2013 Third Annual Composite Repair Users Group Workshop

Hilton Garden Inn NW America Plaza (Houston, Texas)
Thursday, September 26, 2013

Presentation by Chris Alexander

CRUG COMPOSITE REPAIR USERS GROUP

Taking on your toughest technical problems

STRESS ENGINEERING SERVICES INC.

an employee-owned company

3rd Annual Workshop

- Welcome and introduction
- Preliminary items
  - Facilities and safety moment
  - Sponsors / Exhibitors
  - Information packet (schedule and ballot)
- Today's meeting schedule
- CRUG Mission Statement
- CRUG Board Members
- Presentations

Sponsors

- Silver Sponsor – Pipe Wrap®

STRESS ENGINEERING SERVICES INC.
an employee-owned company

Sponsors

- Gold Sponsor – Stress Engineering Services, Inc.

Exhibitors

- Air Logistics
- Armor Plate, Inc.
- Citadel Technologies
- Fyfe Co.
- Neptune Research, Inc.
- Oceaneering International, Inc.
- WrapMaster

Today's Meeting Schedule (1/2)

8:00 to 8:15	**Meet, greet and check-in: *Breakfast Sponsored by Pipe Wrap®***
8:15 to 8:25	Introductions, welcome ,and workshop overview - Chris Alexander
8:25 to 8:50	History of Composite Repairs in the Industry - Chris Alexander
8:50 to 9:30	Keynote: ***Shale Oil & Gas: You Ain't Seen Nothing Yet!*** – Earl Crochet – Kinder Morgan
	Market Overview
9:35 to 9:55	Presentation 2: Input from Pipeline Industry - Mike Collins – Dow
9:55 to 10:15	Presentation 3: Input from Plants – Frances Labry – Team, Inc.
10:15 to 10:35	Panel Discussion: Earl Crochet, Mike Collins, Francis Labry
10:35 - 10:50	**Morning break and booth time**
	Composite Repair Standards, Quality Control & Inspections
10:50 to 11:10	Presentation 4: Mike Collins – Walker Technical Resources
11:10 to 11:30	Presentation 5: Richard Lee – ESR Technology
11:30 to 11:50	Presentation 6: Robert Rettew - Chevron
11:50 to 12:10	Panel Discussion: Simon Frost, Richard Lee, Robert Rettew, Paul Hill (Furmanite)
12:10 to 12:20	Voting for 2013-2015 Board Members (Ballot Submission) / Door Prizes
12:20 to 1:00	**Lunch Break and booth time: *Sponsored by Stress Engineering Services, Inc.***

Today's Meeting Schedule (2/2)

	PHMSA / DOT / TRRC / PRCI / R&D – Past and Future Work
1:00 to 1:20	Presentation 7: Julian J. Bedoya – Stress Engineering Services, Inc.
1:20 to 1:40	Presentation 8: Randy Vaughn – TRRC
1:40 to 2:00	Presentation 9: Max Kieba – PHMSA
2:00 to 2:20	Panel Discussion: Julian J. Bedoya, Randy Vaughn, Max Kieba
2:20 to 2:40	**Afternoon Break and Booth Time**
	Future Testing / Composite Research Roadmap
2:40 to 3:00	Presentation 10: Casey Whalen – Pipe Wrap® - Temperature Effects on Comp. Repairs
3:00 to 3:20	Presentation 11: Chris Alexander – Crack Reinforcement
3:20 to 3:40	Presentation 12: Robert Rettew / Chris Alexander – Composite Roadmap
3:40 to 4:00	Panel Discussion: Casey Whalen, Robert Rettew, Chris Alexander
4:00 to 4:20	Time allotted for knowledge gaps (as needed)
4:20 to 4:30	Wrap-Up: Board election results and closing comments

CRUG Mission Statement

The Composite Repair Users Group has been organized to promote the proper use of composite materials and provide education for industry on structurally repairing pipelines, piping, and other pressure containing equipment subject to industry accepted standards.

