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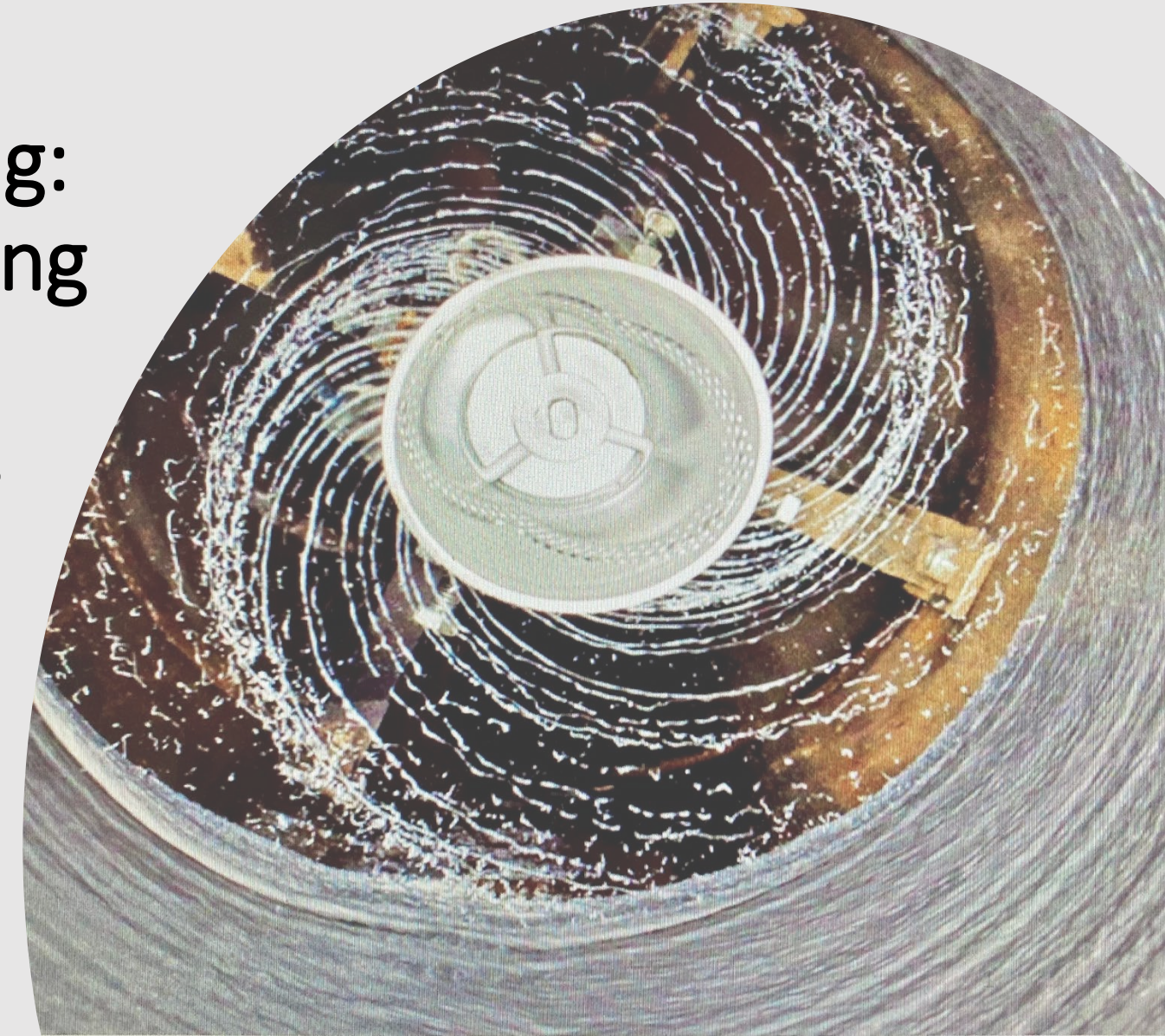
Advancements in SIPP Lining: A Look at Current & Emerging Spray Applied Pipe Rehabilitation Technologies



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SIPP lining is becoming a more commonly used methodology for pipeline remediation, and has several *potential* advantages over other more established rehabilitation methods

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What is SIPP lining? The past and present

2

SIPP: The future and new developments

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SIPP and the Dept of Energy ARPA-E project

What is SIPP lining?

