STATE OF CALIFORNIA
BUILDING STANDARDS COMMISSION

PUBLIC COMMENT on PROPOSED BUILDING STANDARDS

For Publication in Title 24, California Code of Regulations

See instructions for completing this form on Page 2.

Commenter Contact Information

Name: Joanne Carroll   Date: 10/29/2018

Representing: National Association of Sewer Service Companies (NASSCO)

Mailing Address: Number & Street: 3470 Longstone Lane, Suite M

City: Marriottsville   State: MD   Zip Code: 21104

Telephone #: 918-527-8975   Email: jcarroll@subtegic.com

Proposed Building Standard

Title 24 Part #: (*select one*) **Part 5**   Section #: **715.3**

Proposing State Agency

This comment is intended for review during: (*select one*)

- ☐ Code Advisory Committee
- ☒ 45-Day Comment Period
- ☐ 15-Day Comment Period
- ☐ Commission Meeting

Your recommendation based on the criteria of Health and Safety Code Section 18930(a) printed on the back of this form is: (*select one*)

- ☐ Approve
- ☒ Disapprove
- ☐ Further Study Required
- ☐ Approve as Amended

In support of your recommendation above, provide the rationale based on the criteria of Health and Safety Code Section 18930(a) printed on the back of this form. If you recommend anything other than approve, cite the criteria in your comment. If you oppose a proposed building standard, offer a solution or alternative for the state agency to consider. Please use separate pages if your comment does not fit in this space.

Rationale in opposition of the proposed adoption of Section 715.3 of the 2018 Edition of the Uniform Plumbing Code is attached. Alternative for consideration is to maintain Section 715.3 of the 2016 California Plumbing Code.

Attachments?

☒ Check if you have attached additional pages. The number of pages attached is: 47

For CBSC Office Use Only Date Received: ________ Rulemaking Item #: ___________

California Building Standards Commission – Plumbing Code Adoption

Public Comment on Proposed Building Standards
Title 24, Part 5, Section 715.3

Disapprove

Proposal:

Disapprove adoption of Section 715.3 of the 2018 Edition of the Uniform Plumbing Code. Maintain Section 715.3 of the 2016 California Plumbing Code.

2016 California Plumbing Code – Section 715.3:

Replacement of existing building sewer and building storm sewer using trenchless methodology and materials shall be installed in accordance with ASTM F1216.

2018 UPC – Section 715.3 Proposed for Adoption [underlined changes]:

Replacement of existing building sewer and building storm sewer using trenchless methodology and materials shall be installed in accordance with ASTM F1216. Cast-iron soil pipes and fittings shall not be repaired or replaced by using this method aboveground or belowground. Replacement using cured-in-place pipe liners shall not be used on collapsed piping or when the existing piping is compromised.

Criteria for Consideration:

Technical Merit:

Section 715.3 of 2018 Edition of the Uniform Plumbing Code ("UPC") must not be adopted for three reasons. First, as currently drafted, Section 715.3 is internally inconsistent. Second, Section 715.3 prohibits, without technical justification, the methods by which cast iron soil pipes and fittings may be repaired or replaced. Third, Section 715.3 prohibits, without technical justification, the use of cured in place pipe ("CIPP") liners to replace collapsed or compromised piping.

1. Section 715.3 is Internally Inconsistent.

The first sentence of Section 715.3 reads, "Replacement of existing building sewer and building storm sewer using trenchless methodology and materials shall be installed in accordance with ASTM F1216." In this sentence, the UPC requires that replacement of existing building sewer and building storm sewer using trenchless methodology and materials be installed in accordance with ASTM F1216 (mandatory referenced standard).

ASTM F1216 (hereafter “F1216”) sets forth the standard of practice for repairing, replacing or rehabilitating sewer pipe using CIPP.[1] Section 1.1 of F1216 reads:

> This practice describes the procedures for the reconstruction of pipelines and conduits (2 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 or introducing controlled steam within the tube. When cured, the finished pipe will be continuous and tight-fitting.[2]

This process describes CIPP.[3] Further, F1216 explains, “This reconstruction process can be used in a variety of gravity and pressure applications such as sanitary sewers [and] storm sewers . . ..”[4]

a. F1216 Expressly Contemplates the Repair, Replacement or Rehabilitation of Collapsed or Compromised Pipe.

F1216 explains that before a pipe can be repaired, it must be “carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as . . . collapsed or crushed pipe . . . .”[5] Such an inspection is required “so that [harmful conditions] can be corrected.”[6] F1216 further explains that “[t]he original pipeline should be clear of obstructions such as . . . crushed or collapsed pipe . . . that will prevent the insertion of the resin-impregnated tube.”[7] F1216 provides that “[i]f 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.”[8]

Thus, F1216 expressly contemplates the use of CIPP to repair, replace or rehabilitate crushed or collapsed pipe. F1216 explains that where the pipe is crushed or collapsed, it must be cleared “by conventional sewer cleaning equipment.”[9] If it cannot be cleared by conventional sewer cleaning equipment, “then a point repair excavation should be made to uncover and remove or repair the obstruction.”[10]

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[1] ASTM F1216-16 at § 1.1.
[2] *Id.*
[3] F1216 at § 3.2.1; *see* E. Allouche, *et al.*, *A Retrospective Evaluation of Cured-in-Place Pipe (CIPP) Used in Municipal Gravity Sewers*, United States Environmental Protection Agency, EPA/600/R-12/004 at § 2.2.2, pp. 6-9 (Jan. 2012) (describing the CIPP process and referencing ASTM F1216).
[4] *Id.*
[5] F1216 at § 7.1.3.
[6] *Id.*
[7] *Id.* at § 7.1.4.
[8] *Id.*
[9] *Id.*
[10] *Id.*

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Moreover, F1216 provides design considerations for the use of CIPP to repair, replace or rehabilitate "partially deteriorated pipe"[11] and "fully deteriorated pipe."[12] In the case of partially or fully deteriorated pipe, F1216 explains the necessary adjustments to the thickness of the CIPP designed to strengthen the CIPP to withstand loads without collapsing.[13]

b. Section 715.3 Prohibits the Use of CIPP to Replace Collapsed or Compromised Pipe.

The first and third sentences of Section 715.3 are inconsistent. The third sentence of Section 715.3, as currently drafted, reads, "Replacement using cured-in-place pipe liners shall not be used on collapsed piping or when the existing piping is compromised." This prohibition conflicts with the first sentence of Section 715.3. As discussed above, F1216, which is mandated by the first sentence of Section 715.3, authorizes the use of CIPP where the pipe is "collapsed or crushed," "partially deteriorated," or "fully deteriorated."

Due to the internal conflict in Section 715.3, one cannot comply with the directive in the first sentence of Section 715.3 — which requires one to follow F1216 — and the prohibition in the third sentence of Section 715.3 — which forbids the use of CIPP on collapsed or compromised pipe. For this reason alone, the third sentence of Section 715.3 should be stricken.

Additionally, the reference to "compromised" pipe in the third sentence of Section 715.3 is incoherently vague. The dictionary definition of "compromised" is "[e]xposed to risk, danger, or discredit."[14] Under its broadest definition, any pipe in need of repair or rehabilitation is "compromised." If that is the case, the third sentence of Section 715.3 categorically prohibits the use of CIPP while the first sentence of Section 715.3 expressly permits it.

Likewise, the reference to "collapsed" pipe in the third sentence of Section 715.3 is vague and in direct conflict with the first sentence of Section 715.3. F1216 allows the use of CIPP on "crushed" or "collapsed" pipe when the pipe can be cleared "by conventional sewer cleaning equipment" or, when "clearing the pipe by conventional sewer cleaning equipment cannot be done, by "a point repair excavation."

c. F1216 Contemplates Repair, Replacement and Rehabilitation of Cast Iron Pipe by CIPP.

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[11] *Id.* at § X1.1.1 ("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.")
[12] *Id.* at § X1.1.2 ("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.")
[13] *Id.* at §§ X1.2.1, X1. 2.2.
[14] "compromised, adj.". OED Online. July 2018. Oxford University Press. http://www.oed.com/view/Entry/37905?result=2&rskey=2O03Uz&.

F1216 does not prohibit the use of CIPP to repair, replace or rehabilitate cast iron pipe. F1216 clearly and concisely defines "partially deteriorated pipe" and "fully deteriorated pipe" which explains that an existing pipe may have "longitudinal cracks and up to 10.0% distortion of the diameter" or may "not [be] structurally sound" whereby the "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."[15] Cast iron pipe can be damaged after installation and does corrode. And, F1216 provides design considerations for adjusting the thickness of the CIPP liner to repair damaged, deteriorated and corroded pipe.[16] The second sentence of Section 715.3, which prohibits the use of trenchless, CIPP technology to repair or replace cast iron soil pipe, directly conflicts with the first sentence of Section 715.3.

In summary, the second and third sentences directly conflict with the first sentence of Section 715.3. The first sentence of Section 715.3 requires that building sewer pipe and building storm sewer pipe be repaired and replaced in accordance with the well-developed practice and procedure set forth in F1216. The second and third sentences of Section 715.3 restrict the practice described in F1216 and arguably ban it altogether. Deleting the second and third sentences of 715.3 resolves this internal conflict.

2. The Restriction on the Use of the Trenchless Methodology and Materials to Repair or Replace Cast Iron Soil Pipe Lacks Technical Support or Justification.

The second sentence of Section 715.3, as currently drafted, prohibits the use of CIPP to repair or replace cast iron soil pipe. However, F1216 includes no prohibition or suggestion of any prohibition on the use of CIPP, the trenchless technology described in F1216, to repair, replace or rehabilitate cast iron soil pipe. To the contrary, F1216 sets forth the procedures for application of CIPP to reconstruct deteriorated, damaged and corroded existing sewers, which is the purpose of Section 715.3 Existing Sewers. Cast iron pipe is affected by corrosion, deterioration and damage with main defects found in cast iron gravity sewer systems listed in a whitepaper published by the EPA in 2009.[17].

The relevant literature overwhelmingly supports the assertion that CIPP is an appropriate method for rehabilitating cast iron pipe. The Submitters of this Public Comment were unable to find a single technical paper, engineering study or report that suggested CIPP could not be used to repair cast iron soil pipe or any other cast iron pipe. Indeed, all of the literature around the use, performance and track record of CIPP shows that its efficacy is not dependent on the pipe material to which this well-established pipe repair, replacement and rehabilitation method is applied.

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[15] *Id.* at § X1.1.2 (emphasis added).

[16] *Id.* at § X1.2.2

[17] R. Sterling, *et al., White Paper on Rehabilitation of Wastewater Collection and Water Distribution Systems,* United States Environmental Protection Agency, EPA/600/R-09/048 § 3.3 Table 3 at p. 15. (May 2009).

