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Evolution of Clock Spring®



SPRING

- In 1963 Amoco pioneered the use of composites for underground storage tanks using a polyester resin/e-glass system
 - In 1970's the fireman's breathing apparatus and the Natural Gas Vehicle Storage tanks were developed by NCF Industries

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Composite History in Pipelines



- In 1986 NCF
 Industries
 developed Clock
 Spring
- Designed for arresting cracks in high pressure gas pipelines





Original Clock Spring®





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Original Clock Spring®



□Bonded In Place with Fast-**Curing Methacrylate** Adhesive² □High-Modulus Filler³ □Unique Composite. □Layers.¹ □Simple Application leads to **Cost Savings and Ensures** Reliability □A composite sleeve was created







- □ 10-Year Research Program Started in 1987
- Goal: Find a Non-Intrusive Alternative to Steel Sleeves
- □ Steering Committee of Pipeline Experts from Academia & Industry
- □ Program Design Called for a Battery of Lab & Field Studies
- Complete Test Reports Available
- Commercially Available since 1993
- □ 50-Year Minimum Working Life





Sixty-Nine Units Installed



See GRI 98/0027 and GRI 98/0032 for complete reports



NuStai

Stress Rupture Testing



SEE GRI 95-0071 for complete test report





Woven Cloth

- Used in the first Clock Spring®
- Only 50% of the glass is in the load direction
- Problems with cyclical loads
- Good for low pressure
- (< 500 psi) applications
- Under cyclical loads
 - Fibers move and chaff
 - Diminished strength
 - Long term performance difficult to predict

Be careful of woven cloth for reinforcement of cyclical loads.





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Unidirectional Glass



□Saturation of fibers is consistent

- □100% of the load carrying fibers are in the hoop direction
- Fibers will not chafe or cut one another during cyclical loading







Clock Spring® History

- Originally Designed as a Crack Arrestor
 Metal Loss Repairs Validated by Full-Scale Burst Tests
- Extensive R&D Reports Submitted to
 - Regulators
- □20 Year Commercial History of Permanent Repairs
- □Over 1 Million Years of Total, Cumulative

Repair Service





Application Method











2. Position the Clock Spring and mark position around pipe





5. Apply adhesive to Pipe Surface











10. Re-coat and backfill - Coal Tar O.K. after Cure (2+ hrs and 40 on a Shore A scale)





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Pipe Details						Operating Details							
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Case Study One-NuStar Terminal Overview





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□ Terminal Overview

- Port of Los Angeles-NuStar Energy Terminal
 - ≻ 607,000 bbls of storage capacity
 - Marine receipt/delivery across multiple 6, 8, 10, 12 inch dock pipelines
 - Multiple product grades handled and isolated by line for product quality purposes
 - ➢ Facility handles ~30 barges or vessels per month
 - Wharf downtime of any kind would become critical path to customer base
 - Wharf and associated piping are slated to be significantly modified as a result of MOTEMS seismic evaluation
 - Repair strategy utilized established corrosion rates to allow for a safe amount of remaining thickness; considering the useful life of the wharf









□ Challenging Maintenance Scenario

- Regulatory inspection requirements and associated repair strategies
 - Pipes suspended beneath the decking of a timber pile structure via full encirclement split clamp hung with all-thread from timbers
 - Access to repair sites can be challenging due access through timber cross-members depending on changing tidal conditions
- API 570, API 2611, DOT, PSM Process Piping Inspection/Repair Criteria
 - Depending on regulatory driver or repair strategy, the requisite training/application requirements for installer and the qualifications for that installation may be critical path to complete in a timely manner
 - DOT involvement and Operator Qualifications
 - Approved contractors based on company policy
 - Availability of capable and qualified contractors





























□ Recent Example at NuStar Terminal

- API 570 inspection revealed areas of significant external corrosion on uncoated pipe with as little as .10" remaining thickness
- Based on established corrosion rates, some areas only required external coating to mitigate future corrosion
- Areas under pipe clamps were unknown and were not able to be inspected with UT
 - Pipe to clamp areas were known not to have a nonconductive material between pipe and steel support
 - Dissimilar metals creates a known corrosion cell in the marine environment where moisture is trapped
 - These areas were treated as unknowns and were to be inspected separately with the proper precautions





□Two Part Strategy to exposed pipe repair

- Depending on site-specific corrosion, either prep and externally coat, or
- In the areas of exposed piping (away from pipe supports), "Snap-Wrap" Clockspring© materials were chosen as final mitigations
- □Majority of piping had majority of original thickness and could be coating as the full mitigation
- □Isolated areas required clockspring repairs; generally as a result of improper support-to-pipe buffer material
 - Generally in areas of trapped water to pipe
 - Dissimilar metal to metal contact















Pipe Support Repair Strategy

- Original plan was to support, remove clamps, UT, then repair similar to the exposed pipe depending on the RT under the pipe support
- No evidence or history of leak or weep on the pipe or support
- Alternative was to construct new transfer line and to demo existing.







❑ Why we choose non-metallic repairs versus fullencirclement sleeves?

- Hot work-need to de-product the line and risk to the surrounding environment
- Prep work for sleeves includes significant downtime
- The finished product with non-metallic repair has built-in corrosion resistance
- Biggest issue-spill risk if breaking flanges torching, cutting
- Time line is considerably shorter
- Finished product has equal strength & integrity as original pipe







Product Options Available









Low Pressure Pipe Repair - up to 500psi



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Clock Spring® Snap Wrap

Pre-Fabricated Bi-Directional Sleeves 3/4" to 56"
4 Layer System
3" minimal clearance is required
Up to 90% Wall Loss
2hr Cure Time on Adhesive



Crevice Corrosion













□360°Protection at Contact Points





Clock Spring® Pipe Support

Pre-Fabricated Bi-Directional Sleeves from 3/4" to 56"
3 Layer System
Bonded 360° for Protection at Contact Points
2hr Cure Time on Adhesive







Clock Spring® Pipe Support



Corrosion is a Leading Cause of Piping Failures
Water Entrapment, Disbondment, Coating Failure
360° Encirclement by Clock Spring® Pipe Support offers Maximum Protection at Contact Points
Design Works with Virtually Any Support Type
Fast, Easy Installation





Application











Pipe Repair - up to 1000 psi.





CONTOUR®

- □Wet Lay Up System 1" to 36"
 - Repairs: Straight Pipe, Tees, Bends & Flanges
- □Up to 1000psi on corrosion type defects
- □Leaks are temporary up to 350psi
- □ 6-10hr Cure Time on Oil Base Epoxy















Elbows & Connections







Bends & Reducer



Clock Spring® Today

- □Clock Spring began Commercial Operations in 1993
- □Today: Sales in Over 75 Countries
- □Over 1 Million Years of Cumulative Repair Service
- □Clock Spring is Successful Because:
 - Technically Sound Product
 - Economically Advantageous
 - Trouble-Free

Questions?

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