Composite Repair Solutions for Corrosion Under Insulation
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Presented By: Mr Ron Campbell
Belzona Polymerics Ltd
Corrosion Under Insulation – Root Causes and Effects

Water Ingress

- Trapped during construction
- Leakage of weather-proofing
- Sprinkler Systems

Exacerbating Factors

- Contaminants in the insulation material
- Atmospheric pollutants
- Chemical Spillage

Temperature

- CUI most aggressive in the range of 15 – 150 C
- Cyclic wetting / drying accelerates corrosion
Corrosion Under Insulation – Effects

Carbon Steels
- Accelerated Corrosion
- Pitting

Stainless Steels
- Crevice Corrosion
- Pitting corrosion
- SCC (high risk: chloride + T>60 C)
Corrosion Under Insulation – Problem Areas

Water penetration into Insulation is the primary cause of CUI – if the water can be prevented from entering the Insulation – CUI can be negated.
Corrosion Under Insulation – Results

CUI problems can be Repaired and Negated On Line using Specialized Solutions
Corrosion Under Insulation – On Line Composite Repair Solutions

Compliant Repairs
Where there is an accepted International Standard for the use of composite materials for repair of pipe - work and tanks and where the client requires certification:

- ASME PCC-2-2008
- ISO / TS 24817

Non-Compliant Repair and Protection
Where there is no internationally recognized standard required for the application but they are effective and have been and are currently in use within industries worldwide and are widely accepted based on historical performance.
Corrosion Under Insulation – Compliant Composite Repair Solutions

ASME PCC-2-2008

This Standard provides methods for repair of equipment and piping within the scope of ASME Pressure Technology Codes and Standards\(^1\) after it has been placed in service. These repair methods include relevant design, fabrication, examination, and testing practices and may be temporary or permanent, depending on the circumstances.

ISO / TS 24817

The objective of ISO/TS 24817 is to ensure that composite repairs to pipework when qualified, designed, installed and inspected using ISO/TS 24817 will meet the specified performance requirements. Composite repairs are designed for use in oil and natural gas industry processing and utility service applications. The main users of this Technical Specification will be owners of the pipework, design contractors, suppliers contracted to deliver the repairs, certifying authorities, installation contractors and maintenance contractors.
ASME PCC-2 and ISO/TS 24817 allow for the repair of the following:

- Thinned wall defects
- Through wall defects
- Straight Pipe
- Complex Geometries, Bends, Tees, Reducers etc.
- Tanks and Vessels
Limitations of Compliant Composite Repairs

- Require Grit Blasted surface preparation
- Limitations on Substrate temperature during application of the composite (circa: 50°C)
- Limit on upper temperature resistance of the composite materials (circa: 80-100°C)

HOWEVER:
Within these parameters they still offer effective repair solutions to CUI situations
Composite Repairs are Classified within the Standards

Repairs can only be carried out by Manufacturers Trained and Validated Personnel:

Class 1: Manufacturers Trained Validated Applicator
Class 2: Manufacturers Trained Validated Applicator and Supervisor
Class 3: Manufacturers Trained Validated Supervisor

<table>
<thead>
<tr>
<th>Repair class</th>
<th>Typical service</th>
<th>Design pressure</th>
<th>Design temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Low specification duties, e.g. static head, drains, cooling medium, sea (service) water, diesel and other utility hydrocarbons</td>
<td>&lt; 1 MPa</td>
<td>&lt; 40 °C</td>
</tr>
<tr>
<td>Class 2</td>
<td>Fire water/deluge systems</td>
<td>&lt; 2 MPa</td>
<td>&lt; 100 °C</td>
</tr>
<tr>
<td>Class 3</td>
<td>Produced water and hydrocarbons, flammable fluids, gas systems</td>
<td>Qualified upper limit</td>
<td>Qualified upper limit</td>
</tr>
</tbody>
</table>

Class 3 also covers operating conditions more onerous than described.
Corrosion Under Insulation – Compliant Composite Repair Solutions

Types of Defects

The standards detail the types of repairs that can be carried out using compliant composite systems.

