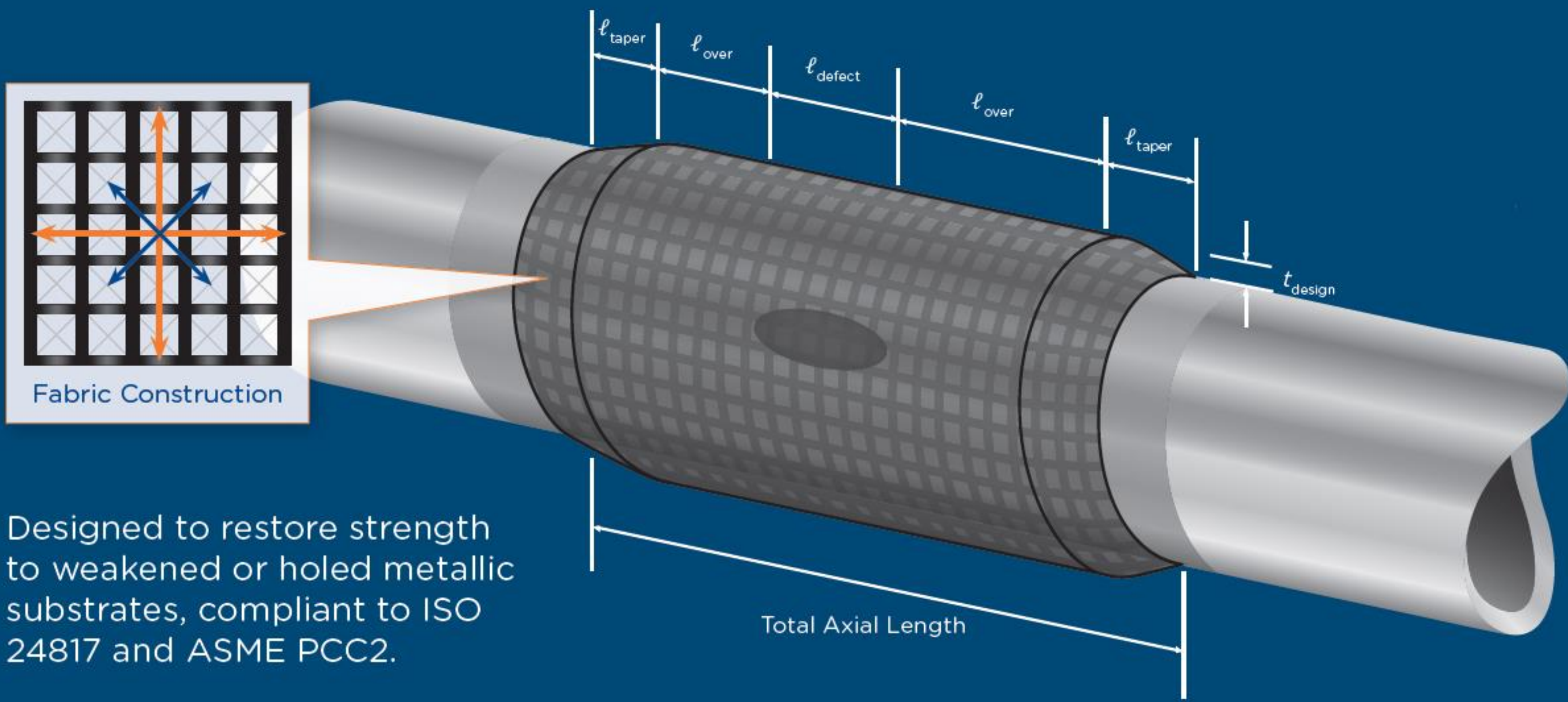
Compliant Repair Solutions for Pipework and Equipment in Petroleum, Petrochemical and Natural Gas Industries

ISO / ASME COMPLIANT COMPOSITE REPAIR SYSTEM



Designed to restore strength to weakened or holed metallic substrates, compliant to ISO 24817 and ASME PCC2.

