

electro^oscan^{inc.}

Focused Electrode Leak Location (FELL) Pipeline Assessment By Major Pipe Materials



Pipeline Quality Assurance Testing Dig & Replace Construction Trenchless Rehabilitation



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FELL PIPE ASSESSMENT BY PIPE MATERIAL

New standards have emerged to provide fast, accurate, independent, unbiased, and unambiguous assessments of new & existing pipe watertightness. Using Focused Electrode Leak Location (FELL), agencies and owners can now assess watertight connections of joints and service connections, with data accuracy within 3/8th of an inch (1cm) and defect severities expressed in common units of measure of Gallons per Minute (GPM) to meet the expected level of water tightness needed for a structurally sound and long-lasting pipe.

Common FELL Assessments By Pipe Materials

ABS	Acrylonitrile-butadiene-styrene	PCCP	Prestressed Concrete Cylinder Pipe
ACP	Asbestos Cement Pipe	PE	Polyethylene
BRK	Brick	PFP	Pitch Fiber Pipe
CMLSP	Cement Mortar Lined Steel	PP	Plastic Pipe
CON	Concrete	PVC	Polyvinyl Chloride
CIPP	Cured-In-Place Pipe	RCP	Reinforced Concrete Pipe
DIP	Ductile Iron (w/Protector 401)	RPM	Reinforced Plastic Mortar
FRP	Fiberglass Reinforced Pipe	RTR	Reinforced Thermosetting Resin
FRPM	Fiberglass Reinforced Polymer	SIPP	Spray-in-Place Pipe
GRP	Glass Reinforced Pipe	SPR	Spiral Wound Pipe
HDPE	High Density Polyethylene	TC	Terracotta or Clay Pipe
ORP	Orangeburg Pipe	VCP	Vitrified Clay Pipe
PB	Polybutylene		

PRE-REHABILITATION



Asbestos Cement Pipe



High Density Polyethylene Pipe



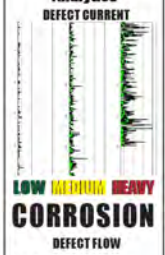
Prestressed Concrete Cylinder Pipe



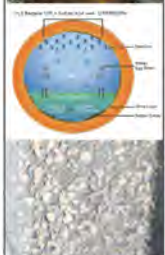
Vitrified Clay Pipe

Electro Scan FELL is unique in its ability to geometrically map the remaining wall, i.e. corrosion of ACP.

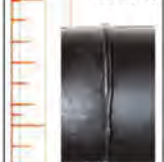
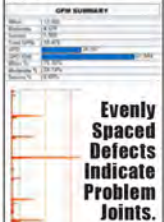
Finding & Measuring Pipe Corrosion Using Electro Scan's Patented Data Analytics



As demonstrated by independent benchmarks, since acoustic and transient pressure sensors are unable to provide detail geometric assessments of pipe walls, and therefore unable to estimate remaining pipe walls, Electro Scan represents a game changing solution to assess & prioritize ACP.



Poor mechanical or fused joints are the Achilles heel of HDPE, and not seen by CCTV cameras or heard by acoustic data loggers or sensors. But found & quantified by FELL in accordance with ASTM F2550.



Electro Scan represents the only technology able to reliably & consistently find & measure leaks in GPM. While other devices may attempt to locate corroded wire mesh that may or may not indicate a weakness in the pipe wall, Low Voltage Conductivity represents a game-changing solution to provide unbiased leak locations & severity for each defect.



Superior to acoustic and electromagnetic sensors, Electro Scan's Low Voltage Conductivity detects leaks other technologies miss.

How PCCP Fails?



It doesn't matter whether you evaluate VCP from the outside or inside of a pipe, CCTV, Laser, LIDAR, Sonar, GPR, or Acoustic, are not able to detect or measure defect flows.



Electro Scan's FELL is the only technology, representing a Non-Destructive Test (NDT) able to follow a 90° pipe bend to locate a pathway for water to enter or exit a pipe.

By measuring the change in current and the amount of flow, the size of the opening can be computed and translated into an estimated GPM.



Open trench evaluation of FELL, located defects missed by CCTV, exactly showed three matching leaks due to fittings that were never tightened. Just one of over a dozen tests proving FELL's superiority.

POST-REHABILITATION



Cured-In-Place Pipe



Grout



Spray-In-Place Pipe



Spiral Wrap Pipe

CIPP liners may not be watertight and defects not seen by certified operators using CCTV cameras. As a result, ASTM F2550 should be added to CIPP specifications to ensure pipe quality & integrity.

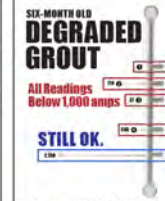
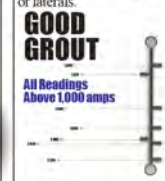


- RECOMMENDED USE:**
- To Find & Quantify Leakage From:
 - Accelerant Burns
 - Accidental Cuts
 - Bad Service Reconnect
 - Bad Lateral Liners
 - Blisters
 - Delamination
 - Defective Epoxy
 - Equipment Damage
 - Foreign Objects
 - Pinholes
 - Poor Curing
 - Overcooking
 - Stretching
 - Top-Hat Defects
 - Wet-Out Failures
 - Wrinkles, including: Buckling, Fins, Folds, Lifts, and Ridges

FELL is now preferred over using traditional packers to test joints for water tightness, due to FELL's Non-Destructive Testing (NDT) of joints, laterals, and cracks.

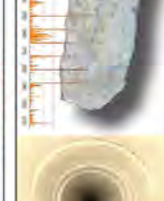
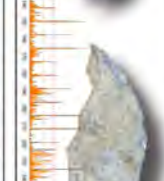
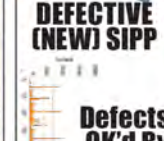


Unlike air testing, FELL does not force any added pressure on joints or laterals. Since air testing can open joints, shift pipes, and even temporarily correct out-of-round conditions in plastic pipes as areas around joints are inflated, packers are no longer recommended for testing the quality of joints or laterals.



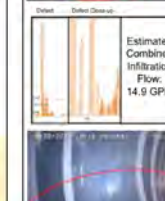
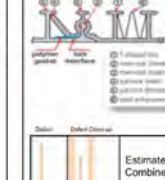
- RECOMMENDED USE:**
- All Pre-Grouted Pipes.
 - Post-Grouted Pipes, 6-12 Months After Grout to Detect Drying or Shrinkage.
 - Prior to Warranty Acceptance.

