On-Line Repair Solutions for Corrosion Under Insulation
On-Line Composite Repair Solutions for Corrosion Under Insulation

NACE Jubail Technical Workshop
Corrosion under Insulation
10th December 2015

Presented By : Mr Rob Dawson
Belzona® Product Manager
Hajjan Trading & Industrial Services Co. Ltd. (HATCON)
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)
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
CUI - Solution Criteria

Prevent Moisture from getting to the Metallic Substrate
1. Insulation Effectively Sealed
2. Coating that has excellent Immersion and Temperature Resistance

Coating Solution – Technical Properties
- High Adhesion
- Low Permeability for Immersion Resistance
- Surface Preparation Tolerance
- Application to a range of substrate temperatures

Commercial Considerations
- Simple to apply
- On-Line application
- Quick curing
- Long life Expectancy
- Minimal surface preparation
- Cost effective
Belzona Can Provide On Line Solutions to Corrosion Under Insulation Problems on Hot Substrates Including:

- Bonding Doubler Plates
- Filling of Pitting Corrosion
- Vessel Protection
- Pipe Protection

HA – Metal Paste Grade

HA – Barrier Coating Grade

Vessel Protection

Pipe Protection
Belzona® Heat Activated Products

**Single pack product**
- No weighing or mixing
- Effectively unlimited usable life

**Heat-activated cure when applied onto hot pipework**
- No equipment shutdown necessary
- Minimum cure temperature 70ºC (158ºF)
- Optimum performance up to 150ºC (302ºF)
- Rapid 15 minute cure at ≥100ºC (212ºF)

**Surface tolerant**
- Excellent adhesion even on manually prepared surfaces

**Safe to apply directly onto hot surface**
- No volatile components up to 150ºC (302ºF)
Adhesion on ambient temperature substrates

Is best achieved through mechanical locking such as by grit blasting.
Adhesion on hot surfaces

Achieved by penetration of micro-pores in metal which increase in size on heating
CUI Simulation Testing

- Partially rusty test sleeve manually abraded using P36 abrasive paper is placed over heater.
- Test coating is applied onto the hot sleeve.
- End flange is bolted on and sealed.
- Mineral fiber insulation taped into place.
- Outer cladding/water funnel attached/sealed.
CUI Simulation Test Results

- Two litres of water added each week
  - 1 litre of water and 1 litre of 5% salt water solution

- Results
  - No attack or corrosion at 70°C to 90°C
  - Negligible attack/corrosion at 100°C to 150°C
  - Very slight surface erosion in full immersion areas Belzona®5851
  - No attack or corrosion in full immersion Belzona®5841
Salt spray testing

Generates a very corrosive fog of warm salt water. Coated panels are exposed to the salt water fog, with a scribed “X” cut through the coating. Tested in accordance with ASTM B117. Test not ideally representative of CUI but industry standard test for corrosion resistance.

Salt Spray Results

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

Results

No field blistering or corrosion. Minimal corrosion creep under the scribe mark.
Adhesion testing

Substrates:

**Unprepared Steel**

Unprepared, uncorroded steel direct from the manufacturers.
Surface covered in firmly attached millscale.
Adhesion testing

Substrates:

Unprepared Steel

Ground Steel

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

Substrates:

- Unprepared Steel
- Ground Steel
- Rusty Steel

Steel weathered externally for 3 months. Rusted to ISO 8501-1 grade C, i.e. significant rusting with some pitting. Loose surface rust brushed away, but no other preparation.
Adhesion testing

Substrates:

- Unprepared Steel
- Ground Steel
- Rusty Steel
- Wire-Brushed Rusty Steel

Started with rusty steel panel (ISO 8501-1 grade C).
Thoroughly abraded with wire brush to ISO 8501-1 St 2.
Pitted surface covered in firmly attached rust.
Adhesion testing

Substrates:

- Unprepared Steel
- Ground Steel
- Rusty Steel
- Wire-Brushed Rusty Steel
- Abraded 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.
Belzona® 5851 performance

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

- Cure time decreases with increasing cure temperature
- Rapid 15 minute cure at 100ºC/212ºF
We are pleased to provide you with a copy of this Cathodic Disbondment on Belzona 5851 (HA-BARRIER) Test Report. The product was tested in accordance with ASTM G8 Standard Test Methods for Cathodic Disbonding of Pipeline Coatings. This test method covers an accelerated procedure for simultaneously determining comparative characteristics of insulating coating systems applied to steel pipe exteriors for the purpose of preventing or mitigating corrosion that may occur with underground service where the pipe will be in contact with inland soils and may or may not receive cathodic protection.