SIPP = Spray-In-Place-Pipe lining

- ✓ Method of trenchless pipeline rehabilitation
- ✓ Pipe lining that is spray applied using man entry, spin cast or specialty application systems
- ✓ Can line a variety of pipe sizes and configurations
- ✓ Two main types – cementitious and polymeric

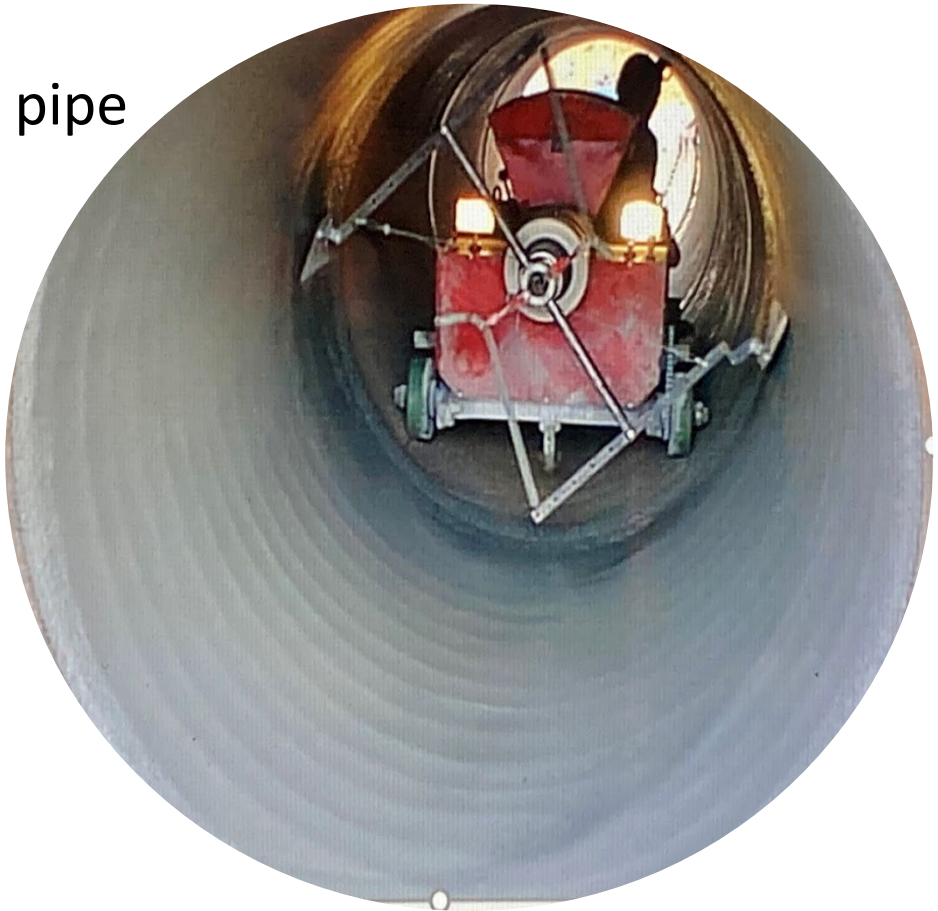
Primary SIPP lining types

- Cementitious: Includes geopolymers, Portland cement, microsilicas
  - ✓ Common type of spray applied pipe lining
  - ✓ Typically used for larger diameter pipes (>30”), storm culverts and sewer pipes
  - ✓ Capable of producing a fully structural lining system
  - ✓ Most established type of spray applied lining

- Polymeric: Includes epoxies, poly-ureas, polyurethanes
  - ✓ Typically spin cast application for smaller diameters (<36”) , man entry for larger pipelines
  - ✓ Currently capable of semi-structural lining. Progress toward fully structural lining applications
  - ✓ **Polymeric SIPP lining will be the main focus of this presentation**