NACE Jubail Technical Workshop

Corrosion Under Insulation

10th December, 2015

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Topics

- Introduction
  - Need for Composite Repairs
  - Compliant V/s Non-Compliant Repairs
  - Governing Standards
- Technical Considerations
  - Process Parameters
  - Product Parameters
- Case Histories
- HATCON Capabilities
  - Design, Installation, Supervision, Testing and Inspection
- Conclusion

Introduction

- Need for Composite Repairs
  - Various types of composite repair systems have been in place across the years and are still being used to restore strength to weakened metallic substrates damaged by corrosion, abrasion, impact etc.

Introduction

- Compliant V/s Non-Compliant Repairs
  - Repairs can normally be divided into two broad categories based on the methodology adopted
  - Both are being used worldwide to address the various problems faced by plants when it comes to the damaging effects of wear and chemical attack on pipes and equipment
  - Our desired scenario
    - A safe, reliable system that can last for an intended lifetime
    - What must the applied system go through?
      - Various internal and external loads, effects of chemicals (water to hydrocarbons and many more), corrosive external environment and multiple wear modes
  - Both compliant and non-compliant repairs basically appear the same; so where’s the difference?

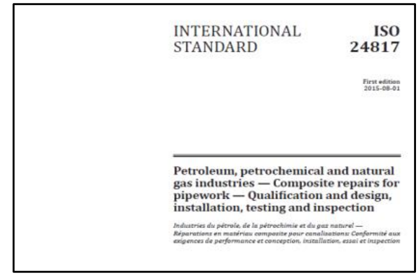
Introduction

- Compliant V/s Non-Compliant Repairs
  - Compliant Repairs
    - Designed using scientific methods and engineering formulae
    - Each design in unique
    - Applied only by validated and certified installers
    - Fully traceable
    - Confidence to the end user
      - Product quality
      - Process control
  - Non - Compliant Repairs
    - Designed on the need of the hour and often based on empirical design calculations – not scientific methods
    - Traceability is not guaranteed
    - Liabilities?

Introduction

- Governing Standards:

ISO 24817:2015
Petroleum, petrochemical and natural gas industries – Composite repairs for pipework – Qualification and design, installation, testing and inspection


INTERNATIONAL STANDARD

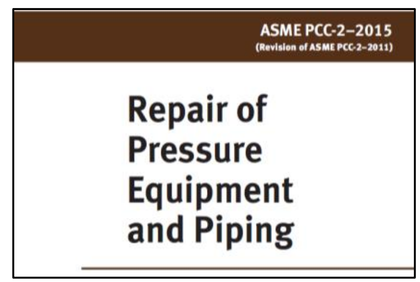
ISO 24817

First edition
2015-08-01

Petroleum, petrochemical and natural gas industries — Composite repairs for pipework — Qualification and design, installation, testing and inspection

Industries du pétrole, de la pétrochimie et du gaz naturel — Réparations en matériau composite pour canalisations: Conformité aux exigences de performance et conception, installation, essai et inspection

ASME PCC – 2 – 2015
Repair of Pressure Equipment and Piping


ASME PCC-2–2015
(Revision of ASME PCC-2–2011)

Repair of Pressure Equipment and Piping

[The above standards are available for purchase through the websites of ISO and ASME]

Technical Considerations – Process Parameters

- System Life Cycle
  - Qualification of the repair system
  - Design
  - Installation, testing and inspection
  - Validation process and control
  - On-going integrity management through repair design life
  - Decommissioning of engineered composite repair

Technical Considerations – Process Parameters

- Qualification of the repair system
  - Even before a product (system) can be recommended for a particular application or situation, it must be pre-qualified for that scenario; else the final repair is considered to be non-compliant
  - Pre-qualification tests (adapted from ISO 24817:2015; for information / educational purposes only):
    - Mechanical properties
      - Young's modulus
      - Poisson's ratio
      - Shear modulus
      - Thermal expansion coefficient
      - Tg (Glass transition temperature) or HDT (Heat Distortion Temperature) of the resin when cured at relevant temperatures
      - Barcol or Shore Hardness
    - Adhesion strength
      - Lap shear
    - Performance data
      - Energy release rate
      - **Short-term pipe spool survival test (ISO 24817, Annex C)**
      - **Impact survival test (ISO 24817, Annex F)**

