.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797/E797M. A minimum of eight (8) evenly spaced measurements shall be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 in. to 18 in. from the end of the pipe. For pipe diameters of fifteen (15) in. or greater, a minimum of sixteen (16) evenly spaced measurements shall be recorded. The ultrasonic method to be used is the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of E797/E797M. A calibration block shall be manufactured from the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendations. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.7 *Inspection and Acceptance*—The installation shall be inspected visually if practical, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed through the CIPP itself. All service entrances shall be accounted for and be unobstructed.

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(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required.

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe*:

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N} \qquad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa), measured from the invert of the pipe
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
DR = dimension ratio of CIPP,
C = ovality reduction factor =

$$\left(\left[1-\frac{\Delta}{100}\right]/\left[1+\frac{\Delta}{100}\right]^2\right)^3$$

Δ = percentage ovality of original pipe equals

$$100 \times \frac{(Mean\ Inside\ Diameter - Minimum\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

or

$$100 \times \frac{(Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

and

N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum SDR of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\,\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR = \frac{\sigma_L}{PN} \qquad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter, in. (Inside Diameter of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, t, in.	Maximum Allowable Groundwater Load[A] (above invert)	
			ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A]Assumes K = 7.0, E = 125 000 psi (862 MPa) (50-year strength), ν = 0.30, C = 0.64 (5 % ovality), and N = 2.0

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$$q_t = \frac{1}{N}\left[32\,R_w\,B'\,E'_s \cdot C\left(E_L I/D^3\right)\right]^{1/2} \qquad \text{(X1.3)}$$

where:

q_t = total external pressure on pipe, psi (MPa),
= $0.433H_w + wHR_w/144 + W_s$, (English Units),
$0.00981H_w + wHR_w/1000 + W_s$, (Metric Units)
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
w = soil density, $lb.ft^3$ (KN/m^3),
W_s = live load, psi (Mpa),
H_w = height of water above top of pipe, ft (m)
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1 + 4e^{-0.065H})$ inch-pound units, $(1/(1 + 4e^{-0.213H})$ SI units
I = moment of inertia of CIPP, $in.^4/in.$ (mm^4/mm) = $t^3/12$,

t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long-term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm)

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093\ (inch - pound\ units), \qquad \text{(X1.4)}$$

or

$$\frac{E}{12(DR)^3} \geq 0.00064\ (SI\ units)$$

where:

E = initial modulus of elasticity, psi (MPa)

NOTE X1.3—For pipelines at depth not subject to construction disturbance, or if the pipeline was originally installed using tunneling method, the soil load may be calculated using a tunnel load analysis. Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eq X1.1 and X1.2.

X1.3 *Pressure Pipe*:

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eq X1.6 or Eq X1.7, as directed by Eq X1.5, and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eq X1.5-X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \qquad \text{(X1.5)}$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(DR-1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \qquad \text{(X1.6)}$$

where:

DR = dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eq X1.1, Eq X1.3, Eq X1.4, and Eq X1.7, and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(DR-2)\,N} \qquad \text{(X1.7)}$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
DR = dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of

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sizes from 2 in. to 108 in. diameter which would be impractical to list here.

X2. CHEMICAL-RESISTANCE TESTS

X2.1 *Scope*:

X2.1.1 This appendix covers the test procedures for chemical-resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical-Resistance Testing*:

X2.2.1 Chemical resistance tests should be completed in accordance with Practices D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical-resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical-resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–21) that may impact the use of this standard. (Approved August 15, 2022.)

(1) Changed non-mandatory wording to mandatory wording throughout the standard.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–16) that may impact the use of this standard. (Approved November 1, 2021.)

(1) Added 3.2.4 and 7.6.3.

(2) Section 7.6.4 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3541 – 22

Standard Practice for Sectional Repair of Existing Gravity Flow, Non-Pressure Pipelines and Conduits by Pushed or Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F3541; 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 sectional repair of gravity flow, non-pressure pipelines and conduits 3 in. to 60 in. (75 mm to 1500 mm) diameter by the installation of a resin-saturated liner which is placed onto or wrapped around a carrier device, pushed or pulled into an existing pipeline or conduit and expanded against the interior of the host pipe or conduit with air pressure. The resin is cured under ambient conditions, by photoinitiated reaction or with the application of heat. When cured, the finished sectional repair will be tight-fitting across its installed length. This repair process is used in a variety of gravity flow, non-pressure applications such as sanitary sewers, storm sewers, drains, electrical conduits and ventilation systems.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D578/D578M Specification for Glass Fiber Strands

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

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

F2019 Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method

2.2 *ASCE Standard:*[3]

Manual of Practice 145, Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

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2.3 *ISO Standard:*[4]

ISO 11296-4 , Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes

2.4 *NSF Standard:*[5]

NSF/ANSI-14 , SE10990 – Rehabilitation by Point Repair of Existing Pipe

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binding material, n*—A material utilized to secure the resin-saturated liner to the carrier device prior to placement into the pipeline.

3.2.1.1 *Discussion*—Examples include, but are not limited to, wire, nylon ties, adhesive tape or elastomeric bands.

3.2.2 *carrier device, n*—An apparatus utilized to deliver the resin-saturated liner to a section of host pipe identified for repair by pushing or pulling force.

3.2.3 *catalyst, n*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

3.2.4 *cured-in-place pipe (CIPP), n*—A hollow cylinder consisting of a liner cured (cross-linked) with a thermosetting resin. The CIPP is installed inside an existing pipe and pressed against the pipe interior to form a tight fit.

3.2.5 *delamination, n*—Separation of layers of the CIPP.

3.2.6 *design reconciliation, n*—A process conducted post-construction to determine whether the original design objectives for the installation have been met.

3.2.6.1 *Discussion*—Design reconciliation is completed to assess the net impact of post-construction variations present including fit, finish, wall thickness and mechanical properties on the installed product's ability to conform to design requirements as established by the owner or engineer.

3.2.7 *dry spot, n*—An area of the installed CIPP which is deficient or void of resin.

3.2.8 *lift, n*—A portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.9 *photoinitiated reaction, n*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

3.2.10 *protective membrane, n*—An impermeable polymer sleeve or film that is used to prevent resin contact with the carrier device, resin contamination or washout, when required, is properly sized for the host pipe diameter, and is designed to accommodate the application, installation, resin system and curing process.

3.2.11 *release agent, n*—A non-reactive, sacrificial chemical applied to a surface to prevent bonding.

3.2.12 *tight-fitting, adj*—conformance of a lining system to the host pipe interior geometry whereas intimate contact is realized across the entire perimeter.

3.2.13 *wellpoint system, n*—A series of closely spaced, small diameter, shallow wells connected to a common header pipe and pumped with a high-efficiency vacuum dewatering pump.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of gravity flow, non-pressure pipes through the use of a resin-saturated liner installed within a section of damaged or leaking existing pipe. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Liner*—The liner utilized shall consist of one or more layers of fiberglass matting, reinforced composite, flexible needled felt or an equivalent nonwoven or woven material, or a combination thereof. The liner shall be capable of carrying resin, withstanding installation pressures and curing temperatures, bridging pipe defects, conforming to irregular shapes and negotiating bends as applicable. The liner shall be a manufactured tube or an overlapping flat sheet, with or without a plastic coating, that is compatible with the resin system used, and fabricated to a size that, when installed, will be tight-fitting across the entire length identified for sectional repair. The liner shall be appropriately sized to extend at least 1 ft (0.30 m) in all directions beyond the limits of the host pipe defect when installed.

5.1.1 *Fiberglass Matting*—Chemically resistant E-CR fiberglass meeting Specification D578/D578M or similar material meeting the requirements herein; consisting of single or multiple layers of woven or nonwoven material, with or without chopped strand mat.

5.1.2 *Reinforced Composite*—Needled felt, or an equivalent woven or non-woven material, with E-CR fiberglass meeting Specification D578/D578M or similar reinforcement material meeting the requirements herein.

5.1.3 *Overlapping Flat Sheet*—Liners designed as overlapping flat sheets having a minimum circumference = $\pi \times D_i \times 1.1$, where D_i = inside diameter of the host pipe. When multiple layers of liner are required to achieve the desired thickness, the ends of the liner are tapered as required to obtain a smooth transition to the host pipe by adding additional layers in a stepwise fashion in accordance with the manufacturer's guidelines such that each subsequent layer is slightly longer than the adjacent, underlying layer.

5.1.4 *Manufactured Tubes*—Liners manufactured as tubes shall be sized per the manufacturer's recommendations relative to the host pipe inside diameter to permit radial expansion and a tight fit against the host pipe during installation and cure.

5.1.5 *Resin*—A chemically resistant, thermosetting resin and catalyst system that is cured under ambient conditions, by

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

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photoinitiated reaction or with the application of heat and is compatible with the installation process shall be used. Resin systems that are heat cured shall have an initiating temperature less than 180 °F (82 °C).

5.2 *CIPP System:*

5.2.1 *Mechanical Properties*—The CIPP system shall have as a minimum the initial mechanical properties given in Table 1. These mechanical properties shall be determined in accordance with Section 7.

6. Installation

6.1 *Cleaning and Pre-Inspection:*

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

6.1.2 *Cleaning of Pipeline*—To the extent practical, all internal debris shall be removed from the original pipeline using hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television (CCTV) or worker-entry techniques. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that will prevent proper installation of the resin-saturated liner. The manufacturer shall provide guidance as needed to determine whether existing conditions will prohibit a successful installation or if additional measures are necessary in advance of lining. This includes addressing points of infiltration that will cause resin wash out or adversely impact the cure and finished quality of the CIPP sectional repair. Corrective actions include, but are not limited to, injecting chemical grout, dewatering using a wellpoint system, or utilizing a protective membrane as defined in 3.2.10 and described in 6.4.4.

6.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions that will hinder or prevent the installation of the resin-saturated liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, a point repair excavation shall be made to uncover and remove or repair the obstruction.

6.2 *Resin Saturation*—The liner shall be fully saturated with resin (wet out) under controlled conditions and free of any dry spots or resin lean areas. The resin system shall be proportionally mixed, handled and applied in accordance with manufacturer's recommendations. The volume of resin used shall be sufficient to fully saturate the liner material and shall be adjusted by adding excess resin to account for the change in resin volume due to polymerization, to allow for migration of resin into the cracks and joints in the original pipe, and to account for any resin loss expected during the liner insertion process. For each CIPP installation, wet out data shall be recorded and retained by the user for quality assurance and record keeping purposes, and submitted to the purchaser as required.

TABLE 1 CIPP Initial Mechanical Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural Strength[B]	D790	Declared value, but not less than 4 500	Declared value, but not less than 31
Flexural Modulus[B]	D790	Declared value, but not less than 250 000	Declared value, but not less than 1 724

[A] The values in Table 1 are for test results on field specimens. The purchaser shall consult the manufacturer for the long-term mechanical properties.
[B] The value indicates minimum strength in the circumferential direction.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass shall be made by capturing flow from all contributing points upstream of the pipe to be reconstructed and discharging the flow to a downstream point or adjacent system. The bypass pumping and piping system shall be of adequate capacity and size to handle the flow. Prior to cleaning and pre-inspection and during installation, all upstream contributing flows impacting the repair area shall be isolated and bypassed around the repair area. Bypassing shall be coordinated between all parties involved.

6.3.1 Public advisory services shall be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the pipeline is back in service.

6.4 *Liner Insertion:*

6.4.1 The carrier device shall be able to navigate the host pipe alignment and geometry to the point of installation without compromise to the host pipe, installation process or finished quality of the CIPP; shall be designed to expand with air pressure to press the resin-saturated liner tightly against the interior of the host pipe for the duration of cure; shall be compatible with the curing process; and, when required, shall have flow-thru capabilities for flow control.

6.4.2 When required, a protective membrane shall be secured to the carrier device and a compatible release agent shall be liberally applied to its entire surface area as required.

6.4.3 The resin-saturated liner shall be centered and rolled tightly against the carrier device and secured with binding material. The binding material shall be placed approximately 1 in. (25 mm) from each end of the liner and spaced along the remaining length of the repair, typically 1.5 ft to 2.0 ft (0.46 m to 0.61 m) apart; shall be used to secure the leading edge of the liner to the front of the carrier device as required to ensure the liner's position is maintained as it is pushed or pulled into the host pipe; and shall be designed to release or break under tension when the carrier device is pressurized and the resin-saturated liner is expanded against the host pipe.

6.4.4 When required, to prevent resin contamination or washout and as directed by the manufacturer, a protective membrane shall be attached to the resin-saturated liner across the affected area.

6.4.5 The resin-saturated liner shall be positioned into the host pipe using push rods or a winching process. Prior to insertion and as directed by the manufacturer, the carrier device shall be inflated to a low pressure to increase rigidity and reduce material drag along the pipe invert. The carrier device

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shall be equipped with adequate air supply for proper inflation and full expansion of the liner against the host pipe interior for the duration of cure.

6.4.6 CCTV inspection shall be conducted concurrently with the placement of the resin-saturated liner to verify proper positioning and the host pipe condition and resin saturation in accordance with 6.2 prior to inflation and cure.

6.5 *Curing*—The resin-saturated liner shall be cured in accordance with manufacturer's recommendations, and the curing process shall be documented and submitted to the purchaser as required. The estimated minimum and maximum pressures recommended to form a tight-fitting liner against the existing pipe during the curing process shall be provided by the manufacturer.

6.5.1 *Using Air or Air/Steam*—Curing of the resin-saturated liner shall be accomplished without pressure interruption with air or a mixture of air and steam for the duration of time in accordance with the manufacturer's recommendations for a complete cure. For CIPP cured under ambient conditions, to the extent practical, a representative coupon of the resin impregnated liner suspended at the access point shall be used to confirm curing time as required.

6.5.2 *Using Photoinitiated Reaction*—While the liner is expanded under pressure against the host pipe, a CCTV inspection shall be performed to verify that the liner is properly positioned and tight-fitting. Any anomalies shall be corrected prior to initiating the curing process.

