Using Epoxy Adhesives in place of Hot Metal Welding

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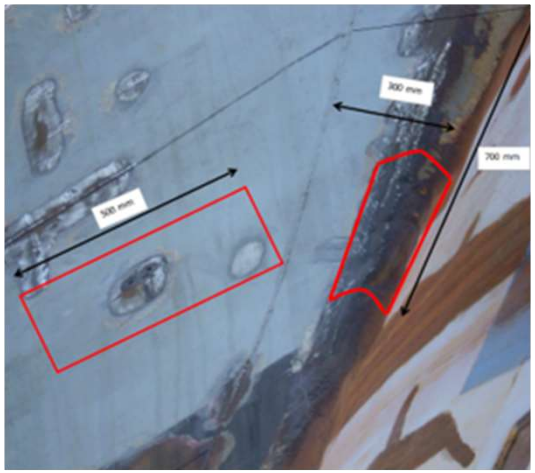
Repair • Protect • Improve

What's the Problem?

Pipework, pipelines, tanks and other metal structures

Thin-wall and pitting

Through-wall defects



Large assets

Localised damage

Pipe support erosion/corrosion

The Challenges

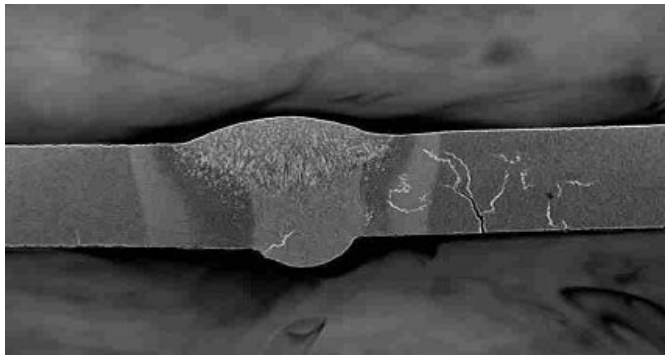
Issues – Existing assets

Three main factors cause deterioration on structures

- Environmental - Corrosion
- Process – Acidic/alkali
- External – Abrasion, impact and erosion

- Wear and through-wall defects take place

- Stress concentration nodes
  - A combination of these factors are often found working together e.g. stress corrosion cracking



The Challenges

Issues – New build

Traditional joining methods during fabrication are not always achievable

- Changing the substrate microstructure as a result of hot work
- Creation of cavities behind welded patches or brackets

Welding: Hot Works

Advantages

- Can restore metalwork to almost original condition
- Alloys can be added for additional strength
- Can be tested/inspected after
- A proven solution

Disadvantages

- Dissimilar metals can be difficult to weld
- Distortion & Stress due to heat introduction
- Safety risks associated with the heat
- Heat Affected Zone
- Internal linings can be affected by the heat
- **Requires Trained Personnel**

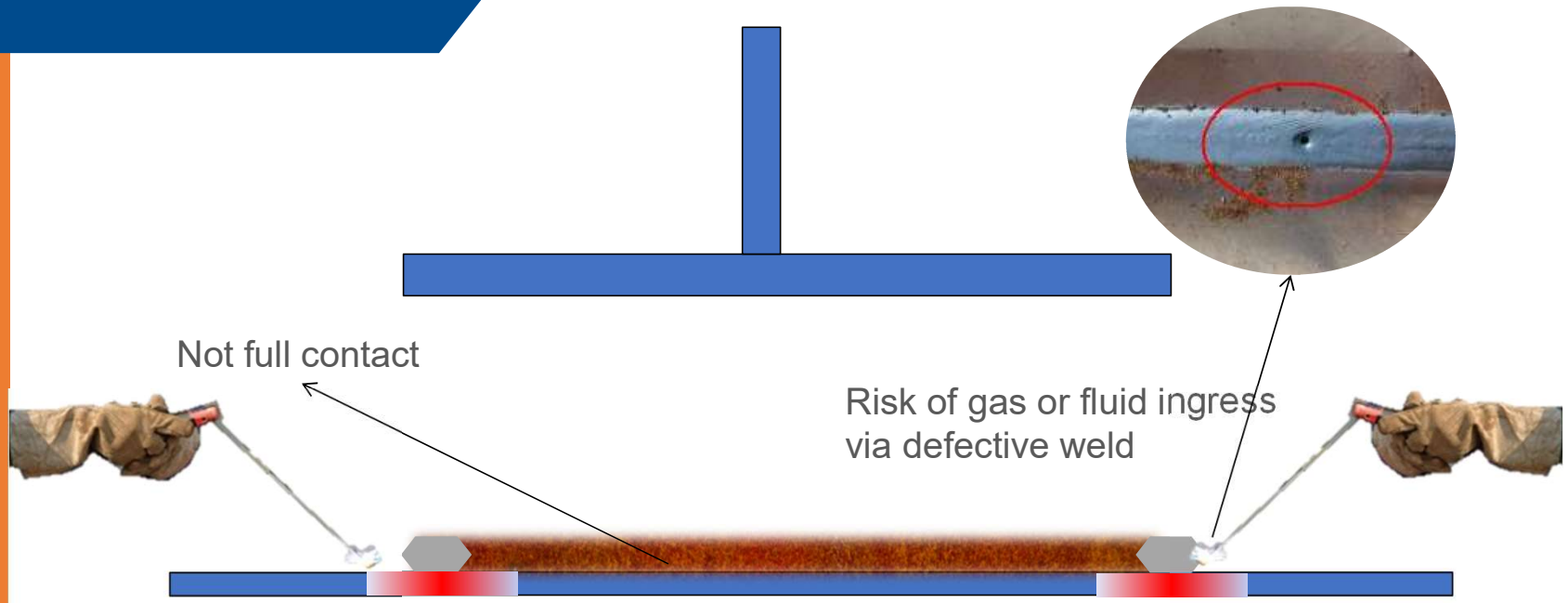
Welding

Hot Works

Additional Control Measures

HAZ

Corrosion



Example: welding deck, tank external, separator internal fittings

What is the Alternative?