2012-2013 CRUG Board Members

Officers:

- Chris Alexander, Stress Engineering, Chair Emeritus
- Franz Worth, Air Logistics, Chair
- Steve Siever, Pipe Wrap®, Vice-Chair
- Bart Davis, NRI, Public Relations
- Amanda Hawkins, Citadel Technologies, Meeting Coordinator
- Julian J. Bedoya, Stress Engineering, Secretary/Treasurer

2012-2013 CRUG Board Members

Board Members:

- Simon Frost, Walker Technical Resources
- Dit Loyd, WrapMaster, Inc.
- Donald McNicol, Oceaneering International, Inc.
- Tommy Precht, Armor Plate, Inc.
- David Miles, Pipestream, Inc.
- Mike Collins, Dow
- Darren Duhon, NiSource
- Dave Wilson, P66

History of Composite Repairs in the Pipeline Industry

Presentation Overview

- Composite repair overview (State of the Art)
- Composite repair timeline
- Industry interest as reflected in PRCI studies
- Contribution of composite materials to the integrity management of pipelines
- Case study: Re-rating pipeline (Pipestream)
- Looking forward

State of the Art

- Composite materials have been used to repair high pressure transmission pipelines for more than 20 years
- The key to integrating composite technology is properly designed and installed systems possessing adequate service life
- Performance testing has been an essential element in demonstrating the capacity of composite repair technology

Composite Repair Timeline (1/2)

(Based on work done by Stress Engineering)

1994 Started testing Clock Spring with GRI

(primary interest reinforcing mechanical damage)

1997 Started testing Armor Plate® Pipe Wrap

(wide range of studies including load transfer, dents, cyclic, etc.)

2000 Started testing for NRI and WrapMaster

2004 Started working with Pipe Wrap

2005 Started testing Aquawrap

2006 Stress Engineering ASME PCC-2 involvement

Start of significant individual operator funding

(e.g. El Paso, TransCanada, Panhandle, CenterPoint, & Chevron)

Composite Repair Timeline (2/2)

(Based on work done by Stress Engineering)

2008 PRCI long-term buried project (13 mfgs) See below

Armor Plate, Inc. (10 years)
Air Logistics Corporation (3 years)
Clock Spring Company, LLC (3 years)
Citadel Technologies (10 years)
EMS Group (10 years)
Pipe Wrap, LLC (3 years)
T.D. Williamson, Inc. (10 years)
Walker Technical Resources Ltd. (3 years)
Wrap Master (3 years)
3X Engineering (3 years)
Furmanite (3 years)
Neptune (3 years)
Pipestream (10 years)

2009 First meeting of what would become CRUG

Started testing for Western Specialties

2010 Started testing for Pipestream (re-rate / cracks)

2012 Started testing for Fyfe Company

2013 Development of PRCI Comp. Guideline Doc.

PRCI Research Programs

- MATR-3-4 Long-term performance (10-year study)
- MATR-3-5 Repair of dents
- MATR-3-6 Repair of subsea pipelines/risers
- MATR-3-7 Girth weld reinforcement
- MATV-1-2 Wrinkle bend reinforcement
- MATR-3-9 Re-rating to establish MAOP
- NDE 2-3 NDE & Inspection Techniques
- MATR-3-10 Composite Repair Guideline Document
- Composite Roadmap
- Future (potential) programs
  - Crack repair and reinforcement
  - Effects of pressure during installation
  - Elevated temperature testing

Composite Repair Past Uses

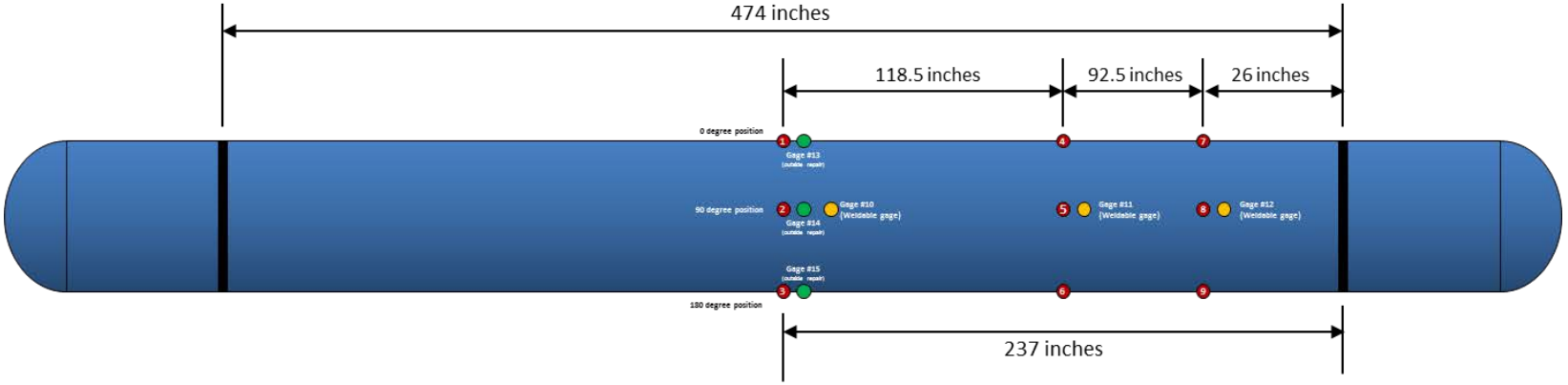
- Corrosion
- Dents (Plain; dents in seam and girth welds)
- Mechanical damage (dents with gouges)
- Tees, elbows, bends, and branch connections
- Girth welds
- Seam weld defects
- Wrinkle bends (cyclic pressure, bending, and tension)
- Cracks
- Pipe spans
- Hydrotest leak repair
- Re-rating to establish MAOP
- Elevated temperature service
- Offshore pipelines and risers