Tests to be carried out in line with relevant ISO, ASTM standards or Annexures of ISO 24817 as defined in ISO 24817:2015

Technical Considerations – Process Parameters

- Qualification of the repair system
  - Belzona® SuperWrap II - Published Performance Data

Symbol	Property	Belzona 1981	Belzona 1982	Unit
E_c	0° Tensile Modulus	38800	38600	MPa
E_a	90° Tensile Modulus	18300	15500	MPa
	0° Tensile Strength	524	505	MPa
	90° Tensile Strength	126	121	MPa
v	0° Poisson's Ratio	0.26	0.26	
v	90° Poisson's Ratio	0.27	0.13	
$^{\varepsilon}$short	0° Strain to Failure	1.37	1.34	%
$^{\varepsilon}$short	90° Strain to Failure	0.81	1.24	%
G	Shear Modulus	7830	7630	MPa
E	0° Bending Modulus	37977	37462	MPa
E	90° Bending Modulus	14247	14031	MPa
α_c	0° Thermal Expansion Coefficient	0.00000944	0.00001126	mm/mm°C
α_a	90° Thermal Expansion Coefficient	0.00001296	0.00002076	mm/mm°C
T_g	Resin Glass Transition Temperature	90 / 194	115 / 239	°C / °F
	Shore D Hardness	90	91	
	Lap Shear Adhesion	15.5	12.3	MPa
	Lap Shear Adhesion *(1000 hour immersion)*	15.5	19.0	MPa
$^{\gamma}$LCL	Energy Release Rate	68.57	76.53	J/m²
	ISO24817 Annex C / ASME PCC2 4.1 Appendix III	Passed	Passed	
ε_{lt}	Lower Confidence long term strain	ISO: 0.036075	ISO: 0.036075	mm/mm
S_{lt}	Performance Data (1000 hour) *ISO24817 Annex E / ASME PCC2 4.1 Appendix V*	ASME: 1397.70	ASME: 1392.50	N/m²
	Impact Performance *ISO24817 Annex F / ASME PCC2 4.1 Appendix VI*	Passed	Passed	

0° = hoop direction, 90° = axial direction

Technical Considerations – Process Parameters

- Design
  - Each repair is unique and designed only by certified designers using the methodology defined in the standard
  - Designers must pass rigorous validation exams and meet minimum levels of competence
  - Two design scenarios: Type A (Thin-wall defects) and Type B (Through-wall defects)

Thin wall defects

Through wall defects

Technical Considerations – Process Parameters

- Design
  - Every design problem is only as good as the quality of the input
  - The input is provided by the client through ASR forms as shown below:

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Belzona SuperWrap Application Survey Report

FOR OFFICE USE ONLY

Repair Reference Number	

CUSTOMER DETAILS

Contact	
Company Address	
City County	
Country Postcode	
Telephone Number	
Mobile Number Email Address	

DEFECT LOCATION DETAILS (IF DIFFERENT TO CUSTOMER DETAILS)

Contact	
Company Address	
City County	
Country	
Postcode Telephone Number	
Mobile Number Email Address	

Please Select Units From Dropdown Menu:	Metric

PIPE DETAILS

Installation					
Location Quantity					
Pipe identification					
Pipe reference Pipe Specification					
Material / Grade					
External Diameter mm					
Original Wall Thickness mm Medium Transported					
Design Temperature	Minumum	°C	Maximum		°C
Operating Temperature	Minumum	°C	Maximum		°C
Cleaning (steam out etc.) Temperature and Chemical Pipe Coating (existing)					

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Belzona SuperWrap Application Survey Report

RISK ASSESSMENT

Pipe Geometry (dropdown menu)	Bend
Repair Class (pick from dropdown list)	1
Repair Lifetime (pick from dropdown list)	2
Other Data	

