Established Composite Engineering in 2017

IMG Composites

October 2017

CompoSol®

WHAT IS A COMPOSOL® REPAIR?

- CompoSol® repair systems are Fibre Reinforced Polymer (FRP) materials that are applied in-situ. They are a type composite materials
- A composite material can be defined as a combination of a matrix and a reinforcement, which when combined gives properties superior to the properties of the individual components
- The reinforcement is the fibres and is used to fortify the matrix in terms of strength and stiffness
- The matrix, normally a form of resin, keeps the reinforcement in the desired orientation and protects the reinforcement from chemical and environmental attack. It transfers the load to the fibres
- These fibres can be aligned in different ways to affect the properties of the resulting composite

Key Advantages of Composite Materials

- Cold Work
- Lightweight
- High strength and stiffness properties
- Corrosion protection and resistance
- Chemical Resistance
- Contour to different geometries (wet lay-up system)
- Anisotropic - Efficient design
- Localised repair
- Cost-effective

COMPANY CREDENTIALS

- IMG Composites formed in 1998
- CompoSol® range of services
- ISO9001
- F-Pal verified
- ACoReS Audited

GLOBAL PRESENCE

- UK
- India
- UAE
- Saudi Arabia
- Bahrain
- Qatar
- Oman
- Malaysia

First Use In Oil & Gas Industry

- Commonly utilised for pipe repairs to:
  - Provide unquantified reinforcement
  - Seal leaks
  - Protect substrate

- Functionality and convenience of composites made this possible

1998-2017: A DEFICIT IN RELIABILITY

- Nearly 20 years of development in composite engineering has brought ‘wraps’ a long way from their early utilisation.

- It would seem that the Oil & Gas Industry has not maximised the benefits of this development.

Health & Safety Executive 2015:

As a consequence of asset ageing, the extent and use of engineered composite repairs has increased dramatically over recent years. ….Such repairs present an attractive proposition both technically and financially. However, whilst in general the performance of such repairs has proven to be satisfactory, there continues to be uncertainty relating to their long-term integrity and performance.

FUNCTIONALITY REPAIR?

You do not need a standard for a composite repair to work?!

Composite repairs have always been functional but methodologies and standardisation were required to move beyond an unquantified, and therefore unreliable, level of reinforcement.

PERFORMANCE OF COMPOSITES

- The experience of a specialised Composite Repair Vendor is invaluable in achieving reliability. 'Me too' organisations should be cautious.

- Specialist ISO 9001 scope definition is a good first step for a composite repair vendor that wants to be reliable:

The design and provision of composite repairs and reinforcements to various types of pipes, structures, tanks and flat surface, primarily (but not exclusively) to the offshore industries.

- IMG Composites have carried out over 1,215 composite repair projects in the UK alone in the last 10 years (from October 1st 2007). We are continually improving and learning.

Composite Structural Repairs

- Composite repairs to structures have also come a long way in the last decade with increasing sophistication to approaching problems and client appreciation of capabilities/expectations

- IMG Composites CompoSol® Structure repairs have pushed boundaries for structural repairs to various types of members, cutting a trail for standardisation.

- Health & Safety Laboratory validation testing of the CompoSol® deck repair system further improves long term reliability for Operators.

History

- The ISO Standard came out of the Composite Repair Workgroup (JIP) in the early 2000s
- IMG Composites were involved from the beginning, with our Technical Director as representative
- Operator representatives included; Shell, BP, Saudi Aramco, Amerada Hess, Petrobras, Petronas, Statoil & BG-Hydrocarbon Resources Ltd
- Work group was lead by AEA Technology, now ESR Technology, & Richard Lee sits on the ISO24817 Committee for ESR.

HISTORY

'The Composite Overwrap Repair Workgroup, led by AEA Technology, was established with the objective of delivering a documentation framework for use with FRP composite overwrap repairs when applied to Oil and Gas industry applications.'