Locking individual wraps is key to any successful Spiral Wrap Pipe project, with problems not identified by CCTV.



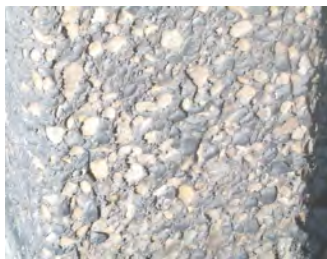
- RECOMMENDED USE:**
- Pre-SIPP.
 - Post-SIPP All Liners.
 - Prior to Warranty Acceptance.

In contrast, Electro Scan FELL inspection can find defects to individual couplings.



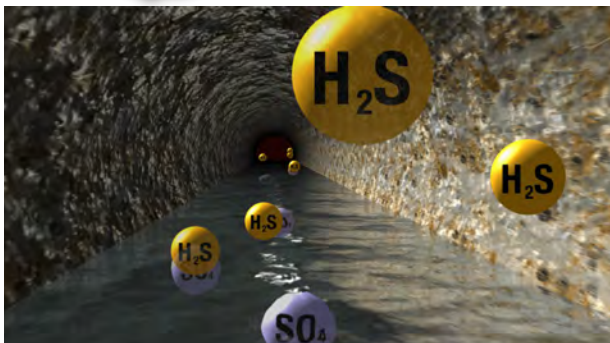
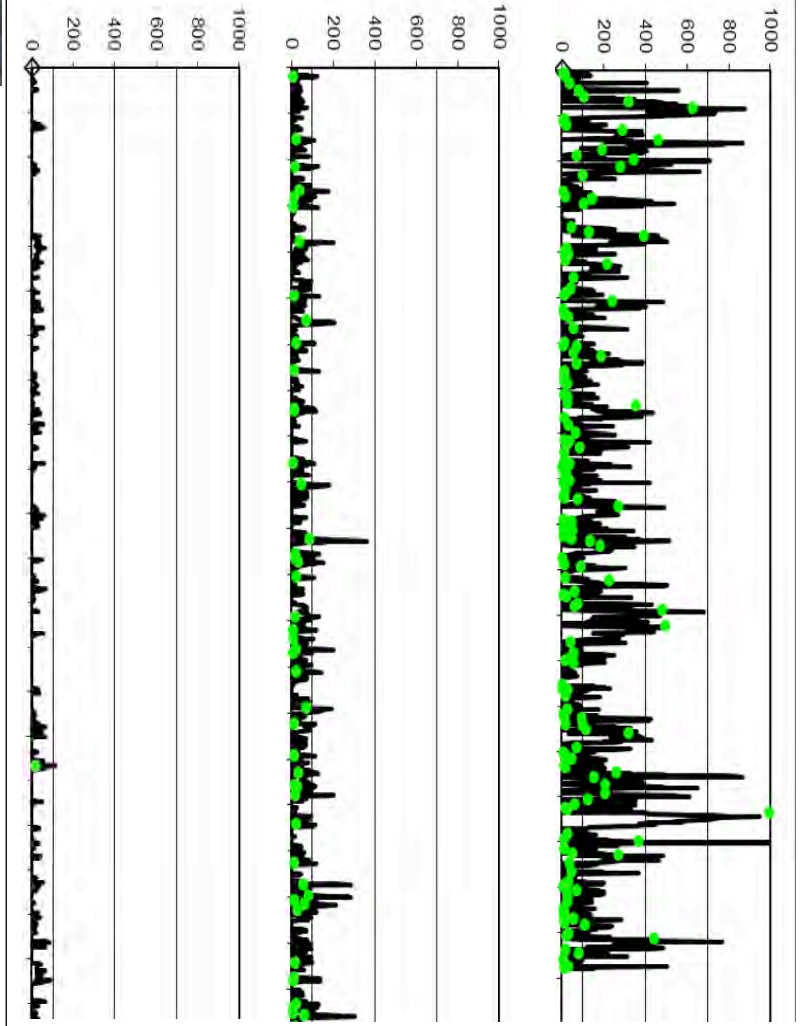
- RECOMMENDED USE:**
- Pre-Spiral Wrap.
 - Post-Spiral Wrap.
 - Prior to Warranty Acceptance.

Asbestos Cement Pipe



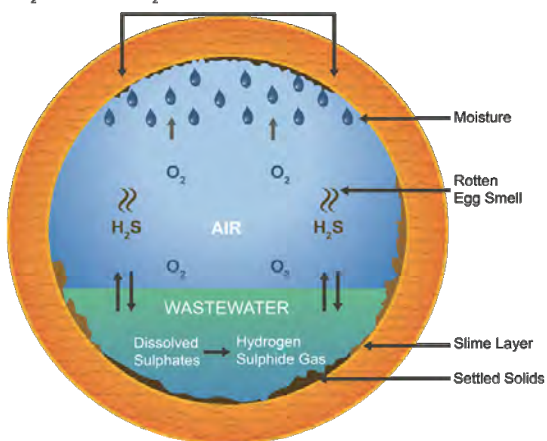
Rating Levels of Corrosion in ACP

LOW **MEDIUM** **HEAVY**



AC pipe has been installed in water systems in North America starting in the 1930s and up until the early 1980s, mainly as an affordable, non-corroding alternative to metallic pipes in areas prone to corrosion. But, AC pipes can deteriorate as a result of a variety of factors, including working environment and operational conditions, and eventually, when stresses exceed their strength, they fail.

