OTD Sponsored Research

Pipeline Remediation/Repair

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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

- 3rd 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
Composite Pipeline Repair Systems (CPRS)

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.
Composite Pipeline Repair Systems (CPRS)

**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
Composite Pipeline Repair Systems (CPRS)

**Technique and Results (Con’t)**

> 15 inch arm provides maximum mechanical advantage of 54:1

> Less than 2% load variation through 0.150 inch travel

> 6 inch center to center

> Design load of 1800 lbs

> Load verified before testing conducted
Composite Pipeline Repair Systems (CPRS)

**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
Composite Pipeline Repair Systems (CPRS)

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
Composite Pipeline Repair Systems (CPRS)

**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.
Composite Pipeline Repair Systems (CPRS)

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
Composite Pipeline Repair Systems (CPRS)

**Situation**

> The objective is to research, test and assess various repair techniques and provide justification for their use as 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.
Composite Pipeline Repair Systems (CPRS))

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
Composite Pipeline Repair Systems (CPRS)

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.
Composite Pipeline Repair Systems (CPRS)

**Status**

> The testing program was completed during the 1st Quarter of 2009.

> Data Analysis and generation of the Final Report will be completed during the 2nd 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 exopy) and heat reaction
  - blowing gas application

Aging Infrastructure/Pipeline Rehabilitation

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

- **Liners (Starline)**
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