Oilfield Engineering with Polymers Conference paper 3-4th November 2003

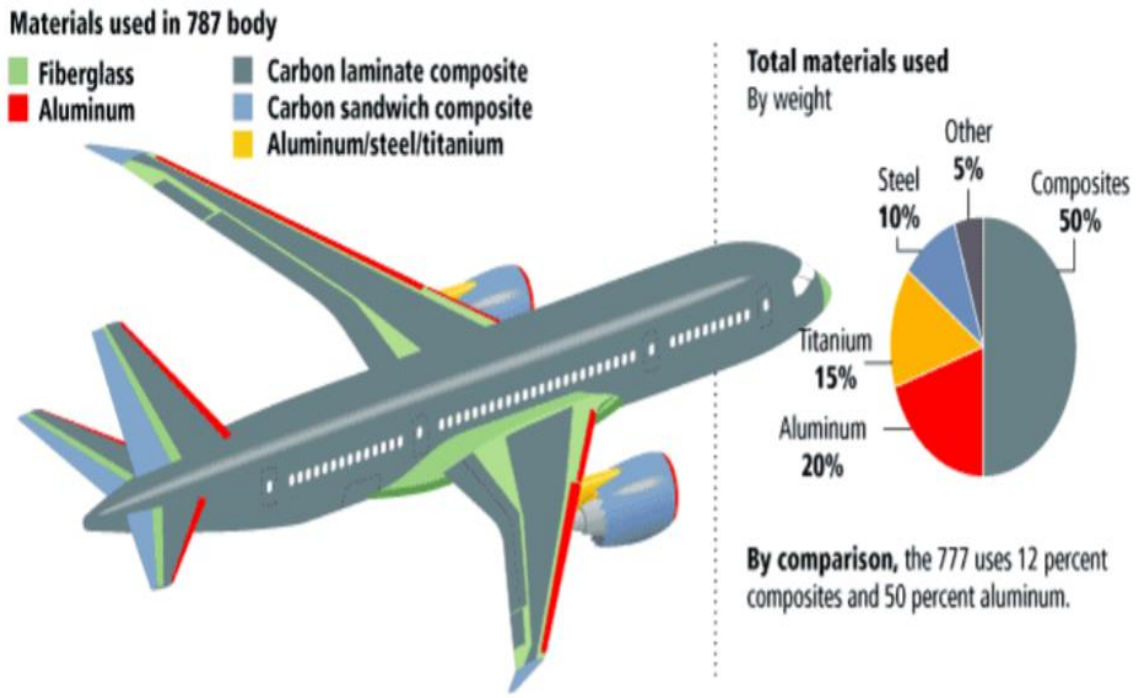
Composites in Industry

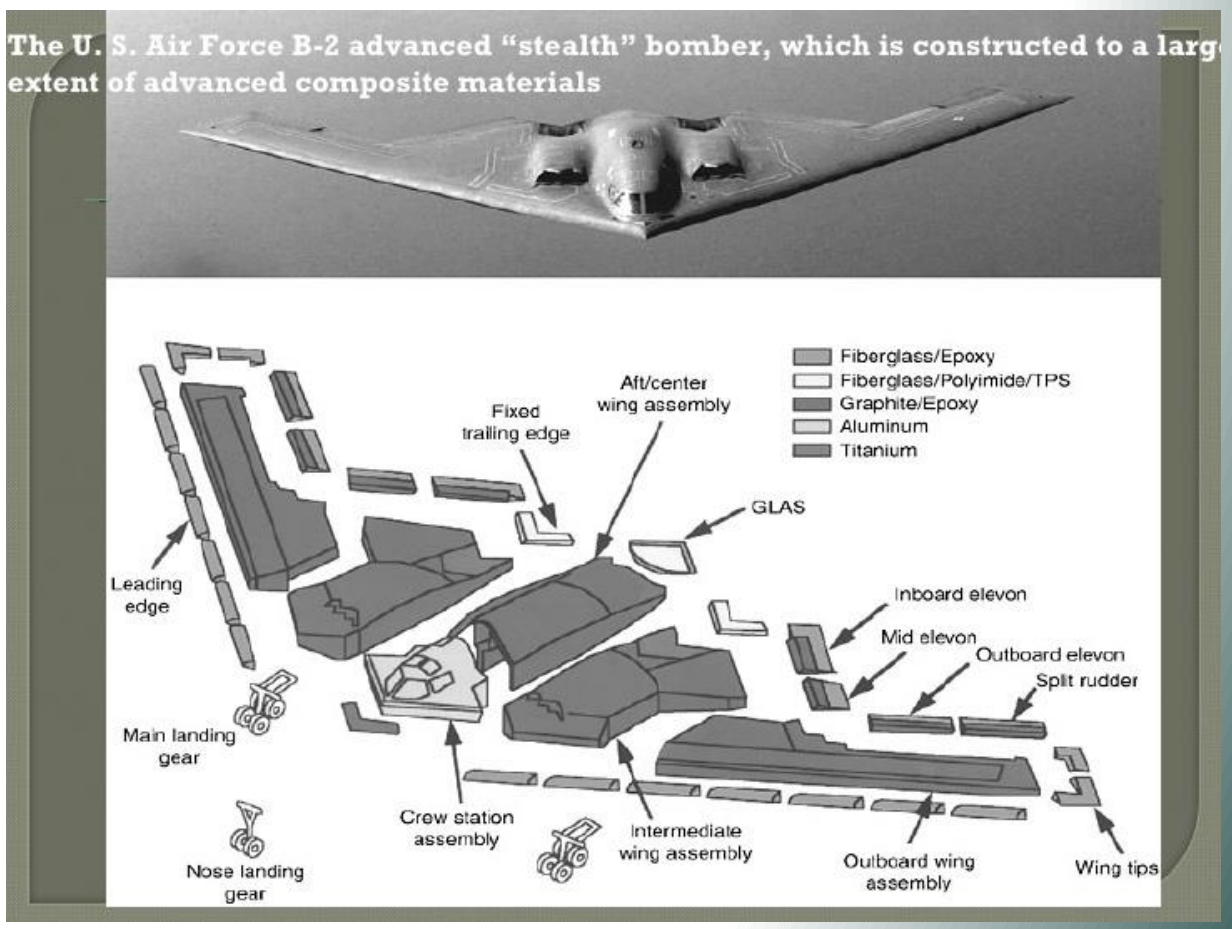
- In 1200 AD when the Mongols invented the first composite bows made from a combination of wood, bamboo, bone, cattle tendons, horns, bamboo and silk bonded with natural pine resin