Cold Bonding

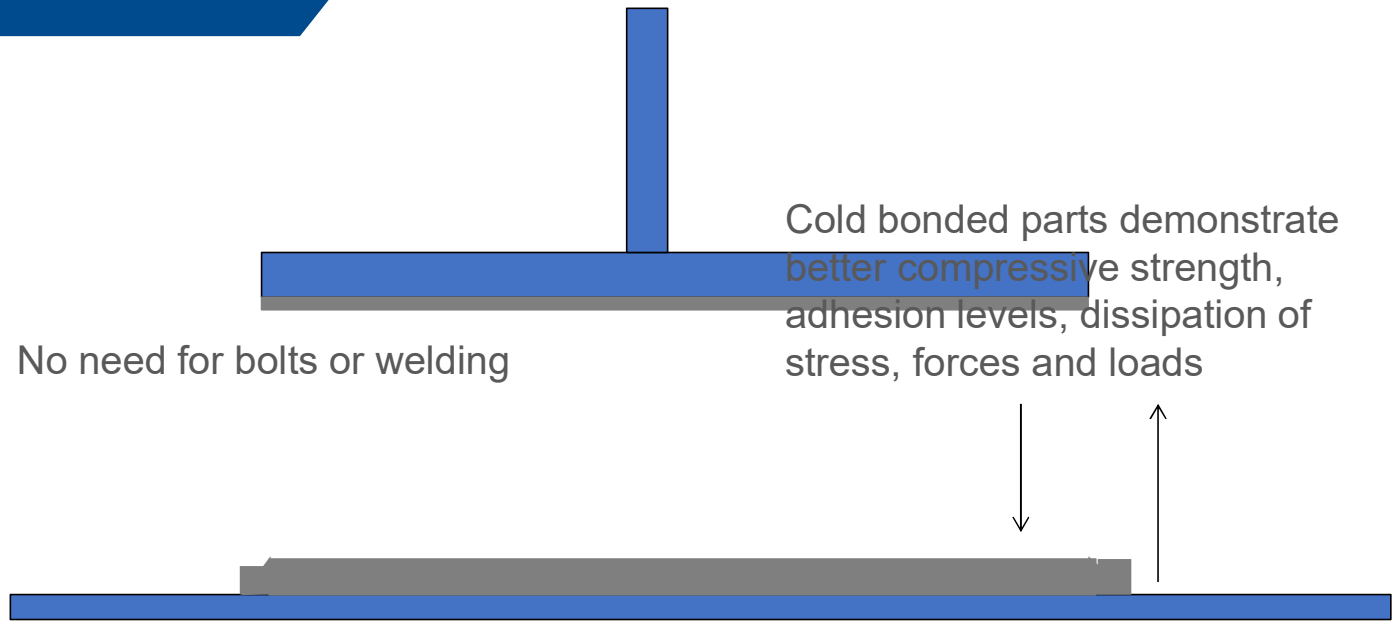
This method offers numerous advantages:

- No external heating
- Inert once cured
- Relatively high strength
- Will adhere to an extensive range of substrates
- Some varieties suitable up to 200^0C service temperature

Cold Bonding

- No Hot Works
- Easy to Apply
- No HAZ
- Corrosion Protection

Think of it as a “composite sandwich”



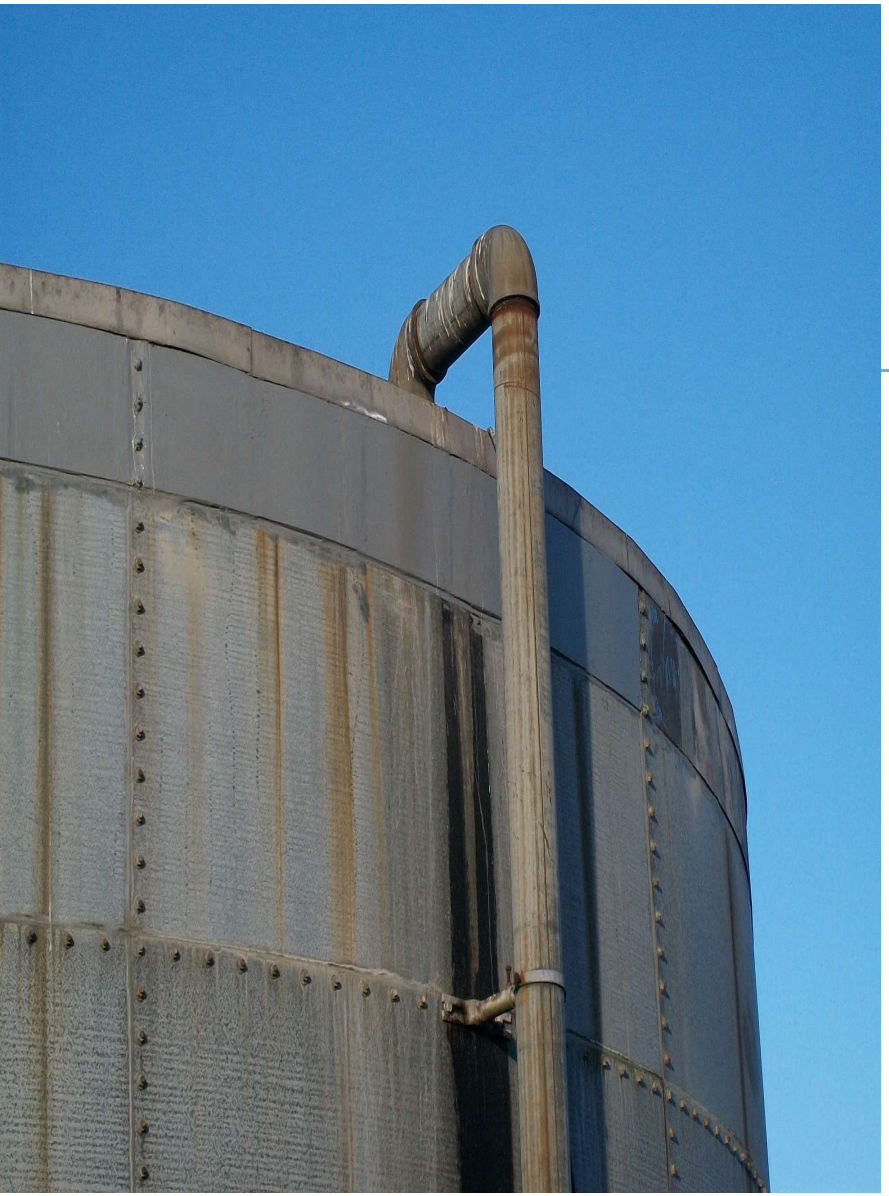
Cold bonded parts demonstrate better compressive strength, adhesion levels, dissipation of stress, forces and loads