For example, in 2012, the United States Environmental Protection Agency ("EPA") published a study entitled, A Retrospective Evaluation of Cured-in-Place Pipe (CIPP) Used in Municipal Gravity Sewers.[18] The study explained that the use of CIPP to repair sewer pipe dates back to 1971 and it has been used in the United States since 1976.[19] The study found that municipal sewer lines repaired with CIPP "were in excellent condition after being in use for 25 years, 23 years, 21 years, and 5 years."[20] The EPA study concluded, "Overall, there is no reason to anticipate that the liners evaluated in this pilot study will not last for their intended lifetime of 50 years and perhaps well beyond."[21]

In a whitepaper published by the EPA in 2009, the white paper observed, "Open-cut replacement has been the standard practice in the past, but its preferential use over trenchless techniques has been significantly diminished in the past two decades – particularly in the wastewater sector."[22] Utilization of trenchless techniques, such as CIPP, has been extensive over the last four decades. If there were any indication that CIPP was incompatible with cast iron soil pipe, it would have been reported in some study by now. But, it has not.

Bill LeVan, Cast Iron Soil Pipe Institute, as submitter of the 2018 UPC Code proposal to add the exclusionary language cited as substantiation: "The ASTM and CISPI standards for cast iron soil pipes and fittings prohibit the repair of the cast iron soil pipes and fittings by any means. ASTM F1216 allows for the repair of partially deteriorated piping and would conflict with the manufacturer's instructions and the product standards."[23] A comprehensive review of CISPI Standard 301-12, ASTM A74-17 and ASTM A888-18 [all of the referenced standards relating to cast iron soil pipes and fittings within the UPC] revealed no prohibition of use of CIPP and not a single reference to the repair or rehabilitation of installed cast iron soil pipe or fittings. The only mention of repair found in these standards [each were identical] addressed the correction of "cosmetic or material defects that occur *during the course of manufacturing*."[24] Section 715.3 Existing Sewers defines technology addressing existing pipe, not manufacturing criteria for new pipe. These findings rule out the substantiation provided to the UPC Technical Committee and eliminate the basis for the addition of this language.

Further, CIPP has been successfully utilized to repair, rehabilitate and reconstruct cast iron pipe throughout the State of California since its introduction to the United States decades [four] ago. Small and large businesses have invested significantly to obtain access to CIPP technology and provide the benefit of this less invasive, green technology to municipalities, utilities, business owners and residents throughout the State of

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[18] E. Allouche, *et al.*, *A Retrospective Evaluation of Cured-in-Place Pipe (CIPP) Used in Municipal Gravity Sewers, United States Environmental Protection Agency*, EPA/600/R-12/004 (Jan. 2012).
[19] *Id.* at § 2.2.1, p. 5.
[20] *Id.* at § 9.1.2, p. 126.
[21] *Id.* at § 9.1.2, p. 127.
[22] R. Sterling, *et al.*, *White Paper on Rehabilitation of Wastewater Collection and Water Distribution Systems*, United States Environmental Protection Agency, EPA/600/R-09/048 § 2.3 at p. 8 (May 2009).
[23] IAPMO Plumbing Technical Committee. Report on Proposal: *The Plumbing Technical Committee Report on Proposals for Public Review and Comment,* IAPMO, 2016, Proposal Item #204 at p. 322.
[24] ASTM A74-17 at § 4.5, ASTM A888-18 at § 4.5, and CISPI 301-12 at § 4.9 (emphasis added)

California. Adoption of the UPC Section 715.3 prohibits the use of CIPP technology by prohibiting its use and artificially constructing unreasonable alternatives which will have adverse impact on small business and economic impact on businesses[25], municipalities, utilities and state government. Those impacted will include the plumbers providing CIPP and the users/owners receiving the benefits of reconstruction using CIPP in accordance with ASTM F1216, the mandatory referenced standard within the 2016 State of California Plumbing Code.

Moreover, Section 715.3, by prohibiting the use of CIPP to repair or replace cast iron soil pipe, requires that such pipe be rehabilitated using older techniques such as open-cut replacement even though that technique "has been significantly diminished in the past [four] decades – particularly in the wastewater sector."
Thus, while Section 715.3, as currently drafted, advances the interests of cast iron soil pipe manufacturers, it lacks any technical support or justification.

3. The Restriction on the Use of CIPP to Repair or Replace Collapsed or Compromised Pipe Lacks Technical Support or Justification.

The third sentence of Section 715.3, as currently drafted, reads, "Replacement using cured-in-place pipe liners shall not be used on collapsed piping or when the existing piping is compromised." However, the Submitters of this Public Comment have searched the literature around the use of CIPP and found no technical papers, engineering studies or any other studies or reports suggesting that CIPP cannot be used for collapsed or compromised pipe.

To the contrary, F1216, which is mandated by the first sentence of Section 715.3, defines the procedures to address "collapsed or crushed pipe" followed by the use of CIPP for compromised pipe defined concisely within F1216 as "partially deteriorated" or "fully deteriorated" Moreover, at least two studies published by the EPA have lauded the ability to utilize CIPP to reconstruct or rehabilitate existing sewer pipe.[26] And, a research document funded by the Water Environment Research Foundation (WERF) delivers comprehensive documentation on the problems associated with sewer laterals and evaluates through case histories the cost effectiveness of lateral rehabilitation. These case histories include CIPP rehabilitating cast iron pipe which was found to have severe mineral buildup over time reducing hydraulic capacity from 4" to 2" pipes.[27] Therefore, the prohibition in the third sentence of Section 715.3 not only lacks technical support or justification, but also flies in the face of published studies on the effectiveness of CIPP.

[25] State of California, Government Code Section 11346.2(b)(4)(A-C)
[26] E. Allouche, *et al.*, *A Retrospective Evaluation of Cured-in-Place Pipe (CIPP) Used in Municipal Gravity Sewers*, United States Environmental Protection Agency, EPA/600/R-12/004 (Jan. 2012); R. Sterling, *et al.*, *White Paper on Rehabilitation of Wastewater Collection and Water Distribution Systems*, United States Environmental Protection Agency, EPA/600/R-09/048 (May 2009).
[27] R. Sterling, *et al., Methods for Cost-Effective Rehabilitation of Private Lateral Sewers,* Water Environment Research Foundation, 02-CTS-5 (2006).

Impact Summary:

The 2018 UPC version of Section 715.3 effectively bars the use of a well-established and economical method of repairing, replacing or rehabilitating building sewer pipe and building storm sewer pipe. In so doing, it limits consumer choice and requires far more costly and destructive methods of repairing, replacing or rehabilitating such pipe. For example, in places like California, where concrete slab construction is common and frequently involves pre-stressed concrete, by prohibiting use of trenchless technologies, such as CIPP, to repair or replace cast iron soil pipe or compromised pipe, Section 715.3 mandates use of substantially more expensive, destructive and hazardous methods of repairing, replacing or rehabilitating building sewer pipe and building storm sewer pipe.

Moreover, Section 715.3 prohibits the use of CIPP to repair, replace or rehabilitate building sewer pipe and building storm sewer pipe without any technical justification. Thus, Section 715.3 arbitrarily and capriciously limits consumer choice and increases consumer costs. While this trade-off might be justifiable if it were supported by safety, performance or other technical reasons, it is not.

At the same time, Section 715.3, brazenly protects cast iron soil pipe manufacturers by specifically prohibiting the use of CIPP or other trenchless methods to repair or replace such pipe. That the Cast Iron Soil Pipe Institute participated in the drafting of the 2018 version of the UPC has not gone unnoticed. And, an action by a standard setting organization that has an anticompetitive impact without substantial justification is not immune from the antitrust laws.[28]

Therefore, in order to maintain the integrity and enforceability of the California Plumbing Code, restore consumer choice and to remove the anticompetitive impact of the 2018 UPC Section 715.3, the adoption by the State of California of Section 715.3 must **not** be approved for the 2018 California Plumbing Code. Alternatively, maintaining Section 715.3 of the 2016 California Plumbing Code for the 2018 California Plumbing Code update must be approved.

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[28] *See Allied Tube & Conduit Corp. v. Indian Head, Inc.*, 486 U.S. 492 (1988).

change.org

Recipient: The State of California Building Standards Commission

Letter: Greetings,

Petition to Disapprove Adoption of Section 715.3 of the 2018 Uniform Plumbing Code.

We, the undersigned, petition the State of California Building Standards Commission to disapprove the adoption of Section 715.3 of the 2018 Edition of the Uniform Plumbing Code. And, approve Title 24, Part 5, Section 715.3 of the 2016 California Plumbing Code as is, for the 2018 California Plumbing Code.

We represent service providers, small businesses, property owners, municipal and utility managers and others that would be adversely impacted in the event Section 715.3 of the 2018 Edition of the Uniform Plumbing Code is adopted by the California Building Standards Commission. Section 715.3 of the 2016 California Plumbing Code provides the means to utilize specific technologies, equipment, and prescriptive standards to address the repair and replacement of existing sewers.

Whereas, adoption of Section 715.3 of the 2018 Uniform Plumbing Code will prohibit the ability to consider reasonable alternatives for the repair and replacement of existing sewers; may produce increased risk and/or exposure to health and safety construction issues; may result in a negative economic impact on small businesses, negative social impact through increased construction time and disruption, and negative environmental impact through increased carbon footprint.

Signatures

Name	Location	Date
The Board of NASSCO	marriottsville, MD	2018-10-18
Tim Back	Cincinnati, OH	2018-10-18
Jason Walborn	Mission Viejo, CA	2018-10-18
Joanne Carroll	Cary, NC	2018-10-19
Beth Hunt	Martinsville, VA	2018-10-19
Michelle Beason	Walnut Creek, CA	2018-10-19
Francisco Ceniceros	Fullerton, CA	2018-10-19
Tom Bowman	San Diego, CA	2018-10-19
Marco A Santoyo	Orange, CA	2018-10-19
Grant Duxbury	North Port, FL	2018-10-19
Zach Petit	Hayward, CA	2018-10-19
Jose Magana	Long Beach, CA	2018-10-19
Mark Ames	San Diego, CA	2018-10-19
Lori Maya	San Diego, CA	2018-10-19
Rob Bolger	Torrance, CA	2018-10-19
Victor Roberts	Escondido, CA	2018-10-19
Mark Metcalfe	El Mirage, AZ	2018-10-19
Amanda Combs	San Diego, CA	2018-10-19
Kathy Romans	Pasadena, TX	2018-10-19
Aidan Lam	Melville, NY	2018-10-19

Name	Location	Date
Greg Ruiz	Chino Hills, CA	2018-10-20
Scott Johnson	Logan, UT	2018-10-20
John Raymond	West Jordan, UT	2018-10-20
Matt Enton	Holiday, FL	2018-10-20
Joe Castro	Los Angeles, CA	2018-10-20
Hayden Page	Las Vegas, NV	2018-10-20
Sam Dayton	Denver, CO	2018-10-20
Paul Page	Blackfoot, ID	2018-10-20
melissa chance	US	2018-10-20
Joshua Fretwell	Vista, CA	2018-10-20
Jeremy Ingle	Wadsworth, OH	2018-10-20
Alison Fretwell	San Marcos, CA	2018-10-20
Cliff Hunter	Las Vegas, NV	2018-10-20
Randall Lee	Layton, UT	2018-10-20
Brittany Johnson	Logan, UT	2018-10-20
Scott Fisher	Encinitas, CA	2018-10-21
Daniel Roy	US	2018-10-21
Donna Siegel	US	2018-10-21
McKenzie Page	Salt Lake City, UT	2018-10-21
Josh Victorino	Los Angeles, CA	2018-10-21
Tara Johnson	US	2018-10-21
Turieon Mitchell	US	2018-10-22