6.5.2.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photoinitiators shall be optimized to the output of the curing lights.

6.5.2.2 For dynamic curing processes, the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific liner dimensions to initiate polymerization and facilitate the cure of the CIPP resin.

6.5.2.3 A full curing protocol shall be provided by the manufacturer and be recorded and maintained as documentation verifying the curing process. As a minimum, data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, and the power output of the light assembly.

6.6 *Overlapping Installations*—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end with a minimum overlap to adjacent CIPP sections in accordance with manufacturer's recommendations. To the extent practical, installations shall progress from the furthest point downstream towards the upstream end so that overlapping ends of the CIPP are streamlined with the flow.

6.7 *Workmanship:*

6.7.1 The finished CIPP shall be continuous over its entire length and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations. If these conditions are present, CIPP in these areas shall be removed and replaced. The CIPP shall be tight-fitting against the host pipe at its termination points with transitions at each end that do not create a ledge, a change in direction of flow, or a location where debris will accumulate during uniform flow conditions. In sections of pipe of constant internal diameter and straight alignment, the CIPP shall not introduce surface irregularities in addition to those of the host pipe which exceed 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater. Applications where surface irregularities exceeding 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater, are anticipated due to geometric features, condition or alignment of the host pipe shall be evaluated by the owner, engineer and manufacturer to determine feasibility and compliance of this practice. Examples include CIPP that is installed through bends, joint offsets, diameter transitions and other discontinuities in the host pipe which can result in localized radial or longitudinal fins or folds, or other surface irregularities in the CIPP.

6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active service connections shall be reinstated. This shall be performed without excavation and, in cases of non-worker-entry sized pipes, from the interior of the pipeline by the means of CCTV inspection and a remote-control cutting device. Reinstated service connections shall be cut smooth and free of burrs and rough edges. All laterals where a plug by the end of the lateral was not visible by the pre-inspection shall be reinstated if the purchase agreement does not specify it differently.

7. Inspection Practices

7.1 *Sampling*—CIPP samples for mechanical properties testing shall be prepared when required and as directed by the engineer or purchaser. Representative samples of the resin-saturated liner shall be restrained in a like diameter pipe or prepared in a clamped mold and cured in the same manner as the installed CIPP. Samples shall be prepared in a manhole or other point of access, or under simulated conditions above ground, and shall be of adequate size to perform flexural properties testing as described in 7.2.

7.2 *Short-Term Flexural (Bending) Properties*—For isotropic materials, the tangent flexural modulus of elasticity and flexural strength shall be measured in accordance with Test Method D790. For anisotropic composites, flexural testing shall be conducted in the hoop direction on specimens cut from plate samples in accordance with Test Method D790 or on curved beam specimens cut from restrained samples in accordance with the modified Test Method D790 method as described in Annex B of ISO 11296-4 and Practice F2019, Appendix X2. Flexural properties shall meet or exceed values listed in Table 1.

7.3 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 7.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and

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shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. If minimum wall thickness requirements are not met, a design reconciliation shall be performed. If it is determined through design reconciliation that the installed CIPP is non-compliant, the designer or purchaser shall determine whether corrective action is necessary.

7.4 *Inspection and Acceptance*—The CIPP installation shall be inspected visually if appropriate or by CCTV inspection if visual inspection cannot be accomplished. No infiltration of groundwater shall be observed. The CIPP shall comply with 6.7.

8. Keywords

8.1 ambient cure; binding material; CIPP; carrier device; cured-in-place pipe; design reconciliation; E-CR; fiberglass matting; photoinitiated reaction; protective membrane; reinforced composite; release agent; sealing mechanism; sectional repair; silicate resin; tight-fitting; wellpoint system

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 During the initial design phase, consideration should be given to anchoring mechanisms required to limit downstream movement or dislodging of the CIPP sectional repair once it is put into service, which is of particular importance on lines with steep slopes, high velocity flows, surcharge conditions or broad temperature swings. The selected CIPP sectional repair system should align with design objectives for each application (for example, thermal properties or minimum levels of adhesion), and should be demonstrated through proper host pipe preparation and installation practice in accordance with this standard and manufacturer's guidelines.

X1.2 For circular host pipes with up to 10% ovality, the CIPP system should be designed for minimum wall thickness in accordance with ASCE Manual of Practice 145 or, alternatively, Practice F1216, Appendix X1, with the exception that Eq. X1.2 and X1.4 be excluded from the calculations. For non-circular host pipes or circular host pipes with greater than 10 % ovality, the design method described in ASCE Manual of Practice 145 is recommended. The design of the CIPP shall take into consideration the type of deterioration or damage to the existing pipe as well as relevant hydrostatic, soil and live loads.

X1.3 Further, when Practice F1216 is used for design, note X1.2 of Practice F1216 suggesting a maximum SDR of 100 be used for liners installed in pipes where the groundwater is not above the pipe invert shall be ignored. Instead, the partially deteriorated design shall be determined by using F1216, Eq X1.1 with the actual groundwater load or, in the case of no groundwater being present, a virtual groundwater load equal to a minimum of 5.0 ft (1.5 m) above the pipe invert or at least 0.33 ft (0.10 m) above the crown of the liner – whichever is greater (but in no case should this height exceed the cover depth of the host pipe). The fully deteriorated design condition shall be determined using F1216, Eq X1.3 with H_w being the height of the groundwater above the invert of the pipe.

X2. CHEMICAL RESISTANCE TESTS

Scope:

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

Procedure for Chemical Resistance Testing:

X2.2.1 Chemical resistance tests should be completed in accordance with Practice D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with 7.2 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

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serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

X3. CERTIFICATIONS

X3.1 The CIPP system may comply with NSF/ANSI-14 and may be tested and certified to be in compliance with NSF SE 10990.

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CONTINUOUS MATERIAL INSTALLATION

EXHIBIT D
PG. 1 of 1

Inverted "Continuous" Liner
ASTM F1216

7.4.2 Using Air Pressure...

"The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from ***point of inversion to point of termination*** *and hold the tube tight to the pipe wall,* ***(A) producing dimples at side connections."***

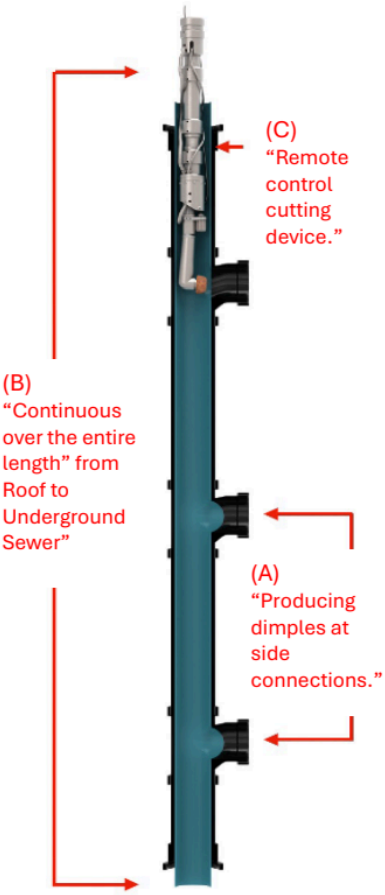
("Dimples" identify Branch Connections to be robotically reinstated not gapped.)

7.8 Workmanship

"The finished pipe shall be ***(B) continuous over the entire length*** *of an inversion run and be free of dry spots, lifts, and delamination."*

7.9 Service Connections

"After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a ***(C) remote-control cutting device."***



Pulled-in-Place "Continuous" Liner
ASTM F1743

6.4.2 Pulling Resin-Impregnated Tube into Position...

"The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point... ***(A) producing dimples at side connections."***

("Dimples" identify Branch Connections to be robotically reinstated not gapped.)

6.8 Workmanship

"The finished CIPP should be ***(B) continuous over the entire length*** *of an installation and be free of dry spots, lifts, and delamination."*

6.9 Service Connections

"After the new CIPP has been installed, the existing active (or inactive) service connection should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a ***(C) remote-control cutting device.*** *Service connections shall be reinstated to at least 90% of the original area as it enters the host pipe or conduit."*

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Rationale:

The proposed language to which this alternate modification is submitted in response imposes unnecessary confusion, inconsistency, and constraints on practical and effective CIPP rehabilitation methods.

The term "continuous," as used in ASTM F1216, ASTM F1743, **and** ASTM F3541 does not require that a CIPP liner extend uninterrupted through the entire piping system.

Instead, ASTM F1743 emphasizes the structural integrity and uniformity of each installed segment. It requires each CIPP segment to be free of seams, dry spots, or discontinuities, ensuring that where a liner is installed, it is installed completely and performs as intended. It does not mandate that the entire piping network be lined in a single run.

Requiring a single continuous liner from the building vent to the city main is not only impracticable in many existing buildings, but it is also not necessary to ensure system performance. The proposed clarification aligns with ASTM F1743's actual requirements and intent, allowing installers to rehabilitate pipelines efficiently and effectively while maintaining compliance with established performance and safety standards.

Still, to eliminate further confusion as to the plain meaning of the code, the incorporation of ASTM F3541 into Section P3012.1 is the ideal option. ASTM F3541 specifically addresses sectional repairs for gravity flow, non-pressure pipelines, and conduits, and likewise emphasized the structural integrity and proper installation of each installation length without mandating a single continuous application. This approach aligns more closely with industry best practices, promotes flexibility, and ensures that each installed length is free of gaps, seams, dry spots, lifts, or delaminations, thereby achieving the intended performance and safety standards. Incorporating ASTM F3541 not only mitigates confusion but also supports more efficient and reliable rehabilitation processes.

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February 27, 2025

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Re: Declaration of Rudy Rudisill in Support of Modification

Dear Mr. Madani,

Please take notice that I, Rudy Rudisill, President of Pipe Restoration Solutions, Inc., declare that the following is true and correct based on my personal knowledge and professional experience:

1. I am the President of Pipe Restoration Solutions, Inc., a company specializing in trenchless pipeline rehabilitation services, including cured-in-place pipe (CIPP) lining. With over 20 years of experience in the pipeline restoration industry, I am well-versed in various methods of performing service connections following CIPP installations. My company regularly performs CIPP lining using both the "gapping" and "reinstatement" methods.

2. Based on extensive experience and industry best practices, I strongly favor the gapping method over traditional robotic reinstatement for service connections following CIPP lining for smaller diameter pipe (2" thru 4") installed inside the building. My company's goal is to provide the best end-product for our customers, and we often favor the gapping method to accomplish this. We do not prefer the gapping method over the "cutting" reinstatement method simply because of the additional cost and time required for installation (although these are relevant factors that we respectfully believe the Committee should consider). Instead, Petitioner prefers the gapping method to the "cutting" reinstatement method because Petitioner wishes to deliver the best product to its customers, including 100% watertight pipelines, which the "cutting" reinstatement method does not allow for.

3. Our preference for gapping is due to the significant advantages that the gapping method provides in terms of efficiency, reliability, and long-term performance. The gapping method offers numerous benefits, including but not limited to:

   i. <u>Capability to Install 2" Liners</u>: Unlike traditional reinstatement methods, the gapping method allows for the installation of 2" liners, expanding service capabilities for smaller diameter pipes.

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ii. Installation of Fitting Liners: Gapping enables the efficient lining of pipe fittings, which is not achievable through standard reinstatement techniques.

iii. Preservation of Flow Capacity: Unlike robotic reinstatement, which can reduce flow capacity due to uneven cuts or lips, the gapping method maintains the full flow capacity of the pipe.

iv. Reduced Downtime for Unit Owners: This method eliminates the need for overnight curing, significantly reducing downtime and inconvenience for residents or tenants.

v. Ability to Perform Emergency Point Repairs: Gapping allows for rapid and efficient point repairs, making it ideal for emergency situations.

vi. No Lips on 90% of Reinstatements: The gapping method prevents the formation of protruding lips, which are a common issue with robotic reinstatement.

vii. Elimination of Delamination Risk: By removing the risk of water infiltration behind reinstatement lips, the gapping method prevents delamination and ensures liner integrity.

viii. Prevention of Damage to Fittings: Robotic reinstatement can often cause damage to fittings during the cutting process, whereas the gapping method avoids this issue entirely.

4. My personal knowledge and experience have convinced me that the gapping method represents a superior solution for service connections following CIPP installations. It offers enhanced performance, reduced risk, and greater customer satisfaction compared to traditional robotic reinstatement methods. As such, I strongly advocate for its adoption as the preferred industry standard for service connection restorations.

Executed on February 27, 2024 at Sarasota, Florida.

Rudy Rudisill
Rudy Rudisill
President, Pipe Restoration Solutions, Inc.

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PIPE RESTORATION SOLUTIONS

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3541 – 22

Standard Practice for Sectional Repair of Existing Gravity Flow, Non-Pressure Pipelines and Conduits by Pushed or Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F3541; 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 sectional repair of gravity flow, non-pressure pipelines and conduits 3 in. to 60 in. (75 mm to 1500 mm) diameter by the installation of a resin-saturated liner which is placed onto or wrapped around a carrier device, pushed or pulled into an existing pipeline or conduit and expanded against the interior of the host pipe or conduit with air pressure. The resin is cured under ambient conditions, by photoinitiated reaction or with the application of heat. When cured, the finished sectional repair will be tight-fitting across its installed length. This repair process is used in a variety of gravity flow, non-pressure applications such as sanitary sewers, storm sewers, drains, electrical conduits and ventilation systems.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D578/D578M Specification for Glass Fiber Strands

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

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

F2019 Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic Cured-in-Place (GRP-CIPP) Using the UV-Light Curing Method

2.2 *ASCE Standard:*[3]

Manual of Practice 145, Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

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2.3 *ISO Standard:*[4]
ISO 11296-4 , Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes
2.4 *NSF Standard:*[5]
NSF/ANSI-14 , SE10990 – Rehabilitation by Point Repair of Existing Pipe

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binding material, n*—A material utilized to secure the resin-saturated liner to the carrier device prior to placement into the pipeline.