No need for bolts or welding

Example: bonding deck, tank external, separator internal fittings

How do we test these materials and prove that they work?

Two methods, and two types of repair



Method 1: Hand Calculation

Unlike steel, the failure mode of these materials is notoriously difficult to predict. Failure happens on a small scale.

With that in mind, let's take the example on the left. This is based on a similar, real life application – bonding a plate onto the external of a corroded tank.

The key to this is simplicity.

Inputs:

Steel Plate

- Profile: 1000mm (L) x 100mm (W) x 4mm (T)
- Yield: 235 N/mm^2

Adhesive

- Type: 2-part Epoxy Bonding Agent
- Adhesive Strength (20^0C): 22.3 N/mm^2

The bonded area is 1600mm^2. Let's take a force of 3000N (pressure) to act from inside the tank across the plates surface. This gives:

Force: 3000 N

Area: 1600 mm^2

Stress: 1.875 N/mm^2

Safety Factor: 12

Method 2: Finite Element Analysis (FEA)

FEA can be used to predict stresses in certain applications involving epoxy materials.

After inputting all relevant data, we can build a simple design.

Testing

Finite Element Analysis

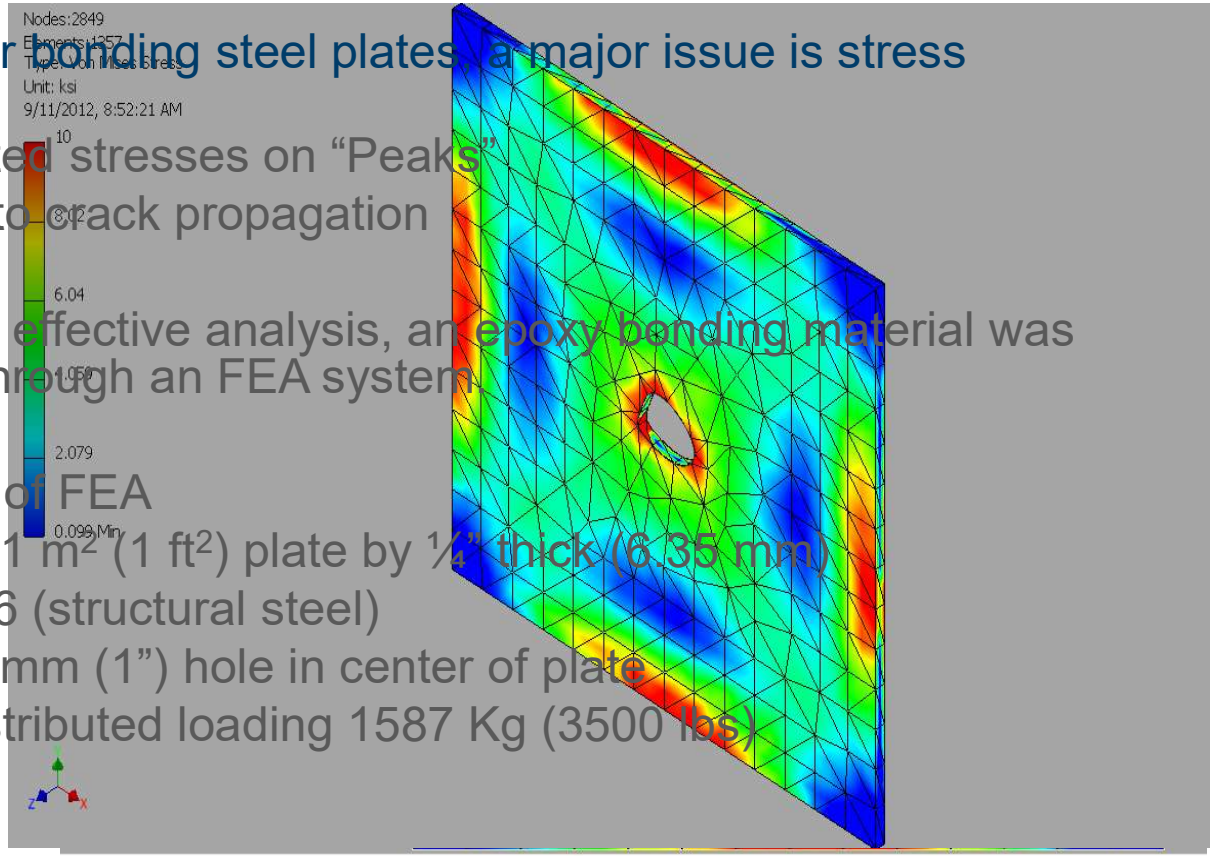
When welding or bonding steel plates, a major issue is stress concentrations.