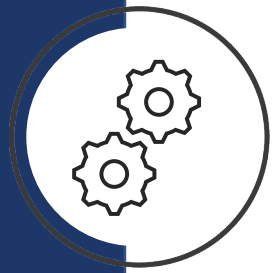
Spray applied pipe lining: Some history

- Some early spray applied lining examples have included:
  - ✓ Cement Mortar Lining (CML) in water industry
  - ✓ Shotcrete or gunite applications for tunnels and large pipe
  - ✓ Spray-applied epoxies (man entry)



- Surface preparation is **critical**
- Mostly non-structural to semi-structural (interactive) classifications to date
- Commonly used for water **quality**, corrosion mitigation and leakage control
- Spin cast application has become more common

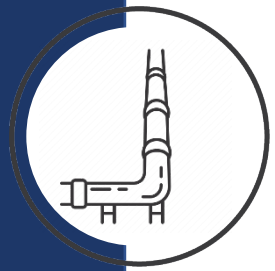
What are some potential advantages of SIPP?



Minimally invasive, fast installation process

Smaller, more versatile footprint

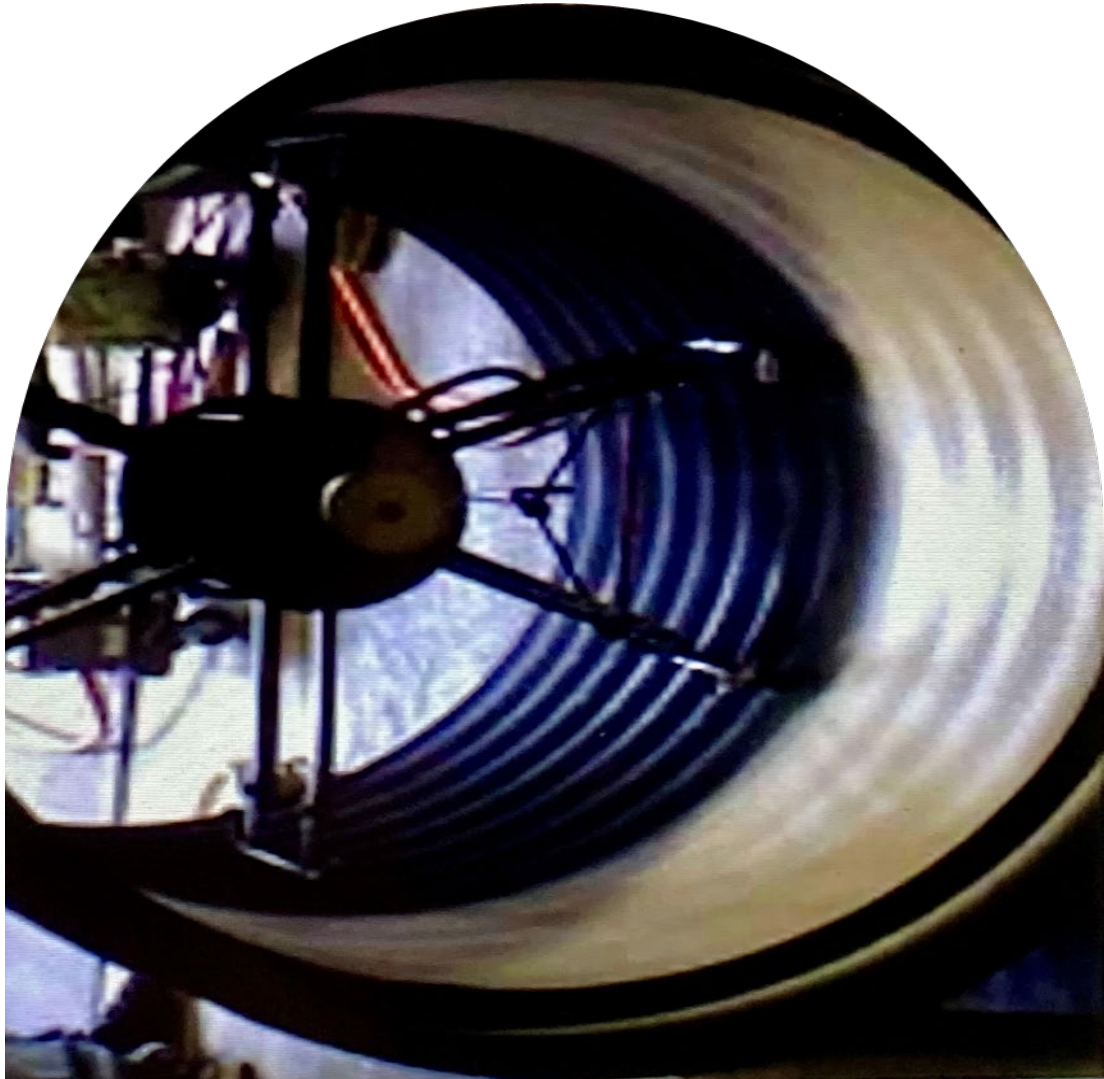
No styrenated resins and less overland shipping restrictions