3.2.1.1 *Discussion*—Examples include, but are not limited to, wire, nylon ties, adhesive tape or elastomeric bands.

3.2.2 *carrier device, n*—An apparatus utilized to deliver the resin-saturated liner to a section of host pipe identified for repair by pushing or pulling force.

3.2.3 *catalyst, n*—A curing agent, hardener, initiator, diluent, admixture, or combination thereof.

3.2.4 *cured-in-place pipe (CIPP), n*—A hollow cylinder consisting of a liner cured (cross-linked) with a thermosetting resin. The CIPP is installed inside an existing pipe and pressed against the pipe interior to form a tight fit.

3.2.5 *delamination, n*—Separation of layers of the CIPP.

3.2.6 *design reconciliation, n*—A process conducted post-construction to determine whether the original design objectives for the installation have been met.

3.2.6.1 *Discussion*—Design reconciliation is completed to assess the net impact of post-construction variations present including fit, finish, wall thickness and mechanical properties on the installed product's ability to conform to design requirements as established by the owner or engineer.

3.2.7 *dry spot, n*—An area of the installed CIPP which is deficient or void of resin.

3.2.8 *lift, n*—A portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.9 *photoinitiated reaction, n*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

3.2.10 *protective membrane, n*—An impermeable polymer sleeve or film that is used to prevent resin contact with the carrier device, resin contamination or washout, when required, is properly sized for the host pipe diameter, and is designed to accommodate the application, installation, resin system and curing process.

3.2.11 *release agent, n*—A non-reactive, sacrificial chemical applied to a surface to prevent bonding.

3.2.12 *tight-fitting, adj*—conformance of a lining system to the host pipe interior geometry whereas intimate contact is realized across the entire perimeter.

3.2.13 *wellpoint system, n*—A series of closely spaced, small diameter, shallow wells connected to a common header pipe and pumped with a high-efficiency vacuum dewatering pump.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of gravity flow, non-pressure pipes through the use of a resin-saturated liner installed within a section of damaged or leaking existing pipe. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Liner*—The liner utilized shall consist of one or more layers of fiberglass matting, reinforced composite, flexible needled felt or an equivalent nonwoven or woven material, or a combination thereof. The liner shall be capable of carrying resin, withstanding installation pressures and curing temperatures, bridging pipe defects, conforming to irregular shapes and negotiating bends as applicable. The liner shall be a manufactured tube or an overlapping flat sheet, with or without a plastic coating, that is compatible with the resin system used, and fabricated to a size that, when installed, will be tight-fitting across the entire length identified for sectional repair. The liner shall be appropriately sized to extend at least 1 ft (0.30 m) in all directions beyond the limits of the host pipe defect when installed.

5.1.1 *Fiberglass Matting*—Chemically resistant E-CR fiberglass meeting Specification D578/D578M or similar material meeting the requirements herein; consisting of single or multiple layers of woven or nonwoven material, with or without chopped strand mat.

5.1.2 *Reinforced Composite*—Needled felt, or an equivalent woven or non-woven material, with E-CR fiberglass meeting Specification D578/D578M or similar reinforcement material meeting the requirements herein.

5.1.3 *Overlapping Flat Sheet*—Liners designed as overlapping flat sheets having a minimum circumference = $\pi \times D_i \times 1.1$, where D_i = inside diameter of the host pipe. When multiple layers of liner are required to achieve the desired thickness, the ends of the liner are tapered as required to obtain a smooth transition to the host pipe by adding additional layers in a stepwise fashion in accordance with the manufacturer's guidelines such that each subsequent layer is slightly longer than the adjacent, underlying layer.

5.1.4 *Manufactured Tubes*—Liners manufactured as tubes shall be sized per the manufacturer's recommendations relative to the host pipe inside diameter to permit radial expansion and a tight fit against the host pipe during installation and cure.

5.1.5 *Resin*—A chemically resistant, thermosetting resin and catalyst system that is cured under ambient conditions, by

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.
[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

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photoinitiated reaction or with the application of heat and is compatible with the installation process shall be used. Resin systems that are heat cured shall have an initiating temperature less than 180 °F (82 °C).

5.2 *CIPP System:*

5.2.1 *Mechanical Properties*—The CIPP system shall have as a minimum the initial mechanical properties given in Table 1. These mechanical properties shall be determined in accordance with Section 7.

6. Installation

6.1 *Cleaning and Pre-Inspection:*

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

6.1.2 *Cleaning of Pipeline*—To the extent practical, all internal debris shall be removed from the original pipeline using hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television (CCTV) or worker-entry techniques. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that will prevent proper installation of the resin-saturated liner. The manufacturer shall provide guidance as needed to determine whether existing conditions will prohibit a successful installation or if additional measures are necessary in advance of lining. This includes addressing points of infiltration that will cause resin wash out or adversely impact the cure and finished quality of the CIPP sectional repair. Corrective actions include, but are not limited to, injecting chemical grout, dewatering using a wellpoint system, or utilizing a protective membrane as defined in 3.2.10 and described in 6.4.4.

6.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions that will hinder or prevent the installation of the resin-saturated liner. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, a point repair excavation shall be made to uncover and remove or repair the obstruction.

6.2 *Resin Saturation*—The liner shall be fully saturated with resin (wet out) under controlled conditions and free of any dry spots or resin lean areas. The resin system shall be proportionally mixed, handled and applied in accordance with manufacturer's recommendations. The volume of resin used shall be sufficient to fully saturate the liner material and shall be adjusted by adding excess resin to account for the change in resin volume due to polymerization, to allow for migration of resin into the cracks and joints in the original pipe, and to account for any resin loss expected during the liner insertion process. For each CIPP installation, wet out data shall be recorded and retained by the user for quality assurance and record keeping purposes, and submitted to the purchaser as required.

TABLE 1 CIPP Initial Mechanical Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural Strength[B]	D790	Declared value, but not less than 4 500	Declared value, but not less than 31
Flexural Modulus[B]	D790	Declared value, but not less than 250 000	Declared value, but not less than 1 724

[A] The values in Table 1 are for test results on field specimens. The purchaser shall consult the manufacturer for the long-term mechanical properties.
[B] The value indicates minimum strength in the circumferential direction.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass shall be made by capturing flow from all contributing points upstream of the pipe to be reconstructed and discharging the flow to a downstream point or adjacent system. The bypass pumping and piping system shall be of adequate capacity and size to handle the flow. Prior to cleaning and pre-inspection and during installation, all upstream contributing flows impacting the repair area shall be isolated and bypassed around the repair area. Bypassing shall be coordinated between all parties involved.

6.3.1 Public advisory services shall be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the pipeline is back in service.

6.4 *Liner Insertion:*

6.4.1 The carrier device shall be able to navigate the host pipe alignment and geometry to the point of installation without compromise to the host pipe, installation process or finished quality of the CIPP; shall be designed to expand with air pressure to press the resin-saturated liner tightly against the interior of the host pipe for the duration of cure; shall be compatible with the curing process; and, when required, shall have flow-thru capabilities for flow control.

6.4.2 When required, a protective membrane shall be secured to the carrier device and a compatible release agent shall be liberally applied to its entire surface area as required.

6.4.3 The resin-saturated liner shall be centered and rolled tightly against the carrier device and secured with binding material. The binding material shall be placed approximately 1 in. (25 mm) from each end of the liner and spaced along the remaining length of the repair, typically 1.5 ft to 2.0 ft (0.46 m to 0.61 m) apart; shall be used to secure the leading edge of the liner to the front of the carrier device as required to ensure the liner's position is maintained as it is pushed or pulled into the host pipe; and shall be designed to release or break under tension when the carrier device is pressurized and the resin-saturated liner is expanded against the host pipe.

6.4.4 When required, to prevent resin contamination or washout and as directed by the manufacturer, a protective membrane shall be attached to the resin-saturated liner across the affected area.

6.4.5 The resin-saturated liner shall be positioned into the host pipe using push rods or a winching process. Prior to insertion and as directed by the manufacturer, the carrier device shall be inflated to a low pressure to increase rigidity and reduce material drag along the pipe invert. The carrier device

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shall be equipped with adequate air supply for proper inflation and full expansion of the liner against the host pipe interior for the duration of cure.

6.4.6 CCTV inspection shall be conducted concurrently with the placement of the resin-saturated liner to verify proper positioning and the host pipe condition and resin saturation in accordance with 6.2 prior to inflation and cure.

6.5 *Curing*—The resin-saturated liner shall be cured in accordance with manufacturer's recommendations, and the curing process shall be documented and submitted to the purchaser as required. The estimated minimum and maximum pressures recommended to form a tight-fitting liner against the existing pipe during the curing process shall be provided by the manufacturer.

6.5.1 *Using Air or Air/Steam*—Curing of the resin-saturated liner shall be accomplished without pressure interruption with air or a mixture of air and steam for the duration of time in accordance with the manufacturer's recommendations for a complete cure. For CIPP cured under ambient conditions, to the extent practical, a representative coupon of the resin impregnated liner suspended at the access point shall be used to confirm curing time as required.

6.5.2 *Using Photoinitiated Reaction*—While the liner is expanded under pressure against the host pipe, a CCTV inspection shall be performed to verify that the liner is properly positioned and tight-fitting. Any anomalies shall be corrected prior to initiating the curing process.

6.5.2.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photoinitiators shall be optimized to the output of the curing lights.

6.5.2.2 For dynamic curing processes, the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific liner dimensions to initiate polymerization and facilitate the cure of the CIPP resin.

6.5.2.3 A full curing protocol shall be provided by the manufacturer and be recorded and maintained as documentation verifying the curing process. As a minimum, data collected shall include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, and the power output of the light assembly.

6.6 *Overlapping Installations*—For CIPP installations that span distances beyond the capabilities of the carrier device, longer lengths shall be accomplished by installing multiple repairs end-to-end with a minimum overlap to adjacent CIPP sections in accordance with manufacturer's recommendations. To the extent practical, installations shall progress from the furthest point downstream towards the upstream end so that overlapping ends of the CIPP are streamlined with the flow.

6.7 *Workmanship:*

6.7.1 The finished CIPP shall be continuous over its entire length and be free of dry spots, lifts, uncured areas, unusual discolorations, and delaminations. If these conditions are present, CIPP in these areas shall be removed and replaced. The CIPP shall be tight-fitting against the host pipe at its termination points with transitions at each end that do not create a ledge, a change in direction of flow, or a location where debris will accumulate during uniform flow conditions. In sections of pipe of constant internal diameter and straight alignment, the CIPP shall not introduce surface irregularities in addition to those of the host pipe which exceed 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater. Applications where surface irregularities exceeding 2 % of the nominal diameter or 0.25 in. (6 mm), whichever is greater, are anticipated due to geometric features, condition or alignment of the host pipe shall be evaluated by the owner, engineer and manufacturer to determine feasibility and compliance of this practice. Examples include CIPP that is installed through bends, joint offsets, diameter transitions and other discontinuities in the host pipe which can result in localized radial or longitudinal fins or folds, or other surface irregularities in the CIPP.

6.7.2 *Service Connections*—After the new CIPP has been installed, any existing, active service connections shall be reinstated. This shall be performed without excavation and, in cases of non-worker-entry sized pipes, from the interior of the pipeline by the means of CCTV inspection and a remote-control cutting device. Reinstated service connections shall be cut smooth and free of burrs and rough edges. All laterals where a plug by the end of the lateral was not visible by the pre-inspection shall be reinstated if the purchase agreement does not specify it differently.

7. Inspection Practices

7.1 *Sampling*—CIPP samples for mechanical properties testing shall be prepared when required and as directed by the engineer or purchaser. Representative samples of the resin-saturated liner shall be restrained in a like diameter pipe or prepared in a clamped mold and cured in the same manner as the installed CIPP. Samples shall be prepared in a manhole or other point of access, or under simulated conditions above ground, and shall be of adequate size to perform flexural properties testing as described in 7.2.

7.2 *Short-Term Flexural (Bending) Properties*—For isotropic materials, the tangent flexural modulus of elasticity and flexural strength shall be measured in accordance with Test Method D790. For anisotropic composites, flexural testing shall be conducted in the hoop direction on specimens cut from plate samples in accordance with Test Method D790 or on curved beam specimens cut from restrained samples in accordance with the modified Test Method D790 method as described in Annex B of ISO 11296-4 and Practice F2019, Appendix X2. Flexural properties shall meet or exceed values listed in Table 1.

7.3 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 7.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and

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shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. If minimum wall thickness requirements are not met, a design reconciliation shall be performed. If it is determined through design reconciliation that the installed CIPP is non-compliant, the designer or purchaser shall determine whether corrective action is necessary.

7.4 *Inspection and Acceptance*—The CIPP installation shall be inspected visually if appropriate or by CCTV inspection if visual inspection cannot be accomplished. No infiltration of groundwater shall be observed. The CIPP shall comply with 6.7.

8. Keywords

8.1 ambient cure; binding material; CIPP; carrier device; cured-in-place pipe; design reconciliation; E-CR; fiberglass matting; photoinitiated reaction; protective membrane; reinforced composite; release agent; sealing mechanism; sectional repair; silicate resin; tight-fitting; wellpoint system

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 During the initial design phase, consideration should be given to anchoring mechanisms required to limit downstream movement or dislodging of the CIPP sectional repair once it is put into service, which is of particular importance on lines with steep slopes, high velocity flows, surcharge conditions or broad temperature swings. The selected CIPP sectional repair system should align with design objectives for each application (for example, thermal properties or minimum levels of adhesion), and should be demonstrated through proper host pipe preparation and installation practice in accordance with this standard and manufacturer's guidelines.