Name	Location	Date
ian oakley	Fountain Valley, CA	2018-10-22
Kelli Smith	Manhattan, KS	2018-10-22
Jeremy Griffin	Santa Maria, CA	2018-10-22
MaryAlice Blackmore	US	2018-10-22
Darla Vowell	US	2018-10-22
Connor Moore	Vista, CA	2018-10-22
Mendy Calegari	Oakland, CA	2018-10-22
Wilma Roberts	Escondido, CA	2018-10-22
David Boatright	Sonora, CA	2018-10-22
Tony White	Vista, CA	2018-10-22
Jeremy Wagner	La Quinta, CA	2018-10-22
Joy Griffin	Santa Maria, CA	2018-10-22
Justice Gradowitz	Bakersfield, CA	2018-10-22
Vahik Hacopiannik	Escondido, CA	2018-10-22
Tommy Grambe	US	2018-10-22
Gregory Mayer	Vista, CA	2018-10-22
Jeff Garcia	Long Beach, CA	2018-10-22
Jamarcus Mcgruder	US	2018-10-23
Carlos Lowenberg	US	2018-10-23
Stephen Murphy	US	2018-10-23
Matthew Timberlake	Livermore, ME	2018-10-23
Michael Locascio	US	2018-10-23

Name	Location	Date
Christopher Thompson	US	2018-10-23
jon black	Kingston, NH	2018-10-23
Tom Hlavac	San Bernardino, CA	2018-10-23
Karina Baxter	US	2018-10-23
Adam Gallagher	San Mateo, CA	2018-10-23
Jonathan Boyne	Honolulu, HI	2018-10-23
Claudio Ingrassia	Long Beach, CA	2018-10-23
Tom Esposito	US	2018-10-24
Nakiya Anthony	US	2018-10-24
C Chase	La Mesa, CA	2018-10-24
Jonah Mcclain	US	2018-10-24
Nick Ghosn	San Diego, CA	2018-10-24
AnthonY calderon	US	2018-10-24
Doogie HAUSER	US	2018-10-24
Briana Sandoval	Buda, TX	2018-10-24
tyler matthews	US	2018-10-24
Alyssa Regalado	US	2018-10-24
Gary Sweeney	La Mesa, CA	2018-10-24
Alfred Edwards	Los Angeles, CA	2018-10-24
VINCENT VELA	US	2018-10-24
Marion Marsh	US	2018-10-24
Mary Estella	US	2018-10-24

Name	Location	Date
Jean Busboom	US	2018-10-24
Russell Griesmer	US	2018-10-24
Everett Penny	US	2018-10-24
Bob Hilbet	US	2018-10-24
Brooke Kerstetter	Atlanta, GA	2018-10-25
Allen Moore	US	2018-10-25
Cesar Escobar	US	2018-10-25
Matt Marlow	US	2018-10-25
Jerry Chen	Tustin, CA	2018-10-25
Dalen Berard	Los Angeles, CA	2018-10-25
Mark Burel	Mission Viejo, CA	2018-10-25
Samuel Solorzano	Chula Vista, CA	2018-10-25
Mark Metcalfe	Mission viejo, CA	2018-10-25
kevin granich	Anaheim, CA	2018-10-25
Robert Anthony	Mission Viejo, CA	2018-10-25
Marcine McBride	West Babylon, NY	2018-10-25
Wendy Creamer	Anaheim, CA	2018-10-25
Nora Warren	Anaheim, CA	2018-10-25
Dale Escobar	Santa Barbara, CA	2018-10-25
Vito Mancini	Anaheim, CA	2018-10-25
Bradley Rahrer	Santa Barbara, CA	2018-10-25
THOMAS MILLES	US	2018-10-25

Name	Location	Date
Mauricio Calvillo	Chatsworth, CA	2018-10-25
Monte Yoder	Dana Point, CA	2018-10-25
Monika Lucas	San Diego, CA	2018-10-25
Bruce Katz	Lancaster, CA	2018-10-25
John Sobczak	Laguna Niguel, CA	2018-10-25
Billy Bennett	US	2018-10-25
Carmen Guzman	Anaheim, CA	2018-10-25
Martha Lester	Mission Viejo, CA	2018-10-26
Joseph Patterson	US	2018-10-26
Prince Banini	US	2018-10-26
Matthieu Gol	US	2018-10-26
N A	US	2018-10-26
Julian Carrillo	US	2018-10-26
Drew Brandon	US	2018-10-26
Hayden Kam	San Francisco, CA	2018-10-26
Ben Kohn	Ventura, CA	2018-10-26
Carlos Sanchez	Santa Clarita, CA	2018-10-26
Russell Price II	US	2018-10-26
Katrina Poblinka	US	2018-10-26
Michael Smith	Fremont, CA	2018-10-26
Jacopo Vasile	Downingtown, PA	2018-10-26
Thomas Carlisle	Warren, MI	2018-10-26

Name	Location	Date
John Curtis	Monclova, OH	2018-10-26
Joe Rushing	Lubbock, TX	2018-10-26
Jason Klaus	Oconomowoc, WI	2018-10-26
Jack Kenney	Lake Mills, WI	2018-10-26
Joe Walsh	Milwaukee, WI	2018-10-26
Jason Haas	Watertown, WI	2018-10-26
Christi Woods	Perry, OK	2018-10-26
David Napier	Richmond, KY	2018-10-26
Todd Kulak	Clovis, CA	2018-10-26
Nate hrabosky	Racine, WI	2018-10-26
Ryan Ley	Lake mills, WI	2018-10-26
Jon Porter	Albion, NE	2018-10-26
Patrick Hooper	Loveland, OH	2018-10-26
Michele Robertson	Bedford, OH	2018-10-26
Keith Witt	Willard, UT	2018-10-26
Ben Smith	Minneapolis, MN	2018-10-26
James Smith	Houston, TX	2018-10-26
destiny palacio	US	2018-10-26
Jacob Taylor	US	2018-10-26
Alex Valdez	Oxnard, CA	2018-10-26
Chris Slocum	Clearfield, UT	2018-10-26
Yolanda Mowad	Ventura, CA	2018-10-26

Name	Location	Date
Ben Lehman	BATAVIA, IL	2018-10-26
William Llamas	La Habra, CA	2018-10-26
Cameron Manners	San Diego, CA	2018-10-26
Matt Stahmann	US	2018-10-26
John Heisler	Anaheim,, CA	2018-10-26
Chad Miller	Birch Run, MI	2018-10-26
J Wild	Oconomowoc, WI	2018-10-26
Mike Jennings	Sacramento, CA	2018-10-26
Monica Dixon	Santa Maria, CA	2018-10-26
Elijah Aldridge	US	2018-10-26
Todd Williams	US	2018-10-26
Suliman Khan zaman Suliman	Apo, AE	2018-10-26
Trenton Wollman	Alexandria, SD	2018-10-26
Petrina Hillje	US	2018-10-26
Pamela Eastman	Sioux Falls, SD	2018-10-26
Nazir Ahmed	US	2018-10-26
Mel Young	Webster, NY	2018-10-26
Dennis Persaud	San Diego, CA	2018-10-26
Lloyd Gower	San Diego, CA	2018-10-26
Sean Ansari	Santa Maria, CA	2018-10-26
Vicki Duvall	Monticello, IN	2018-10-26
Mark Ellefson	Lakewood, CA	2018-10-26

Name	Location	Date
Aulanis Torres	US	2018-10-26
Abby Hale	Janesville, WI	2018-10-26
Courtney Wood	Mesa, AZ	2018-10-27
Karrie Misley	US	2018-10-27
Matt Down	Long Beach, CA	2018-10-27
L Trogan	US	2018-10-27
Paul Emond	Saint-jean-sur-richelieu, Canada	2018-10-27
Mike Eastman	Sioux Falls, SD	2018-10-27
Marc Watson	Seekonk, MA	2018-10-27
Alex Baik	US	2018-10-27
Phupei Gardner	Springfield, MO	2018-10-27
Robert Nemetz	Marshfield, MO	2018-10-27
Jessica Shuey	US	2018-10-27
Dennis Ryan	Highland, CA	2018-10-27
ابو يزن محمد	US	2018-10-27
Shannon Meister	US	2018-10-27
Camila Cabello	US	2018-10-27
Sade Amarao	US	2018-10-27
Joseph morgan	US	2018-10-27
anthony james	US	2018-10-27
stacy bacus	US	2018-10-27
Aaron Baker	Sycamore, IL	2018-10-27

Name	Location	Date
Russel Polak	Indianapolis, IN	2018-10-27
Margo Gardner	Springfield, MO	2018-10-27
Jake Saltzman	Anderson, SC	2018-10-27
David Marsh	Roslindale, MA	2018-10-27
TIMOTHY MATUTAT	Brentwood, GA	2018-10-27
John Martin	Asheboro, NC	2018-10-27
Abiah Schrader	Casey, IL	2018-10-27
Cindy Saltzman	Channahon, IL	2018-10-27
Jill Stargardt	Yorkville, IL	2018-10-27
Sonia Martin	Hartwell, GA	2018-10-27
Ryan Boldan	Phoenix, AZ	2018-10-27
Jacob Swanson	Burnsville, MN	2018-10-27
Michelle Strasburg	West Des Moines, IA	2018-10-27
Nick Patrick	Sumner, WA	2018-10-27
Curt Hlavacek	Watertown, SD	2018-10-27
karen krulevitch	US	2018-10-27
Maria n Centeno	Oxnard, CA	2018-10-27
Amber Moore	Madison, AL	2018-10-27
Travis Laffey	Oswego, IL	2018-10-27
Britian Miller	US	2018-10-27
Fargol Sabet	US	2018-10-27
Linda Gazzola	US	2018-10-27

Name	Location	Date
Roberto Leon	Los Angeles, CA	2018-10-27
Brittany Saladino	US	2018-10-27
Teja M	US	2018-10-27
Amanda Gibbens	US	2018-10-27
Richard Velasco Chua	US	2018-10-27
Ben Stahl	Sioux Falls, SD	2018-10-27
Gavin Merryman	US	2018-10-27
Sarah Rizzo	US	2018-10-27
Jermaine James	US	2018-10-27
michael cunningham	US	2018-10-27
David Simmons	Bloomfield, IA	2018-10-27
Shadd Matthews	Uniontown, PA	2018-10-27
Gary Andler	Murrysville, PA	2018-10-27
George Huseman	Masontown, PA	2018-10-27
Antonio DeLeon	US	2018-10-27
Leah Jones	Valley Springs, SD	2018-10-27
Fawn Delcamp	Conway, AR	2018-10-27
Pepsi vs Diet cola! JohNson	US	2018-10-27
Morgan Faris	Uniontown, PA	2018-10-27
Aaron Blomberg	Canon, GA	2018-10-27
Max Greenberg	Sacramento, CA	2018-10-27
Jenna O’Maley	US	2018-10-27

