INSTITUTE OF CORROSION

MARINE CORROSION FORUM

FOR ALL WET CORROSION ISSUES

Marine Corrosion Forum and Institute of Corrosion partnering with

Henry Smith

Belzona

29th April 2020

INSTITUTE OF CORROSION

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“Hot topic: Cold Bonding, Using Epoxy Adhesives in Place of Hot Metal Welding”

About Me

Henry Smith joined Belzona Polymerics back in September 2013 as a technical service engineer, after completing a bachelor's degree in mechanical engineering. In this role Henry was responsible for providing technical support for up to 100 distributors across the globe. Since then, he has worked his way up to UK Technical Supervisor, and is currently leading a young team of engineers in providing engineered repairs & support throughout the Oil & Gas industry, among others in the UK. He is currently part of the IMechE as an associate member, and is actively dedicating time as a sponsor to the Arkwright Scholarship Trust Scheme, which is a course designed to pair up-and-coming young engineers with businesses in order to give them experience of real engineering professions.

Q&A

Selection of Questions to **Henry Smith**, Post-Presentation 29/04/2020

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** How do these joints handle thermal cycling conditions where the CTE of the epoxy may differ significantly from the metal plates?
  - **A.** Generally you will find that the epoxies have a fairly similar CTE to the metal. Remember all we need is for the epoxy to transfer the loading to the metal plate. This is also helped by having a good bond to the surfaces – a strong bond is much harder to break, even when the metal expands a bit more than the epoxy.
  - You are correct though, in some case the expansion may be too large for the epoxy to cope. In this case, you can potentially look at using a different type of bonding material, such as a polyurethane. See the answer to the question on slide 13 for a bit more detail on thermal expansion testing.
- **Q.** Could you expand if possible on how you qualify your repair methods against various sources of Vibration that occur in Production Facilities?
  - **A.** Currently our methods for vibration analysis are almost entirely historical. However, as we have expanded into new areas, such as chocking and shimming, this has become a more important issue. We are actively looking at this for future Belzona products, and testing Is currently under consideration.

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** Could the injection of epoxy under a plate be used as sealer in the case of a pipe leak
  - **A.** The difficulty with injection in this scenario is getting the balance right between viscosity/fluidity (i.e. can be injected) & being thick enough to plug the leak. Using a standard 2 part epoxy would not allow you to do this. For high pressure leaks, or larger defects - the best method would involve designing a material which cures through a technique other than exotherm. Perhaps a material which cures when in contact with water, or a certain chemical. As soon as this material contacts the process fluid, it would cure very quickly to seal the leak. You can see a similar process in UV cured systems, however it is difficult to get UV light into the space behind a place.
  - On a low pressure, or small defect (pinhole) leak, you can use a more viscous material to plug the leak, provided the leaking substance cannot escape through the injected material prior to it curing solid.
- **Q.** Regarding the repair of the platform legs, is it classified as temporary repair? just acts as a sealing agent? can it survive the wave loading??
  - **A.** Many clients still maintain that these repairs are temporary. As failure prediction models are difficult to create for these materials, much of the work is done on historical data. However, many repairs that are completed as temporary will still be in-service long after their “expiry” date.
  - I would expect most products to survive wave loading, provided the surface is prepared correctly. The mechanical properties are much better than most would think. You can see examples of epoxies coatings at work at this link - https://khia.belzona.com/en/view.aspx?id=3718