- Exacerbated stresses on “Peaks”
- Can lead to crack propagation

To obtain an effective analysis, an epoxy bonding material was processed through an FEA system.

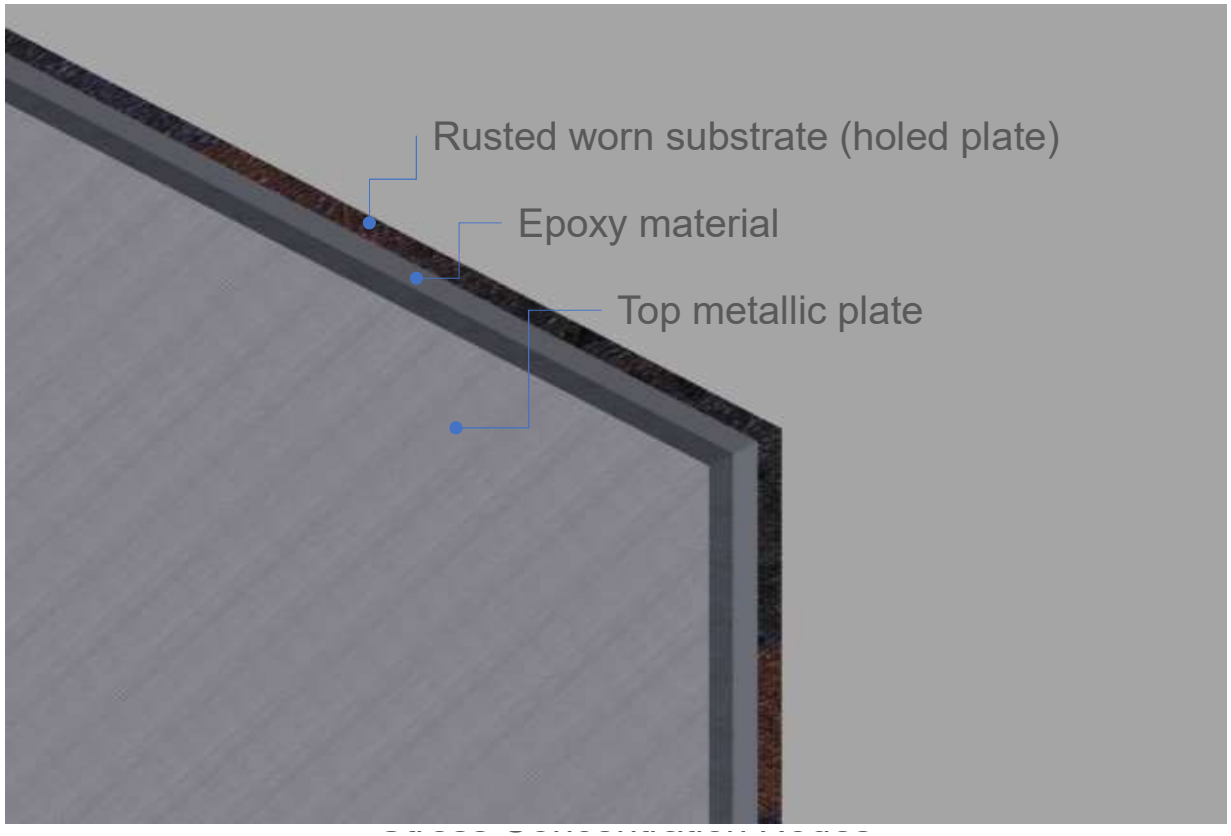
An example of FEA

- 0.01 m^2 (1 ft^2) plate by ¼” thick (6.35 mm)
- A36 (structural steel)
- 25 mm (1”) hole in center of plate
- Distributed loading 1587 Kg (3500 lbs)