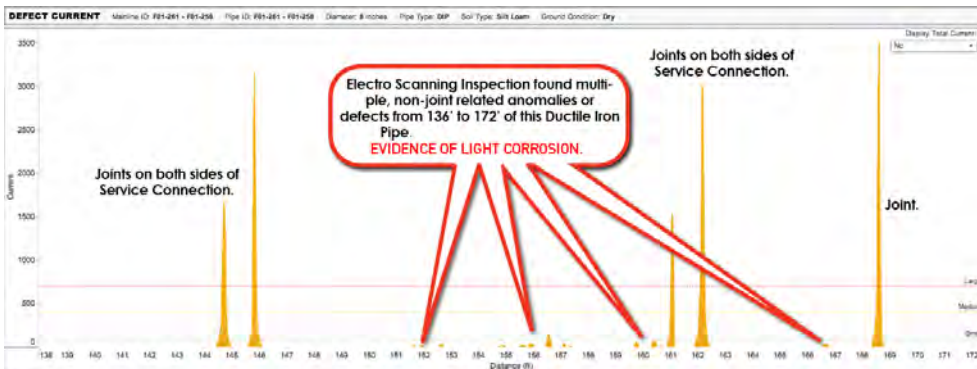
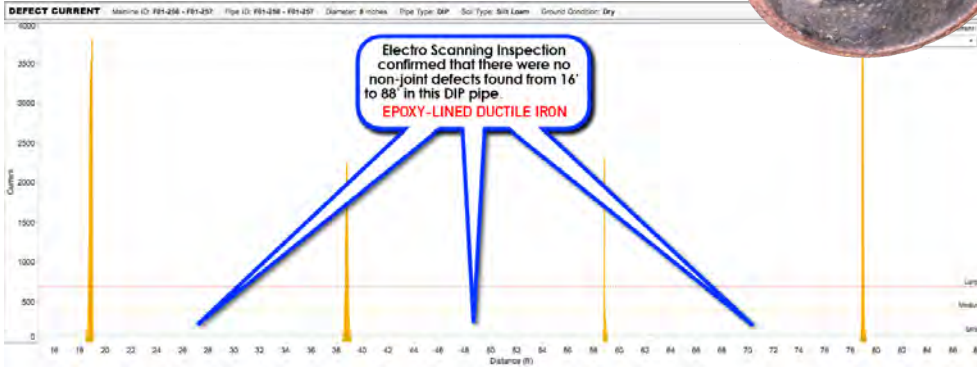
Due to the substantial variability in the deterioration rate of AC pipes, and therefore also in their condition, FELL has become a new way to assess remaining pipe walls and corrosion.



Ductile Iron Pipe



While bare metallic pipes are not typically assessed with FELL's low voltage electric current, the used of Induron's 401 Protector allows Ductile Iron Pipe and other metallic pipes to be evaluated.



AMERICAN Ductile Iron Pipe

P.O. Box 2727
Birmingham, AL 35202-2727
Phone: (800) 442-2347
Fax: (800) 442-2348
<http://www.american-usa.com>

Canada Pipe Company, LTD.

1757 Burlington Street East
Hamilton, Ontario L8N 3R5
Phone: (905) 547-3251
Fax: (905) 547-7369
<http://www.canadapipe.com>

McWane Ductile

P.O. Box 6001
Coshocton, OH 43812-6001
Phone: (205) 414-3100
<http://www.mcwaneductile.com>

U.S. Pipe and Foundry Company

Two Chase Corporate Drive
Suite 200
Birmingham, AL 35244
Phone: (205) 254-7442
Fax: (205) 254-7165
<http://www.uspipe.com>

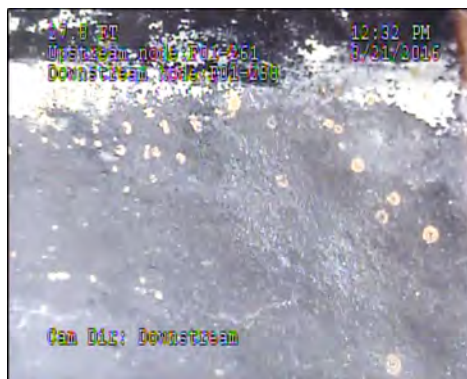
Induron Protective Coating

401 Protector
Induron Coatings Inc.
3333 Richard Arrington Jr. Blvd N
Birmingham, AL 35234-2303

Ductile Iron Pipe Research Association

P.O. Box 190306
Birmingham, AL 35219
Phone: 205.402.8700

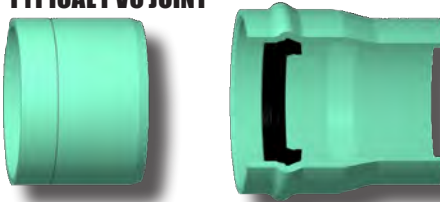
New DIP Corrosion, Poor Installation, and Joint Damage



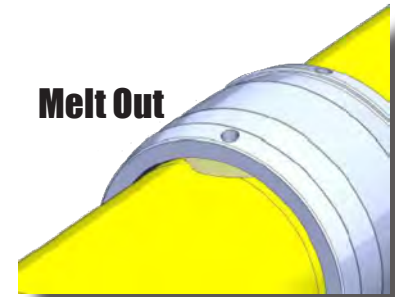
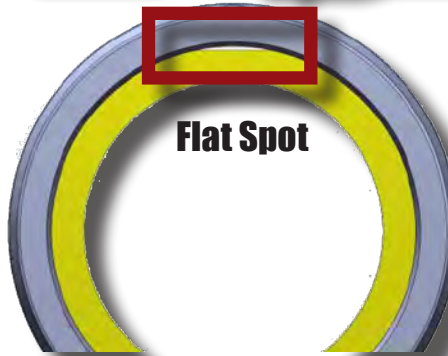
High Density Polyethylene Pipe & PVC

Poor mechanical or fused joints are the Achilles heel of HDPE, and not seen by CCTV cameras or heard by acoustic data loggers or sensors. But, found & quantified by FELL in accordance with ASTM F2550.

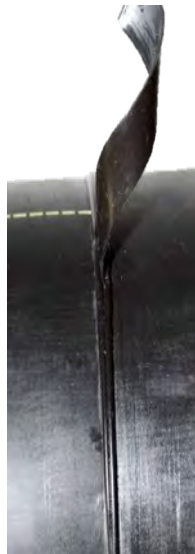
TYPICAL PVC JOINT



GPM SUMMARY	
Minor	13,900
Moderate	4,570
Severe	0,000
Total GPM	18,470
GPD	26,597
GPD IDM	61,944
Minor %	75.26%
Moderate %	24.74%
Severe %	0.00%

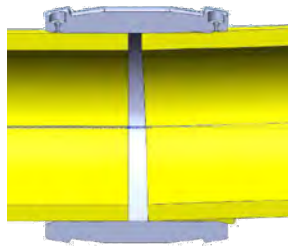


Evenly Spaced Defects Indicate Problem Joints.



Inconsistent results and the inability to pressure test pipes with lateral connections has led agencies to substitute F2550 to test and certify plastic pipes as watertight.