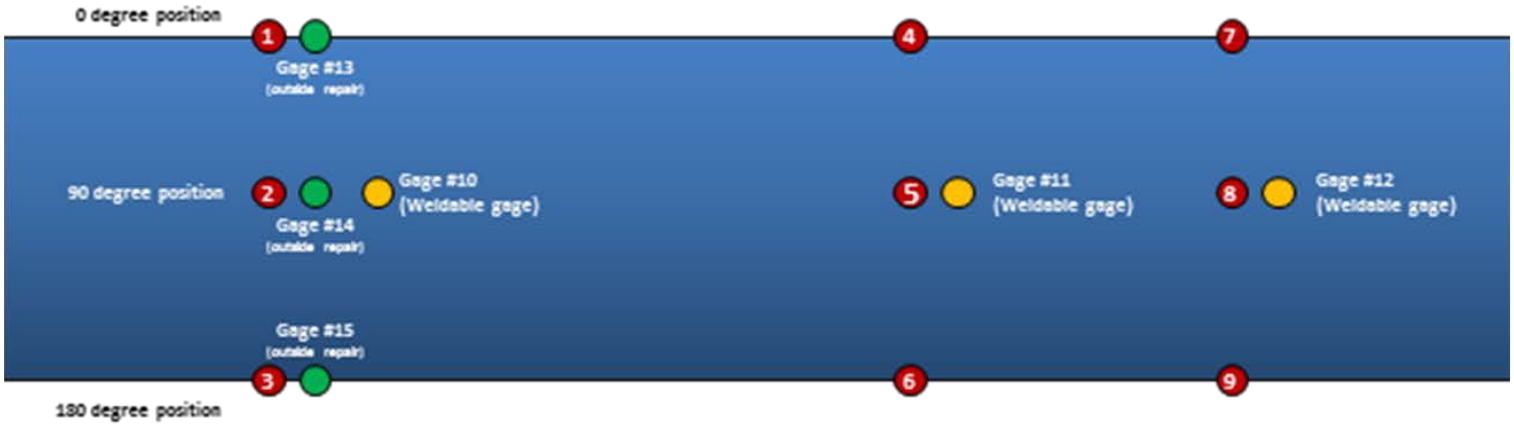
Case Study
Re-rating Pipelines

Project Overview

- Establishing Maximum Allowable Operating Pressure (MAOP) arises when class location changes for gas pipelines are required for the pipeline due to encroachment.
- The pipeline industry has shown interest in using composite materials for the purpose of re-rating.
- The concept of re-rating can be viewed as an extension of existing repairs.
- Any reinforcing option must include both static and cyclic pressure considerations, as well as long-term considerations.

Sample Configuration





Close-up View

Pipe Sample Details
(Repaired and Unrepaired)

Nominal Diameter:	26 inches
Nominal Wall Thickness:	0.281 inches (avg. measured value of 0.290 inches)
Grade:	X52 (SMYS = 52 ksi | SMTS = 66 ksi)
Actual properties:	S_y = 66 ksi and S_{UTS} = 88 ksi
SMYS Pressure:	1,124 psi
SMTS Pressure:	1,426 psi
MAOP (Class 1D2):	809 psi (72% SMYS pressure)
MAOP (Class 3):	562 psi (50% SMYS pressure)
XHab properties:	0.160 inches thick (4 layers at 0.040 inches per layer, SMTS XHab of 203 ksi)

Pre-test Activities

- Prior to burst testing, the reinforced pipe sample was pressure cycled from 100 to 909 psi for 13,400 cycles; representing 20 years of service with a safety factor of 10 assuming an “Aggressive” pressure cycle condition for gas transmission pipelines.
- Strain gages were installed on both the unreinforced and reinforced test samples to monitor reinforcement levels during testing.