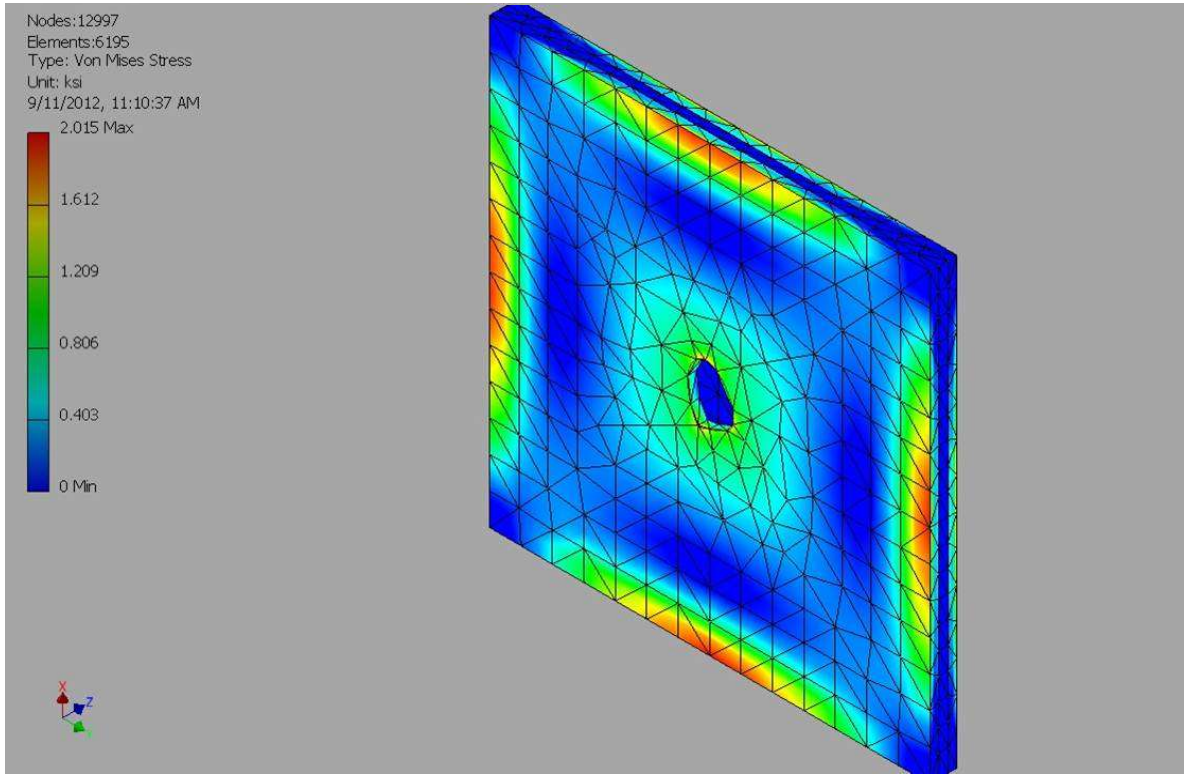
Testing

Finite Element Analysis



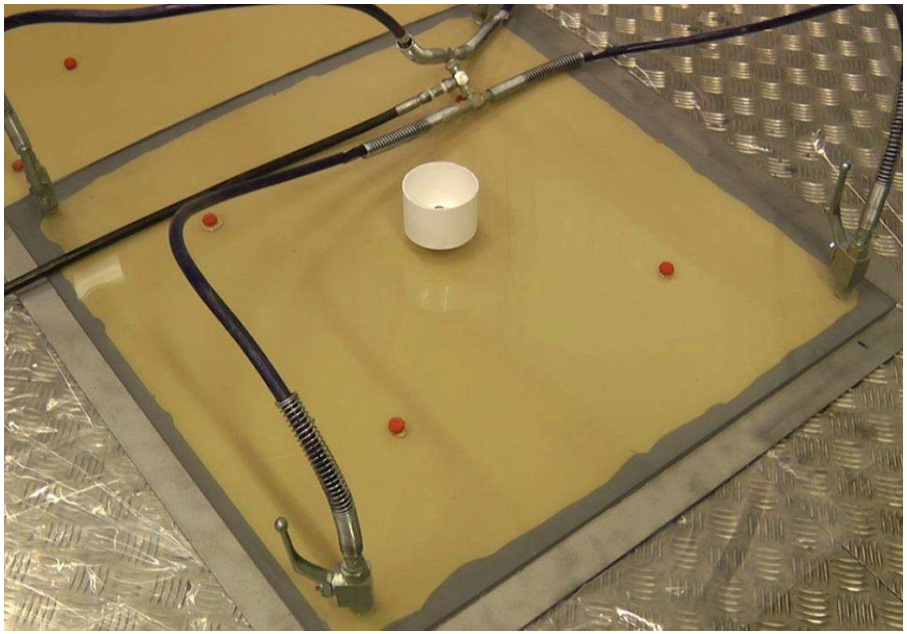
Testing

Finite Element Analysis



Application Techniques

Hand/Tools



Injection

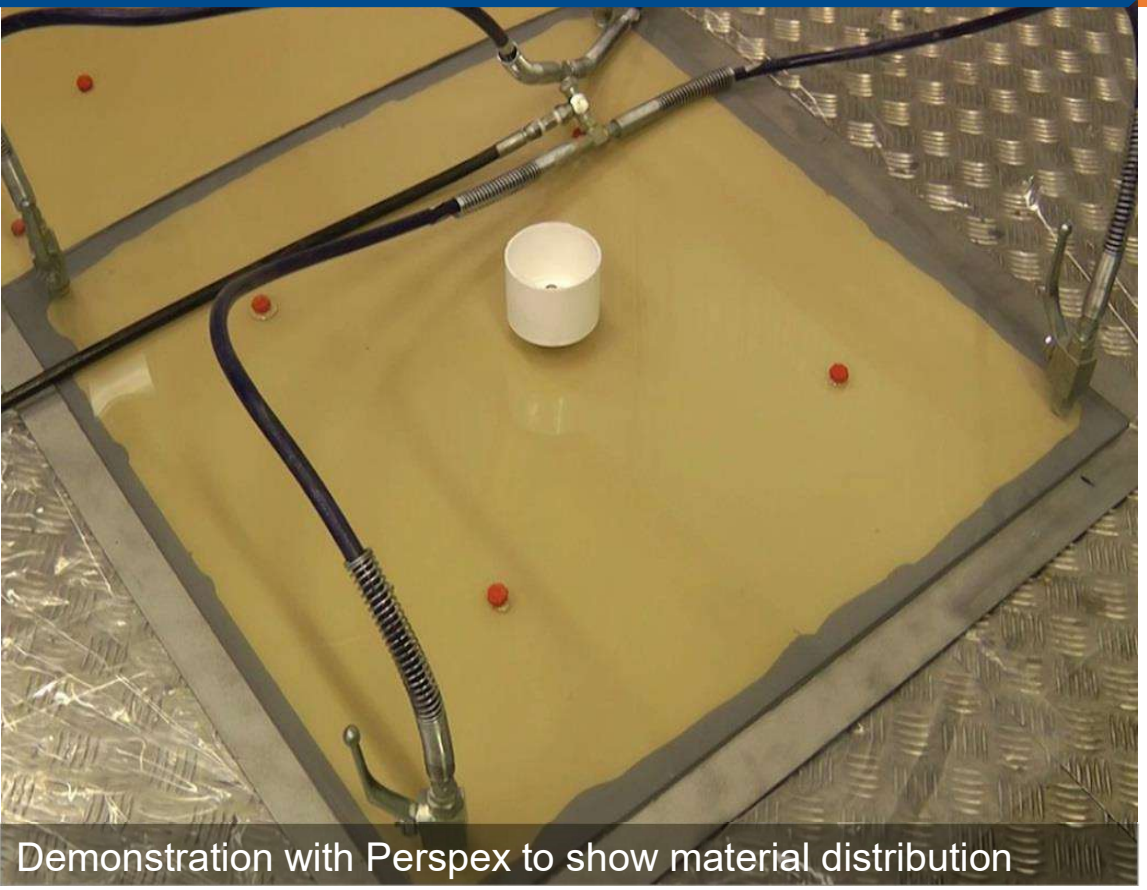
Case Study: Deck Bonding

Laydown area was badly corroded and weakened through daily operation

- North Sea
- Aberdeen
- 2004

Application: How it works

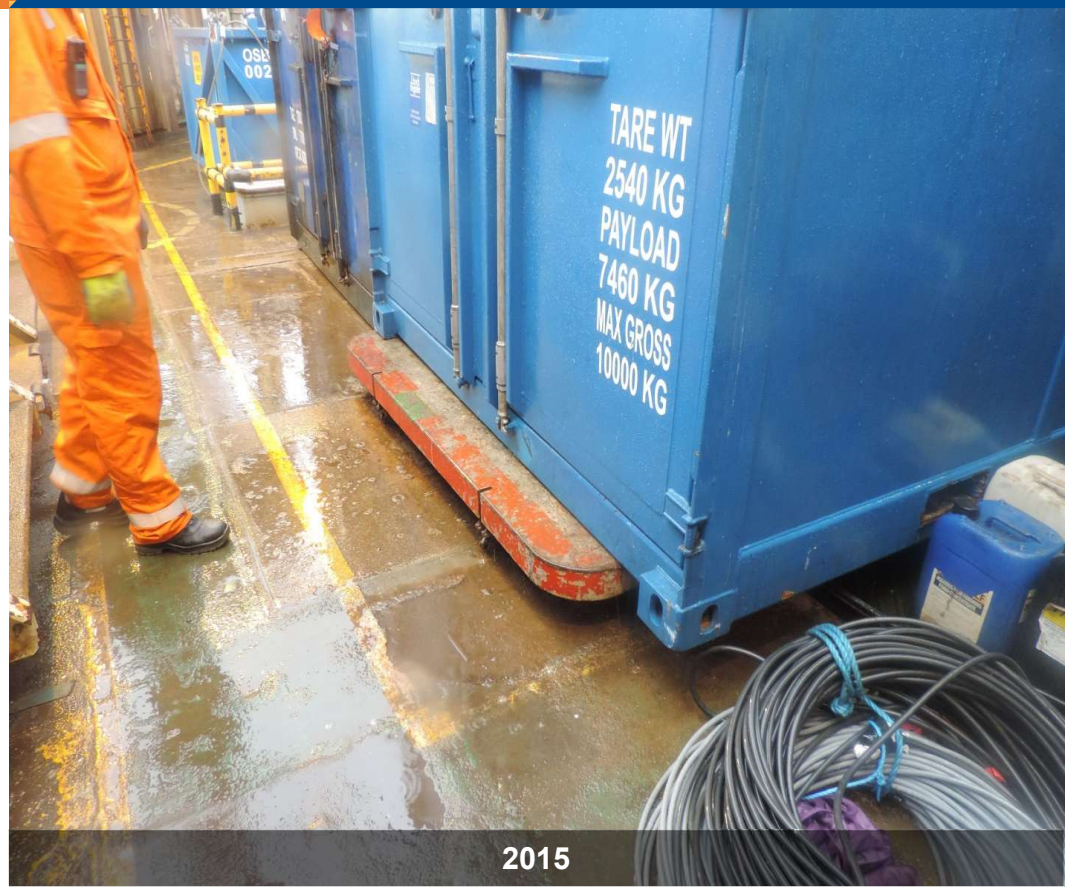
Injection Bonding Using Fluid Grade Systems



Demonstration with Perspex to show material distribution

Inspection

2012



2015

Protecting Offshore Platform Legs at the Waterline

Equipment

Platform legs damaged by corrosion and impact from service/crew boats at the waterline.

Problem

Due to corrosion and impact damage platform legs were at risk of losing structural integrity. Client wanted to terminate damage to avoid further deterioration. Customer had welded top and sides of half wrap without welding bottom, due to water/wave action. Corrosion had accelerated between the leg and half wrap.

Application Details

Epoxy filler was used to seal the bottom of split shells, and an epoxy coating was then injected to fill cavity between platform leg and steel wrap.