Inadequate Clamping or Restraint During Fusion



Leaking Joint Missed By CCTV



Out of Round

COMMON PLASTIC PIPE DEFECTS

- Accidental Tears
- Bad Fusions
- Bad Joints
- Flat Spots
- Internal Damage
- Loose Clamps
- Melt Outs
- Out of Rounds
- Stress Fractures



Leaking Joint Missed By CCTV

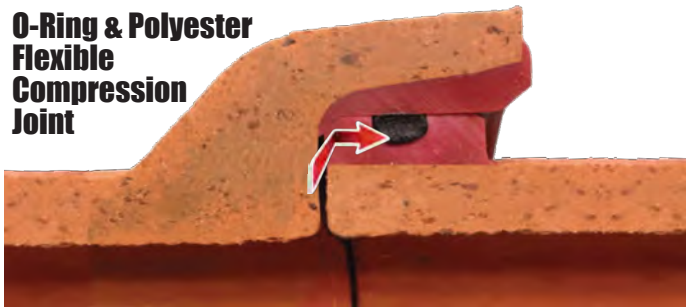
Vitrified Clay Pipe

New and Existing Vitrified Clay Pipe

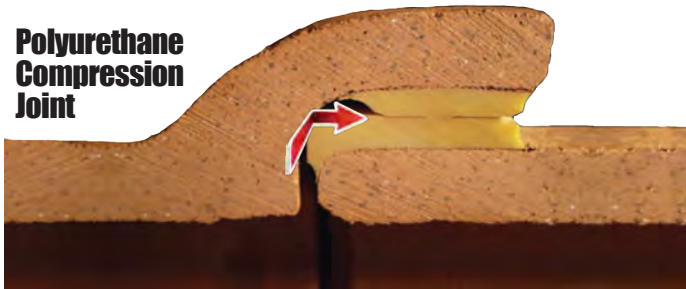
According to the National Clay Pipe Institute, over 5 billion feet (nearly 1 million miles) of clay pipe has been installed in the United States. So how can we tell which one should be replaced, first?

Bell & Spigot Joints with Compression Gaskets

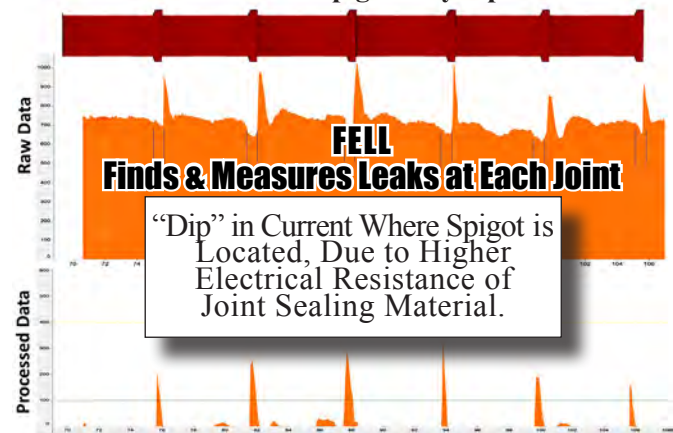
O-Ring & Polyester Flexible Compression Joint



Polyurethane Compression Joint



15" Bell & Spigot Clay Pipe



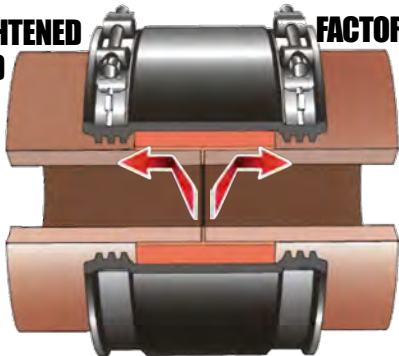
FELL Finds & Measures Leaks at Each Joint

"Dip" in Current Where Spigot is Located, Due to Higher Electrical Resistance of Joint Sealing Material.

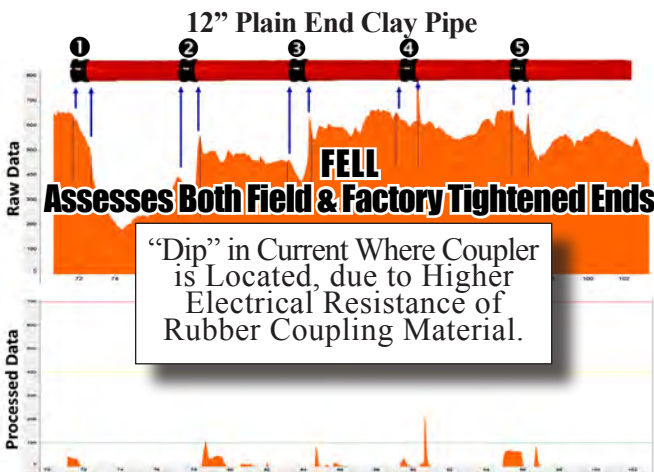
While able to visually rate pipe wall defects and anomalies, Closed-Circuit Television (CCTV), Lasers, LiDAR, and Sonar, are unable to assess, detect, or quantify pipe gaps or defective joints inside bell and spigots.

Plain End Clay Pipe with Rubber Couplings

FIELD TIGHTENED END **FACTORY TIGHTENED END**



12" Plain End Clay Pipe



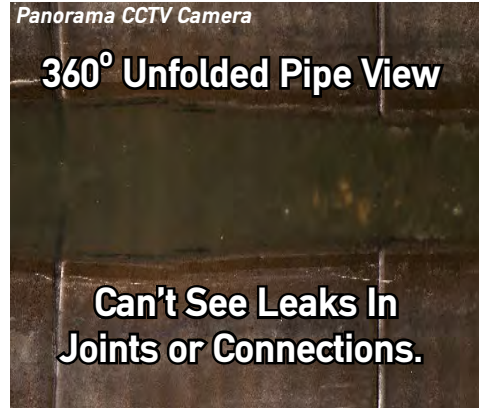
FELL Assesses Both Field & Factory Tightened Ends

"Dip" in Current Where Coupler is Located, due to Higher Electrical Resistance of Rubber Coupling Material.

FELL Identified Defects, By Coupling

- ① Watertight connection. No potential leakage.
- ② Leak from Field-Side (downstream) tightened side of coupler.
- ③ Minor leakage from Field-Side tightened coupler. Does not cross FELL Defect Threshold.
- ④ Leak from Field-Side tightened coupler.
- ⑤ Minor leakage from Field-Side tightened coupler. Does not cross FELL Defect Threshold.

Superficial Cracks v. Cracks Through The Pipe Wall. Which leaks?