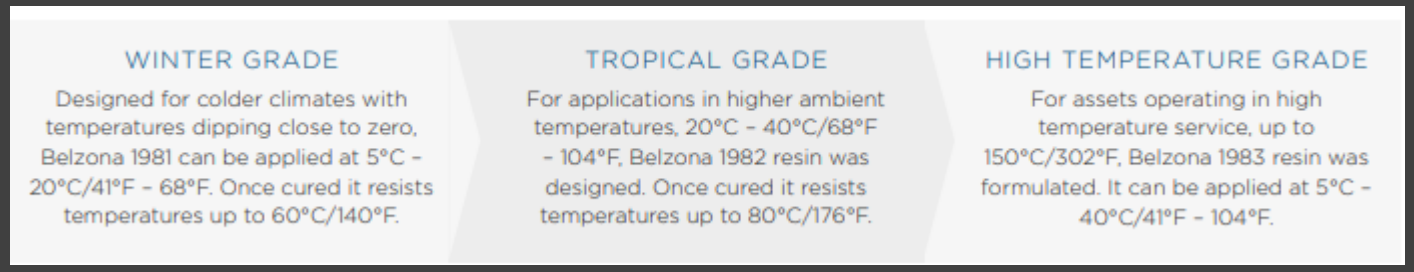
Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** Are there any industry codes or guidelines on Belzona application?
  - A. The two main standards we follow are SSPC Sp-10 (NACE 2)/SA 2 ½ for cleanliness, and specify a surface roughness of 75 microns.
  - For the composite repairs, we must follow ISO 24817 and ASME PCC-2 Article 4.1/4.2 for the repair to be compliant.
  - In terms of physical application of other Belzona products, only surface preparation standards are specified – application techniques are down to the person using the material and the codes associated with that equipment.
- **Q.** Are SSC repairs on boilers and pressure vessels valid with Belzona? There are many welding standards/codes for this but do you have any case studies on Belzona?
  - **A.** SSC repairs are difficult due to the nature of the damage type. We have a few case studies of work completed to repair stress corrosion cracking - https://khia.belzona.com/en/search-results.aspx?q=stress%20corrosion%20cracking#gsc.tab=0&gsc.q=stress%20corrosion%20cracking&gsc.page=1

  However, we do not have any relating to sulfide stress cracking.
  - One requirement for SSC is stress, which can be introduced via welding – using an epoxy may avoid this. Although, stresses can be relieved post-welding.
  - It's a new area for our materials, and the concern for the future is if we can repair this type of damage without it continuing underneath. Once the embrittlement & subsequent cracking has begun, it can be very difficult to prevent it from propagating further.

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** Are these repairs now qualified to be considered as permanent repairs by the HSE-UK and other global equivalent organisations?
  - **A.** The HSE-UK have just completed a research project into composite repairs according to ISO/ASME standard and whether they can be considered permanent repairs. You can see the basics of the program here - https://www.hse.gov.uk/aboutus/assets/docs/1511043-shared-research-engineering.pdf
  - As for other types of repair such as plate bonding, it is entirely down to the client to decide on how permanent a repair is, with advice from the manufacturer.
- **Q.** What temperature of cure is needed for the wrap?
  - **A.** It depends on the resin used as there are 3 types. The image below shows the temperatures associated with each.



Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** How is disbonding or delamination or improper curing issues are addressed
  - **A.** From experience, the vast majority of failures can be attributed to application factors. Surface preparation has a huge influence on the strength of a bond. Belzona (and most other manufacturers) follow a rigorous quality control program, so failures are investigated immediately.
  - Usually it can be attributed to a couple of factors – incorrect mixing, poor surface preparation (e.g. rust on surface, contamination from oil etc.), or incorrect product selection. All of this can usually be counteracted through training prior to any repairs being carried out.
- **Q.** Any considereations around application of the wrap on external corrosion scabs where surface preparation is not possible.
  - **A.** Currently we cannot recommend applying these products onto a surface with no preparation at all. The adhesion levels are incredibly low. You would always require a surface free from loose material. Some products are surface tolerant, meaning they can be used underwater and through some contamination though.
- Q. So it can extend life till next shut down as well?
  - **A.** The example I gave showed the repair the client wanted to allow the system to operate until the next shutdown scheduled in for the FPSO. Those composite repairs can be designed to operate for between 2 to 20 years. So yes, they can extend the life of an asset, and increase the time until the next shutdown for that particular asset.

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** What are the expected problems with applying thermoset resin? after how long?
  - **A.** Issues with these types of products are commonly related to incorrect application. Delamination and cracking are common results of this. Soft spots in the material may also appear if the mixing was not completed correctly.
  - This would normally appear after a short time in the products lifespan.