Ability to conform to a variety of pipe sizes and configurations without the need for liner pre-manufacturing and wet out

SIPP systems, until recently, have had a number of limitations

- Being able to produce a ***verifiable*** fully structural, stand-alone liner (i.e. Class IV) has been a big challenge for many systems
- Surface preparation for bonded lining systems can be challenging, expensive and time consuming
- Deployment length limitations
- Consistent design criteria has been lacking
- Misinformation regarding structural capabilities



Times are changing: Recent advances & improved understanding are helping overcome some of the limitations

- Evolving design criteria and industry standards
- Cementitious & geopolymers now have a proven track record
- Improvements in SIPP lining materials and installation
- Introduction of innovative application approaches
- Better understanding of liner structural classifications
  - ✓ Fully structural vs semi-structural
- What degree of surface preparation is *really* needed?

What are the polymeric SIPP systems available today?

- Spin cast, orbital or manual plural component pipe lining application
- High build lining materials available
  - ✓ 100% solids epoxy systems
  - ✓ Polyurethane systems
  - ✓ Polyurea hybrid lining systems
- Wide range of pipe sizes and configurations can now be lined with SIPP
- Mostly gravity pipe applications, some progress toward pressure
- Liner thicknesses can range from 5 mils to 500 mils+, depending on system

Current polymeric systems often require a thorough surface preparation process to allow for intimate bonding of the applied liner

- Adequately prepared substrate is critical to bonding
  - ✓ Establishes anchor profile, removes corrosion, contaminants and debris
- Common surface preparation methods
  - ✓ Abrasive blasting
  - ✓ High pressure water jetting
  - ✓ Chemical preparation
- Different substrates and lining materials can require different preparation
- Time consuming and expensive process

How good does the surface preparation really have to be?

SIPP design methodologies need to be consistent and appropriate

- By design, a bonded semi-structural, interactive lining system is reliant to some degree on existing host pipe integrity
- Claims of fully structural Class IV lining, but this can be challenging to verify and is it correct?
- An interactive structural solution *can* be acceptable if the composite system is taken into account during design (host pipe & liner together)
- Progress toward verifiable structural design through different approaches
  - ASME PCC-2 vs. thin shelled ring theory vs. ASTM F1216 vs. FEA, etc.
- Industry standards (ASTM, etc) for SIPP lining are evolving too

