GTI Research Activities New Construction and Materials

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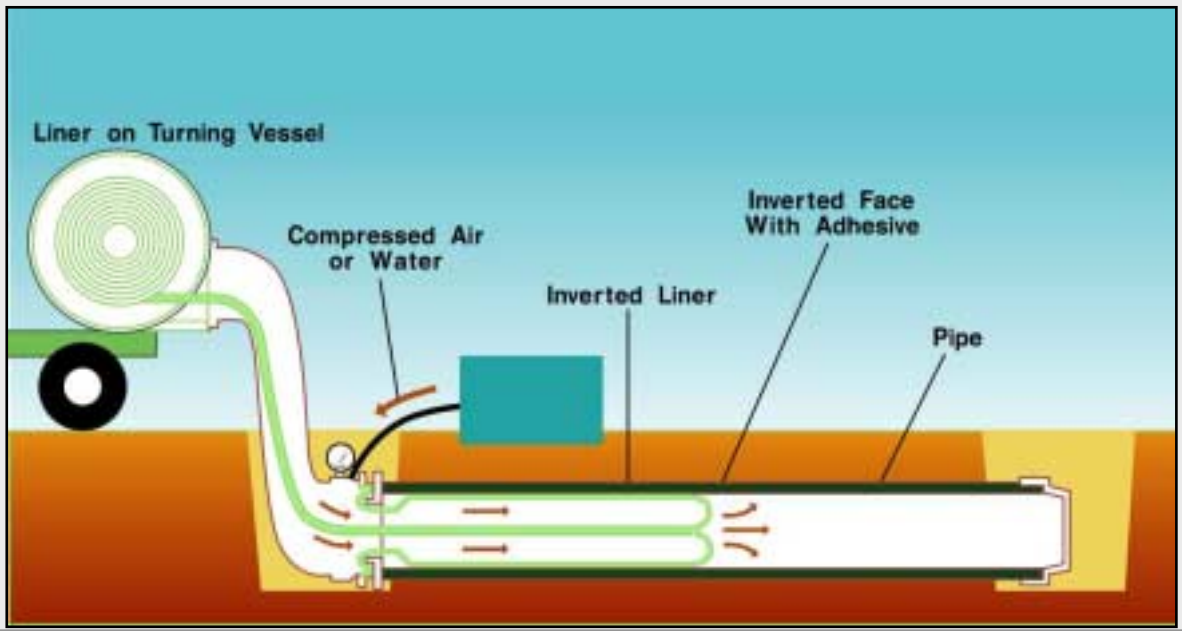
Cured In-Place (CIP) Liners – Bringing New Life to Aging Gas Pipe

- PROJECT - GRI/GTI transferred, tested, enhanced, and deployed this trenchless construction method.
- PRODUCT: Starline®
- Sizes ¾”- 24” OD, Pressure: Up to 250 psig MAOP
- Seal existing and future leaks, reduced maintenance costs by 30%-50% in urban areas.



Cured In-Place (CIP) Liners – Bringing New Life to Aging Gas Pipe

- ASTM F2207-02 Gas CIP Liner
- 80,000 ft main installed in U.S since 1998, 300 services, growing
- On-Going R&D Enhancements

PA11 High Pressure Plastic Piping Systems

- **Operating up to 200 psig**
- **Replacing steel pipe at higher pressures**
- **Has overall benefits of PE systems**
- **No corrosion protection issues**

PA11 High Pressure Plastic Piping Systems

- **5 successful utility installations**
- **Conventional installation techniques utilized**
- **Samples being removed at 12 and 24 months for evaluation**