X1.2 For circular host pipes with up to 10% ovality, the CIPP system should be designed for minimum wall thickness in accordance with ASCE Manual of Practice 145 or, alternatively, Practice F1216, Appendix X1, with the exception that Eq. X1.2 and X1.4 be excluded from the calculations. For non-circular host pipes or circular host pipes with greater than 10 % ovality, the design method described in ASCE Manual of Practice 145 is recommended. The design of the CIPP shall take into consideration the type of deterioration or damage to the existing pipe as well as relevant hydrostatic, soil and live loads.

X1.3 Further, when Practice F1216 is used for design, note X1.2 of Practice F1216 suggesting a maximum SDR of 100 be used for liners installed in pipes where the groundwater is not above the pipe invert shall be ignored. Instead, the partially deteriorated design shall be determined by using F1216, Eq X1.1 with the actual groundwater load or, in the case of no groundwater being present, a virtual groundwater load equal to a minimum of 5.0 ft (1.5 m) above the pipe invert or at least 0.33 ft (0.10 m) above the crown of the liner – whichever is greater (but in no case should this height exceed the cover depth of the host pipe). The fully deteriorated design condition shall be determined using F1216, Eq X1.3 with H_w being the height of the groundwater above the invert of the pipe.

X2. CHEMICAL RESISTANCE TESTS

Scope:

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

Procedure for Chemical Resistance Testing:

X2.2.1 Chemical resistance tests should be completed in accordance with Practice D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with 7.2 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

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serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

X3. CERTIFICATIONS

X3.1 The CIPP system may comply with NSF/ANSI-14 and may be tested and certified to be in compliance with NSF SE 10990.

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EXHIBIT D

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines
D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D903 Test Method for Peel or Stripping Strength of Adhesive Bonds
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]
D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
D4814 Specification for Automotive Spark-Ignition Engine Fuel
D5813 Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method
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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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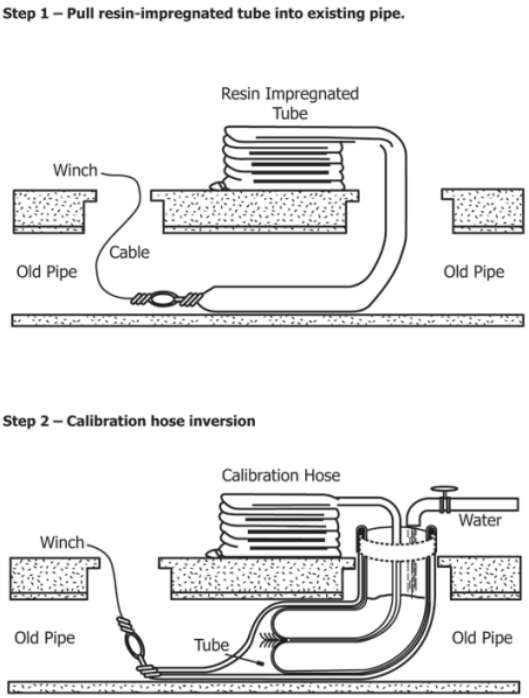

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F ± 3.6 °F (23 °C ± 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A] In accordance with Specification D4814.
[B] Cottonseed, corn, or mineral oil.
[C] In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1743 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; 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 reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]

D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D4814 Specification for Automotive Spark-Ignition Engine Fuel

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

E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

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

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

***A Summary of Changes section appears at the end of this standard**

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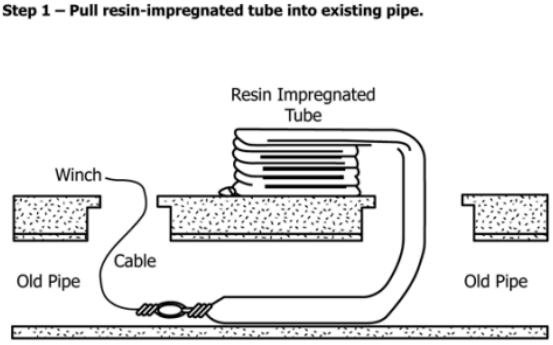

FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]
Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

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material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power

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winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multi-linear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an

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exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F 6 3.6 °F (23 °C 6 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

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TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

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8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

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APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

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This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F1216 – 22

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2]

This standard is issued under the fixed designation F1216; 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 reconstruction of pipelines and conduits (2 in. to 108 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water, introducing controlled steam within the tube, or by photoinitiated reaction. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process is used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and 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 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D903 Test Method for Peel or Stripping Strength of Adhesive Bonds

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe

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

E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method

F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standard:*[4]

M 28 Rehabilitation of Water Mains, Third Ed.

2.3 *NASSCO Standard:*[5]

Sewer Pipe Cleaning Specification Guideline

3. Terminology

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

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "*Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois*," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[3] 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.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] Available from the National Association of Sewer Service Companies, 5285 Westview Drive, Suite 202, Frederick, MD 21703. http://www.nassco.org/

***A Summary of Changes section appears at the end of this standard**

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3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—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.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.4 *photoinitiated reaction*—the polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube shall consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube and any non-structural plastic coating or flexible membrane included in the tube construction shall be compatible with the resin system used. The material shall be able to stretch to fit irregular pipe sections and negotiate bends. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance shall be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process shall be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The CIPP system shall be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties shall be determined in accordance with Section 8.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

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

7.1.2 *Cleaning of Pipeline*—All internal debris that will interfere with the installation or adversely affect the performance of the CIPP shall be removed from the original pipeline. Gravity pipes are cleaned with hydraulically powered equipment, high-velocity jet cleaners, mechanically powered equipment, or other applicable method(s) (see NASSCO Sewer Pipe Cleaning Specification Guideline). Pressure pipelines are cleaned with cable-attached devices, fluid-propelled devices, or other applicable method(s) (see Chapter 3 "Pipe Cleaning Methods" in AWWA, M 28 Rehabilitation of Water Mains, Third Ed.).

7.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or worker entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions shall be noted and corrected prior to installation of CIPP.

7.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % to ensure proper installation of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation shall be made to uncover and remove or repair the obstruction prior to the installation of the CIPP.

7.2 *Resin Impregnation*—The tube shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all the void space present in the tube material at nominal thickness and diameter. The volume shall be adjusted by adding excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

NOTE 1—In pipelines 8 in. diameter and less, 5 % to 10 % excess resin should be added.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the pump and bypass lines shall be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

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7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube shall be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head shall be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube shall be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube shall be turned inside out. The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions shall be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed.

NOTE 3—After inversion is completed, pressures can be adjusted to facilitate the safe installation of condensate removal equipment or other mechanisms required to transition to the curing process.

7.5 *Lubricant*—When lubricant is used to reduce friction during inversion, the lubricant shall be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used shall be a nontoxic product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.1.1 The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam-generating equipment is required and shall be capable of producing a sufficient amount of thermal energy throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The volume of air being sent through the pipe shall be sufficient to minimize condensation of the steam occurring during the curing. The temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.2.1 The steam-generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing steam. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the distribution of thermal energy via control of steam and air flow maintains the stated temperature. The curing of the CIPP must take into account the existing pipe material, the resin system, the current vertical alignment (that is, sags), and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.3 *Using Photoinitiated Reaction*—After the inversion is completed, while the tube is expanded under pressure, a light

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curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

7.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

7.6.3.2 *Processing*—Before the inversion begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

7.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

7.6.4 *Required Pressures*—The estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process shall be provided by the tube manufacturer and shall be increased to include consideration of the external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures shall be maintained until the cure has been completed. The pressure shall be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP shall be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 7.8 and Section 8.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113 °F (45 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care shall be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe shall be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes shall be sealed by an approved method using compatible materials, if required by the owner in contract documents.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the Contract documents or purchase order, the preparation of a CIPP sample is required, using one of the following two methods, depending on access and the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample shall be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 In medium and large-diameter applications and areas with limited access, the sample shall be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used. This method can also be used for sizes 18 in. or less, in situations where preparing samples in accordance with 8.1.1 can not be obtained due to physical constrains, if approved by the owner.

8.1.3 The samples for each of these cases shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures shall be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and shall meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength shall be measured for pressure pipe applications in accordance with Test Method D638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes shall be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test shall take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end shall not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe shall be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The

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leakage quantity shall be gauged by the water level in a temporary standpipe placed in the upstream plug. The test shall be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36-in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes shall be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test shall be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the owner in the contract documents or purchase order, a delamination test shall be performed on each inversion length specified. The CIPP samples shall be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample shall be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate shall be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchase and seller.

8.6.1 *Ultrasonic Testing of Wall Thickness*—An alternative method to 8.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797/E797M. A minimum of eight (8) evenly spaced measurements shall be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 in. to 18 in. from the end of the pipe. For pipe diameters of fifteen (15) in. or greater, a minimum of sixteen (16) evenly spaced measurements shall be recorded. The ultrasonic method to be used is the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of E797/E797M. A calibration block shall be manufactured from the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendations. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.7 *Inspection and Acceptance*—The installation shall be inspected visually if practical, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed through the CIPP itself. All service entrances shall be accounted for and be unobstructed.

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APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required.

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe*:

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N} \qquad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa), measured from the invert of the pipe
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
DR = dimension ratio of CIPP,
C = ovality reduction factor =

$$\left(\left[1-\frac{\Delta}{100}\right]/\left[1+\frac{\Delta}{100}\right]^2\right)^3$$

Δ = percentage ovality of original pipe equals

$$100 \times \frac{(Mean\ Inside\ Diameter - Minimum\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

or

$$100 \times \frac{(Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

and

N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum SDR of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\,\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR = \frac{\sigma_L}{PN} \qquad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter, in. (Inside Diameter of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, t, in.	Maximum Allowable Groundwater Load[A] (above invert)	
			ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A]Assumes K = 7.0, E = 125 000 psi (862 MPa) (50-year strength), ν = 0.30, C = 0.64 (5 % ovality), and N = 2.0

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$$q_t = \frac{1}{N}\left[32\,R_w\,B'\,E'_s \cdot C\,(E_L I/D^3)\right]^{1/2} \qquad \text{(X1.3)}$$

where:

q_t = total external pressure on pipe, psi (MPa),
= $0.433H_w + wHR_w/144 + W_s$, (English Units),
$0.00981H_w + wHR_w/1000 + W_s$, (Metric Units)
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
w = soil density, lb.ft^3 (KN/m^3),
W_s = live load, psi (Mpa),
H_w = height of water above top of pipe, ft (m)
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1 + 4e^{-0.065H})$ inch-pound units, $(1/(1 + 4e^{-0.213H})$ SI units
I = moment of inertia of CIPP, in.^{4}/in. (mm^4/mm) = $t^3/12$,

t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long-term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm)

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093\ (inch - pound\ units), \qquad \text{(X1.4)}$$

or

$$\frac{E}{12(DR)^3} \geq 0.00064\ (SI\ units)$$

where:

E = initial modulus of elasticity, psi (MPa)

NOTE X1.3—For pipelines at depth not subject to construction disturbance, or if the pipeline was originally installed using tunneling method, the soil load may be calculated using a tunnel load analysis. Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eq X1.1 and X1.2.

X1.3 *Pressure Pipe*:

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eq X1.6 or Eq X1.7, as directed by Eq X1.5, and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eq X1.5-X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \qquad \text{(X1.5)}$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(DR-1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \qquad \text{(X1.6)}$$

where:

DR = dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eq X1.1, Eq X1.3, Eq X1.4, and Eq X1.7, and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(DR-2)\,N} \qquad \text{(X1.7)}$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
DR = dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of

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sizes from 2 in. to 108 in. diameter which would be impractical to list here.

X2. CHEMICAL-RESISTANCE TESTS

X2.1 *Scope*:

X2.1.1 This appendix covers the test procedures for chemical-resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical-Resistance Testing*:

X2.2.1 Chemical resistance tests should be completed in accordance with Practices D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical-resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical-resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–21) that may impact the use of this standard. (Approved August 15, 2022.)

(1) Changed non-mandatory wording to mandatory wording throughout the standard.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–16) that may impact the use of this standard. (Approved November 1, 2021.)

(1) Added 3.2.4 and 7.6.3.

(2) Section 7.6.4 was revised.

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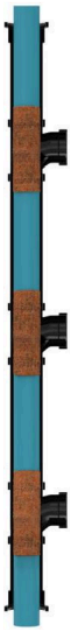
Pipelining Technologies, Inc.

AEC Project Number: 2024.02-101

Continuous v. Gapped Cured-in-Place Pipe Repair Methodology Review

Engineering Evaluation Rev. 3



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This report has been digitally signed and sealed by M. James Aronsohn, PE, FRSE on August 23, 2024.

Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

M. James Aronsohn, PE, FRSE
(Civil/Structural Engineer)
Florida License Number 78248

Report: (20 Pages)
Representative Photographs:
(13 Photographs on 7 Pages)

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August 23, 2024

Mr. Michael Wilson, President
Pipelining Technologies, Inc.
1500 North Mango Road, Suite #1
West Palm Beach, Florida 33409

Re: Engineering Evaluation Rev.3
Continuous v. Gapped
Cured-in-Place Pipe Repair Methodology Review
AEC Project Number: 2024.02-101

Report Revisions:

Rev.1: Reflects changes to the original Signed & Sealed Engineering Evaluation, dated 4/3/2024, made in accordance with redlines submitted by Melissa Delgado, Assistant, PTI in email correspondence dated 6/23/2024.

Rev.2: Reflects changes to Revision 1, dated 6/23/2024, as aligned with PTI during a workshop held on 7/2/2024. Revisions in toto include change of the header background color scheme used for Table 1 and Table 2, and incorporation of legends in same.

Rev.3: Reflects changes to Revision 2, dated 7/2/2024, based on a red-line version of that report received from PTI on 8/22/2024. Revisions in toto include the removal of references to complaints filed by PTI and the removal of the names of individuals associated with those complaints to facilitate PTI's Declaratory Statement Submittal.