Name	Location	Date
Monica Saenz	Sacramento, CA	2018-10-27
Michael Fletcher	US	2018-10-27
Donald Johnson	Anoka, MN	2018-10-27
John McBride	Woodinville, WA	2018-10-27
Lucy mclane	US	2018-10-28
Lisette Peña	US	2018-10-28
amanda griffiths	US	2018-10-28
James Mcgalla	Uniontown, PA	2018-10-28
Bruce Clites	Greensboro, PA	2018-10-28
Josh Morris	Uniontown, PA	2018-10-28
Mike Pishioneri	Rancho Santa Margarita, CA	2018-10-28
Michael Todora	Belle Vernon, PA	2018-10-28
David Krause	Nashville, TN	2018-10-28
Jimmy Huff	Anderson, SC	2018-10-28
Jason Mathey	New Port Richey, FL	2018-10-28
Chris Tatro	Breckenridge, CO	2018-10-28
Saleesha Matthews	US	2018-10-28
James Hauserman	US	2018-10-28
Sriram Ganesan	Singapore, Singapore	2018-10-28
Zack Seah	Singapore, Singapore	2018-10-28
Josh Johnston	Uniontown, PA	2018-10-28
NICHOLAS LAGASSE	US	2018-10-28

Name	Location	Date
Bonnie Childress	Lynchburg, VA	2018-10-28
Bob Chilli	US	2018-10-28
Joshua Bellows	Aguanga, CA	2018-10-28
Yazmin Valenciana	US	2018-10-28
Sean Lipscomb	Bel Air, MD	2018-10-28
Michael Bouchet	Aberdeen, MD	2018-10-28
Jesus Urias	US	2018-10-28
Kotru Uit	US	2018-10-28
Jon Storz	Roebling, NJ	2018-10-28
rawaz Karim	US	2018-10-28
William Cacossa	Trenton, NJ	2018-10-28
Robert Reh	Trenton, NJ	2018-10-28
Tim Champlain	US	2018-10-28
Dan Parise	Murrysville, PA	2018-10-28
Linda Bannister	Anderson, SC	2018-10-28
Donald Kronenbitter	Peoria, AZ	2018-10-28
Kenneth Elenich	US	2018-10-28
Harry Fisher	Trenton, NJ	2018-10-28
Jessica Schmalz	Hamilton, NJ	2018-10-28
Geraldine Octave	US	2018-10-28
Sarahjayne Hirt	Richmond, VA	2018-10-29
Lorna Zamora	US	2018-10-29

Name	Location	Date
stevenson malloy	US	2018-10-29
Todd Chen	US	2018-10-29
Carsyn Whitmore	US	2018-10-29
daniel Oshskh	US	2018-10-29
Daniel Smith	US	2018-10-29
Jane Adamo	US	2018-10-29
Barbara Ramos	Hartford, CT	2018-10-29
Tone Collins	US	2018-10-29
Christy Andler	Canfield, OH	2018-10-29
Rudy Serrano	US	2018-10-29
j r	US	2018-10-29
Mary Poreau	US	2018-10-29
Akeyra Saunders	US	2018-10-29
donna bracke	Trenton, NJ	2018-10-29
Albert Castillo	US	2018-10-29
Destiny Castro	US	2018-10-29

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A Retrospective Evaluation of Cured-in-Place Pipe (CIPP) Used in Municipal Gravity Sewers

SCIENCE

Office of Research and Development
National Risk Management Research Laboratory - Water Supply and Water Resources Division

A Retrospective Evaluation of Cured-in-Place Pipe (CIPP) Used in Municipal Gravity Sewers

by

Erez Allouche, Ph.D., P.E., Shaurav Alam, Jadranka Simicevic, and Ray Sterling, P.h.D., P.E., Trenchless Technology Center at Louisiana Tech University

Wendy Condit, P.E., Ben Headington, and John Matthews, Ph.D. Battelle Memorial Institute

Ed Kampbell, Tom Sangster, and Dec Downey, Ph.D. Jason Consultants, Inc.

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Ariamalar Selvakumar, Ph.D., P.E.
Task Order Manager

U.S. Environmental Protection Agency
Urban Watershed Branch
National Risk Management Research Laboratory
Water Supply and Water Resources Division
2890 Woodbridge Avenue (MS-104)
Edison, NJ 08837

National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

September 2011

Some sections of a sewer system may be in good overall structural condition, but have leaking cracks or joints that allow excessive infiltration and inflow (I/I) into the system. Other pipes may need partial or complete upgrading of the structural condition of pipe to withstand internal pressures, or external soil and groundwater pressures.

The focus of this initial retrospective evaluation was chosen to be CIPP liners used in gravity sewer systems. This choice was made on the basis of the extensive current use of this technology in the U.S. market. Apart from sliplining, CIPP was the earliest trenchless relining technology used in the U.S. with liners that have been in service for up to 30 years in the U.S. and nearly 40 years in the U.K. A more detailed description of CIPP rehabilitation and related research and testing as related to its use for the rehabilitation of gravity sewer mainlines follows in the rest of this section.

2.2 Cured-in-Place Pipe

2.2.1 Historical and Commercial Background. The first known municipal use of a CIPP lining occurred in 1971 in the relining of a 230-ft (70-m) length of the Marsh Lane Sewer in Hackney, East London. This 100-year old brick egg-shaped sewer had dimensions of 3.85 ft × 2 ft (1,175 mm × 610 mm). The work was carried out by inventor Eric Wood supported by entrepreneurs Doug Chick and Brian Chandler and following this successful trial, they registered the company Insituform Pipes and Structures, Ltd., and proceeded to market the technology and make improvements in the materials, preparation, and application of the technology (Downey, 2010). It should be noted that this first installation was a pull-in-and-inflate liner – inversion was not possible until coated felt was used in 1973. The name and structure of the Insituform family of companies have changed over the years and, over time, other companies have entered the market with similar and competitive technologies.

Eric Wood applied for the first patent on the CIPP process on August 21, 1970 in the U.K. and was granted his first U.S. Patent on the process (U.S. Patent No. 4009063) on February 22, 1977. After granting licenses to British contractors to begin using this new process to rehabilitate sewers in England, Insituform expanded its business in 1976 by granting licenses to contractors in mainland Europe and in Australia. In 1976, Wood began licensing his process to contractors in North America. In 1994, however, the patent for Insituform's inversion process expired and this resulted in new competition in the trenchless rehabilitation industry (Rose and Jin, 2006). Another important patent related to the process concerned vacuum impregnation. The U.S. version of this patent was granted on December 28, 1982 (U.S. Patent No. 4366012). The patent expired on February 5, 2001. U.S. patents on various aspects of the CIPP process are still being sought and granted, e.g., U.S. Patent Nos. 5798013 and 6679966 issued in 1998 and 2004 related to the Brandenburger CIPP lining process and U.S. Patent No. 6942426 related to control of the thermal curing process granted to Kampbell and Cuba in 2005. Insituform has continued to file a variety of patents related to CIPP. These include U.S. Patent No. 4135958, granted on January 23, 1979, which includes a discussion of the light curing of liners and "Method for Remote Lining of Side Connections" (U.S. Patent No. 4434115) issued on February 28, 1984.

In 1976, the first Insituform® liner was installed in the U.S. in a 12-in.-diameter line in Fresno, California. Since then, approximately 19,000 miles (100 million ft) of CIPP liner have been installed by U.S.-based Insituform contractors (Osborn, 2011). The original installations involved an inverted resin-felt composite liner impregnated with polyester resin and cured with hot water. Other companies also started installing CIPP liners in the U.S. through the 1980s and 1990s. These include the Inliner® system which was first introduced in 1986 with over 9 million ft installed since then. Other longstanding liner suppliers that are still operating include National Liner® and Masterliner®.

Other early municipal users of CIPP in the U.S. included the Washington Suburban Sanitary Commission (from 1978) (Hannan, 1990) and the City and County of Denver (from 1984) (Barsoom, 1993). St. Louis, Houston, Baltimore, Little Rock, Memphis, and Indianapolis were among other cities that established early CIPP rehabilitation programs (Iseley, 2011). By 1990, four liner systems were reported to be available in the U.S. (see Table 2-1).

Table 2-1. CIPP Products Available in the U.S. in 1990 and Their Characteristics (Hannan, 1990)

Liner Parameter	Product			
	Insituform	**Paltem**	**In-Liner**	**Insta-Pipe**
Insertion	Inversion using water head	Inversion using air pressure	Winched into place	Floated and winched into place
Materials	Non-woven tube materials and thermoset resin	Woven and non-woven tube materials and thermoset resin	Non-woven tube materials and thermoset resin	Woven and non-woven tube materials & epoxy thermoset resin
Curing Process	Circulating hot water	Circulating hot steam	Circulating hot water	Circulating hot air

As the original patents on key aspects of the CIPP process expired, the breadth of competition increased. Overall, since 1971, it is estimated that about 40,000 miles (210 million ft) of CIPP liners have been installed worldwide. It is by far the leading method for rehabilitating gravity sewers.

2.2.2 The CIPP Process. A CIPP project involves a variety of investigative, planning, and execution phases. Once a line has been identified as needing rehabilitation or replacement, the characteristics of the line and the problems experienced will determine if the CIPP process is a suitable candidate for replacement. CIPP is generally available in diameters of 4 to 120 in., depending (especially in the larger diameters) on the supplier's and contractor's capabilities and experience. Guidance on this type of decision can be found in a variety of published sources on rehabilitation technologies and in the literature from manufacturers and suppliers. Software to support the method selection process also has been developed and a review of such software development can be found in Matthews et al. (2011).

Prior to the relining work, the existing host pipe will be carefully examined (typically using a closed-circuit television [CCTV] camera inspection) and any necessary additional measurements (such as pipe diameter) are collected. Data on pipe depth, soil type, and groundwater conditions will also be gathered.

Based on this data, the following major design parameters would be determined for the use of CIPP in gravity flow sewers:

- Accurate measurements of the internal diameter of the host pipe and any variations in diameter along individual sections of pipe to be relined.
- Any ovality in cross-section dimensions for the host pipe (more than 10% ovality is typically not considered suitable for relining with CIPP because of greatly increased thickness requirements for the liner).
- Whether the host pipe is considered structurally sound (i.e., the lining is not required to support the surrounding soil loading). If the pipe is not considered structurally sound, then additional data regarding the potential soil loading is required.