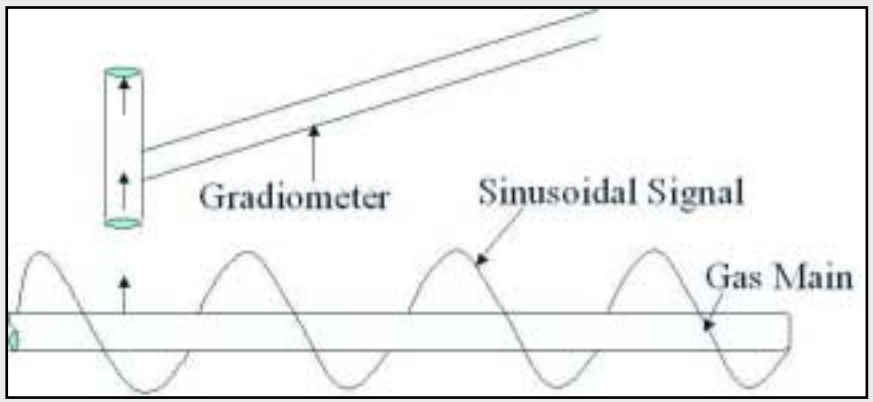
Magnetically Detectable Polyethylene Pipe (Mag Pipe)

- Polyethylene pipe that can be directly located without the use of tracer wire
  - No tracer wire required
  - Reduce third party damage

- Extensive laboratory and field tests were performed to identify optimum particle concentration
  - 17% Strontium Ferrite for 2” and larger can be buried up to 5 feet
  - 24% Strontium Ferrite for sizes less than 2” for a 3 feet burial depth

Magnetically Detectable Polyethylene Pipe (Mag Pipe)

- **Developed a 3-axis locator**
- **Completely compatible with PE systems**
- **Annexed within ASTM D2513 - 2001**



Evaluation of Soil Compaction Measuring Devices

Soil Compaction Measuring Devices – Project Tasks

- Phase-I: Evaluation of various devices for soil compaction control during utility restoration work
- Phase-II : Work with the regulators to establish the QC/QA procedures
- Phase-III: Development & modification of selected soil compaction devices

Evaluation of Alternative Shoring Technologies

Pipeline Research and Development Forum Dec. 11-12, 2004

Alternative Shoring Technology

- Implement soil-nailing technology in a flexible shoring system to replace traditional trench boxes.
- Develop various light-weight panels for facing stabilization of the cuts
- Demonstrate the technology in a field test section at GTI

Evaluation of Pavement Restoration Practices

Pipeline Research and Development Forum Dec. 11-12, 2004

Evaluation of Pavement Restoration Practices

- Effect of back fill type and compaction on pavement performance
- Effect of freeze of backfill materials on pavement settlement
- Use of flowable fill in Restoration of Utility Cuts
- Evaluation of excavation Methods of Frozen Soils

GTI Flame Spray Technology

Pipeline Research and Development Forum Dec. 11-12, 2004

GTI Flame Spray Technology

- A man-portable, simple system to field-apply high-performance coatings onto irregular shapes (valves, elbows, tees, etc).

- Works with primer coatings already available and provides excellent adhesion, hardness, impact, penetration, abrasion, and cathodic disbondment properties.

GTI Flame Spray Technology

Fast and Cost Effective

Portable and Simple

Multi-layer Protection

Excellent Coverage and Quality

GTI Field Applied Coatings Research Program

Pipeline Research and Development Forum Dec. 11-12, 2004

Pipeline Integrity/Safety & New Coating Performance

1. Integrity is critical for the safe operation of gas distribution or transmission system.
2. Preventing corrosion of submerged steel pipe is a key component of integrity.
3. A comprehensive corrosion control program is needed which includes specifying the correct coatings for use in conjunction with cathodic protection.

The Challenge to Corrosion Engineers & Integrity Managers

- Large selection of coating systems to chose from
- Endless new product introductions
- Product reformulations
- Lack of comprehensive, product specific testing

The Solution: Through carefully specified and comprehensive testing, one can confidently identify and select coating system(s) to meet particular protection needs.