LOADING

MAWP (Maximum Allowable Working Pressure)	MPa

	Unit	Operating	Design	Test	Comments
Pressure Rating	MPa				
Axial Load	kN				
Bending Moment	Nm				
Shear Load	kN				
Torsion	Nm				
Other Loads, Please Specify	kN				

REPAIR SPECIFICATION

Type of Defect (pick form dropdown list)	Thin Wall	Is Defect Expected to go Through Wall before end of Repair Life	No	Depth of Defect mm	
Shape of Defect (dropdown menu)	Circular				
Current Size of Defect	Diameter				
Projected Size at End of life (if different from Current)	Diameter				
Cause	Other	If Other Please Specify			
Effect	Internal				

ANTICIPATED CONDITIONS DURING REPAIR

	Minimum	Maximum
Pipe Temperature °C		
Ambient Temperatu °C		
Pipe Pressure MPa Pipe Contents		
Humidity %		
Other		

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Belzona SuperWrap Application Survey Report

FACILITIES TO BE PROVIDED BY THE CLIENT / INSTALLATION
(SURFACE PREPARATION / SCAFFOLDING / CONTROLLED ENVIRONMENT)

OTHER INFORMATION
(PHOTO'S ETC)

SIGNATURE

Sign	
Print Name	
Position in Company Company Name	
Date	

Technical Considerations – Process Parameters

- Design

  - There are two outputs to every design problem which then becomes the basis for estimating the quantity of materials required, costs, planning of operational activities etc.
    - Thickness of the repair (minimum required in axial / circumferential direction, whichever is larger and within the constraint imposed by the standard)

$$\boxed{t_{design} < \frac{D}{12}}$$

, where D is the outer diameter of the pipe

    - Total axial extent (total length of the repair and consists of the defect size, axial length of the repair and the taper length which is set to approximately 5 times the thickness of the system in either direction)

Technical Considerations – Process Parameters

- Installation, testing and inspection
  - Just as every design problem is only as the input received, every application is only as good as the quality of the installers responsible for installing the system in line with the design specifications, while ensuring that all *Application Reports* and necessary *QA / QC documentation* are duly filled through the course of the application ☞
  - In order for the repair to be compliant, the level of training of the Installer (or Supervisor) and the class of repair is important as mandated by the standard. Belzona® uses a slightly stricter approach here:

Repair Class	Typical Service	Pressure	Temperature
Class 1	Low specification duties, e.g. static head, drains, cooling medium, sea (service) water, non-leaking utility hydrocarbons	< 1 MPa (145 psi)	< 40^0 C (104^0 F)
Class 2	Fire water/deluge systems	< 2 MPa (290 psi)	< 100^0 C (212^0 F)
Class 3	Produced water and hydrocarbons, flammable fluids, gas systems. Class 3 also covers operating conditions more labor demanding than described.	Qualified upper limit	Qualified upper limit

Class 1 repairs can be carried out by Validated Installers

Class 2 and Class 3 repairs can be carried out by Validated Installers **only** when the application is Supervised by Validated Supervisors

Technical Considerations – Process Parameters

- Installation, testing and inspection

  - It is critical that various checks are carried out at “Hold Points” as defined in the table below:

Hold Points	Class of repair	Checked by
Method Statement - Belzona® SuperWrap Design Document	All Classes	Installer
Materials Preparation -Reinforcement -Resins	All Classes	Installer
Surface Preparation -Visual inspection (Cleanliness) -Surface profile test -Mechanical test	All Classes	Installer (Class 1) Supervisor (Class 2 and 3)
Stage Check on Reinforcement	All Classes	Installer
Tests on Repair Laminate -Thickness -Dimensions -External inspection	 All Classes All Classes All Classes	Installer (Class 1) Supervisor (Class 2 and 3)
Pressure Test	Class 3	Inspection Authority