- The depth of the pipe below the groundwater level (the maximum depth is often used when the groundwater depth varies). This water pressure acts on the outside of the liner through the defects present in the host pipe. The liner thickness is calculated to provide an adequate safety factor against local buckling of the liner under the external water pressure.

The key American Society for Testing and Materials (ASTM) standards pertaining to different types of CIPP liner installation are shown in Table 2-2. The structural requirements of the liner are designed in all of the standards using the procedures specified in ASTM F1216. This is based primarily on formula for the buckling of thin liners restrained within a host pipe. Since a CIPP liner is a thermoset plastic material, it exhibits creep displacements over time under constant load and hence its resistance to buckling over long loading periods is much less than its short-term buckling resistance. This is accounted for in the F1216 design approach by using an estimate of the effective modulus of deformation of the liner over the planned design life of the rehabilitation. This effective modulus value typically is established by using extended (often 10,000 hour) creep and/or buckling tests for the liner/liner material. The measured values are then extrapolated to the typical 50-year design life values. Much research has been carried out and many papers written on the analysis of long-term buckling in such liners. References to a selection of these papers are provided within the text at the end of this section.

Table 2-2. Key ASTM Standards Covering CIPP Installations

ASTM F1216	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
ASTM F1743	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)
ASTM F2019	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled-in-Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)
ASTM F2599	Standard Practice for the Sectional Repair of Damaged Pipe by Means of an Inverted Cured-in-Place Liner

The required thickness of the liner depends on the effective long-term modulus of the liner, its Poisson's ratio, its mean diameter, its ovality, and the chosen safety factor, as well as the external loading conditions provided by the groundwater pressure and/or external soil/traffic loadings. An important factor in the ASTM buckling equation is a correction factor (K) for the degree of buckling restraint provided by the close fit of the liner within the host pipe. However, in typical designs, only a single fixed value (K = 7.0) is used for this parameter.

In most cases, the application of the ASTM F1216 equations results in a conservative design for the required thickness of the liner (Zhao et al., 2005). Conservatism can occur for a variety of reasons, e.g., because the groundwater loading used for design is seldom at the assumed value, because only a limited section of the pipe has the ovality assumed in the design, because the contractor chooses to exceed the minimum required value of liner modulus to make sure of product acceptance, and/or because the buckling restraint factor is conservative for the application considered. Such conservatism may provide a cushion against unacceptable performance in failure modes not considered explicitly in the design process (e.g., local imperfections in the shape of the host pipe) and accommodate liner flaws that are not identified by the quality assurance (QA) or quality control (QC) procedures such as locally weak or porous areas of the liner.

Once the liner materials, liner cross section, curing method, and installation procedure have been decided, the project execution can occur. Most CIPP liners are impregnated with resin (also known as “wet out”) in a factory setting. Typically, a vacuum impregnation process is used to allow the resin to flow more easily into the liner fabric and to more fully saturate it. Prior to 2001, this vacuum impregnation process was covered by a separate Insituform patent and, hence, other CIPP lining companies often used modified procedures to work around the patent. After wet out and during transport to the site, thermally-cured liners are kept in refrigerated storage or in a chilled condition to avoid premature curing of the liner.

Small diameter liners (e.g., for sewer laterals) and very large liners can be wet out at the site. For small liners, this can be for convenience and is facilitated by the relative ease of handling a small diameter liner during wetting out. For large diameter liners, the large liner thickness coupled with the large host pipe diameter means that the lay-flat liner becomes too heavy or too wide to transport when wet out. However, on-site wet out puts an extra burden on QC for the impregnation process.

When the impregnated liner is ready, it is introduced into the host pipe to be relined. This can be done by inversion of the liner along the host pipe using water or air pressure or by pulling the liner into place and then inflating it to a close fit using water or air (see Figure 2-2).

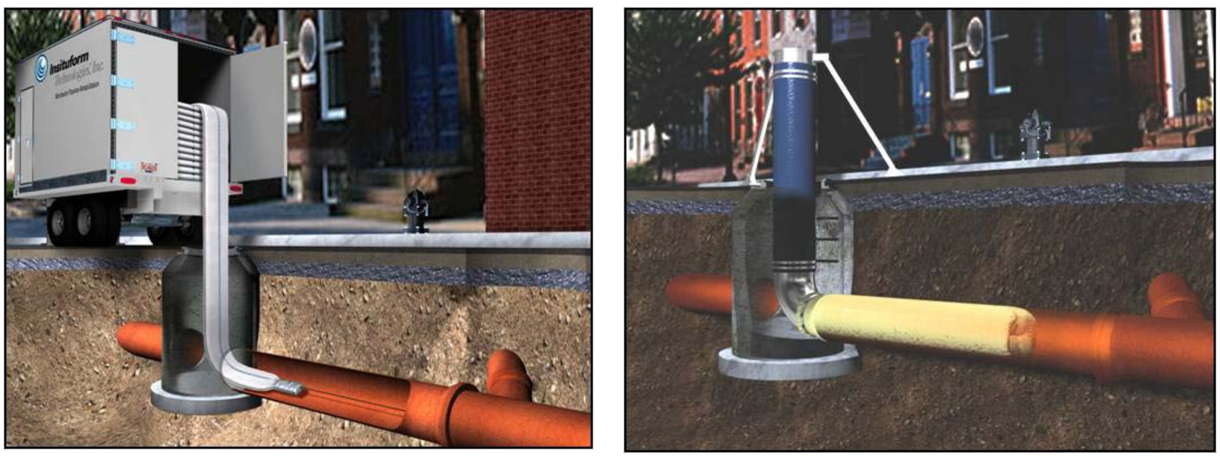

Figure 2-2. CIPP Installation Options: Liner Pull-in (Left) and Liner Inversion (Right) (Courtesy Insituform Technologies, Inc.)

Once the uncured liner is in place and held tightly against the host pipe, the liner is cured using hot water, steam or ultraviolet (UV) light causing the liner resin to become a cross-linked and solid liner material. The curing procedures (e.g., time and temperature curves for thermal curing and UV light intensity and advance rate for UV curing) are important in making sure that the full thickness of the liner becomes properly cured and that thermal or other stresses are not introduced into the liner in a partially cured state.

Following the full curing of the liner and removal of any accessory installation materials, the restoration of lateral connections can be carried out. These are typically simply restored by cutting openings at the lateral connection. A dimpling of the liner can aid in the identification of the position of the connection, but such dimpling is less identifiable in liners with higher strength fabrics. If the CIPP liner has a significant annular space and if the connection is not grouted or sealed to the sewer lateral, then this connection can be a source of continued infiltration into the mainline sewer. Research into the magnitude of this effect can be found, for example, in Hall and Matthews (2004), Bakeer et al. (2005), and Bakeer and Sever (2008).

Figure 2-3 highlights the main differences in CIPP technologies available today based on tube construction, method of installation, curing method, and type of resin. The original CIPP product was a needled felt tube, impregnated with polyester resin that was inverted into a sewer through a manhole and cured using hot water. This product is still used for gravity sewers.

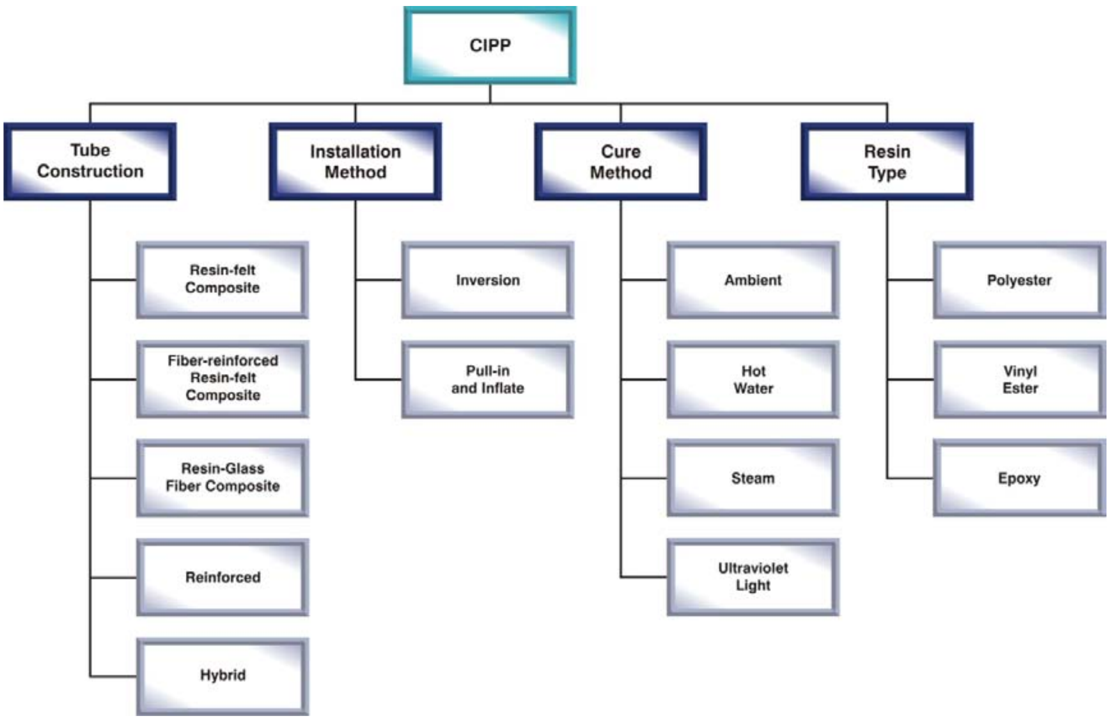

Figure 2-3. Summary of Common CIPP Technologies

The following sections describe the major generic technology variants for CIPP rehabilitation in terms of the tube construction, choice of resin, cure method, and insertion method. Appendix A in the companion EPA report (Sterling et al., 2010) contains datasheets provided by some of the most established vendors for specific products representing these variants. Due to the wide range of manufacturers and contractors offering CIPP rehabilitation, it was not possible to represent all products with individual datasheets in that report.

2.2.3 Installation Method: Inversion or Pull-In. From the first installation of CIPP in 1971 until 1973, the installation method involved a pull-in-and-inflate procedure. In this method, the uncured liner is pulled into position directly as shown in Figure 2-2. An outer layer confines the resin during impregnation and pull-in. This layer remains between the cured CIPP liner and the host pipe, which reduces the potential for interlock between the resin and the host pipe, but fully confines the resin, thus avoiding the potential for blocked laterals and washout of the resin by high groundwater inflows. Either an internal hose (called a calibration hose) inflates the liner within the host pipe and holds it under pressure until the liner is cured, or the ends are tied or plugged and the liner is simply inflated while curing.

In 1973, coated felt was introduced allowing the liner inversion process to be used (see Figure 2-2). In this process, the impregnated but uncured liner is forced by water or air pressure to turn itself inside out along the host pipe section to be lined. Since there is a sealing layer outside the felt tube, this liner can be

9.0: SUMMARY AND RECOMMENDATIONS

9.1 Summary

9.1.1 Tasks to Date. This retrospective evaluation pilot study grew out of discussions among the research team during the early stages of the overall project, Rehabilitation of Wastewater Collection and Water Distribution Systems, which was to perform a comprehensive review and evaluation of existing and emerging rehabilitation/ repair technologies for wastewater collection and water distribution systems and to conduct demonstrations of innovative sewer and water rehabilitation technologies. The need for such information was reinforced by the participants at an international technology forum held as part of the project activities in September 2008.