Pipeline Coatings Evaluations Currently Underway at GTI

Phase I - 500+ Pipeline Coating Applications with 50+ Pipeline Systems

Generic Coating Types in Test on 24” and 8” Pipes

1. Epoxies (Coal Tar, 100% Solids, Water Tolerant, Fusion Bonded, Dual Coat FBE Systems)
2. Polyurethanes
3. Polymer Concretes
4. Shrink Sleeves and Tape Coatings (Cold Applied, Hot-Applied, Heat-Shrinkable, Wax-Type)
5. Wax Coatings (Hot-Applied, Cold Applied Mastics)
6. Hybrid Systems

Phase I - 500+ Pipeline Coating Applications with 50+ Pipeline Systems

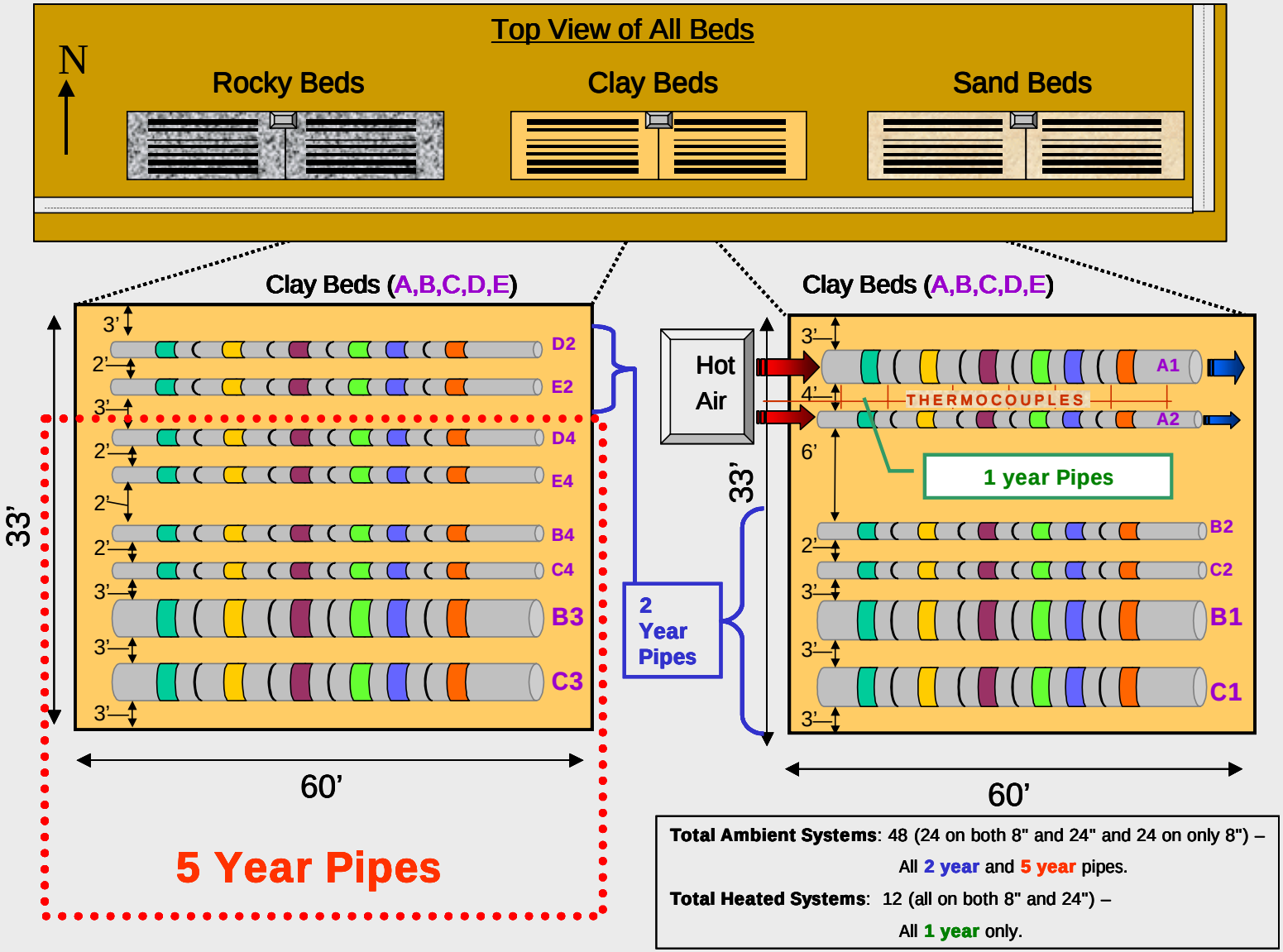
SHOW DVD OF PROJECT

Phase I – FBE Parent Pipe

- Over 50 Coating systems are currently in test:
  - In 3 extreme soil types.
  - On small and large pipe.
  - At ambient and elevated temperatures (for high temperature systems).
  - Under short and long term burial.
- Comprehensive as applied, short, and long term analytical testing is being performed.


Pipes prior to Start of Field Joint Applications

GTI Soil Bed Construction



Creating Real World Test Conditions Using Geotextile & Geomembrane

To regulate moisture and control washout of test soil.

Maintaining Real World Test Conditions - Installation of Drainage System

To control moisture in order to create the conditions of shrink swell soil.

FBE Shop-Applied Mainline Coating with Cutbacks for Field Welds

Removal of tape from shop system to expose area for simulated girth welds.

Pipeline Coatings Evaluation
Pipe Arrival and Staging at GTI

Pre-grooving and Welding of Cut Back Areas

Surface Preparation of Pipes: Feathered Edges & Sandblasted

Application Methods & Participating Manufacturers

1. Induction Heaters & FBE Powder
2. Brush, Spray, Roller, Sponge, Squeegee, Pouring and Hand
3. Flame Spray
4. Heat Shrink Sleeve
5. Airless Spray
6. Plural Component Spray