Dear Mr. Wilson:

In accordance with your January 30, 2024 email notice of intent, Aronsohn Engineering Co., LLC (AEC) conducted an expert engineering review of the Continuous Cured-in-Place Pipe (CIPP) repair methodology developed by your team in contrast to Gapped CIPP methodology and prepared this report documenting findings under this research. Mr. M. James Aronsohn, PE, FRSE, MBA, Principal, performed this study in collaboration with key personnel from Pipelining Technologies, Inc. (PTI) during the months of February and March 2024.

AEC is a professional services firm whose principal brings more than four decades of civil/structural/forensic engineering experience to bear in providing expert consultation and testimony for its clients. Principally, AEC's mission as an engineering consultancy is to assist property owners, insurance carriers, and legal professionals in closing/resolving commercial and residential property-damage claims resulting from extreme weather events, soil subsidence, insect damage, and plumbing and construction defects.

Concerning this matter, during our January 30, 2024 Scoping Alignment call and our subsequent February 6, 2024 CIPP Methodology Review Workshop, AEC was specifically requested to contrast and evaluate Continuous and Gapped (where Gapped in some cases is referred to as Start and Stop) cured-in-place-pipe repair methodologies for conformance with governing industry-prescribed standards; specifically, ASTM International (formerly, American Society for Testing

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and Materials) Designation: F1216-22 and Designation: F1743-22, and the plumbing provisions of the Florida Building Code (FBC).

Beyond business ethics and professional canons, which dictate that we act as responsible stewards of our clients' finances and infrastructure, a clear and present need for these proceedings has been established through the passage of Florida Senate Bill SB 4D. This bill, which was passed by the Florida Legislature in May 2022, dictates that as of December 31, 2024, condominium and cooperative associations conduct milestone structural inspections, perform structural integrity reserve studies (SIRS), and adequately fund items identified as needing repair or replacement.

Failure to comply with SB 4D can result in personal liability on the part of board members. Further to the foregoing, once made public, these proceedings will provide board members with valuable insights to facilitate their work as responsible stewards of the communities they were elected to serve.

Holistically, a SIRS is comprised of eight (8) specific elements, which include plumbing systems, and which establishes the critical and time-sensitive business need to codify requirements governing pipelining repairs. To this end, this report provides a comparison study of the physical characteristics of each cured-in-place lining methodology and our evaluation and conclusions regarding the requested scope of work.

Evaluation Activities

AEC performed the following tasks to evaluate conformance with the above-cited ASTM specifications taken in concert with the applicable provisions of the FBC:

- Researched CIPP installation methodology and governing specifications;
- Studied exemplar mockups of actual Continuous and Gapped CIPP installations to understand the physical characteristics of each installation methodology;
- Conducted a background interview with Mr. Wilson and other PTI Staff to establish a timeline of the conditions and develop an understanding of the primary concerns;
- Held a project Scoping Alignment Meeting and a CIPP Methodology Review Workshop with the PTI team to define the business requirements for this report;
- Conducted interviews with the following stakeholders to obtain supplemental first-hand feedback concerning the design, installation, and in-service performance of Continuous and Gapped CIPP installations:
  - Mr. Michael Wilson, President, Pipelining Technologies, Inc.;
  - Mr. Sam Dosdourian, Principal, Pipelining Technologies, Inc.;
- Reviewed the documentation listed in the *Document Review* section of this report;
- Assimilated all information collected and performed an engineering evaluation to assess the observed conditions; and
- Prepared this report summarizing the results of the above-cited work along with the applied evaluation and ensuing conclusions.

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Background Information

At the onset of the work required to prepare this report, AEC scheduled a two-day-long project kick-off workshop with key PTI staff to define the scope of work and the business requirements for this project. These staff members included Mr. Michael Wilson, President; Mr. Sam Dosdourian, Principal; Mrs. Melissa Delgado, Assistant; and Mr. Wilson Crespo, Assistant.

To facilitate the engineering analysis presented herein, Mr. Wilson and his team provided full unrestricted access to PTI's shop and all relevant information in their possession. Furthermore, Mr. Wilson documented materially significant historical events that ultimately dictated the need for this report. Thus:

- **August 2005:** Incorporated Pipelining Technologies, Inc. (PTI) as a business entity to identify and service a Florida market for small diameter, 2"-12", Cured-in-Place drainage pipe rehabilitation in South Florida. Initially used NuFlow pull-in-place CIPP product.
- **September 2012:** PTI invested in Perma-Liner Industries CIPP inversion lining equipment and the Dancutter robotic tool, a critical tool (ASTM F1216-22, Article 7.9 – Service Connections); equipment required to complete the pipe repair.
- **November 2015:** Mr. Michael Wilson, President/Qualifier of PTI, is instrumental in implementing the Florida Declaratory Statement DS 2015-106, which requires licensed plumbing contractors to process a plumbing permit in order to perform small diameter CIPP installation work according to the manufacturer's written installation instructions, and in compliance with the applicable ASTM Standards and Florida Building/Plumbing Codes.
- **October 14, 2022:** PTI retained Mr. Kyle Rea with Adams Reese, LLP, to represent PTI in its complaints to the Florida Department of Business and Professional Regulation (DBPR), the Florida Construction Industry Licensing Board (CILB), and the Florida Board of Professional Engineers (FBPE), and further to facilitate any communication with the State of Florida Building Commission.
- **January 30, 2024:** PTI retained Mr. M. James Aronsohn, PE, FRSE, MBA, Principal, Aronsohn Engineering Co., LLC, to contrast, compare, and evaluate continuous and gapped CIPP repair methodologies with respect to the applicable ASTM specifications and provisions of the Florida Building Code, which, collectively, provide industry-standard guidelines and procedures governing the installation of the CIPP material. Mr. Aronsohn's evaluation includes a review of the manufacturer's installation instructions and the Florida Building/Plumbing Codes.

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Document Review

The following documentation was provided and reviewed as part of this assessment:

- *Pipelining Technologies, Inc. (PTI), Evaluation of Findings* – Prepared by Mr. Michael Wilson, President, Pipelining Technologies, Inc. and dated September 15, 2023; this document provides an evaluation of the conformance of the Gapped CIPP repair methodology with respect to the governing ASTM provisions on 10 pages. The document includes four illustrations and no photographs.

  The engineering analysis conducted and the conclusions derived therefrom, as presented within the framework of this expert review, undergird findings offered in the above-cited PTI report.

- *ASTM International Designation: F1216-22, Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of Resin-Impregnated Tube* – This international standard, presented on eight pages, was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

- *ASTM International Designation: F1743-22, Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)* – This international standard, presented on nine pages, was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

- *2024 International Plumbing Code*.

- *2023 Florida Building Code, Plumbing, Eighth Edition*.

- *2024 Supplement to the 8th Edition (2023) Florida Building Code*

  - **Chapter 7 SANITARY DRAINAGE**

    718.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743

  - **Chapter 30 SANITARY DRAINAGE**

    Section P3012 – REHABILITATION OF BUILDING SEWERS AND BUILDING DRAINS P3012.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743

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- *Perma-Liner Industries, LLC, Perma-Liner™ Pull-in-Place Installers Manual* – Dated January 1, 2015, this document provides guidelines for the installation of cure-in-place lining for the reconstruction of sewer drains and vent pipeline without excavation.
- *Florida Statue SB 4D* – A Senate Bill which establishes a statewide inspection program, requiring condominium and cooperative associations to conduct milestone structural inspections and perform structural integrity reserve studies to ensure that condominium and cooperative buildings are safe for continued use.

  The relevance of this bill to these proceedings is the statute-required evaluation of plumbing systems to facilitate repair/replacement decisions, the life-cycle costs for which can be significantly impacted by the selected repair methodology.

Analytical Approach – General

Objective contrasting/comparing and evaluation of the Continuous and the Gapped CIPP methodologies requires a comprehensive understanding of the physical characteristics of each cured-in-place pipe repair methodology and how those characteristic impact performance over time. The *Evaluation* section of this report that follows provides a detailed comparison study of the two pipe lining methodologies and illustrates conformance with critical industry-recognized performance-based standards. The results of this evaluation are then utilized to develop and substantiate the conclusions presented herein.

Cured-in-Place Pipe Repair Characteristics

PTI prepared actual mock-ups of a Continuous CIPP installation performed using the inversion methodology (ASTM F1216-22) and a Gapped CIPP installation performed using Pull-in-Place (PIP) methodology (ASTM F1743-22). In this regard, it bears mentioning that a Continuous liner may be installed using either the Inversion methodology or the PIP methodology. In furtherance of this, and by virtue of the gaps between the multiple discrete independent liner sections that collectively form a segmented-liner appliance run over the length of an installation, and the need to ensure that these independent sections of liner are accurately placed so as not to obstruct the branch fittings, installation of Gapped liners is limited to the PIP methodology.

Key differences between Continuous CIPP repairs and Gapped CIPP repairs are illustrated at the sanitary crosses depicted in Figure 1 and Figure 2, respectively, below. These key documented differences provide the basis for the detailed analysis that follows.

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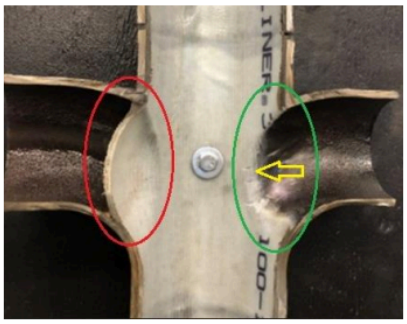

Figure 1: Section Cut Through a Mock-Up of a Continuous Liner Installation

With reference to Figure 1, above, the Continuous CIPP mock-up illustrates liner continuity and tight fit (ASTM F1216-22, Article 1.1 and 7.8); in essence, seamless coverage of the sanitary cross pipe joints and the pipe interior wall from the upstream pipe segment into and throughout the full length of the sanitary cross and continuing into the downstream pipe segment. Figure 1 further illustrates the required liner dimple protruding into a branch of the sanitary cross (circled red) (ASTM F1216-22, Article 7.4.2), competent liner reinstatement to the pipe substrate (yellow arrow), and the resulting faired condition of the finished unobstructed lining transition into the inlet of the sanitary-cross branch (circled green) (ASTM F1216-22, Article 7.9).

Figure 2, below, illustrates a mock-up of a Gapped CIPP installation. The light-blue arrow in the center of the sanitary cross indicates the direction of flow through the pipe for the purpose of defining hydraulic obstructions, whereby a hydraulic obstruction is a discontinuity in the surface of a fluid conveyance system that is in direct contact with the fluid contained within that system. The importance of this in terms of system longevity, is that these discontinuities introduce hydraulically-induced shear and axial forces which in turn act on the system components, thus adversely impacting system performance and reducing component life.

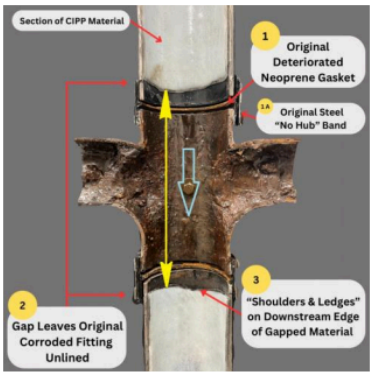

Figure 2: Section Cut Through a Mock-Up of a Gapped Liner Installation

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With further reference to Figure 2, Figure 3 that follows, and with the foregoing discussion in mind, note the bare section of pipe (gap) between the upstream and downstream liner segment termini that extends across the entire length of the sanitary cross and into the pipes to which it is connected (yellow arrow, Comment #2) thus leaving the original neoprene seals at the pipe joints exposed (Comment #1, Comment #1a, Figure 3).

Additionally, the liner terminus at the downstream end of the sanitary cross (the upstream end of the downstream liner segment) creates a condition where the liner shoulder/ledge created by that terminus (Comment #3) is subjected to hydraulically-induced loads as introduced above. These loads in turn cause the liner material to separate from the pipe host over time. This condition is documented in the *Observations* section of this report that follows and is discussed in greater detail under the subsection *Liner Separation* within the *Evaluation* section below.

Observations: Cured-in-Place Pipe Repair Performance

The following is a summary of in-service conditions observed by PTI through the pan-and-tilt sewer camera evaluation of pipe system repairs. Please reference the *Representative Photographs* section at the end of this report for the photographs cited below:

A view looking downstream toward a sanitary tee fitting with a side inlet branch inside of a pipe within which a Continuous CIPP repair was made illustrates the continuity and smoothness of the lined pipe walls across the joint, the competent reinstatement (faired finish) of the liner at the branch inlet, and the absence of obstructions at those inlets (Photograph 1). A close-up view of a side inlet branch illustrates robotically-produced liner reinstatement at a sanitary-tee branch, the absence of inlet obstructions, and the absence of gaps between the liner and the pipe substrate at the branch inlet. (Photograph 2)

A view looking downstream toward a sanitary tee inside of a pipe within which a Gapped CIPP repair was made illustrates the lack of continuity and the presence of hydraulic obstructions (blockages, ledges, and/or ridges and depressions that rise above or lie below the predominant plane of the pipe wall) that are present between any given two liner segments upstream and downstream of the sanitary tee. Noteworthy is the cured excess epoxy blocking a portion of a branch inlet (Photograph 3).

Sewer camera images looking downstream toward the upstream (top) edges of Gapped CIPP liner segments in three locations illustrate common conditions across all three repairs. The conditions include the presence of bare unlined pipe between the Gapped liner segments, and debris lodged between the bare pipe wall and the Shoulder/Ledge at the exposed upstream edge of the downstream liner segment (Photographs 4, 5, and 6).

A close-up view at a no-hub coupling illustrates cracks and pitting in the exposed neoprene gasket component of the pipe coupling (Photograph 7). The no-hub coupling depicted in Figure 3 below further illustrates the cracking and pitting observed in the in-service neoprene gasket, which, for the purpose of this discussion, works with Figure 2 above.