The basis for the test is breaks and holidays in pipe coatings may expose the pipes to possible corrosion, since the pipe is underground, the surrounding earth will be more or less moisture bearing and it constitutes an effective electrolyte. Normal soil potentials as well as applied cathodic protection potentials may cause loosening of a coating, beginning at holiday edges, and in some cases increasing the apparent size of the holiday. Holidays may be caused by such potentials. While apparently loosened coating and cathodic holidays may not result in corrosion, this test provides accelerated conditions for loosening to occur and therefore gives a measure of resistance of coatings to this type of action.

You may remember that one of the early field trials with Belzona® 5851 (HA-BARRIER) involved an underground pipe at ExxonMobil. The pipe definitely used cathodic protection. The results of the field trial were favorable and since that time applications to underground pipes have taken place in Texas and Latin America.

The cathodic disbondment test involves coating the outside of a pipe, the making of an artificial holiday in the coating, immersing the coated pipe in an electrolyte solution, and connecting the test specimen to the anode under a 1.5V potential for 30 days. Radial 45º degree cuts are made through the coating intersecting at the center of both the intentional holiday and a reference holiday with a sharp, thin bladed knife. An attempt is made to lift the coating with the point of a sharp, thin bladed knife. The total area of disbonded coating is measured and recorded. The result in this particular test of 0.01367 in² of equivalent circle diameter of disbondment is excellent.

### ASTM G8

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>5851</td>
<td>Av disbonded radius</td>
</tr>
<tr>
<td>-1.5 volts for 30 Days (720 hrs) @ 23°C</td>
<td>= 0.01367 inch² = 1.7mm rad = 3.3mm dia.</td>
</tr>
</tbody>
</table>

### ASTM G42

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>5831</td>
<td>Av disbonded radius</td>
</tr>
<tr>
<td>-1.5 volts for 30 days (720 hrs) @ 80°C</td>
<td>= 0.149 inches = 3.8mm rad = 7.6mm dia.</td>
</tr>
</tbody>
</table>

### ASTM G42

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>5841</td>
<td>Av disbonded radius</td>
</tr>
<tr>
<td>-1.5 volts for 30 days (720 hrs) @ 80°C</td>
<td>= 0.153 inches = 3.9mm rad = 7.8mm dia.</td>
</tr>
</tbody>
</table>
On-Line Repair Solutions for Corrosion Under Insulation

Historical Case Studies in the Oil and Gas Industry

Proof of Performance and Testing Relevance
TOTAL Immingham Refinery UK

- Condensate vessel operating at 85°C suffering severe CUI

- Surface preparation – combination of hand wire brushing and power wire brushing to produce a tightly adherent rusted surface.

- Application carried out 16th March 2001

- Surface temperatures ranged between 110°C at the top of the vessel and 50°C lower down

- Two coats of product applied from top of the vessel down to approximately 2 thirds of the vessel height

- Coating application was halted when the vessel skin temperature dropped to 70°C

- Application completed in 4 hrs & the total cure time was under 3 hrs allowing vessel to be re-insulated.
First in service inspection of Belzona 5851 on vessel 8D91 carried out 27th February 2002.
The condensate vessel had been lagged and had been in continual service for approx 12 months.
Sections of the lagging at various points had been cut away to facilitate this first 12 month inspection.
This area was performing extremely well with no defects in the coating.
Second in service inspection of Belzona 5851 on vessel 8D91 carried out late 2008.