Vitrified Clay Pipe

Newly Installed Vitrified Clay Pipe

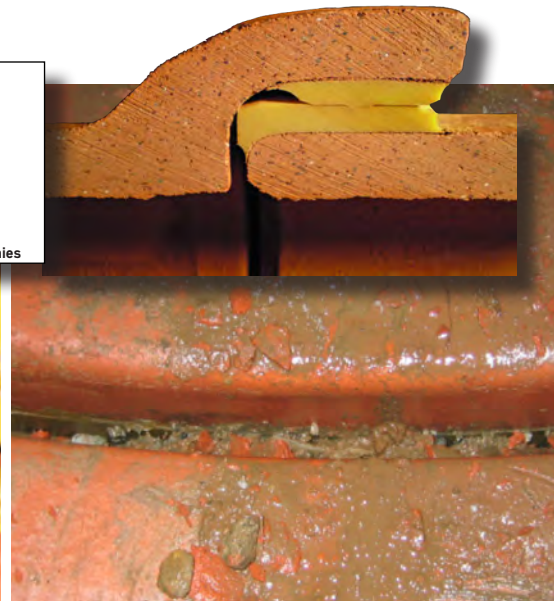
WHY NEW CLAY PIPES ARE NOT WATERTIGHT AFTER INSTALLATION?

- Different manufacturers.
- Pipes manufactured out of specification (e.g. ovality, especially in 15" diameter pipes and larger pipes).
- Pipes damaged during shipment and/or installation.
- Contractor performance.
- Worksite cleanliness.
- Worksite soil conditions.
- VCP Installation technique.
- Pipe slope (i.e. the greater the slope, the more dirt or debris that can containment joint seals).
- Not homing the pipe.
- Lenient pressure test standards.
- Other factors.



Clay Pipe Manufacturers
Can Clay Corp.
Gladding, McBean LLC
Mission Clay Products LLC
Superior Clay Corp.
The Logan Clay Products Co.

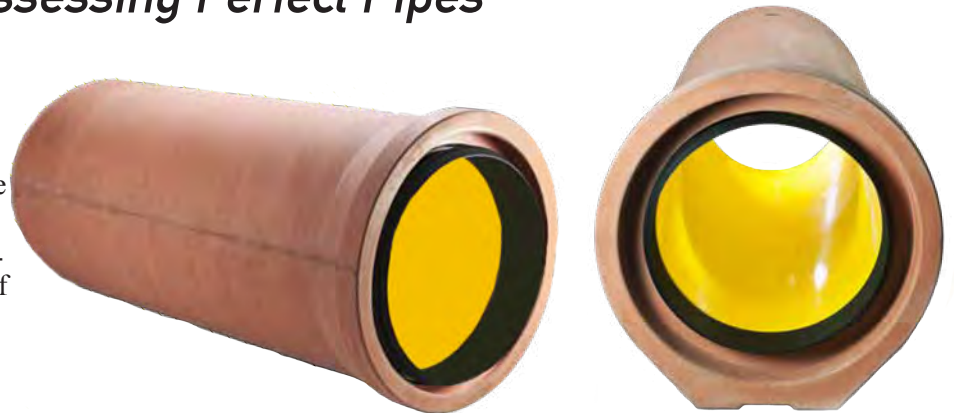
Major Trade Associations
 National Clay Pipe Institute
 National Assoc. of Sanitary Sewer Companies



Specialty Gaskets – Assessing Perfect Pipes

Even gaskets with overwhelming design qualities may experience defects. As shown below, the average distance between these double FELL spikes is approximately 8 inches, i.e. measured width of the pipe connector, meaning that openings or leakage was detected on both sides of the connector.

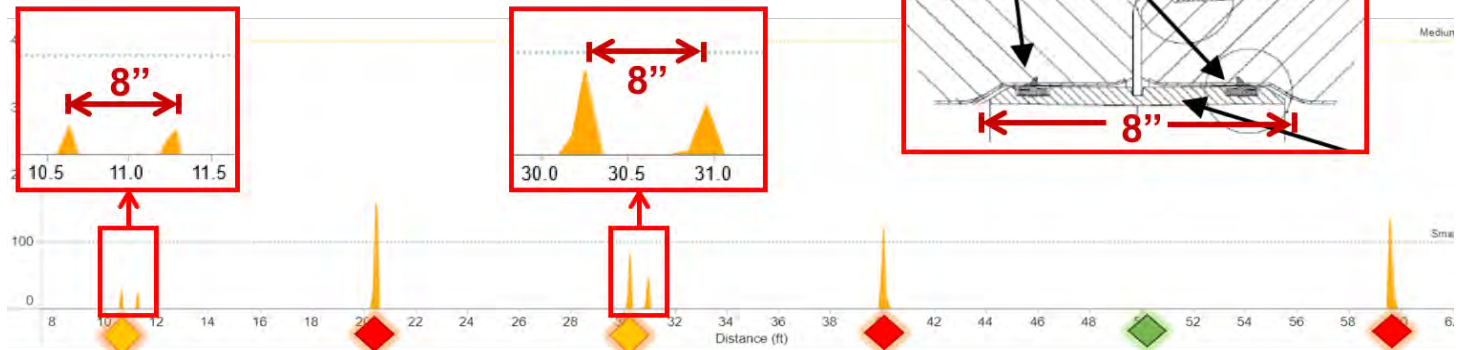
Given that some joints are in perfect condition while others show varying amounts of leakage, Electro Scan does not believe that these defects are false positives. Typically when there is a material that may cause a false positive, Electro Scan's readings will show higher signs of consistency.