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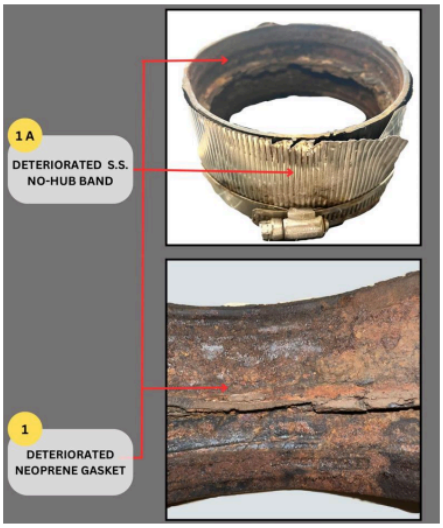

Figure 3: No-Hub Band Connection used with a Gapped Liner Installation

Looking downstream toward the upstream edge of a liner segment below the bare unlined section of the host pipe within a Gapped CIPP lining repair illustrates fraying and delamination of the exposed upstream (leading) edge of the liner segment and the gap (space) between the liner Shoulder/Ledge and the bare pipe wall at the upstream edge of the liner segment (Photograph 8).

Looking downstream toward the upstream edges of a liner segment below the bare unlined section of the host pipe within a Gapped CIPP lining repair illustrates gaps (spaces) between the liner Shoulder/Ledge and the bare pipe wall at the upstream edge of the liner segment, debris lodged between the liner and the pipe wall at these gaps, and bulge-like deformations in the liner that extend along its length and originate at the gaps between the liner Shoulder/Ledge and the host pipe at the upstream edge of the liner segment (Photograph 9).

A sewer camera image looking downstream within a Gapped CIPP liner segment illustrates a longitudinal bulge within and along the length of a liner segment that extends along the visible length of the liner segment (Photograph 10).

A close-up image at a point along a liner bulge within a Gapped CIPP liner segment illustrates a burst in the liner material within the bulged portion of the liner. Liner material at the burst is frayed, delaminated, and protrudes outward from the predominant plane of the liner. Water is flowing out of the bulge through the burst in the liner material (Photographs 11 and 12). A close-up image at the downstream end of a bulge within a Gapped CIPP liner segment illustrates discharge of water flowing within the confines of the bulge (Photograph 13).

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Evaluation

Overview

The foregoing physical observations document observed in-service characteristics of Continuous and Gapped CIPP liner installations and provide the basis for the discussion that follows, which is premised on industry standards and codified requirements.

CIPP Repair Methodology Review

Figure 4, Figure 5, Table 1, Table 2, and Figure 8 that follow, respectively, work interdependently to illustrate conformance, or lack thereof, with industry-defined installation standards governing the use of Top-to-Bottom (Continuous) and Start and Stop (Gapped) Cured-in-Place Pipe repairs. Taken holistically, these four analytical tools provide a robust side-by-side comparison of the two pipe repair methodologies, and in that illustrate key differences between the two to facilitate an empirical evaluation of each methodology, void of bias, to ultimately enable a conformance assessment with respect to ASTM standards and the provision of the FBC.

It bears mentioning that cost, in this case, is not a conformance-defining driver and it has no bearing on these proceedings. Further to this point, cost comparisons between repair alternatives founded exclusively on initial cost do not provide insights into the total cost of ownership for these durable goods. In these cases, bias can only be mitigated through a net-present-value life-cycle cost comparison of code-compliant repair alternatives.

To these ends, the analytical approach utilized herein is objective, specification-based, unbiased, and levied in conformance with the scientific method. This analytical standard, in turn, allows us to render unbiased substantiated conclusions. Thus, please reference the above-cited figures and tables which follow below:

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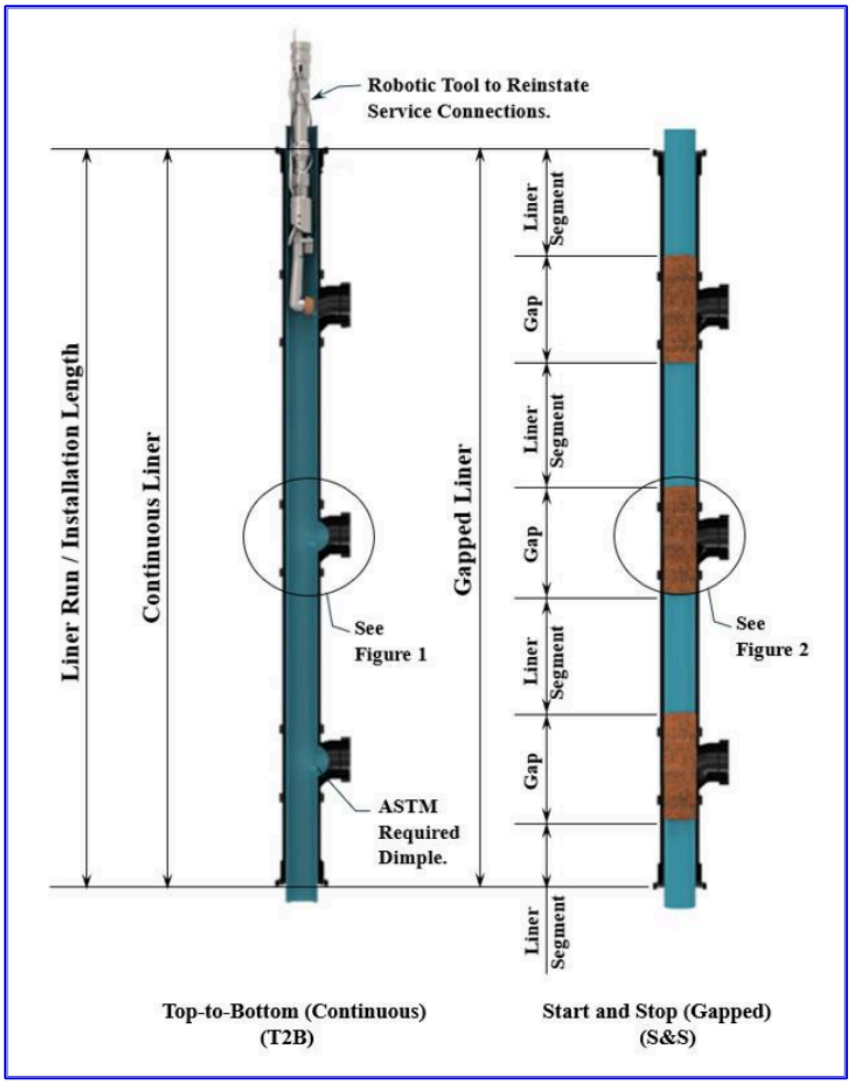

Figure 4: Physical Comparison of Cured -in-Place Pipe Repair Methods

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Continuity

The central question here is fundamentally centered on the definition of the word "Continuous" as it relates to ASTM F1216-22 for Inversion CIPP, and ASTM F1743-22 for Pull-in-Place CIPP. Both of these ASTM standards describe a "Continuous" installed tube with ***no*** gaps, which requires remote-controlled reinstatement of branch fittings. The single difference between the two ASTM specifications is the method of installing the "Continuous" material in the host pipe, which may be accomplished either by the Inversion method or by the Pull-In-Place method. Neither ASTM standard describes "Gapping" the branch fittings.

Further, with reference to Section 201, General, within the 2024 International Plumbing Code (IPC), the term" Continuous" is not defined. Thus, defaulting to IPC Section 201.4 – Terms not Defined, the code provides: *Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.*

To these ends, as it specifically concerns continuity, the underlying question is: Can a manufacturer, engineer, or installer reference ASTM F1743 and/or ASTM F1216 when promoting or approving the installation of multiple liner segments in a single delivery sleeve so as to leave a "Gap" in regions where branch connections or branch fittings occur, thus eliminating the need for a "remote-control cutting device" to reinstate branch connections in a vertical stack CIPP rehabilitation process?

We'll address this question using the Merriam-Webster and the Cambridge Dictionaries' definitions of "Continuous" and supplement those definitions with both narrative and graphic definitions of "Continuous" derived from mathematics. These are as follows:

Merriam-Webster: *marked by uninterrupted extension in space, time, or sequence;*

Cambridge: *without a pause or interruption;*

In mathematics: (RE: *https://en.wikipedia.org/wiki/Continuous_function | www.math.net/continuous*)

With reference to Figure 5 below, *a continuous line is a line that has no breaks or holes*. Intuitively, a mathematical function is continuous at a particular point if there is no break in its graph at that point; a function is continuous when its graph is a single unbroken curve. In contrast, a discontinuous function contains holes or jumps. In example:

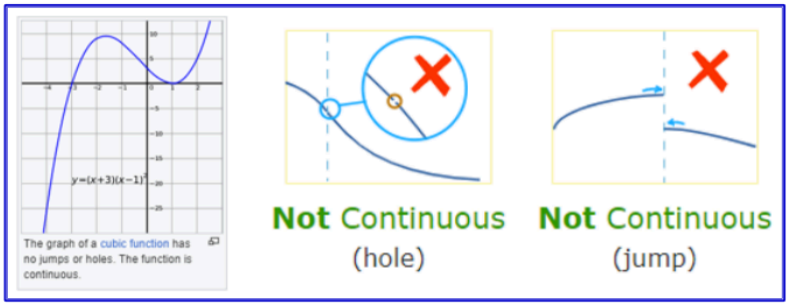

Figure 5: Functional Continuity

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Liner Separation

Collectively, the conditions sequentially reflected in Photographs 9 through 13 illustrate the importance of maintaining conformance with Sub-Section 706.2: Obstructions of both the 2024 International Plumbing Code and the 2023 Florida Building Code, Plumbing, Eighth Edition, and which reads: *The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping* (Table 2).

The bulge within the pipe liner, as it is described within the photographs, is essentially a conduit that formed between the liner and the host pipe due to the forces imparted on that liner by the fluids flowing within the lined pipe. These forces (shear and axial loads) are a result of obstructions created by the Gapped liner segments within the host pipe, which in turn disrupt the flow characteristics of the fluid moving through the pipe. In tangible terms facilitated by the application of basic principles of fluid mechanics (*Engineering Fluid Mechanics,* Robertson/Crowe):

Fluids flowing in a conduit void of obstructions exhibit laminar flow patterns, in contrast to turbulent flow patterns. Laminar flow has a smooth appearance throughout the flow field as characterized by the flow lines depicted in Figure 6 that follows. Intuitively, we can see that the forces acting on the conduit's interior surface under these conditions are shear (frictional) forces acting in the direction of flow at the interface between the fluid and the conduit surface.

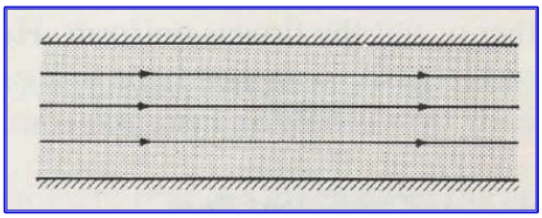

Figure 6: Laminar Flow within a Conduit

In contrast, fluids flowing in a conduit with internal obstructions exhibit turbulent flow within the influence zone of any given obstruction. The intensity of the turbulence is dictated by the geometry and attack angle of the obstruction. Flow patterns associated with turbulent flow are characterized by a mixing action throughout the flow field; this is illustrated in Figure 7 below.

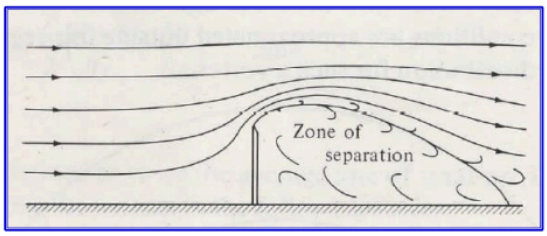

Figure 7: Flow Past an Obstruction

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Intuitively, these fluid models taken in concert with Newton's Third Law (*For every action there is an equal and opposite reaction*.) describe how obstructions influence fluid flow and how these obstructions in turn create the hydraulic forces that adversely impact liner performance. In consideration of the foregoing, and with further reference to Photographs 9 through 13:

The ledge at the upstream end of the liner obstructs flow and introduces hydraulic forces into the system that in turn act on the liner ledge. These forces then cause the exposed edge of the liner to separate from the pipe host, much like wind acting on the exposed leading edge of an asphalt roofing shingle, thus creating a gap between the liner and the host.

The gap in turn exacerbates the effects of the hydraulic forces by the ever-changing geometry of the gap. As the gap advances, prying action further separates the liner from the host and that separation propagates along the length of the liner thus forming a conduit between the liner and the host pipe.

These above-described conditions defeat the purpose of the liner installation itself through loss of protection for the host pipe and reduced hydraulic efficiency, which may be exacerbated by debris captured at these obstructions. Importantly, these understandings support the need for the plumbing code provisions that preclude *ledges, shoulders, or reductions capable of retarding or obstructing flow* from being present in the pipe system.

Discussion: Compliance with Industry Standards and Codified Requirements

Taking the above-provided narrative-form definitions of continuity in concert with the graphical definition of continuity presented in the Figure 5, and incorporating requirements mandated by the 2024 IPC Plumbing Code and the 2023 Florida Building Code, Plumbing, 706.2 Obstructions with further support provide by the foregoing discussion concerning liner separation: **Gapping in vertical stack liner installations is precluded and prohibited**.

The foregoing statement is further validated by comparing and contrasting the collective set of definitions for continuity to the physical characteristics of the CIPP repairs as illustrated in Figure 4. Doing so demonstrates that the Continuous CIPP repair methodology is in conformance with the holistic set of definitions for continuity; the liner is continuous and has no breaks or gaps over the entire installation run.

In contrast, the Gapped CIPP repair is not in conformance with the provisions of the 2024 IPC and the 2023 FBC, Plumbing, and does not meet either the grammatical or the mathematical standards for continuity as evidenced by the sections of bare pipe (gaps) that separate individual liner segments across the length of a liner run. A qualifying factor, in this case, is the length of a liner run, the termini for which encompass multiple sanitary branch fittings; *the installation, by definition, is non-continuous across the installation length*.