<table>
<thead>
<tr>
<th>Type of defect</th>
<th>Applicability of repair system</th>
</tr>
</thead>
<tbody>
<tr>
<td>General wall thinning</td>
<td>Y(^a)</td>
</tr>
<tr>
<td>Local wall thinning</td>
<td>Y</td>
</tr>
<tr>
<td>Pitting</td>
<td>Y</td>
</tr>
<tr>
<td>Gouges</td>
<td>R(^b)</td>
</tr>
<tr>
<td>Blisters</td>
<td>Y</td>
</tr>
<tr>
<td>Laminations</td>
<td>Y</td>
</tr>
<tr>
<td>Circumferential cracks</td>
<td>Y</td>
</tr>
<tr>
<td>Longitudinal cracks</td>
<td>R</td>
</tr>
<tr>
<td>Through-wall penetration</td>
<td>Y</td>
</tr>
</tbody>
</table>

\(^a\) Y implies generally appropriate.

\(^b\) R implies can be used, but requires extra consideration.

Repair Life

Repairs are designed to design lives of up to 20 Years using standard safety factors.
Compliant Composite Repair Solution – Total Refinery France

Repair to 34” Crude Oil Line suffering localised wall thickness loss from 6.2mm to 2mm operating at a pressure of 19 bar. Composite repair applied at 5mm thickness and 4 layers of composite reinforcement
Repair to various produced water lines suffering localised wall thickness loss and through wall defects operating at a pressure of 80 bar. Composite repair applied at 14mm thickness and 6 layers of composite reinforcement
Compliant Composite Repair Solution – Petrobras
Buried Gas Pipework in Brazil

Cleaning using High Pressure Water Jetting

Surface Preparation using Grit Blasting to SA2.5 with 75 micron Profile
Compliant Composite Repair Solution – Petrobras Buried Gas Pipework in Brazil

Application of Base Layer of Composite to Repair Pitting

Wrapping of Composite Fibres
Compliant Composite Repair Solution – Petrobras
Buried Gas Pipework in Brazil

Further Layers of Composite Resins and Reinforcement Fibres applied to Complete the Application.
Corrosion Under Insulation – Compliant Composite Repair Solutions

- Compliant to ISO and ASME Standards
- Designs to match system requirements
- Suitable up to 85C operating temperature
- Pressures up to 200bar
Corrosion Under Insulation – On-Line Solutions for Elevated Temperature CUI Problem Areas

**Heat Activated Repair and Protection System**

- Can Be applied to Hot Surfaces
- Surface Temperatures of 30°C – 180°C
- Minimal Surface Preparation (ST2)
- High Adhesion
- Resists Insulation Saturation / Immersion
- Simple to Use
- Long Service Period
- Can be combined with reinforcing fibres to produce composite repair system for pipe strengthening and pressure containment.
Corrosion Under Insulation – On-Line Solutions for Elevated Temperature CUI Problem Areas

Substrates: Unprepared Steel
- Unprepared, uncorroded steel direct from the manufacturers
- Surface covered in firmly attached millscale

Unprepared steel ground using belt sander (with P36 abrasive)
- Clean metal surface exposed, but negligible profile

Wire-Brushed Rusty Steel
- Started with rusty steel panel (ISO 8501-1 grade C)
  - Initially abraded with wire brush, then further abraded by hand with P36 abrasive paper to ISO 8501-1 St 3
  - Surface a combination of firmly attached rust with some clean steel showing through

Rusty Steel
- Started with ISO 8501-1 grade C steel weathered externally for 3 months
  - Rusted to ISO 8501-1 with some pitting
  - Loose surface rust brushed away, but no other preparation

Pitted surface covered in firmly attached rust
Corrosion Under Insulation – On-Line Solutions for Elevated Temperature CUI Problem Areas