Schlüsselbauer North America LLC, 2607 Grandview Avenue, Nashville, TN 37211

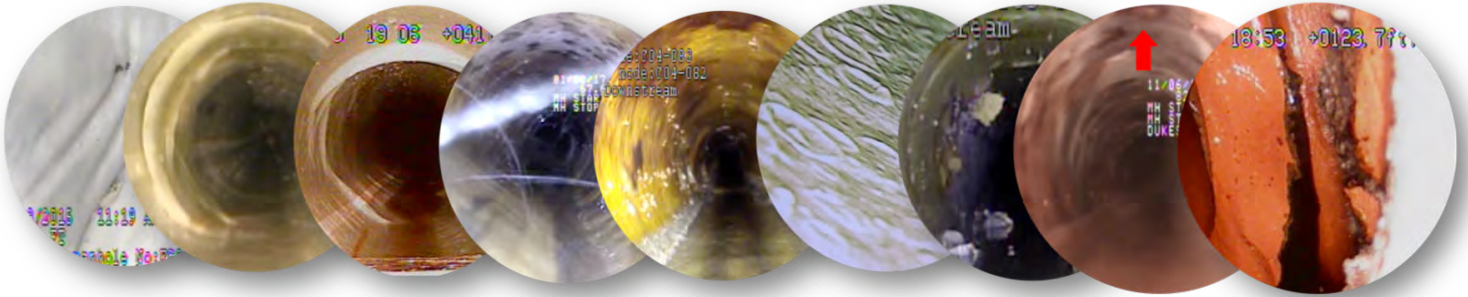
LEGEND

- ◆ - Good
- ◆ - Questionable
- ◆ - Bad

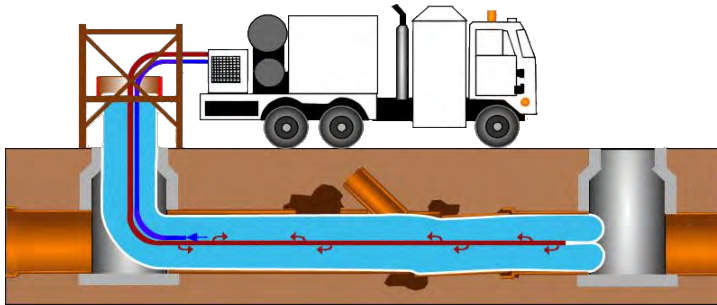


Cured-In-Place Pipe (CIPP)

Finding & Measuring Defects Missed By CCTV



CIPP May Not Reduce Infiltration If Not Properly Installed or Tested



CCTV or Visual Inspection NOT ABLE To Test CIPP Liners.



Common CIPP Defects, Missed By CCTV

- Accelerant Burns
- Accidental Cuts
- Bad Service Reconnections
- Bad Lateral Liners
- Blisters
- Delamination
- Defective Epoxy
- Equipment Damage
- Foreign Objects
- Improper impregnation
- Lower than Recommended Resin-to-Felt Ratios
- Pinholes
- Peeling
- Poor, Incomplete, or Uneven Curing
- Overheating
- Stretching
- Top-Hat Defects
- Wet-Out Failures
- Wrinkles, including Buckling, Fins, Folds, Lifts, & Ridges

FELL CIPP Testing

As of December 31

	2019	2018
Total CIPP Footage FELL Tested	111,607	98,255

Post-CIPP CCTV ZERO PACP DEFECTS

Structural		O & M		Overall	
Grade 1	Index	Grade 1	Index	Grade 1	Index
Grade 2		Grade 2		Grade 2	
Grade 3		Grade 3		Grade 3	
Grade 4		Grade 4		Grade 4	
Grade 5		Grade 5		Grade 5	
Rating	Quick	Rating	Quick	Rating	Quick
	0000		0000		0000

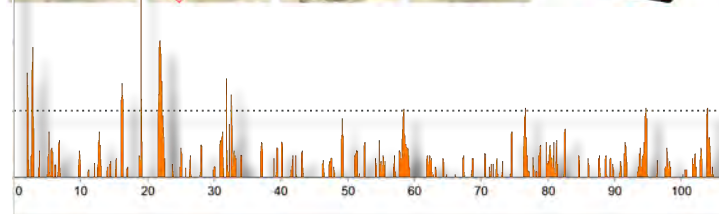


Post-CIPP FELL Assessment

BUT, CURED-IN-PLACE PIPE (CIPP) FAILED 6 MONTHS AFTER CURING.

Ask by the City "why their lining project had so many pinholes?" the CIPP Contractor said that they would all 'self-heal' over time.

**NOT SEEN BY
CCTV**



Total Combined Leaks (ASTM F2550)	14,450	3,964
Large Leaks	1,379	744
Medium Leaks	1,209	516
Small Leaks	5,087	2,704
Pinholes Leaks*	6,775	

* As recommended by IKT, Gelsenkirchen, Germany.

CIPP Liners with Defect Flows	84%	78%
CIPP Liners with ZERO Defect Flow	16%	22%
Defect Flow By Severity		
More than 1 GPM	71%	68%
More than 2 GPM	65%	62%
More than 3 GPM	63%	60%
More than 4 GPM	61%	56%
More than 5 GPM	60%	54%
More than 10 GPM Defect Flow	54%	46%
More than 20 GPM Defect Flow	44%	32%

Source: Electro Scan Inc., CriticalSewers® December 31, 2019.

Cured-In-Place Pipe (CIPP)

How Can CIPP Leak More After Pipe Lining? Simple!

Post-CIPP, Pre-Lateral Reinstatement



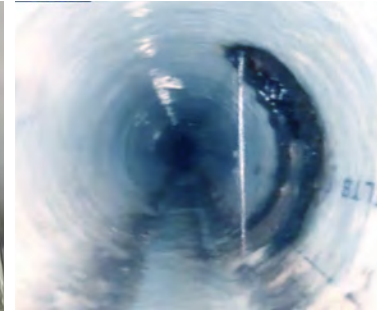
Poor Lateral Cutting Positioning



Damage to Lateral Not Present Pre-CIPP

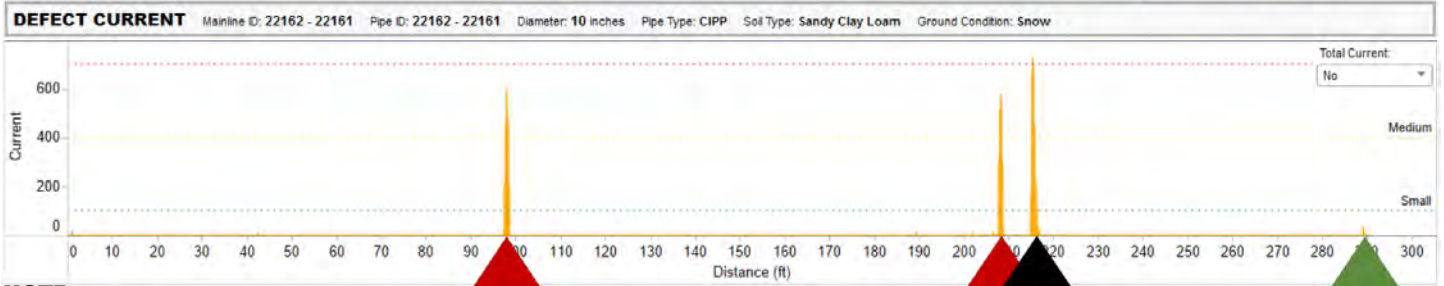


Active Infiltration Where None Occurred



Leaking Laterals & Liner Defects Immediately Detected By FELL After CIPP Curing

DEFECTS		% OF DEFECT LENGTHS	GPM SUMMARY		DIAMETER & DISTANCE		OPERATOR INFO	
Small	1	0.00080	Minor	0.600	10	291.00 ft	Tech Electroscan	
Medium	2	0.00740	Moderate	0.000			Project	
Large	1	0.00310	Severe	20.570	Demo		Job	
All Defects	4	0.01130	Total GPM	21.170	Demo		Demo	
			GPD	30.485			Atmospheric Test	
			GPD IDM	55.322			Scan Start	
			Minor %	2.83%			1/19/2018 6:13:51 AM	
			Moderate %	0.00%			1/19/2018 7:08:36 AM	
			Severe %	97.17%				



NOTE:
Electro Scan Inc. has completed over 150 Post-CIPP Investigations on over 1 million LF of lined pipe.