Manufacturers with Products in Phase I Testing Underway:

3M, Canusa, Chemtron, Denso, Dow, DuPont, Futura, Hempel, IECC, International, Madison Chemical, Polyguard, Power Lone Star, Raychem, SPC, Tapecoat

Fusion Bonded Epoxy Field Applications

Liquid Applications – Brush, Sponge, and Roller

Liquid Applications – Poured into Casting

Flame Spray and Shrink Sleeve Applications

Polymer Concrete and Tape Applications

Airless and Plural Component Applications

Comprehensive Inspection Report on Every Joint with Photographs

gti

MARK 10 Resource Group, Inc.

Inspection Report	Manufacturer	Raychem	Product	HTLP80	Class	Composite
	Inspector	Mike O'Brien	Joint / Pipe	80 02	GTI Sys. #	47	6/5/2002

PRE-SURFACE PREPARATION	Yes	No
Blast nozzle not worn out by > 1/16"	✓	
Blast abrasive conforms to spec	✓	
Blast abrasive contains < 10 µg/cm² chlorides	✓	
Blast abrasive bagged and sized	✓	
Blast abrasive type complies with spec	✓	
Blast air free of moisture / oil contamination	✓	
Blast nozzle pressure between 95 – 100 psi	*	
SSPC contaminants < 3 µg/cm²	✓	
Surface is free of visible oil or grease	✓	

SURFACE PREPARATION	Yes	No
Ambient conditions within spec	✓	
Surface is free of weld spatter	✓	
Surface cleanliness (meets SSPC SP 5/1)	✓	
Surface profile is as specified	✓	
Surface passes clear tape test	✓	
Surface temperature is within spec	✓	
Free of surface imperfections	✓	
Surface is free of visible oil / grease	✓	
Surface is free of visible rust	✓	

TEST RESULT VALUES		BLAST PROFILE (USING REPLICA TAPE)			
Blast condition grade prior to blasting (SSPC VIS 1)	B	Tape # 1	Tape # 2	Tape # 3	Average of Tape
Blast nozzle pressure results	psi*	3.3	3.5	3.4	3.40
Abrasive test results for chlorides	< 1 µg/cm²	Surface Cleanliness Achieved:			White Metal (SSPC SP 5)
SSPC level detected on surface	1 µg/cm² @ 55°F/13°	Blast Abrasive Type Used:			Coal Slag