With the foregoing discussions specific to each CIPP repair methodology in mind, Table 1 and Table 2 that follow graphically illustrate the extent to which each CIPP repair methodology conforms with ASTM installation standards and Section 706.2 of the IPC and FBC, Plumbing, respectively. Please note the legends in these tables, which define the abbreviations used for the terms *Top-to-Bottom* and *Start and Stop* as introduced in Figure 4 above:

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Table 1: Compliance with ASTM Specifications

Legend: ☐ T2B: Top-to-Bottom ☐ S&S: Start and Stop

ASTM F1216-22 Inversion Installation Methodology			ASTM F1743-22 Pulled-in-Place Installation Methodology		
ASTM Specification	**Method**		**ASTM Specification**	**Method**	
	T2B	**S&S**		**T2B**	**S&S**
Article 1.1 – Scope When cured, the ***finished pipe will be continuous and tight-fitting***.	☑	☒	**Article 1.1 – Scope** When cured, the ***finished pipe will be continuous and tight-fitting***.	☑	☒
Article 5.1 – Materials, Tube The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit.	☑	☒	**Article 5.2.1 –Materials, Fabric Tube** The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit.	☑	☒
Article 7.4.1 – Installation, Inversion, Using Hydrostatic Head The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point.	☑	☒	**Article 6.4.2 – Installation, Methods, Pulling Resin-Impregnated Tube into Position** The wet-out fabric tube should be pulled into place using a power winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point.	☑	☒

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Table 1: Compliance with ASTM Specifications

Legend: T2B: Top-to-Bottom S&S: Start and Stop

ASTM F1216-22 Inversion Installation Methodology			ASTM F1743-22 Pulled-in-Place Installation Methodology		
ASTM Specification	**Method**		**ASTM Specification**	**Method**	
	T2B	**S&S**		**T2B**	**S&S**
Article 7.4.2 – Installation, Inversion, Using Air Pressure The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, ***producing dimples at side connections***.	☑	☒	**Article 6.4.4 – Installation, Methods, Using Air Pressure** The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, ***producing dimples at side connections***.	☑	☒
Article 7.8 – Workmanship ***The finished pipe shall be continuous over the entire length of an inversion run*** and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.	☑	☒	**Article 6.8 – Workmanship** ***The finished CIPP should be continuous over the entire length of an installation*** and be free of dry spots, lifts, and delaminations.	☑	☒
Article 7.9 – Service Connections After the new pipe has been cured in place, the ***existing active service connections shall be reconnected***. This should generally be done without excavation, and ***in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device***.	☑	☒	**Article 6.9 – Service Connections** After the new CIPP has been installed, the ***existing active (or inactive) service connections should be reinstated***. This should generally be done without excavation, and ***in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device***.	☑	☒

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Table 2: Compliance with Plumbing Code Provisions

Legend: ☐ **T2B: Top-to-Bottom** ☐ **S&S: Start and Stop**

Plumbing Code	Method	
	T2B	**S&S**
2024 International Plumbing Code **SECTION 706: Connections Between Drainage Piping and Fittings** **Sub-Section 706.2: Obstructions** The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping.	☑	☒
2023 Florida Building Code, Plumbing, Eighth Edition **SECTION 706: Connections Between Drainage Piping and Fittings** **Sub-Section 706.2: Obstructions** The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping.	☑	☒

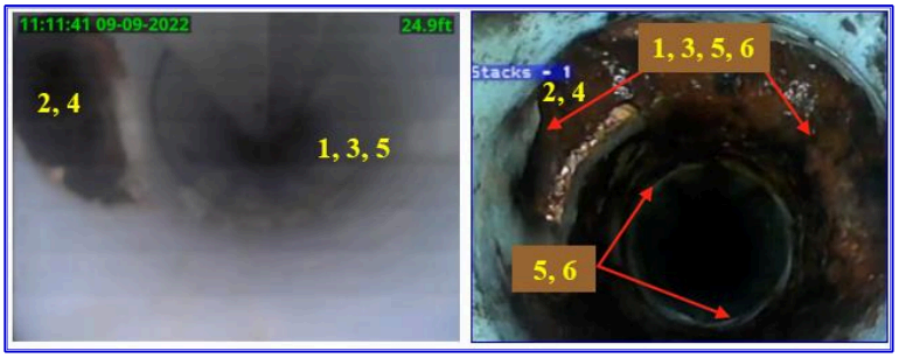

Figure 8: Comparison of Continuous CIPP (Left) and Gapped CIPP (Right)
(The numbers in each photograph correlate to the headers under *Findings* that follow.)

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Findings: Compliance with ASTM Standards and IPC/FBC Requirements

RE: Table 1, Table 2, and Figure 8 –

1. ASTM F1216-22, Article 1.1; ASTM F1743-22, Article 1.1 – CIPP Continuity and Tight Fit;

   Continuous CIPP: The repair depicted in Figure 8 illustrates liner continuity across the sanitary-tee branch inlets and tight fit against the interior pipe wall. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 illustrates liner discontinuity across the sanitary-tee branch inlets; this repair is not in compliance with the above-cited ASTM standards.

2. ASTM F1216-22, Article 7.4.2; ASTM F1743-22, Article 6.4.4 – Dimples;

   Continuous CIPP: The repair depicted in Figure 8 illustrates conditions where dimples were present and removed by a robotic cutting device as indicated by material reinstatement at the sanitary-tee branch inlets. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 illustrates liner discontinuity across the sanitary-tee branch inlets; by virtue of this liner discontinuity, no dimples were present at the branch inlets. The repair is not in compliance with the above-cited ASTM standards.

3. ASTM F1216-22, Article 7.8; ASTM F1743-22, Article 6.8 – CIPP Continuity;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates liner continuity across the visible length of the installation run with no apparent dry spots, lifts, or delaminations. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates liner discontinuity across the installation run; the repair is not in compliance with the above-cited ASTM standards.

4. ASTM F1216-22, Article 7.9; ASTM F1743-22, Article 6.9 – Branch Reinstatement;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates conditions where dimples were present and removed by a robotic cutter as indicated by material reinstatement at the sanitary-tee branch inlets. This installation is in compliance with the above-cited ASTM standards.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates liner discontinuity across the sanitary-tee branches, and as such, no liner material is reinstated at the branch inlets. This installation is not in compliance with the above-cited ASTM standards.

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5. 2024 International Plumbing Code (IPC); Section 706.2 – Obstructions;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates liner continuity across the sanitary-tee; thus, no obstructions are present in the main trunk line or at the branch inlets; the installation meets the requirements of the above-cited IPC provision.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates ledges and obstructions in the main trunk line and in the branch inlets; this repair does not meet the requirements of the above-cited IPC provision.

6. 2023 Florida Building Code (FBC), Plumbing, 8th Ed.; Section 706.2 – Obstructions;

   Continuous CIPP: The repair depicted in Figure 8 above illustrates liner continuity across the sanitary-tee; thus, no obstructions are present in the main trunk line or at the branch inlets; the installation meets the requirements of the above-cited FBC provision.

   Gapped CIPP: The repair depicted in Figure 8 above illustrates ledges and obstructions in the main trunk line and in the branch inlets; this repair does not meet the requirements of the above-cited FBC provision.

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Conclusions

Conformity with ASTM Standards F1216-22 and F1743-22, the International Plumbing Code, and the Plumbing volume of the Florida Building Code is the basis for the quality and consistency of the final CIPP product delivered to the Consumer, and for the investigation and analysis conducted to facilitate Structural Integrity Reserve Studies as required by Florida Senate Bill SB 4D.

Based on the information collected and our subsequent engineering evaluation, it is AEC's professional opinion that:

- The Continuous CIPP repair methodology, whether installed using the Inversion methodology (ASTM F1216-22) or using the Pulled-in-Place method (ASTM F1743-22), is in strict compliance with the governing ASTM installation standards and with the requirements of the International Plumbing Code and the Florida Building Code.
- The Gapped CIPP repair methodology, which can only be installed using the Pulled-in-Place method (ASTM F1743-22), does not comply with the governing ASTM installation standards or with the requirements of either the International Plumbing Code or the Florida Building Code.

Further, this Engineering Evaluation reveals that licensed professionals and a manufacturer alike have collectively promoted, approved, and installed Gapped CIPP repairs that are not in conformance with The Florida Building/Plumbing Code or the Standards of the American Society for Testing and Materials (ASTM). With these considerations in mind, it stands to reason that Gapped CIPP liner installations will be identified as deficient and flawed in the SB 4D mandated statewide SIRS investigations.

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Limitations

The analyses and conclusions expressed herein have been prepared within a reasonable degree of professional certainty. They are based on the results and interpretations of the testing and/or data collection activities performed, the information made available to Aronsohn Engineering Co., LLC (AEC) at the time the report was issued, and the education, knowledge, and skill of the licensed professional noted.

The contents of this report are confidential and are intended for the express use of Pipelining Technologies, Inc. and its representatives or clients. AEC assumes no liability for the misuse of this information by others and reserves the right to update this report should additional information become available.

This document has been signed and sealed in accordance with applicable state statutes. If not signed and sealed by the licensed professional(s) named and shown as its author(s), the observations and conclusions cannot be relied upon, and in such cases, the document shall be construed as being for informational purposes only. This report was reviewed in accordance with AEC's standard quality control procedures.

Aronsohn Engineering Co., LLC appreciates this opportunity to be of service to you. Please do not hesitate to contact us if we can be of further assistance.

Sincerely,

Aronsohn Engineering Co., LLC
5254 SE Schooner Oaks Way, Stuart, Florida 34997
Florida Certificate of Authorization #32996

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Representative Photographs

ARONSOHN ENGINEERING CO., LLC

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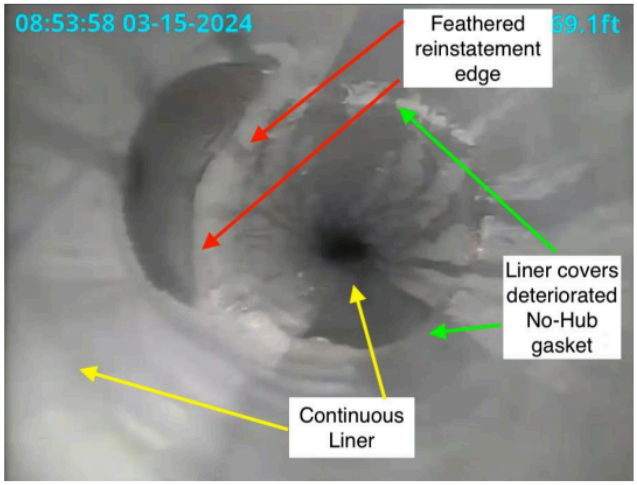
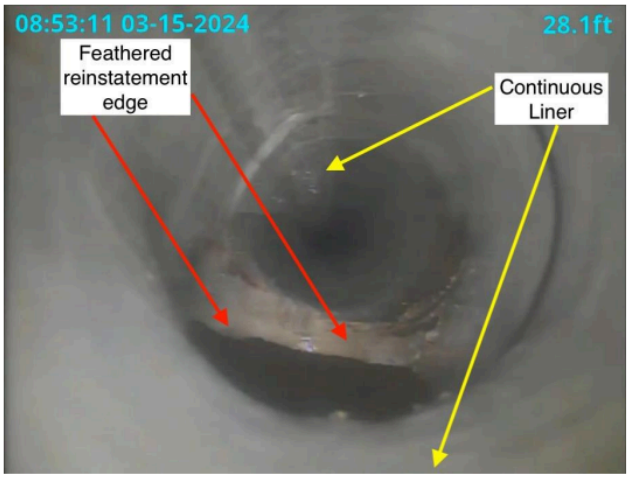


Photograph 1 - Sewer camera image of a Continuous CIPP repair at a sanitary tee. Note the liner continuity across the sanitary tee and at its branch inlet (yellow arrows). Also note the "faired" reinstated finish and the absence of obstructions at the branch inlet (red arrows), and the smooth liner coverage across the no-hub coupling neoprene gasket (green arrows).



Photograph 2 - Close-up sewer camera image of a Continuous CIPP repair illustrating robotically-produced liner reinstatement at the branch of a sanitary tee (yellow arrows). Note the "faired" reinstated finish on the branch opening (red arrows) and the absence of inlet obstructions and gaps between the liner and the pipe substrate at the branch inlet.

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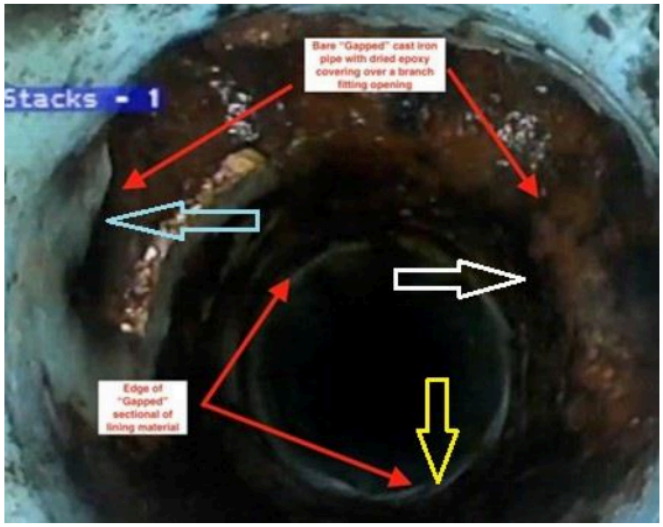
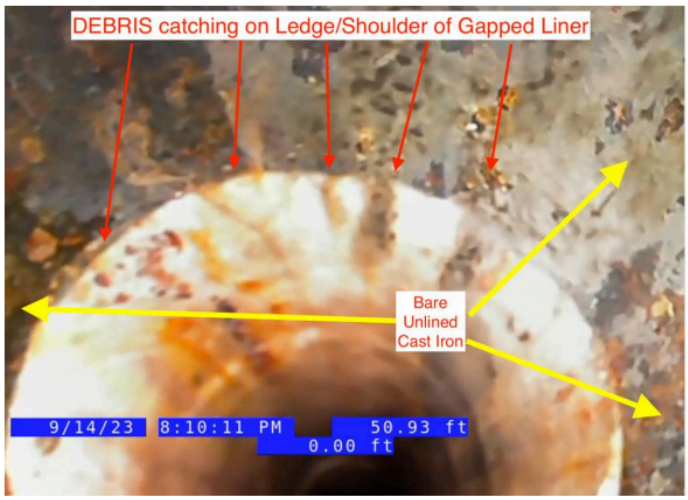


Photograph 3 - Sewer camera image of a Gapped CIPP repair at a sanitary tee. Note the exposed section of pipe (white arrow), the cured excess epoxy blocking a portion of a branch inlet (blue arrow), and the shoulder/ledge on the pipe interior wall formed by the upstream edge of the downstream liner segment (yellow arrow).