Belzona’s long-term CUI solution

The Belzona online CUI solution has enabled global energy giant TOTAL to substantially reduce asset life costs of a number of its vessels. Based at its Lindsey oil refinery, Immingham. The initial application at this site remains in good condition, protecting the asset well into its eighth year in service.

In 2001 the client identified areas of corrosion under insulation (CUI), on an outdoor condensate vessel. Left untreated the corrosion could have caused substantial damage but the client did not want to risk cutting into the vessel.

“We really pushed us whilst onsite. A solution was needed for the vessel.
Belzona’s Barrier is a low cost, fast acting, surface prep, outstanding anti-corrosion coating.

Prior to the application Belzona 5851 was applied in situ, by the client’s contractors, directly to the vessel operating between 60 and 110°C (140 to 230°F).

During the application Belzona provided training to the client’s contractor team. This was found to be extremely valuable and the client commented on how “the contractors found the product easy to use as it required no specialist equipment and could be applied simply by brush thus ensuring the works were completed within the original timescale.”

Commenting on the longevity, and his overall satisfaction with the Belzona CUI solution Simon says:

“The most recent vessel inspection completed in late 2008 has confirmed that the original application, which was carried out in 2001, still remains in good condition to date and required no further action. We are very satisfied with the performance, durability and overall cost-effectiveness of the product. We have since carried out a number of subsequent applications on site using this product with no problems encountered.”
Shell Stanlow Refinery - UK

- Existing coating system failed resulting in severe CUI on distillation columns and fractionator towers operating at temperatures between 50-120°C. Shutdown for repairs was going to be very costly.


- The vessel wall temperatures were above 70°C but the insulation support rings were between 55°C and 65°C.

- Wire brush to remove all loose & flaking paint the apply Belzona® 5841 to the areas up to 75°C.

- This successful application has led to significant use of these systems at the Stanlow refinery.
Ease of Application + Cost and Time effective

- Belzona®5841 and Belzona®5851 developed for on line application onto pipework and vessels operating at elevated temperatures reducing application time from several weeks to a couple of days

Hertel (Shell Stanlow incumbent Coating and Insulation Contractor) application trials

Ian Land, CUI / LIP Project Manager Shell Stanlow ..... 

“Everyone is both surprised and impressed with the ease of application and the results ......

........Completed the top half of a column in 4 days against 6 weeks using existing alternate material”.

Hatcon
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 Repair Solution –
Shell Refinery New Zealand Year 2003

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 12 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 14 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 **10 years in Service.**
Emlyn Roberts  
Works Engineer  
Total Refinery, UK

Bertrand Van Der Hayden  
Fixed Equipment Reliability Inspector  
Caltex South Africa

Bob van den Beuken  
Maintenance Team Leader Mechanical  
Vector Kapuni, New Zealand

**Client Testimonials**

**Emlyn Roberts**  
Works Engineer  
Total Refinery, UK

"The most recent vessel inspection completed in late 2008 has confirmed that the original application, which was carried out in 2001, still remains in good condition to date and required no further action. We are very satisfied with the performance, durability and overall cost-effectiveness of the product. We have since carried out a number of subsequent applications on site using this product with no problems encountered."

With our trial now having run to completion, we can confidently say that these products should perform in the long-term as they have been designed to do. We have no reservations in recommending these products for similar applications within the petrochemical industry. The attached photographs illustrate the surfaces prior to, during, and after application.

**Bob van den Beuken**  
Maintenance Team Leader Mechanical  
Vector Kapuni, New Zealand

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.
Systems Application Temperatures

- 70°C - 150°C - Belzona® 5851
- 30°C - 80°C - Belzona® 5841
- Up to 35°C - Belzona® 5831
On-Line Repair Solutions for Corrosion Under Insulation

Heat Activated and CUI Repair and Protection Systems

- Can Be applied to Hot Surfaces
- Surface Temperatures of 10C – 180C
- Minimal Surface Preparation (ST2)
- High Adhesion
- Resists Insulation Saturation / Immersion
- Simple to Use
- Long Service Period
QUESTIONS?

Presented By: Mr Rob Dawson
Belzona® Product Manager
Hajjan Trading & Industrial Services Co. Ltd. (HATCON)
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