Unreinforced Burst Test

P_{burst} = 1,408 psi (unreinforced)

Reinforced Burst Test

P_{burst} = 4,008 psi (reinforced)

Strain Gage Results

Average Stress Values (psi)		
	Hoop	Axial
Unreinforced Pipe		
50% SMYS	27828	14243
72% SMYS	39957	20476
100% SMYS	61340	30984
Reinforced Pipe		
50% SMYS	17063	9497
72% SMYS	24087	13458
100% SMYS	33856	18880
Percent Reduction		
50% SMYS	-38.4%	-33.2%
72% SMYS	-39.4%	-34.2%
100% SMYS	-43.8%	-38.6%

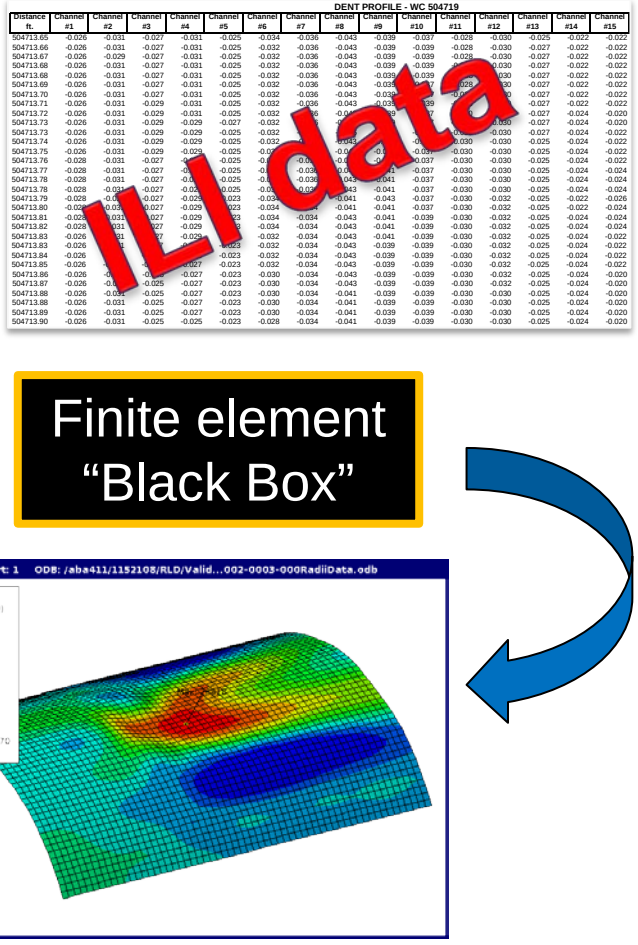
Average Stress Values (% SMYS)		
	Hoop	Axial
Unreinforced Pipe		
50% SMYS	54%	27%
72% SMYS	77%	39%
100% SMYS	118%	60%
Reinforced Pipe		
50% SMYS	33%	18%
72% SMYS	46%	26%
100% SMYS	65%	36%
Percent Reduction		
50% SMYS	-38.4%	-33.2%
72% SMYS	-39.4%	-34.2%
100% SMYS	-43.8%	-38.6%

Closing Comments

- This study was useful for demonstrating the “technical merit” in using composite materials for re-rating pipelines.
- For all range of pressures considered, the XHab system reduced hoop and axial stresses in the pipe samples by 40.6% and 35.3%, respectively.
- As is always the case, long-term performance is an essential ingredient for assessing a composite system’s capabilities.

Composite Repairs: Looking Forward

- Maintaining integrity is a top priority for pipeline companies.
- In-line inspection (ILI) is advancing significantly (can no longer “hide behind the numbers”).
- More ILI data will eventually lead to <u>more repairs</u>.



October 7th DV-CIP meeting (9 AM – 3 PM)
Hosted by Stress Engineering Services and ROSEN

Questions?

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