

*the Energy to Lead*

# OTD Sponsored Research

## Pipeline Remediation/Repair

---

**Government/Industry Pipeline R&D Forum  
Crystal City, VA  
June 24-25, 2009**

**Andy Hammerschmidt  
R&D Manager, GTI**

# OTD Collaborative— Shooting for High Impact Results

- > Separate not-for-profit supporting natural gas infrastructure
  - GTI provides administrative support and performs much R&D
- > Demonstration opportunities
- > New product pipeline
- > Analytical tools and reports

## OTD Size and Scope

- > 20 members
- > Participation cost: \$250,000-\$750,000 per company per year
- > Annual membership dues: Over \$8 million
- > Over 75 projects initiated

# Operations Technology Development

## Pipeline Remediation/Repair Project Focus

- **3<sup>rd</sup> Party Damage – Anomaly Repair**

- Low Stress Pipe Repair Technique Evaluation
- Composite Pipeline Repair – Adhesive Degradation

- **Aging Infrastructure/Pipeline Rehabilitation**

- CARP (Cold Adhesive Repair Program)
- PE Patch – Timberline, OSU
- RTP Review
- Liners (Starline)

# Composite Pipeline Repair Systems (CPRS): Analysis of Adhesive Degradation



# Situation

---

- > Composite system repairs depend heavily on both the fiber structure and matrix/adhesives used to transfer the load from the defect to the repair system.
- > Permanency requires investigating the possibility of repair system degradation over time.
- > Operators need to know if these systems will retain the majority of their shear strength over the predicted lifetime of the system.

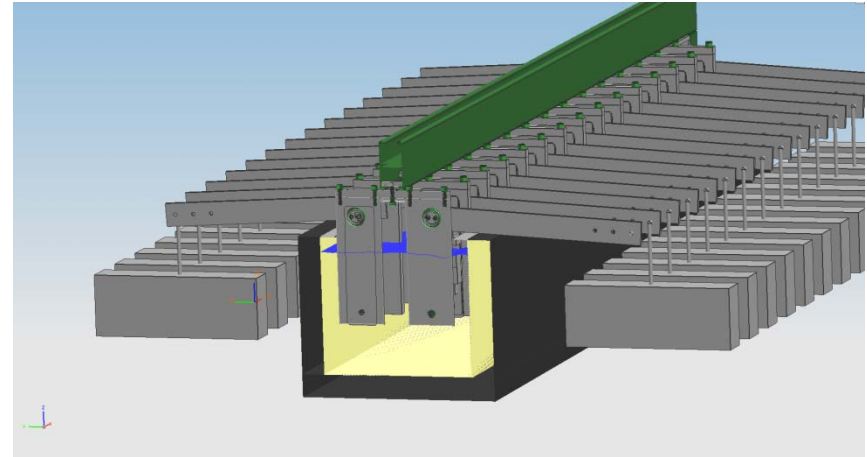
# Solution

---

- > *Adhesives/Matrix* used in composite repair systems are a critical component that bonds the repair to the pipe and bonds the individual layers of the repair to one another (laminates of fibers, weaves, mesh, etc.).
- > If the *bond* between the layers of the repair is inadequate, load will not be transferred from the pipe to the repair\*.
- > *Lap-shear tests* have been used in the past to provide an accurate measure of the long term bond strength in composite repair systems. This type of testing can be set-up to mimic the expected stresses between layers that occur in an actual repair.
- > As a result, the *long term performance* of a repair can be assessed using coupon level tests to represent full scale creep rupture performance.

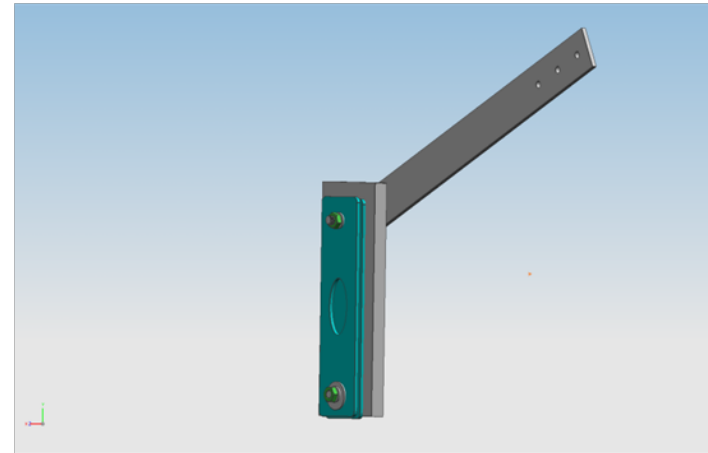
# Technique and Results

- > Simple, and compact
- > 30 Samples loaded per frame
- > 6 frames
- > Capable up to 200°F
- > Motion capturing cameras provide accurate failure time
- > Weights
  - Low loads- steel shot in bags
  - High loads- A36 2"x4" bar