AMBIENT / SURFACE TEMPERATURE & CONDITIONS					POST APPLICATION INSPECTION	Yes	No
Time	1:20 PM	3:30 PM	5:10 PM	5:45 PM	Voids(s) detected:		✓
Air Temperature	60.4°F	60.8°F	56.4°F	56.0°F	Dry film thickness okay (Form A)	✓	
Relative Humidity	73.9%	74.1%	74.5%	74.1%	Checked for holidays	✓	
Dew Point	52.1°F	52.0°F	48.3°F	48.5°F	Holidays found		✓
Surface Temp (Sun side)	60.9°F	62.5°F	58°F	57°F	Holidays repaired	n/a	
Surface Temp (Shade)	60.0°F	61.8°F	--	--	Rechecked for holidays	n/a	
					No holidays detected	✓	

DRY FILM THICKNESS MEASUREMENTS					GENERAL COMMENTS / NOTES
Spot	Individual Readings			Spot Measurement	Avg of Spots
8-1	81.8	36.0	72.4	30.2	76.2
8-2	69.6	69.2	76.4	71.7	
8-3	71.1	66.1	70.6	71.6	
8-4	80.2	84.2	80.8	83.4	

* Blast nozzle pressure was not recorded. Surface profile measurements were within acceptable range.

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Joints Covered in Tyvek and Awaiting Final Holiday Testing

Placement of Field Coated Pipe in Test Facility – Phase I

Triangulation, Sensor Placement, and CP Hook Up

Internal Pipe Heating System

Coating Adhesion Testing

- All primer coats will adhere well to substrates to allow long-term protection, otherwise disbondment will occur.
- The metal surface must be clean and free of rust, mill scale and chemical contaminants to provide best adhesion.
- Roughening the surface increases mechanical locking and surface area to bond to.

Abrasion Resistance Testing

- Pipelines move due to pressure and temperature fluctuations and dry and wet cycling of the soil.
- The pipeline coating should have enough abrasion resistance to resist damage from these stresses.
- If horizontal directional drilling is being used for installation, abrasion/wear resistance becomes even more important.

Cathodic Disbondment

- Pipelines are almost always protected by cathodic protection (CP) current.
- This current reacts with water and oxygen on the steel surface to form OH^- ions and hydrogen gas.
- Leading to under film corrosion.
- The hydrogen gas can lead to film blistering.

Sample of Comparative Data – Control Pipes in Phase I

GTI Sys. No.	Company	Shore D Hardness					Barcol GYZJ 935 Hardness					Penetration Resistance (% penetration)					Impact Resistance (in.-lbs.)				
		0 - 20.9 softer	21.0 - 40.9	41.0 - 60.9	61.0 - 80.9	81.0 - 100 harder	0 - 20.9 softer	21.0 - 40.9	41.0 - 60.9	61.0 - 80.9	81.0 - 100 harder	57.0 - 70 less resistant	43.0 - 56.9	15.0 - 42.9	0.1 - 14.9	0 more resistant	0 - 36 less resistant	36 - 72	72 - 108	108 - 144	>144 more resistant
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tested

currently under test or to be tested

test not applicable due to mastic coating or material too soft for selected scales

Detailed Performance Data

- As applied (i.e., control) test data: e.g., impact resistance, penetration resistance, cathodic disbondment resistance, abrasion resistance, etc.
- Short term and long term field test data as a function of pipe size, soil type, and temperature (ambient and heated) - to include overall summary and comparison of data and all raw data.
- Failure analysis reports on every system pulled out of the ground that details the failure mechanisms, extent of coating damage, and extent of metal loss or pitting.

Next Step – 3-Layer PE/PP Compatible FAC Systems

- The same testing methodology used for the FBE plant coated pipe will be used to evaluate field applied coating systems in conjunction with 3-Layer Polyethylene (PE) coated line pipe.
- 3-Layer PE dominates in the international pipeline market. Quality coating testing and field performance data will have the same impact in this market, leading to reduced operating costs and improved corrosion protection.

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