The initial effort in terms of retrospective evaluation was planned as a pilot study. It targeted CIPP installations only, concentrated on quantitative testing of the CIPP liners, and used samples from both large and small diameter sewers in two cities, Denver and Columbus. For the small diameter (8 in.) sewers in each city, a 6-ft section of pipe and liner was exhumed from a convenient site. For the larger diameter sewers (36 to 48 in. diameter), CIPP liner samples were cut out from the interior of the pipe and the liner patched in-situ.

Testing on the liners included: thickness, annular gap, ovality, density, specific gravity, porosity, flexural strength, flexural modulus, tensile strength, tensile modulus, surface hardness, glass transition temperature, and Raman spectroscopy. In addition, environmental data was gathered as appropriate to each retrieval process including: external soil conditions and pH, and internal waste stream pH. The findings from the testing conducted so far are summarized in the following subsections.

As a companion to the pilot studies in Denver and Columbus, an international scan was made of the approaches used by sewer agencies overseas to oversee their CIPP rehabilitation activities and to track the subsequent performance of installed liners. A variety of approaches are used – more in the area of QA/QC at the time of installation than a planned program of follow up to track deterioration of rehabilitation technologies over time.

Given the insights provided by the pilot studies in Denver and Columbus and the international scan, recommendations are made for an expansion of the retrospective evaluation study to create a broader national database that would help to define the expected life of sewer rehabilitation technologies.

9.1.2 CIPP Liner Condition Findings to Date. All of the samples retrieved from the four locations (five individual liners) involved in the pilot study testing were in excellent condition after being in use for 25 years, 23 years, 21 years, and 5 years. Four of these liners had already been in service for approximately half of their originally expected service life of 50 years. Two sets of coupons out of six sets from five sites had a flexural modulus value that was lower than the originally specified value, but this cannot be tied directly to deterioration of the liner over time. In the case of the Denver 48-in. upstream liner, in particular, it appears likely that the poor physical test properties may have resulted from variability within the liner rather than a change over time since the second set of coupons tested produced much higher test values. Some indication of a softening of the interior surface of the liner that was exposed most to the waste stream (interior invert and spring lines) relative to the interior crown location and that of the exterior surface of the liner was noted in much of the surface hardness testing. However, it is not yet possible to isolate any effect on the resin liner itself from the hydrolysis of the handling layer that was originally present on the inside surface of the CIPP liner. For newer CIPP liners, a different handling/inner layer is used with greater durability.

In Denver, in CCTV inspections of nearly 5,800 ft of CIPP liners installed at the same time as the retrieved sample, a few specific defects were noted at different locations. Most of these appeared to relate to poor practices in cutting or reinstating lateral connections and only three appeared potentially unrelated to lateral reinstatement issues. These were a local liner bulge, a separation of the liner from the wall of the pipe, and a local tear in the liner.

Overall, there is no reason to anticipate that the liners evaluated in this pilot study will not last for their intended lifetime of 50 years and perhaps well beyond.

9.1.3 Initial Findings on Value of Various Physical Testing Approaches. The testing carried out on the CIPP liners and the data collected about the site and environment in which they were used was intended to try to capture any evidence of liner deterioration and possible reasons for such deterioration. The potential value of each type of testing to broader retrospective evaluation studies is briefly identified below.

9.1.3.1 Soil Conditions. Soil testing, including soil type, gradation, density, moisture content, pH, etc., would only be available during a dig-up of a pipe or liner sample. The data could help to identify if the host pipe had uniform soil support or was developing external voids due to leakage into the pipe. The data also can provide a background on external conditions that may relate to corrosion/deterioration of the liner and/or the host pipe. For example, for steel, cast iron, and ductile iron pipes, a number of tests (e.g., soil resistivity, pH, redox potential, presence of sulphates and chlorides, etc.) have been proposed for determining the expected rate of external corrosion of uncoated pipelines. The data is not difficult to collect when an excavation is made and provides a basis to answer questions about external pipe conditions if such questions arise. Soil samples taken during excavation, but not tested unless needed could also provide important backup for later testing as needed, but moisture content and pH at a minimum should be determined when soil sampling is conducted.

9.1.3.2 Visual Inspection. A thorough visual inspection is important to provide the overall appearance of the liner and any evidence of surface changes such as the deterioration or loss of the internal sealing layer, evidence of leakage (e.g., discoloration), or porosity. As with any visual condition assessment using a standard protocol for recording the findings is important to create useful results in a broad database.

9.1.3.3 Thickness and Annular Gap. The thickness of the liner is a critical parameter for the resistance of the liner against a variety of potential failure modes. In particular, it indicates (in conjunction with other physical liner properties) whether the liner currently meets the requirements of ASTM F1216 in terms of its resistance to external buckling. Annular gap measurements provide information about potential shrinkage or displacement of the liner away from the host pipe. A significant annular gap may allow longitudinal movement of the liner in the pipe and increase the possibility of liner buckling under external pressure. A significant annular gap also increases the potential for water migration between the host pipe and the liner. If lateral connections and/or liner terminations at manholes are not sealed, then infiltration into the sewer system can occur.

Annular gap can be measured easily and effectively with feeler gauges. Thickness can be measured using calipers within the area of a sample or a ruler at the edge of the sample. Ultrasonic measurements can also be made when only one side of the sample is available and are potentially very useful both for retrospective evaluations and for QA/QC of new installations. In this pilot study, poor success was experienced with the ultrasonic measurements. They correlated with physical measurements on laboratory-prepared thinner liner samples, but did not return useful results on the field-installed or thicker liners. The problem is thought to be related to the dissipation of the acoustic signal in the resin-fiber

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Rehabilitation of Wastewater Collection and Water Distribution Systems

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May 2009

State of Technology Review Report
on
Rehabilitation of Wastewater Collection and Water Distribution Systems

by

Dr. Ray Sterling
Trenchless Technology Center at Louisiana Tech University

Lili Wang, P.E.
Battelle Memorial Institute

Robert Morrison, P.E.
Jason Consultants, LLC

Contract No. EP-C-05-057
Task Order No. 58

for

Dr. Ariamalar Selvakumar
Task Order Manager

U.S. Environmental Protection Agency
National Risk Management Research Laboratory
Water Supply and Water Resources Division
2890 Woodbridge Avenue (MS-104)
Edison, NJ 08837

National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

March 2009

Table 3. Main Defects in Gravity Sewer Systems by Sewer Material

Material	Potential Problem/Defect
Vitrified Clay	• Cracks/broken pipe • Root intrusion • Grease build-up • Joint misalignment and/or leakage
PVC	• Excessive deflection • Grease build-up • Joint misalignment and/or leakage • Grade and/or alignment • Lateral connections
Concrete	• Internal or external corrosion of concrete and/or reinforcement • Cracks and fractures • Grease build-up • Joint misalignment and/or leakage • Root intrusion • Missing wall sections • Open joints
Cast Iron/Ductile Iron	• Internal corrosion • External (pit) corrosion • Circumferential breaks • Grease build-up • Joint failure and/or leakage • External corrosion • Longitudinal break/split • Corporation cock failure • Leaking laterals
Concrete with Liner	• External corrosion of concrete and/or reinforcement • Liner failure or separation (including weld failure) (leading to internal corrosion) • Grease build-up • Root intrusion • Cracks • Joint misalignment and/or leakage • Capacity
Prestressed Concrete Cylinder Pipe / Concrete Cylinder Pipe	• Corrosion of prestressing wires • Grease build-up • Root intrusion • External corrosion • Joint leakage • Internal corrosion • Pressure capacity
Polyethylene	• Excessive deflection • Grease build-up • Root intrusion • Grade and alignment • Leaking laterals
Pressure Only	• Pressure capability

experience). This means that systems that have gone through their learning curve and become highly reliable techniques may exhibit a more variable performance as the marketplace widens. When, and if, this happens, it is important that QA/QC procedures are in place and used effectively – both to provide a high performance and long-lived product and allow contractors who provide quality to compete fairly with those willing to cut corners to win jobs at a lower cost.

In summary, better QA/QC-related technologies and procedures are an important part of providing improved technologies for water and wastewater system rehabilitation, especially as the governing patents expire and proprietary systems become commodity products.

2.3 Decision Support for Choice of Rehabilitation vs. Replacement and Choice of Rehabilitation Systems

Even with a comprehensive set of fully effective rehabilitation technologies, many issues would still remain about how and when to apply the technologies. According to an EPA report (2007a), "System rehabilitation is the application of infrastructure repair, renewal, and replacement technologies in an effort to return functionality to a drinking water distribution system or a wastewater collection system." The circumstances that affect rehabilitation planning and prioritization include the current condition of the system, the extent of critical repair needs, the availability of funding for rehabilitation work, and the ability to inspect and assess the condition and deterioration rate of each element of the system. The broad activities that determine system-wide planning follow asset management principles and life cycle analyses that are being increasingly employed in water and wastewater systems in the U.S. These principles mean that rehabilitation approaches may include partial rehabilitations to extend performance life as well as full structural rehabilitations to reset the life cycle performance clock. Which one is most appropriate and cost effective depends on the deterioration rate of the asset, the ability of the rehabilitation method to extend performance life, and the cost and social/environmental impact of the method against competing approaches. Unfortunately, most of these parameters are poorly understood and require a significant commitment to ongoing inspection and condition assessment within a system before accurate quantitative behavior parameters can be established. The issues relating to condition assessment and system-wide asset management are being addressed under separate task orders within the EPA program. There remain several issues that apply directly to the selection of rehabilitation methods that have a strong bearing on the cost effectiveness of rehabilitation programs and their impact on traffic and environment in the areas where the rehabilitation work is needed.

The key decision needs are to determine:

- Whether to renovate or replace (via trenchless or open-cut construction methods) water and wastewater pipes
- Which of the commercially available rehabilitation methods are suitable for a particular application

Open-cut replacement has been the standard practice in the past, but its preferential use over trenchless techniques has been significantly diminished in the past two decades – particularly in the wastewater sector. Awareness of the indirect and social costs associated with utility work in congested urban areas (i.e., traffic congestion, loss of pavement life, business impacts, noise, and dust) have encouraged the use of "full" costing approaches in determining the choice between open-cut replacement and trenchless rehabilitation or replacement methods. Often, however, the choice of trenchless technologies is driven by acknowledged environmental constraints and expected public pressure rather than by a quantitative calculation of full direct, indirect, and social costs. Also, differences in social and indirect impacts are often addressed in work requirements that reduce or eliminate any cost advantage to open cut in

REPORT ON PROPOSALS

The Plumbing Technical Committee
Report on Proposals for
Public Review and Comment

BUILDING
IAPMO TRUE
CONSENSUS

IAPMO

International Association of Plumbing and Mechanical Officials

4755 East Philadelphia Street
Ontario, California – USA 91761-2816

Ph: 909.472.4100 | Fax: 909.472.4150
http://www.iapmo.org

To: IAPMO Members and Other Interested Parties

Date: August 2016

Enclosed is your 2016 Report on Proposals (ROP). These proposals were presented to the Plumbing Technical Committee who met in Denver, Colorado on May 2 - 4, 2016.