Photograph 4 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the bare unlined cast iron fitting within the gap between liner segments (yellow arrows), and the debris lodged between the pipe wall and the Shoulder/Ledge at the upstream edge of the liner segment (red arrows).

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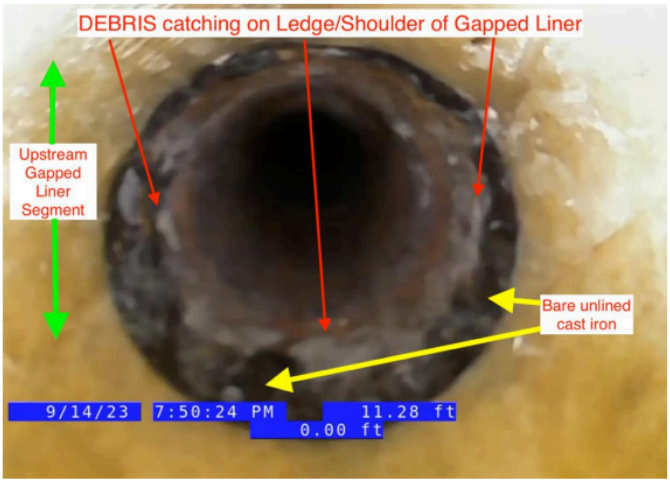
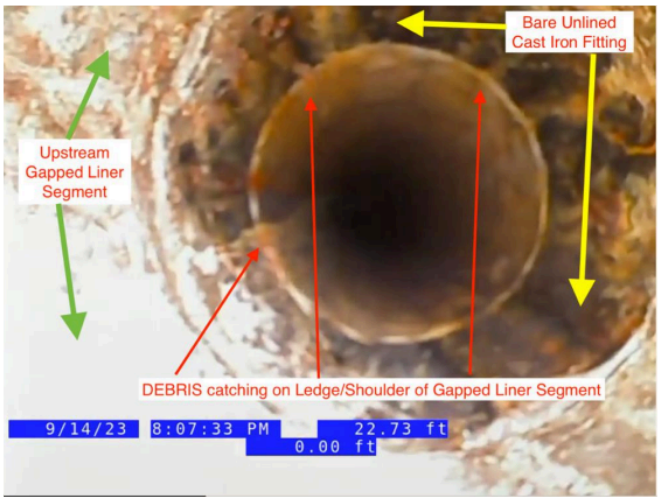


Photograph 5 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the upstream segment of liner (green arrows), the bare unlined cast iron fitting between liner segments (yellow arrows), and the debris lodged between the bare pipe wall and the Shoulder/Ledge at the exposed upstream edge of the downstream liner segment (red arrows).



Photograph 6 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the upstream Gapped liner segment (green arrows), the bare unlined cast iron fitting between Gapped liner segments (yellow arrows), and the debris lodged between the bare pipe wall and the Shoulder/Ledge at the exposed upstream edge of the downstream liner segment (red arrows).

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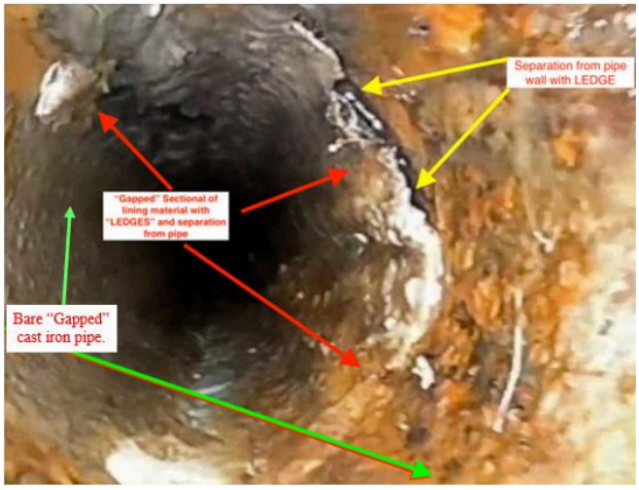
Photograph 7 - Pan-and-Tilt Sewer Camera close-up image of an exposed neoprene gasket in a no-hub pipe coupling illustrating cracks and pitting in the pipe-joint gasket between the liner segments of a Gapped CIPP repair (red arrow).



Photograph 8 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment (red arrows). Note the unlined section of the cast iron fitting above the Gapped liner segment (green arrows), the frayed delaminated upstream edge of the liner segment, and the gap between the liner Shoulder/Ledge and the pipe wall at the upstream edge of the liner segment (yellow arrows).

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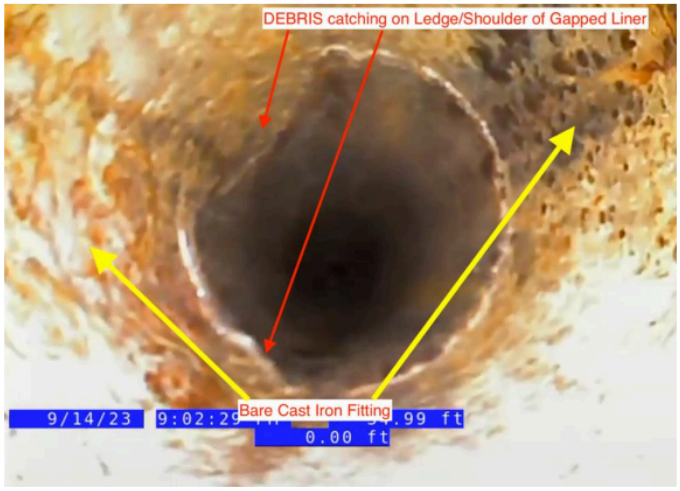

Photograph 9 - Sewer camera image looking downstream toward the upstream edge of a Gapped CIPP liner segment. Note the unlined cast iron pipe above the Gapped liner segment (yellow arrows), the debris lodged between the bare pipe wall and the Shoulder/Ledge at the upstream edge of the liner segment, and the bulge-like deformations along the length of the lining, which originate at the gaps between the liner shoulder and the pipe wall (red arrows; works with Photographs 10, 11, 12, 13).

Photograph 10 - Sewer camera image of a Gapped CIPP liner segment illustrating a longitudinal bulge (red arrows) along the length of a liner segment (works with Photographs 9, 11, 12 and 13).

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Photograph 11 – Sewer camera close-up image of a burst in a liner bulge within a Gapped CIPP liner segment. Note the delamination of the liner material (red arrows; works with Photographs 9, 10, and 12).

Photograph 12 - Sewer camera close-up image of a burst in a liner bulge within a Gapped CIPP liner segment illustrating liner delamination, separation of the Gapped liner from the host pipe, and water penetration between liner and the pipe (red arrows; works with Photographs 9, 10, and 11).

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Photograph 13 - Sewer camera close-up image of a weep hole at the downstream end of a bulge within a Gapped CIPP liner segment illustrating the discharge of water flowing within the confines of the bulge (works with Photographs 9 and 10).

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Residential

21

P11888

Date Submitted	02/12/2025	**Section**	3011	**Proponent**	Michael Wilson
Chapter	30	**Affects HVHZ**	No	**Attachments**	**Yes**
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

None

Summary of Modification

removal of Section P3011 in its entirety.

Rationale

Remove P3011.1 through P3011.10 because " Fold and Form is not relevant to the Florida Building Code. P3011.2 Applicability states, "The relining of existing building and sewer building drainage piping... P3011.6 Relining materials states "The relining material shall be manufactured in compliance with the applicable standards and certified as required in Section 2609" P2609.1 utilized in a “plumbing system”. P2609.4 Third Party certification. “Plumbing products and materials…” The Fold and Form material and installation process is intended to be installed by traditional licensed Underground Utility Contractors for relining Mainline Municipal sewer and storm culvert pipes. It is not used in "building sewers and building drainage piping" or "utilized in a plumbing system".

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
There is no impact.
Impact to building and property owners relative to cost of compliance with code
There would be no impact.
Impact to industry relative to the cost of compliance with code
There would be no impact.
Impact to small business relative to the cost of compliance with code
There would be no impact.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
yes

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

yes.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No it does not.

Does not degrade the effectiveness of the code

No it does not.

P11888Text Modification

~~P3011.1 General.~~

~~This section shall govern the relining of existing building sewer and building drainage piping.~~

~~P3011.2 Applicability.~~

~~The relining of existing building sewer and building drainage piping shall be limited to gravity drainage piping 4 inches (102 mm) in diameter and larger. The relined piping shall be of the same nominal size as the existing piping.~~

~~P3011.3 Pre-installation.~~

~~Prior to commencement of the relining installation, the existing piping sections to be relined shall be descaled and cleaned. After the cleaning process has occurred and water has been flushed through the system, the piping shall be inspected internally by a recorded video camera survey.~~

~~P3011.3.1 Pre-installation recorded video camera survey.~~

~~The video survey shall include verification of the project address location. The video shall include notations of the cleanout and fitting locations, and the approximate depth of the existing piping. The video shall also include notations of the length of piping at intervals no greater than 25 feet (7260 mm).~~

~~P3011.4 Permitting.~~

~~Prior to issuing a permit for the relining, the building official shall review and evaluate the pre-installation recorded video camera survey to determine whether the piping system is capable of being relined in accordance with the proposed lining system manufacturer's installation requirements and applicable referenced standards.~~

~~P3011.5 Prohibited applications.~~

~~Where review of the pre-installation recorded video camera survey reveals that piping systems are not installed correctly, or defects exist, relining shall not be permitted. The defective portions of piping shall be exposed and repaired with pipe and fittings in accordance with this code. Defects shall include, but are not limited to, backslope or insufficient slope, complete pipe wall deterioration or complete separation such as from tree root invasion or improper support.~~

~~P3011.6 Relining materials.~~

~~The relining materials shall be manufactured in compliance with applicable standards and certified as required in Section P2609. Fold and form pipe reling materials shall be manufactured in compliance with ASTM F1504 or ASTM F1871.~~

~~P3011.7 Installation.~~

~~The installation of relining materials shall be performed in accordance with the manufacturer's installation instructions, applicable referenced standards and this code.~~

~~P3011.7.1 Material data report.~~

~~The installer shall record the data as required by the relining material manufacture and applicable standards. The recorded data shall include but is not limited to the location of the project, relining material type, amount of product installed and~~

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P11888Text Modification

~~conditions of the installation. A copy of the data report shall be provided to the building official prior to final approval.~~

~~P3011.8 Post-installation recorded video camera survey.~~

~~The completed relined piping system shall be inspected internally by a recorded video camera survey after the system has been flushed and flow tested with water. The video survey shall be submitted to the code official prior to finalization of the permit. The video survey shall be reviewed and evaluated to provide verification that no defect exist. Any defects identified shall be repaired and replace in accordance with this code.~~

~~P3011.9 Certification.~~

~~A certification shall be provided in writing to the building official, from the permit holder, that the relining materials have been installed in accordance with the manufacturer's installation instructions, the applicable standards and this code.~~

~~P3011.10 Approval.~~

~~Upon verification of compliance with this requirements of Sections P3011.1 through P3011.9, the building official shall approve the installation.~~

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TAC: Plumbing

Total Mods for **Plumbing** in **Pending Review : 22**

Total Mods for report: 22

Sub Code: Residential

22

P12193

Date Submitted	02/16/2025	**Section**	3011.4	**Proponent**	Jennifer Hatfield
Chapter	30	**Affects HVHZ**	No	**Attachments**	No
TAC Recommendation	Pending Review				
Commission Action	Pending Review				

Comments

General Comments No **Alternate Language No**

Related Modifications

717.4, Plumbing Code

Summary of Modification

On behalf of the Building Officials Association of Florida (BOAF), this modification addresses relining of the piping system when it comes to who evaluates the system.

Rationale

It is not the code official or the building official's responsibility to evaluate the existing piping system to determine if it is capable of being relined. This responsibility should be on the registered design professional to document that the piping system is capable to be relined per manufacturer installation requirements and applicable reference standards. This proposal makes that change.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code
None
Impact to building and property owners relative to cost of compliance with code
None
Impact to industry relative to the cost of compliance with code
None
Impact to small business relative to the cost of compliance with code
None

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public
Yes, as it provides for appropriate evaluation by a design professional to ensure if a piping system is capable to be relined.
Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Yes, as it provides for appropriate evaluation by a design professional to ensure if a piping system is capable to be relined.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

It does not.

Does not degrade the effectiveness of the code

It does not.

P12193Text Modification

P3011.4 Permitting.

Prior to issuing a permit for relining, the building official shall review a report submitted by the registered design professional that documents ~~and evaluate the pre-installation recorded video camera survey to determine~~ whether the piping system is capable to be relined in accordance with the proposed lining system manufacturer's installation requirements and applicable referenced standards.

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