## Technique and Results (Con't)

- > 15 inch arm provides maximum mechanical advantage of 54:1
- > Less than 2% load variation through .150 inch travel
- > 6 inch center to center
- > Design load of 1800 lbs
- > Load verified before testing conducted





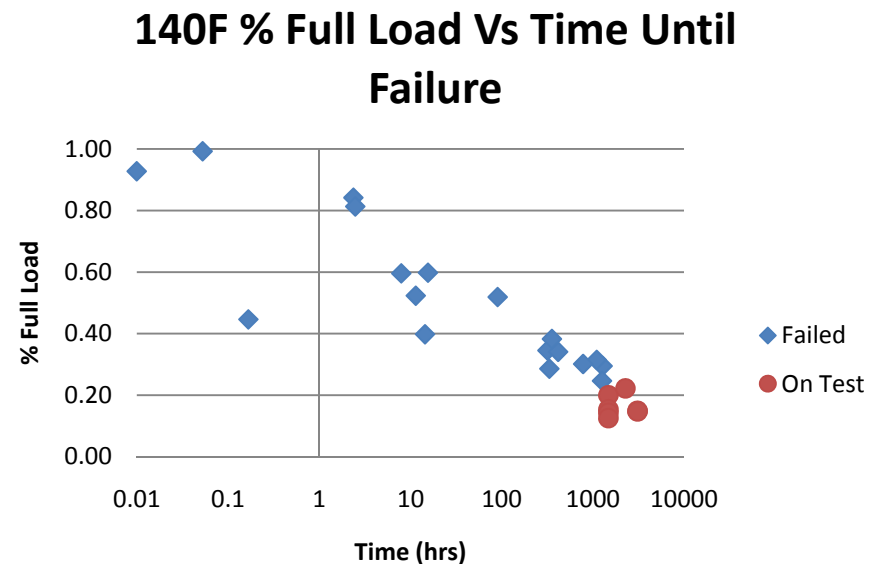
## Technique and Results (Con't)

- > Composed of 304SS tanks, and CPVC tubing
- > Ph level of 9
  - Mixture of filtered water and sodium bicarbonate
- > Automatic refill system keeps levels consistent
- > Allows isolation of single frames



# Technique and Results (Con't)

- > Failures are plotted on Load vs Log time graph
- > 100% load established during short term testing
- > Testing currently being conducted at 65°F, 105°F and 140°F



# Benefits

---

- > Funders will receive clear technical information on the performance of composite repair systems, specifically their predicted retention of shear strength as a function of service life.
- > Results will allow operators to properly select systems based on their predicted service life.
- > A *temporary* repair will be identified as such and repairs considered as *permanent* will now have testing data showing the shear strength as a function of time.
- > The project results will validate and confirm the long-term integrity of already repaired regions.

# Status

---

- > Short Term and Long Term testing on-going
- > Approximately 5,000 hours of 10,000 hour test completed
- > 8 products in program
  - Citadel Black Diamond
  - Neptune
  - TDW Res-Q
  - PipeWrap A+
  - AquaWrap
  - Armor Plate
  - Walker Technical
  - Carbon Ply Crosslink