At the Annual Education and Business Conference, which will be held September 25 – 29, 2016, in Albuquerque, New Mexico, IAPMO members and others attending the conference will have the opportunity to discuss and debate these proposals during the Assembly Consideration Session.

All comments for consideration by the Technical Committee should be submitted to IAPMO by January 3, 2017.

On May 1 – 5, 2017, the Technical Committee will consider all of the comments received in response to the actions contained within the ROP and will vote on whether to modify any of their previous actions.

Thereafter, from September 24 – 28, 2017, IAPMO will be holding its 87th Annual Education and Business Conference in Anchorage, Alaska. The IAPMO voting membership present at that conference will then vote on the actions taken by the Technical Committee during the Technical Meeting Convention. Please visit the IAPMO web site at www.iapmo.org for more information on the consensus code development process and timeline.

Following the ROP is a preprint of the Uniform Plumbing Code, as it would appear in the event that all of the proposals accepted by the Plumbing Technical Committee in May 2016 are ultimately approved for inclusion in the final version of the 2018 edition of the Uniform Plumbing Code. This preprint is provided to you as a courtesy. All changes are tentative and subject to revision. This document is not to be considered the final version of the 2018 Uniform Plumbing Code. Specific authorization from IAPMO is required for republication or quotation.

THE BALLOT RESULTS ON ALL COMMITTEE ACTIONS ON PROPOSALS PASSED EXCEPT FOR THE FOLLOWING THREE ACTIONS:

ITEM 186 **FAILED TO ACHIEVE THE NECESSARY 2/3 AFFIRMATIVE VOTE OF RETURNED BALLOTS.**
ITEM 192 **FAILED TO ACHIEVE THE NECESSARY 2/3 AFFIRMATIVE VOTE OF RETURNED BALLOTS.**
ITEM 211 **FAILED TO ACHIEVE THE NECESSARY 2/3 AFFIRMATIVE VOTE OF RETURNED BALLOTS.**

In accordance with Section 4-3.5.2 where the technical committee actions failed to achieve the necessary 2/3 affirmative vote, a public comment is requested for each proposal listed above. All proposals listed above shall be reconsidered by the technical committee as an automatic public comment.

SUBMITTER: Bill LeVan
Cast Iron Soil Pipe Institute

RECOMMENDATION:
Revise text as follows:

713.0 Sewer Required.

715.3 Existing Sewers. Replacement of existing building sewer and building storm sewers using trenchless methodology and materials shall be installed in accordance with ASTM F1216. Cast iron soil pipes and fittings shall not be repaired or replaced by using this method aboveground or belowground.

SUBSTANTIATION:
The ASTM and CISPI standards for cast iron soil pipes and fittings prohibit the repair of the cast iron soil pipes and fittings by any means. ASTM F1216 allows for repair of partially deteriorated piping and would conflict with the manufacturer's instructions and the product standards.

COMMITTEE ACTION: Accept as Submitted

TOTAL ELIGIBLE TO VOTE: 29

VOTING RESULTS: AFFIRMATIVE: 29

02-CTS-5

METHODS FOR COST-EFFECTIVE REHABILITATION OF PRIVATE LATERAL SEWERS

by:

Raymond L. Sterling
Jadranka Simicevic
Trenchless Technology Center, Louisiana Tech University

Ahmad Habibian
Rick Nelson
Black and Veatch, Inc.

Roger L. Tarbutton
Johnson County, KS

Alan Johnson
Wade and Associates, Inc.

2006

WERF

A.2.1 Background

In Prince William County Service Authority (PWCSA), VA, the privately owned laterals extend from the house to the ROW. The average width of the ROW is about 60э. Early construction standards did not require cleanouts on laterals, which has since been remedied. Before the pilot project, the cleanouts existed on 12 out of 20 laterals, some near the house, others at the ROW. The cleanouts were, however, required to provide access into the lateral for relining of upper laterals, and were therefore installed in the course of the project on the remaining eight laterals near the house.

A.2.2 Initial Steps Preceding Lateral Relining

CCTV Inspection of Mainlines. The agency performed initial CCTV inspection of mainlines with typical mainline CCTV equipment (Aries). This allowed for in-house documentation of the exact location of lateral connections with the mainline. The inspection also revealed that many connections were hammer tap-ins[8] (Figure A-16). Frequently the lateral intruded into the mainline from 1-4".

Figure A-16. Hammer Tap-ins.

CCTV Inspection of Laterals. A lateral CCTV push type camera (LMK® Lateral Push Camera) was inserted into the lateral through the cleanout and directed towards the mainline and the house. All laterals made of Orangeburg materials had failed: all were demonstrating various levels of deformation and in seven cases the condition was so pronounced that it inhibited the passage of the camera. The contractor was able to re-round two of the pipes enough to allow passage of the camera as well as the CIPP materials. The other five laterals were open cut spot-repaired in 10-12э long sections and replaced with sections of PVC pipe. The results of lateral CCTV inspection (Table A-6) clearly showed that all laterals needed rehabilitation.

Table A-6. Prince William Service Authority, VA, 2003: Condition Assessment of Laterals.

Pipe Type	Laterals	Condition
Orangeburg	16	All pipes had failed with blistering and pipe material delaminating in layers.
Cast iron	2	Pipes had severe mineral buildup over time, which reduced their hydraulic capacity from 4" pipes to 2" pipes. These pipes have reached the end of their life (40 years) and would continue to decay.
PVC	2	These pipes were in good condition, but not the connection with the mainline

[8] *Hammer tap-ins refer to construction practices where the contractor making the connection of the lateral to the mainline chooses to use a hammer or similar tool to knock an opening into the sewer mainline and stick the lateral pipe into it. The opening becomes a pathway for groundwater to enter into the sewer system.*

CIP Relining of Mainlines. The Performance Liner® CIPP system was utilized for relining mainlines. This air inversion and steam curing process was supplied by LMK Enterprises, Inc. (the same manufacturer that would supply the CIP T-liner). Lateral connections were re-established using typical, trenchless lateral connection procedures. Once they were opened, the system was ready and prepared for the lateral relining process.

Installation of Cleanouts on Laterals Where Necessary. Hydro excavation was utilized to make excavations for new cleanouts (Figure A-17). The soil was cut with a water jet and vacuumed out with a 6" tube connected to the vacuum truck. The pit size was about 18" in diameter. Such a small excavation was adequate because a lateral saddle assembly product would be used, which snaps onto an existing lateral pipe and requires only a small foot print compared to a typical cleanout installation. It took on average 60 minutes to complete one pit.

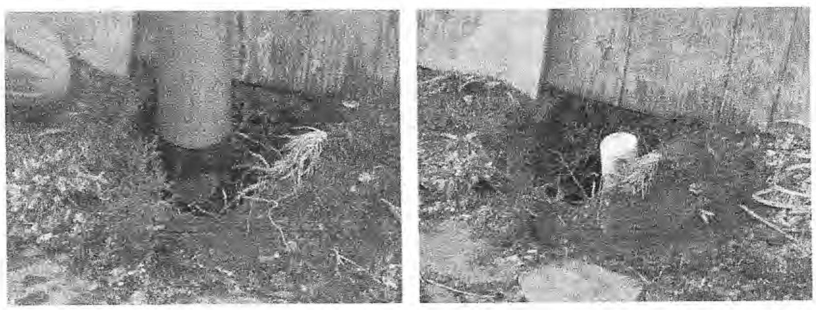

Figure A-17. New Cleanouts. Left: Pit Hydro Excavating. Right: Installed Vac-A-Tee® Cleanout.

For each cleanout, a piece of 4" PVC pipe was used as a riser from the lateral (Figure A-18). It was attached to the lateral using a PVC saddle assembly (4" Vac-a-Tee®) coming up to grade. The water tightness was accomplished by applying a special resin that cured in 30 minutes providing a structural seal. New cleanouts were filled with water to perform a hydrostatic test verifying a non-leaking connection.

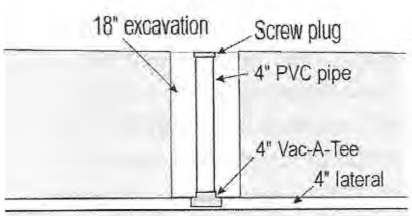

Figure A-18. Schematic of Installation of New Cleanouts.

A.2.3 Construction

Mobilization. The construction crew mobilizing from Chicago arrived on-site with a Harben® 10,000 psi water jett, a reefer unit for on-site wet out, a steam generating truck and other support equipment.

Lateral Pipe Cleaning and Inspection. Cleanouts provided access to clean and inspect the lateral pipes (Figure A-19). High-pressure water and mechanical cutters were used to remove tree roots, blisters in the orange burg and tuberculation from the cast iron. The cleaning process was done with caution as not to cause complete failure of the pipe due to significant deterioration. Each lateral was re-inspected after cleaning to ensure the pipe was adequate for liner insertion.

Once the lines were prepared, a small lateral CCTV camera was inserted through the cleanout near the house into the lateral (Figure A-20). The camera was pushed downstream close to the mainline. The camera would provide accurate robotic positioning of the T-liner and document the inversion process on a video recording equipment.

Figure A-19. Cleanout Ready for Pipe Cleaning.

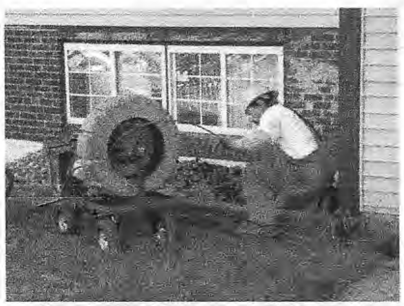

Figure A-20. Inserting the Lateral CCTV Camera into the Lateral.

Liner Preparation. Liners used for rehabilitation were T-shaped. The tube had a short cylindrical section (16") fitting the mainline pipe diameter stitched to the long section fitting the lateral pipe diameter. The T-shaped liner was then surrounded by a T-shaped translucent bladder forming a liner/bladder assembly. The liner/bladder assembly's were constructed at the LMK Manufacturing Facility in Ottawa, IL.

The truck was used as a mobile wet-out unit (Figure A-21). The red hose shown in the picture is the launching device. It is a flexible steam inflatable device that works in all mainline pipe sizes. The resin was mixed first, then poured into the tube and vacuum impregnated (Figure A-22). The mixed resin was poured into the tube through the end that will be installed upstream, near the house. The opposite end of the tube with a short mainline section was connected to a vacuum hose. The resin was spread inside the tube utilizing vacuum impregnation. The person in the figure on right was checking the vacuum impregnation making sure that the thickness of the saturated tube was as specified.