Technical Considerations – Process Parameters

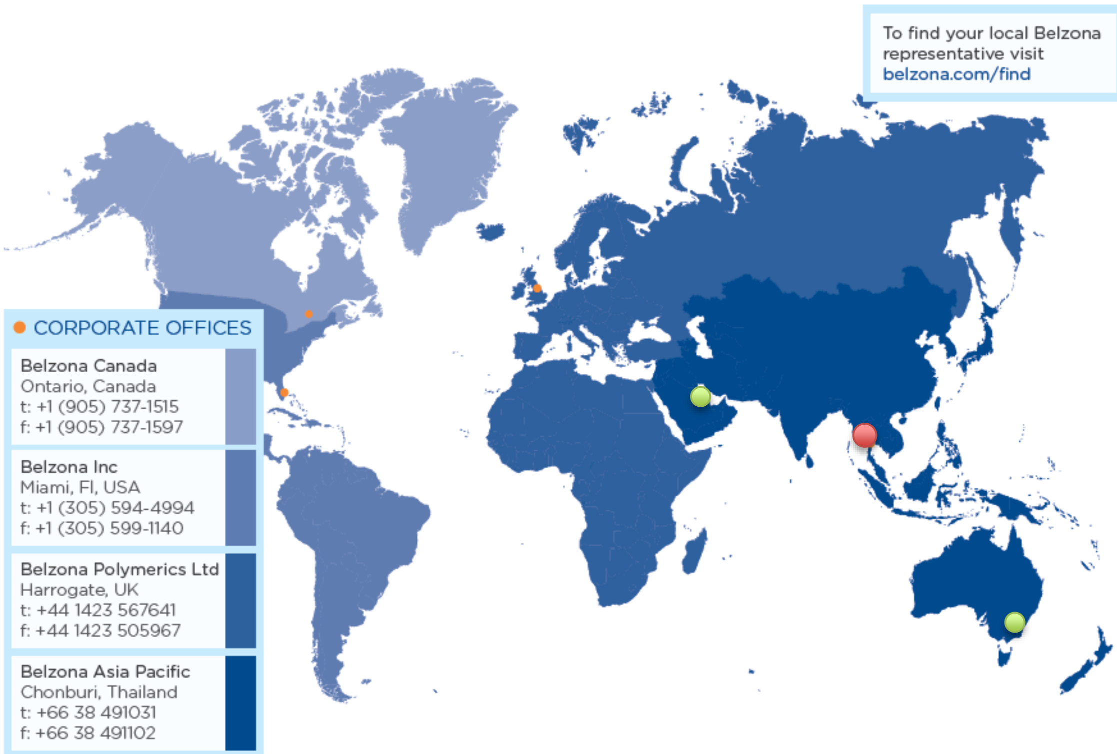
- Validation process and control
  - The validation process is strictly controlled through a series of intensive courses, rigorous theoretical examinations and practical validation in accordance with the requirements of the appropriate sections of ISO 24817:2015 standard
  - All personnel need to undergo and pass the validated Installers course, have adequate years of experience and a current certification as mandated by the standard, prior to be eligible to attend the validated Supervisor's course
  - All validated Installers and Supervisors are issued
  - Point to remember: Class 2 and Class 3 repairs need to have at least one validated Supervisor on site to oversee the works at all times!

Technical Considerations – Process Parameters

- Validation process and control

GLOBAL PRESENCE - LOCAL SUPPORT

Belzona have over 140 Distributors in more than 120 countries ensuring not only the availability of Belzona materials, but also specification support, project management, application and supervision services. Distributorships and their teams are supported by Belzona Corporate offices in Europe, North America and Asia.