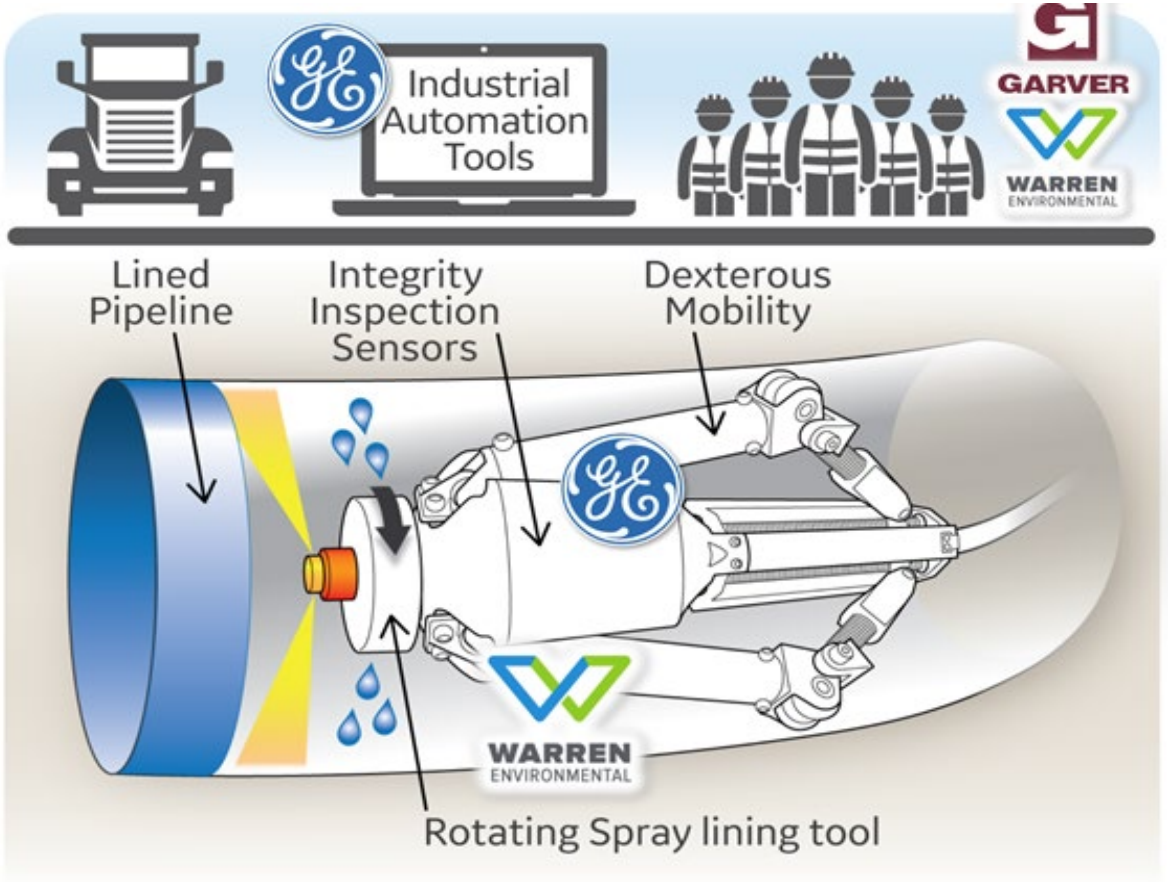
Emerging SIPP systems and new lining concepts

- Advanced robotic lining systems with pre and post inspection capabilities
- Manufactured In-Place Composite Pipe (MICP) fully structural lining
- Composite reinforcement and self-healing additives
- Long reach resin supply hose configurations
- Small diameter SIPP lining for fire lines within buildings
- Selective substrate preparation concepts
- Cold spray metallic applications

Fully structural, independent polymeric SIPP lining is the ultimate goal

The US Department of Energy's groundbreaking ARPA-E REPAIR research and development program focuses on rapid trenchless rehabilitation of existing in-service gas pipelines

- PLUTO is a collaborative effort between GE Research, Warren Environmental/ Garney Construction and Garver
- Minimally invasive, long-range, structural pipeline rehabilitation



arpa·e
CHANGING WHAT'S POSSIBLE

PLUTO concept is a tightly integrated, automated, and easy to use robotic system for gas, water and energy pipeline rehabilitation

- Specially developed lining materials
- Material pumping system
- Long-range robotic positioning & deposition tool consisting of multiple tethered crawling robots
- Tether management system
- Cleaning tools
- Localization tools
- Pre-lining inspection tools
- Post-lining inspection tools
- Multiple user interface devices to control and monitor repair process

The future of SIPP and spray applied lining for pipeline rehabilitation

- SIPP (both polymeric and cementitious/ geopolymer types) will continue to evolve and gain market share
- Material advances, improved application methods, new concepts will emerge
- Robust design criteria will continue to be refined
- Increased growth opportunities in potable water and pressure pipe rehabilitation
- Surface preparation requirements may become less stringent

Fully structural, independent SIPP lining is becoming more of a reality

Questions?

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