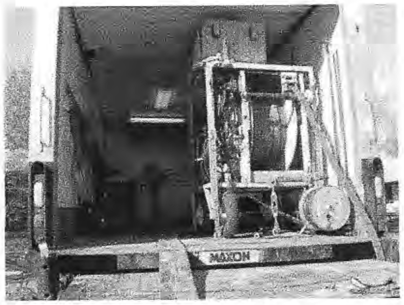

Figure A-21. Truck Used as a Mobile Wet-out Unit.

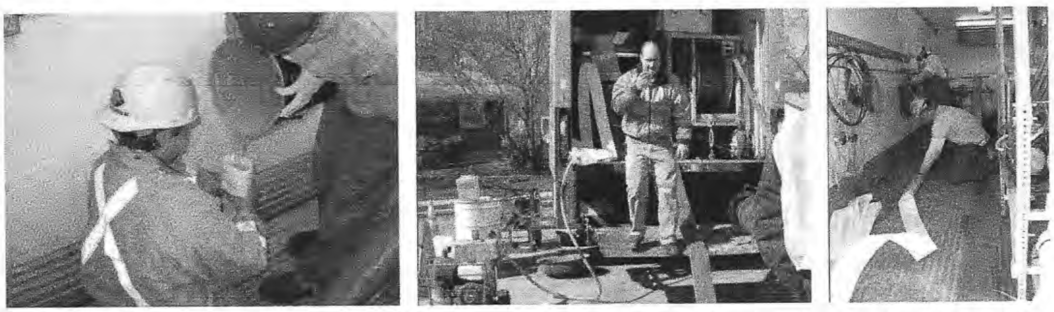

Figure A-22. Liner Impregnation with Resin. Left: Pouring the Resin into the Tube. Middle: Vacuum Hose Connected to the Tube. Right: Vacuum Impregnation.

Loading of the Launcher. The liner/bladder assembly containing the resin-saturated tube was next pulled into the launcher (Figure A-23). Both tubes were laid out on the ground next to the truck. Inside the truck, one end of the launcher (through which a cable was stringed) was affixed onto a piece of pipe and the assembly connected to the cable. As the person outside was pulling the cable, the tube was entering the launcher. The resin remained on the inside of the tube. The loading of the launcher was completed by affixing the short mainline section onto the launcher (Figure A-24). Hydrophilic bands were added.

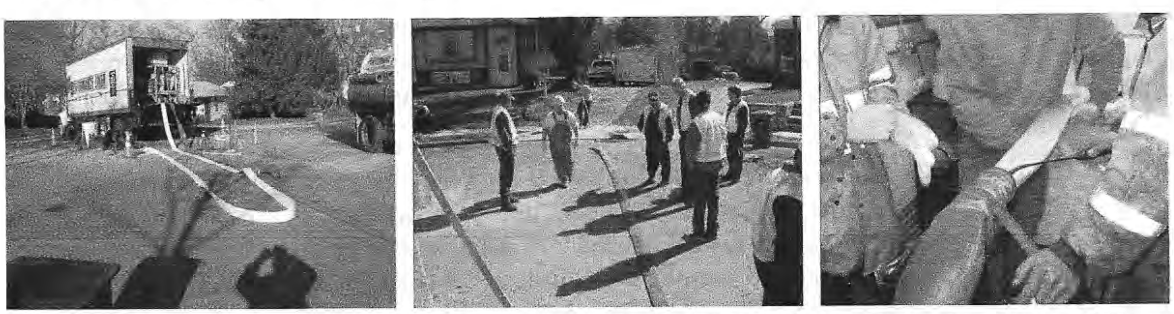

Figure A-23. Pulling the Liner/Bladder Assembly into the Launcher. Left: Both Tubes Laid Out on the Ground. Middle: Pulling the Cable Inside the Launcher. Right: The Assembly Entering the Launcher.

Figure A-24. Completing the Loading of the Launcher.

Inversion of the Liner. The loaded launcher was first positioned inside the mainline to enable inversion of the liner/bladder assembly into the lateral (Figure A-25). The end of the launcher opposite of mainline section was inserted through the manhole first. Once the launcher was completely inside the mainline, it was winched past the lateral connection until its end with the mainline section was positioned exactly at the connection. The CCTV camera inside the lateral was used to monitor the positioning of the launcher.

Air pressure was applied causing the liner/bladder assembly to invert up into the lateral pipe, on some laterals as far as 85э (Figure A-26). Once in place, the air pressure held the bladder/liner assembly tightly against the lateral pipe.

Figure A-25. Positioning of the Launcher. Left: Insertion through the Manhole. Right: Lateral CCTV Camera.

Figure A-26. Air Inversion of the Liner/Bladder Assembly the Lateral.

Resin Curing. Steam was used for resin curing (Figure A-27). The steam tank was connected with the bladder and steam introduced into it. The resin curing took about 30 minutes. During that time, the steam was circulating through the bladder and exiting out of the lateral at the cleanout near the house. The upstream end of the bladder was left slightly open. Once the resin curing was completed, the bladder was pulled out.

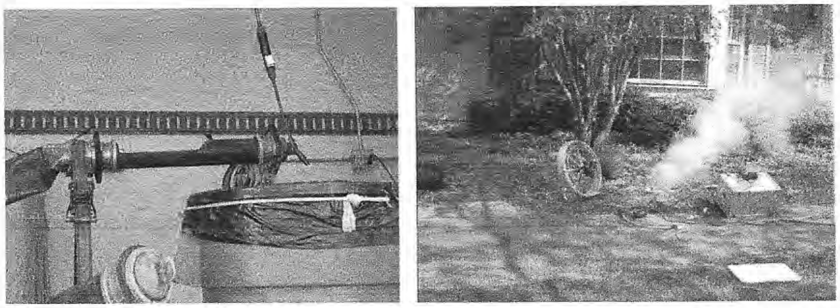

Figure A-27. Resin Cure. Left: Steam Hose Connected to the Bladder. Right: Steam Exiting at the Cleanout Near the House.

Post CCTV Inspection. The installed liner was inspected with both lateral and mainline CCTV. Figure A-28 shows the relined lateral connection viewed from inside the mainline.

Figure A-28. Installed T-liner at the Lateral-to-mainline Connection (a View from the Mainline).

A.2.4 Overview of Performed Work

Table A-7. Prince William Service Authority, VA, 2004: Overview of Performed Work.

Address	Length—Total	Length—Relined	ID
9100 Amherst Court	82.0ɜ	72.0ɜ	4"
9101 Amherst Court	82.0ɜ	85.0ɜ	4"
9102 Amherst Court	82.0ɜ	85.0ɜ	4"
9103 Amherst Court	85.0ɜ	81.0ɜ	4"
9104 Amherst Court	78.0ɜ	77.0ɜ	4"
9105 Amherst Court	24.0ɜ	50.4ɜ	4"
9106 Amherst Court	58.0ɜ	58.0ɜ	4"
9107 Amherst Court	58.0ɜ	57.3ɜ	4"
9108 Amherst Court	54.0ɜ	55.0ɜ	4"
7584 Amherst Drive	79.0ɜ	81.0ɜ	4"
7585 Amherst Drive	80.0ɜ	80.4ɜ	4"
7586 Amherst Drive	49.0ɜ	46.0ɜ	4"
7587 Amherst Drive	84.0ɜ	81.4ɜ	4"
7588 Amherst Drive	58.0ɜ	58.0ɜ	4"
7589 Amherst Drive	70.0ɜ	69.0ɜ	4"
7590 Amherst Drive	56.0ɜ	52.5ɜ	4"
7591 Amherst Drive	50.0ɜ	49.0ɜ	4"
7592 Amherst Drive	58.0ɜ	53.0ɜ	4"
7593 Amherst Drive	56.0ɜ	54.0ɜ	4"
7594 Amherst Drive	54.0ɜ	53.0ɜ	4"

A.2.5 Cost Analysis

Table A-8 summarizes the project cost. By mutual agreement, the agency paid only for the installation of four cleanouts and the installer for the remaining four cleanouts.

Table A-8. Prince William Service Authority, VA, 2004: Summary of Costs.

Activity	Unit Price	Quantity	Amount	Average
CCTV inspection of laterals (in-house by the agency's crew)		20 laterals		
Cleanout installation	$1,500/lateral	8	$12,000.00	
Point repair (open cut)	$5,800 /ea	5	$29,000.00	
T-Liner (includes cleaning and post-CCTV inspection)	$4,471.32/lateral	20 laterals	$89,426.40	
TOTAL—Excluding cleanouts			$118,426.40	$5,921.32
TOTAL—Including cleanouts		20 laterals	$130,426.40	$6,521.32

A.2.6 Project Duration

Time frame for the project, including the excavation and repairs of the failed five laterals took 10 working days. It took about three hours on average to complete installation of each T-liner (Table A-9). The Illinois field crews were able to rehabilitate two laterals per day. There were some learning experiences during the project but overall the construction process went smoothly.

The following were the challenges:

- The Orangeburg pipe material had blistered and delaminated, in some cases it had totally failed. The contractor was able to round out some of the Orangeburg material enough to allow for installation of the CIPP materials but prior to the contractor performing his work, five failed laterals required excavation and point repairs to be made
- The Vac-a-Tee saddles did not conform to the irregularity of the outside diameter of the cast iron pipe due to exterior corrosion. The exterior of the cast iron was very rough with heavy build-up making the outside diameter larger than normal. The standard operating practice for VAC-A-Tee saddles on cast iron has since been amended to sandblast the portion of pipe where the saddle will be set.
- Obtaining permission from all homeowners prior to beginning work
- Public relations (described in the following paragraph)

Table A-9. Prince William Service Authority, VA, 2004: Duration of Construction Work on Each Lateral.

Activity	Average Duration
CCTV inspection of laterals (three person crew)	45 min
Mobilization	15 min
Lateral cleaning. Simultaneously: In-situ liner preparation	45 min
Liner inversion and resin curing (20-30 min)	60 min
Post-CCTV, and demobilization	15 min
TOTAL	3 hrs

A.2.7 Public Relations

The Service Authority worked diligently on informing the public about the coming project. This paragraph shows the following prepared by the agency:

- Door hangers—One of the steps was preparing a door hanger, which explained the nature of the problem and how the relining of laterals would provide the solution (Figure A-29
- Letter to homeowners (Figure A-30)
- Access agreement allowing the crew to enter private property (Figure A-31)

A.2.8 Effectiveness of Rehabilitation

Flow monitoring equipment has been installed in several manholes collecting flow data, however, flow data analysis was still not completed at the time of this report submission. The final FM data analysis report is due in June 2005. From observation of flows however it is apparent that the rehabilitation was very effective in stopping the infiltration. The agency could not see large spikes in the flows due to rain induced infiltration and inflow after installation and believes that the system has completely sealed the relined connections and laterals.