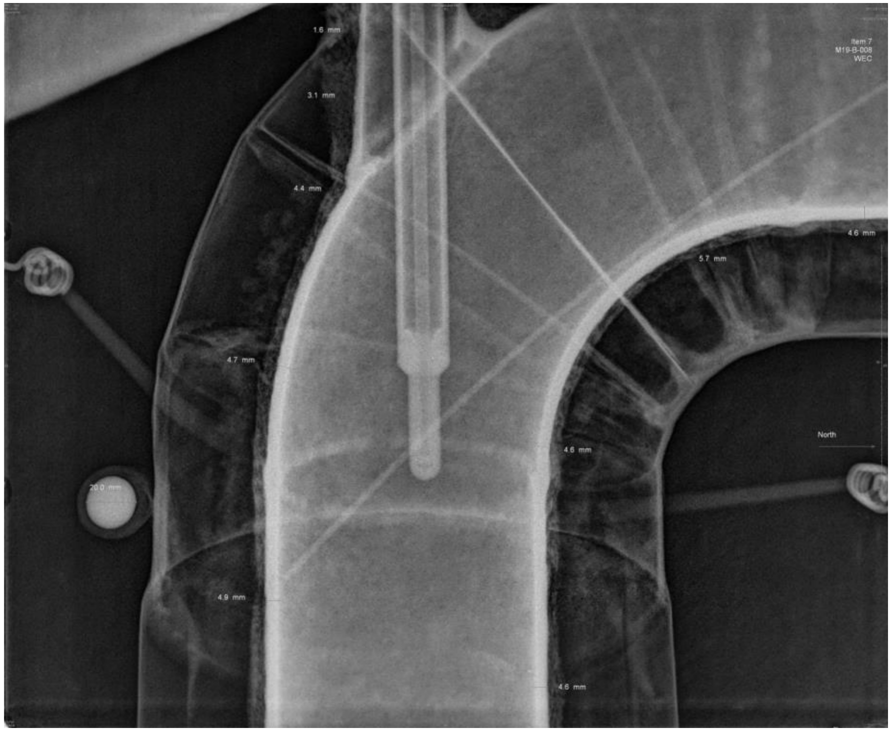


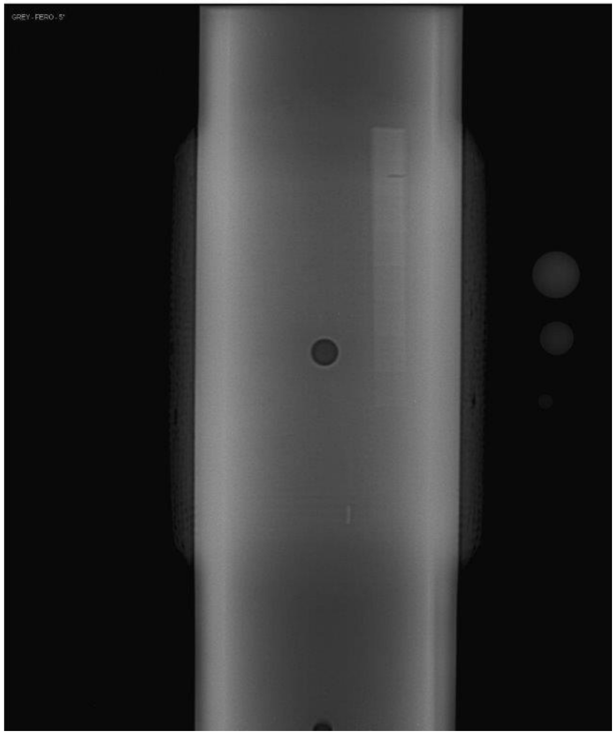
Technical Considerations – Process Parameters

- On-going integrity management through repair design life
  - An important stage in the whole process and is the responsibility of the end user to adopt a Risk Based Approach (RBI) type of inspection technique
    - Due consideration must be given to the reason for which the engineered compliant composite repair system was required in the first place
    - For external corrosion mechanisms and externally applied loads (such as in case of buried or submerged pipes), the integrity of the composite wrap may be examined visually and by using other non-destructive techniques as applicable
    - For internal corrosion modes, the client may use any technique as may be convenient to them and appropriate to the situation at hand.
      - Belzona® has carried out X-Ray detection tests and results have proven to be excellent as shown on the next slide

Technical Considerations – Process Parameters

- On-going integrity management through repair design life





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Technical Considerations – Process Parameters

- Decommissioning of engineered composite repair
  - A decision that is typically taken as the engineered composite repair approaches its design life
  - Adequate systems of work and documentation must be maintained – minutes of meetings shall be recorded; points raised and observations shall be noted.
  - The final (timely and informed) decision would basically be to proceed with a further repair or to seek a replacement of the composite repair system as appropriate

Technical Considerations – Product Parameters

- Belzona® Sue