GOOD CIPP.

No Current Passes Through CIPP. No Leaks!



BAD CIPP.

Electric Current Passes Through CIPP. Liner Leaks!



Minimal Reductions in Infiltration Tied to Poor Quality Assurance Testing of Rehabilitation

Visual and Closed-Circuit Television inspection are not recommended to test full-length, 360-degree pipe walls for leaks or permeability, especially to test the quality of lateral reinstatements. Cities should require ASTM F2550.

Date	Pipe ID	Diameter	Pipe Type	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
11/19/2015	A 1-35-1-34	8	VCP	54	2	1	16.46	23,702	30,592
3/16/2016	B 1-35-1-34	8	CIPP	0	0	2	15.22	21,917	36,908
6/29/2016	C 1-35-1-34	8	CIPP	1	0	0	0.20	288	481



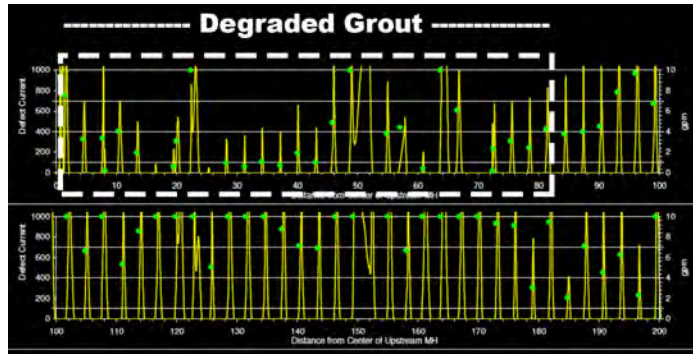
Test
Inspect
Accept

Chemical Grout for Pipe Joints & Laterals

JOINTS



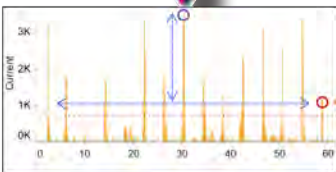
FELL Testing Calibrated to Pre- Post- and Legacy Grout By a National Grout Supplier & Contractor



Diameter for Water Height Label:	18
Mainline ID:	MH1 - MH2
Ground Condition:	Dry
Pipe ID:	MH1 - MH2
Pipe Type:	VCP
Scan Detail Id:	361479778
Soil Type:	Clay
Small:	100.0
Medium:	400.0
Large:	700.0
Min. Select Current:	20.4
Min. Detail Distance (ft):	20.4
Min. final corrected defect current:	3,495

Grout is recommended to be FELL tested at least six months after application to allow sufficient freeze-thaw and/or wet-dry cycles.

Diameter for Water Height Label:	18
Mainline ID:	MH1 - MH2
Ground Condition:	Dry
Pipe ID:	MH1 - MH2
Pipe Type:	VCP
Scan Detail Id:	361480889
Soil Type:	Clay
Small:	100.0
Medium:	400.0
Large:	700.0
Min. Select Current:	50.0
Min. Detail Distance (ft):	50.0
Min. final corrected defect current:	1,094



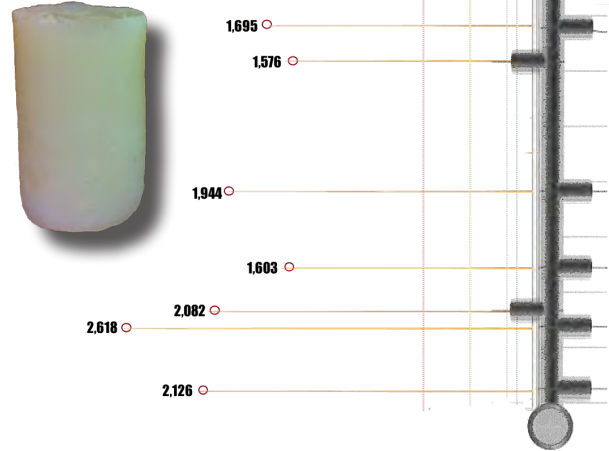
When FELL readings are 1,000 amps or below, calibration tests of 15-year old grouted joints confirms that visible infiltration was evident where lines were previously grouted.

As a result, all laterals that had been grouted during the Post-CIPP phase of the project, with FELL readings of 1,000 or below were identified and reported. Key factors for FELL readings for grouted joints or laterals of 1,000 or lower, may indicate one of the following:

LATERALS

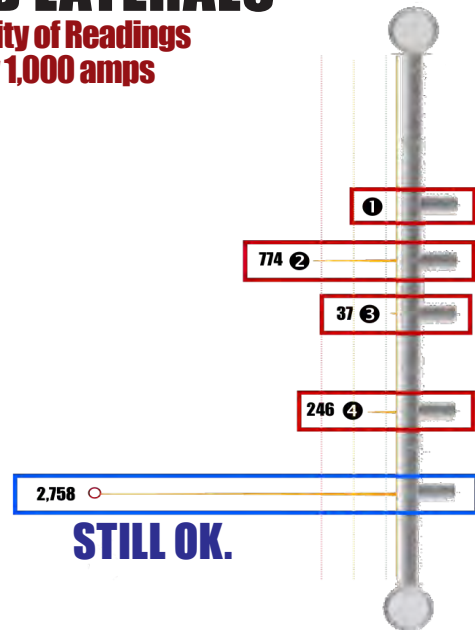
GOOD LATERAL

All Readings Above 1,000 amps



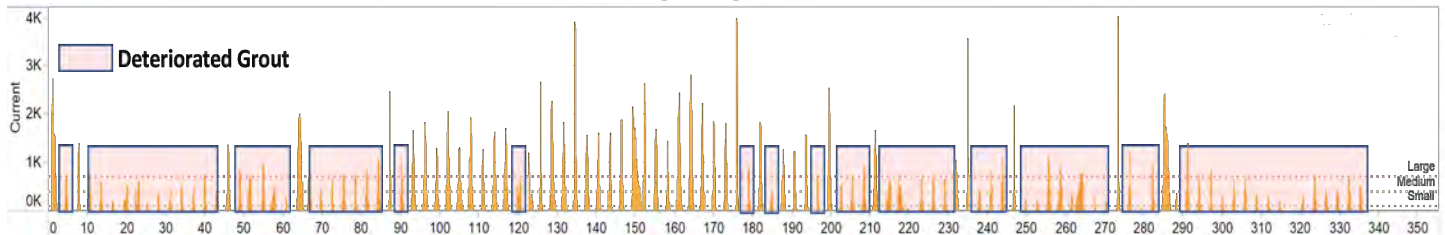
BAD LATERALS

Majority of Readings Below 1,000 amps



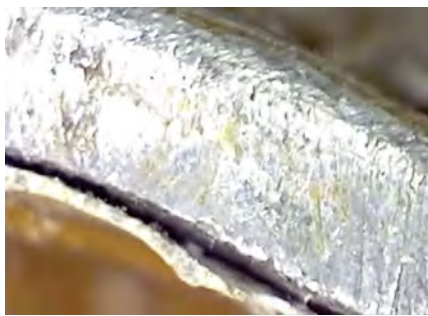
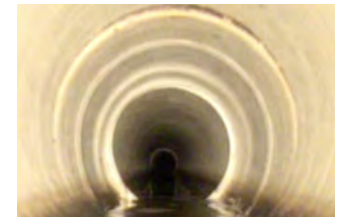
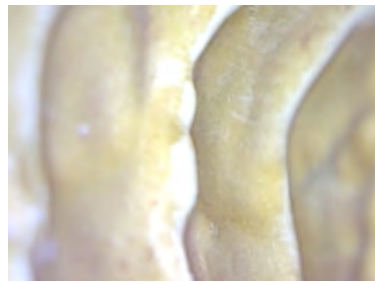
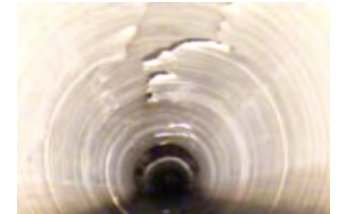
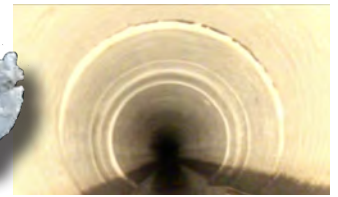
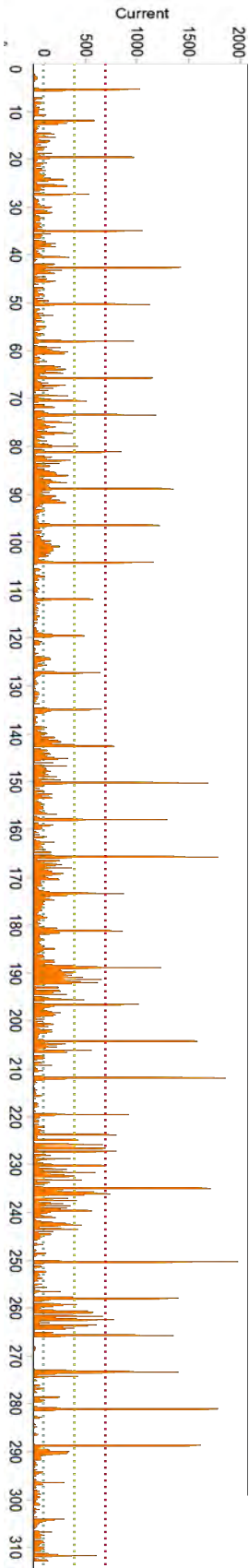
- Grout has decayed and is now termed defective.
- Grout was not applied in enough quantities to fully correct a prior leak, or
- Suspected 'leak' was not sufficient to warrant grout, therefore resulting in a lower FELL reading.

SAMPLE 15-Year Old Grout Showing Signs of Active Infiltration By CCTV



Spray-In-Place Pipe (SIPP)

Sewer Main SIPP Assessment

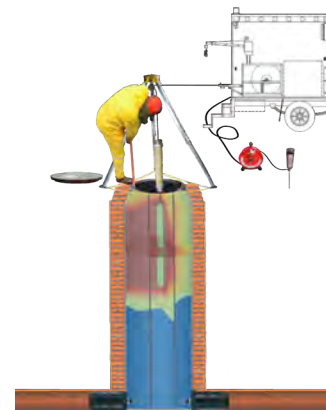
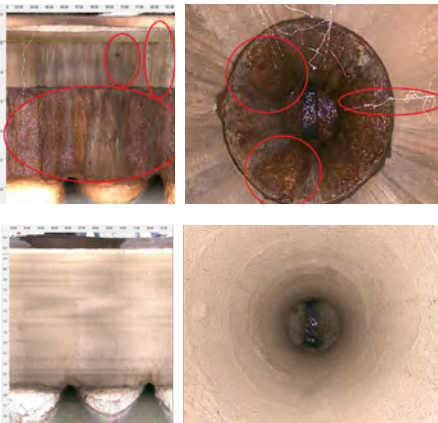


- RECOMMENDED FELL USE:**
1. Pre-SIPP Inspection.
 2. Post-SIPP Certification.
 3. Prior to Warranty Acceptance.

FELL and ASTM F2550 is the new recommended standard to assess Spray-In-Place Pipe (SIPP) for watertightness.



Manhole SIPP Assessment



**SUEZ Water Advanced Solutions
Utility Service Co., Inc.**

1230 Peachtree Street NE
Suite 1100
11th Floor – Promenade Building
Atlanta, GA 30309

Warren Environmental Inc.

137 Pine St.
Middleborough, MA 02346

Spray In Place Pipelining

45-1 Knickerbocker Ave
Bohemia, NY 11716

Spiral Wound Pipe

Headquartered in Georgia, Sekisui has installed over one million ft of SPR-EX liners as part of a single California city. While main lock and sub lock polymer gaskets are not easily able to separately be visually inspected using high resolution CCTV cameras, infiltration and/or exfiltration is difficult to assess in spiral wound pipe, unless FELL and F2550 is utilized.

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 5000 Austell-Powder Springs Road Suite 138
 Austell, GA 30106
 Phone: 678-510-1820
<https://sekisuispra.com>