Products used were Belzona 1161 (Super UW-Metal) & Belzona 5831 (ST-Barrier)

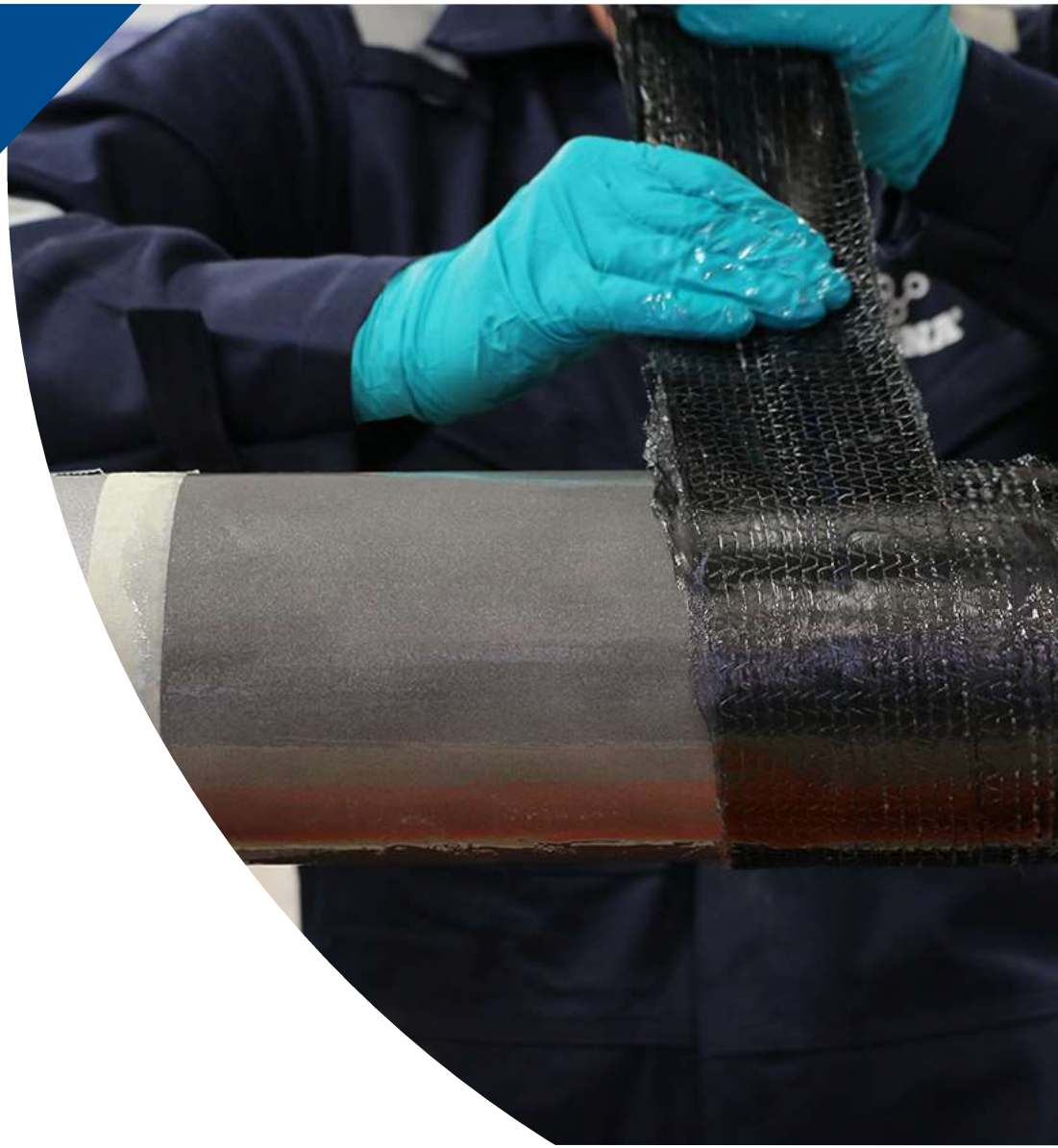
This type of bonding uses mostly indicative design methodology.

We know –

- Compressive strength
- Tensile strength
- Adhesive Strength etc.

However, not all applications are this straightforward, and will require more design input.

Composite Repairs



Repair system fabricated of a thermoset resin used in conjunction with fiber reinforcement sheet.

- **No heat involved**
- **No shutdown required**
- **Cost-effective when compared to other alternatives**

This is designed in accordance with two standards:

ISO 24817 & ASME PCC-2

Application Possibilities

Wrap

When a full circumferential wrap can be achieved.

Patch

When a full circumferential wrap is not practical.

Sample Design:

Inputs:

Design Temperature	- 20^0C
Design Pressure	- 5 bar
Process Fluid	- Cooling water
External Loads	- None
etc.	

Outputs:

Thickness	- 6 mm
Axial Extent	- 400 mm

Application of a composite wrap system

Problem

Corroded flange and fasteners on the high-pressure fuel gas heater inlet and outlet. The client could not afford for the flange or bolts to leak and be shutdown as this would become very costly. Protection of the system was required for 9 months until the next shutdown, where the entire unit would be replaced.

Application Details

The application was carried out by validated Installers as per the method statement provided on the design. Following thorough surface preparation to the live system, an epoxy filler was applied to the flanges, bolts and pipe to create a smooth transition prior to application of the composite system.

How does this apply to patch repairs?

Patch repairs follow a similar methodology, although they lack the hoop strength provided by a full circumferential wrap.

How do we compensate for this lesser strength?