# Composite Pipeline Repair Systems (CPRS): Low Stress Pipe Repair Technique Evaluation



# Situation

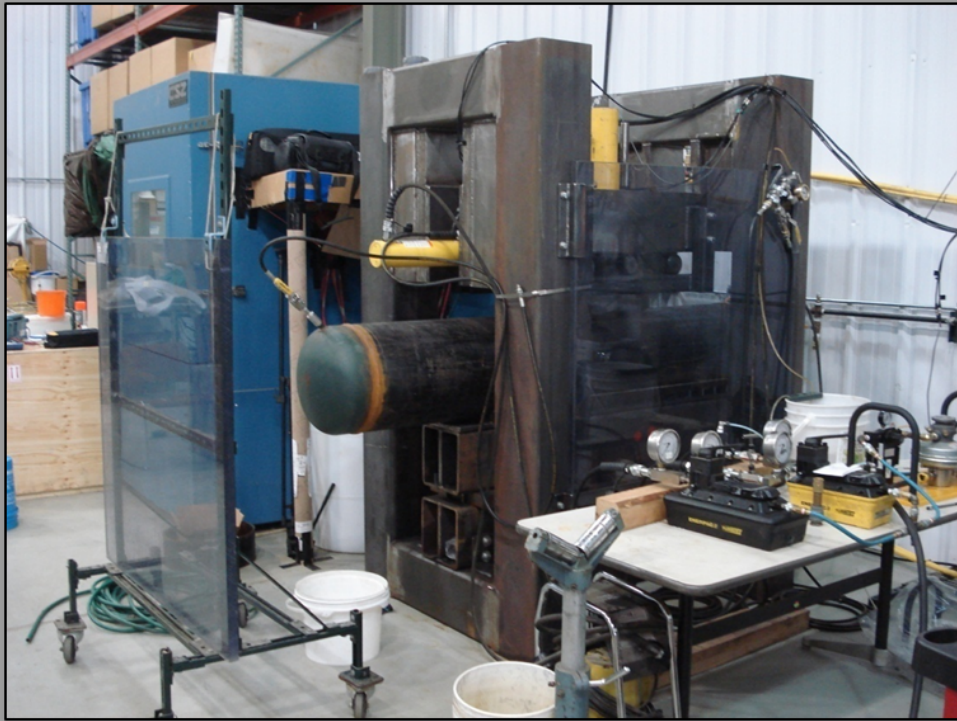
---

- >The objective is to research, test and assess various repair techniques and provide justification for their use as is allowed by CFR 29 Part 192.
- >The results will provide utilities with repair methods that reliable engineering tests and analysis show can permanently restore the serviceability of the pipe.
- >This will substantially reduce the cost of repairing using the cutout method and will allow a comparison of repair techniques used on similar types of pipeline damage.

# Solution/Test Procedure

- > Two Pipe sizes:
  - 8-inch diam., 0.25 wall thickness ( $D/t = 32$ )
  - 16-inch diam., 0.25 inch thick ( $D/t = 64$ )
  
- > Pipe type: Steel X42-X52
  
- > Applied flaw:
  - Apply 12 inch longitudinal gouges (36% wall thickness)
  - Apply 12 Dent (9-12% pipe diameter)
  - Dents (applied at pressurized pipes at 40% SMYS)
  - Dents & gouge cause pipe failure at 70% SMYS
  
- > Pressure: Hydrostatic pressure
  - (Short term: 100% SMYS)
  - (Long term: 1,000-hr tests at 150% SMYS)
  
- > Compare repair methods to unrepaired specimens (control)

# Testing Assembly





# Benefits

---

- > The results will provide utilities with repair methods that reliable engineering tests and analysis show can permanently restore the serviceability of the pipe.
- > This will substantially reduce the cost of repairing using the cutout method and will allow a comparison of repair techniques used on similar types of pipeline damage.

# Status

---

- > The testing program was completed during the 1<sup>st</sup> Quarter of 2009.
- > Data Analysis and generation of the Final Report will be completed during the 2<sup>nd</sup> Quarter of 2009
- > 8 products in program
  - Citadel Black Diamond
  - TDW Res-Q
  - PipeWrap A+
  - AquaWrap
  - Armor Plate
  - Walker Technical
  - Carbon Ply Crosslink
  - Clockspring

# Localized Anomaly Repair – PE Applications

- **CARP (Cold Adhesive Repair Program)**
  - > PE patch (HDPE)
  - > anomalies, squeeze, etc...
- **PE Patch – Timberline, Oregon State University**
  - > full encirclement - HDPE
  - > chemical (2 part epoxy) and heat reaction
  - > blowing gas application

## Aging Infrastructure/Pipeline Rehabilitation

- **Reinforced Thermal Plastic (RTP) Product Review**
  - Example – SmartPipe
  - Status, Operating Parameters, etc...
- **Liners (Starline)**

# OTD - Pipeline Remediation/Repair Project Focus

## Next Steps/Gaps/Needs...

- **CPRS Testing/Data – Fittings, Flanges, Bends, etc...**
- **Application of CPRS to large diameter HP vessels**
  - > above ground and below ground vessels
  - > patch concept
- **RTP Research**
  - > materials, connections, fittings, joining methods
  - > shortcomings/failure points
  - > testing, evaluation, standards, approvals for use
- **Rehabilitation Techniques (Bare Steel, etc...)**
  - > new materials – both local and large sections
  - > procedures – pipe splitting, pipe bursting
  - > processes – low cost, environmentally friendly, hard to access