- **Q.** Possibility of recertification of 3rd party composite wrap on the line operating above glass transition temperature.
  - A. Once the product reaches its glass transition temperature, its ability to retain pressure or dissipate stress is greatly reduced, so we could not certify a wrap repair which is operating out of its maximum service parameters.
  - If the wrap is old and you are looking to recertify, the process according to ISO/ASME is that if the process has not changed (i.e. temperature, chemical, pressure etc.), the wrap can be recertified, if it was designed to ISO/ASME initially. Any change to the process will mean the wrap must be redesigned. If it is found that the line now operates above the glass transition temperature, you will need to remove the wrap and apply a more suitable product.

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- **Q.** In case of repaired flanges (shown in slides) cleaning of corrosion products required or not?
  - **A.** For that case study, all loose corrosion was removed where possible. In practice, it may not be possible to remove 100%, however the ends of the repair where the wrap terminates must have very high standards of surface preparation. Remember this is mainly for pressure retention, so loose sections of wrap do not contribute to the overall strength. Failure to remove corrosion could invalidate your design.
- **Q.** Any other examples of applications for structural repairs (e.g I-Beams/structural members?
  - **A.** You will find some case studies here - https://khia.belzona.com/en/search-results.aspx?q=structural#gsc.tab=0&gsc.q=structural&gsc.page=1
  - We do have some testing completed in previous years relating to I beams. If you email me using the email at the end of this powerpoint, I will send a summary of the testing that I am allowed to share.
- **Q.** For the drink water (France) application, how was compression applied to ensure no air gaps between patch and substrate
  - **A.** I will ask the question to the application team! From what I know, they applied a large excess of material, so there was a higher volume of exuded material than we would normally expect for this type of bonding. It was pressed on by hand.
  - Remember that a couple of small air pockets does not equal a failed application, we still have a very large surface area contact between the plate and the steel.

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- **Q.** Can you use NDT to monitor conditions under a repair??
  - **A.** Yes, methods such as UT and x-ray have both been used for inspection underneath repairs. Some epoxies contain certain fillers which may disrupt UT techniques, however Dynamic Response Spectroscopy (DRS) has recently become a common technique for inspection of the composite wrap systems. A company called Sonomatic have worked with composite manufacturers on a number of occasions to do this, I suggest contacting them for more info.
- Q. What is the anti-corrosion mechanism of this tool on steel for example?
  - **A.** The products mentioned either contain no metallic fillers, or so few that there is no contact between them with either the steel or environment. The products are mostly all electrical insulators, so covering a surface with them prevents the transfer or electrons, or the steel surface reacting with oxygen, stopping corrosion taking place.
- **Q.** How do these repairs handle thermal fatigue (within the epoxy temperature limits)?
  - **A.** We commonly repair equipment such as engine casings, ball mills and heat exchangers. Depending on the service they can be constantly running, or on/off as required. There are a few examples of these repairs on the case study website - https://khia.belzona.com/en/search-results.aspx?q=structural#gsc.tab=0&gsc.q=engine%20elite&gsc.sort=
- Belzona test products for properties such as thermal cyclic loading. Belzona 1593, an epoxy coating for high temperature corrosion resistance, was tested against NACE TM0304 for 252 cycles between +60^{0}C and -30^{0}C, exhibiting no cracking.
- Thermal fatigue is not specifically measured.
- NOTE – please check with the manufacturer prior to application if this is a requirement, as every material behaves slightly differently.

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- **Q.** Can it be used to repair castings? Codes for repair of castings?
  - **A.** We have completed casting repairs before, although they are not strictly adherent to any codes. Currently nothing similar to ISO/TR 10809-2:2011(en).
  - This is likely to remain the case until epoxies are used much more widely for casting repairs. The standards we specify are related to surface prep only, SA 2 ½ cleanliness, 75 micron profile. With cast materials contamination can penetrate much deeper, meaning cleaning needs more attention than other similar repair work.
- Examples of Belzona work on castings can be found here - https://khia.belzona.com/en/search-results.aspx?q=structural#gsc.tab=0&gsc.q=casting&gsc.sort=

For further information or clarification on any of these points, you can contact:

Henry Smith – hsmith@Belzona.com

Belzona HQ – https://www.belzona.com/en/contact.aspx

Or use our distributor finder to locate your local Belzona representative - https://www.belzona.com/en/about/disfinder.aspx

Our public case study site - https://khia.belzona.com/en/default.aspx