Increase the thickness

Advantages this repair type offers:

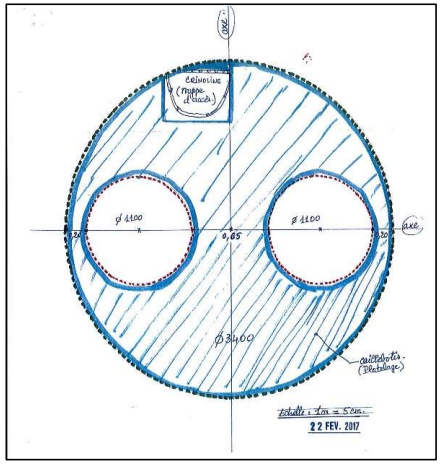
- Versatility as it can be applied on large diameter tanks/pipes
- Less material used than a wrap
- Can potentially provide the same strength as a wrap

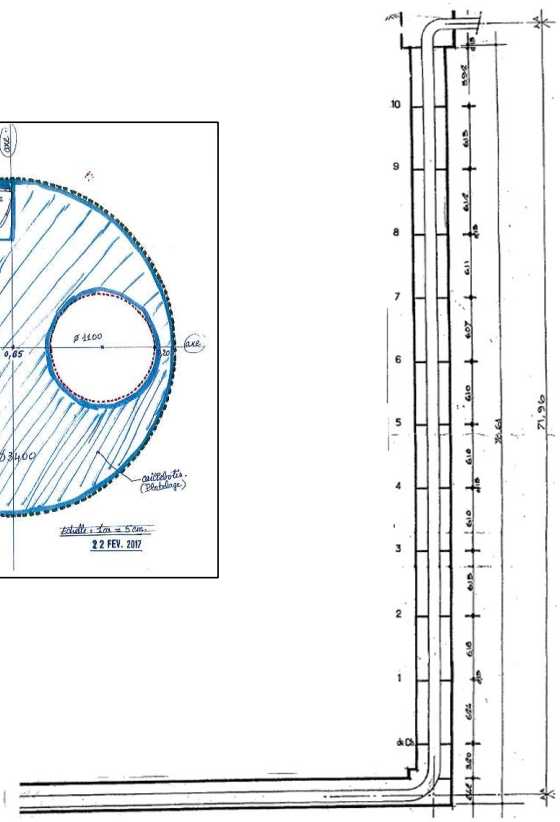
Drinking Water Plant, France

Corroded pipe requires reinforcement

Background

- 2 vertical pipes (diameter: 1.1m)
- On ~ 70m inside a concrete pit (3.2m diameter)
- Bad ventilation system inside the pit → condensation in the bottom section → **Corrosion**





Drinking Water Plant, France

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Corroded pipe requires reinforcement

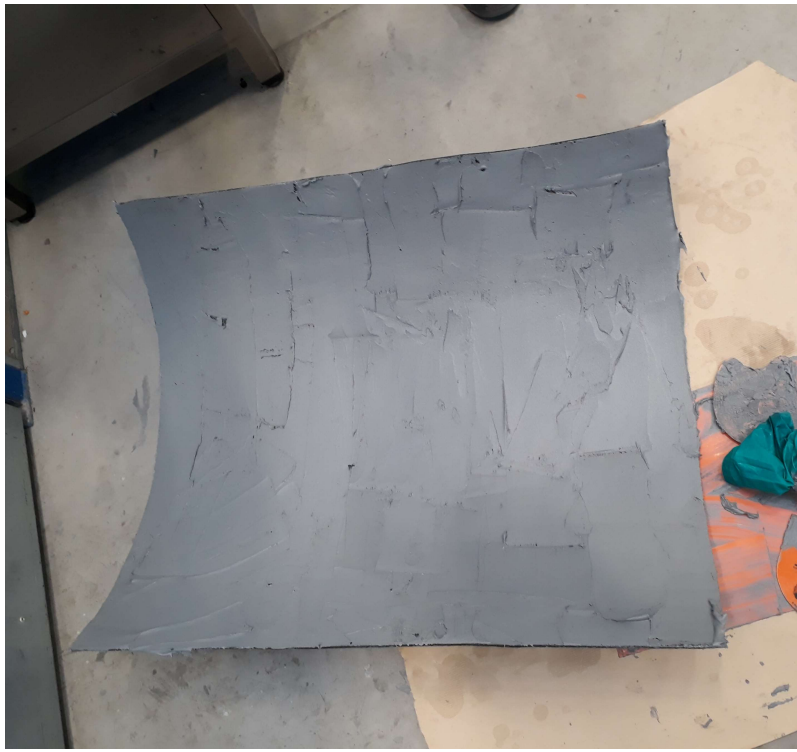
- Tests
  - Visual inspection
  - Ultrasonic tests
  - Laser profilometry on a few damaged sections
- Results
  - Visual inspection: Advanced deterioration of the external coating (only protection against corrosion), especially on the bottom section
  - Water flow alongside the outside of the pipes accelerates the corrosion rate of the steel where the coating is gone
  - Maximum thickness loss between 20.94% and 48.55%.
  - Surface prep. from previous coating was not conducted properly

Drinking Water Plant, France

Corroded pipe requires reinforcement

A composite patch was to be bonded in place on the external of the pipe.

This was to be completed using a pre-fabricated patch (500 x 500 mm), bonded with an epoxy.



Drinking Water Plant, France

Corroded pipe requires reinforcement

Workshop tests were completed:

Advantages of Cold Bonding

- Quick, safe-to-use, **cold-applied and cold-curing** solutions.
- **Simple application** procedures without specialist tools.
- Suitable for equipment operating at **elevated temperatures**.
- **Fast curing grades** for minimal downtime.

- **Excellent adhesion** to a variety of common substrates.
- Excellent **corrosion protection** in harsh environments.
- Outstanding **chemical resistance** to a wide range of chemicals.
- Can be **designed for compliance** with engineering standards.
- Proven **long-lasting** solutions which can **increase an asset's lifespan.**