Adhesion

<table>
<thead>
<tr>
<th>Condition</th>
<th>Adhesion Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manually Abraded</td>
<td>2600 psi - 2410 psi</td>
</tr>
<tr>
<td>Wire Brushed</td>
<td>1720 psi - 1240 psi</td>
</tr>
<tr>
<td>Rusty</td>
<td>1380 psi - 830 psi</td>
</tr>
<tr>
<td>Ground</td>
<td>3490 psi - 2320 psi</td>
</tr>
<tr>
<td>Unprepared</td>
<td>2940 psi - 2280 psi</td>
</tr>
<tr>
<td>Blasted SA2.5</td>
<td>2800 psi - 3200 psi</td>
</tr>
</tbody>
</table>

Up to 80°C / 80 to 180°C
Corrosion Under Insulation – On-Line Solutions for Elevated Temperature CUI Problem Areas

Testing
Steel test panels prepared by abrading manually (no profile)
HA Coating applied onto hot panels and oven cured
Panels exposed for 1000 hours at 35°C (95°F) in saturated salt fog atmosphere

Results
No field blistering or corrosion
Minimal corrosion creep under the scribe mark
Heat Activated Composite Repair Solution – Shell Refinery New Zealand Year 2013

De-Asphalting Column in service with operating of 120 C

Surface Preparation Carried out Using High Pressure Water Jetting

Application of Heat Activated Coating System using rollers and brushes

Ongoing Inspection shows no deterioration of the coating after 11 years in Service.
Heat Activated Composite Repair Solution – Exxon Refinery Singapore Year 2001

Fractionator Tower T102 in service operating at 120°C

Surface preparation carried out using scrapers to remove loose rust to ST2 finish

Application of Heat Activated Coating System using rollers and brushes

Ongoing Inspection shows no deterioration of the coating after 13 years in Service.
Heat Activated Composite Repair Solution – British Gas Offshore Platform Year 2005

Gas - Condensate Pipework operating at temperatures up to 115°C

Surface preparation carried out using high pressure water jetting

Heat Activated Composite wrapping and coating carried out on-line

Ongoing Inspection shows no deterioration of the repairs and after 9 years in Service.
Heat Activated Composite Repair Solution – Shell Stanlow Refinery UK Year 2006

Severe CUI on distillation columns and fractionator towers operating between 50-120°C

Manual preparation of the steel substrate using scrapers and wire brushes

Application of Heat Activated Coating System to Manually Prepared Surfaces
Heat Activated Composite Repair Solution – Shell Stanlow Refinery UK Year 2006

- Application to in service pipework and vessels operating at elevated temperatures dramatically reduced application time from weeks to days.
- Client impressed with the ease and speed of application and longevity of the system
- Heat Activated Coating System now globally approved by Shell
Two years into a six year programme of work, Shell were able to conduct direct comparison with TSA and with other organic coating technologies.

**Heat Activated System Advantages over TSA**
- No need to blast clean substrate
- No need to tent in area to retain blast media
- Not creating confined spaces to manage emergency plans for
- Application of two coats onto hot surfaces easy
- Avoiding equipment “hot work”
- Less risk of misses
- Less risk of coating failure due to thin film or missed areas
- Significant savings in time and money
Heat Activated Composite Pipe Repair and Pressure Testing of Spool with 20mm Diameter Hole. Composite wrap at a Thickness of 10mm
The absorber column at the Vector Kapuni Gas Treatment Plant in Taranaki required painting. It was not possible to take the column out of service long enough to complete the painting programme using normal painting specs. The column runs at approximately 100 degree C so the search began for a product that could be applied at this temperature while the plant remained online. Belzona 5851 was the pick of the products as it had already proven itself at Marsden Point. Belzona 5851 has now been in service for about 2 ½ years and as the pictures show remains in good condition. We have since applied the same product to our Regeneration tower which also runs at similar temperature with no problems encountered.
On-Line Composite Repair Solutions for Corrosion Under Insulation

- ASME and ISO Compliant Systems for Temperatures up to 85°C and pressures up to 200 bar
- Heat Activated Composite Repair Systems for elevated temperature service and pressures up to 180 bar
- Applied to manually prepared surfaces
- Over 10 years of in-service experience and proven capability.
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ANY QUESTIONS?

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