- Most of the research developed in the early 1900's and World War II brought the FRP industry from research into actual production

- Today composites are extensively used in various industries such as aerospace, transportation, medical, electrical field, sports, chemical industry, infrastructre, pipes and tanks and others

Applications of Composites





The use of composite materials is 50% by weight and 80% by volume

Aerospace

Applications of Composites


Transportation

Marine

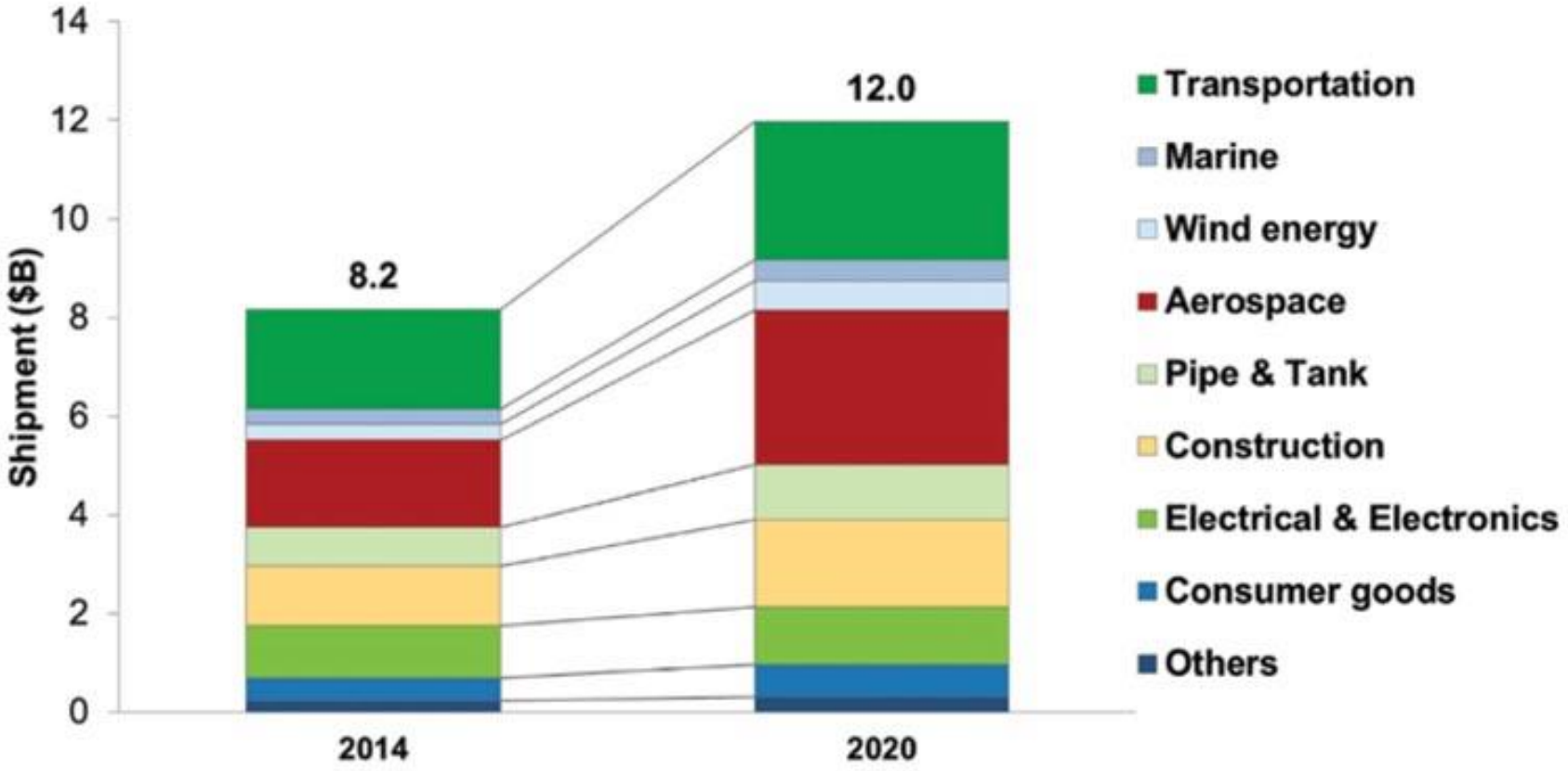
Wind Power

Infrastructure


Medical Equipment


Others

US Composites Materials Market Forecast



Composites in Oil & Gas industry

Why are composites less prominent and trusted in the Oil & Gas sector than other sectors?

- Pervading sense of unreliability stemming from a lack of embracing and knowledge of the ISO 24817 standard
- Lack of awareness towards advanced composites and their capability
- Resistance to change and move away traditionally used materials
- Delayed development of standards to govern composite use in O&G

Composites in Oil & Gas industry

- As composite repairs became more common in the Oil & Gas industry, to deal with integrity issues on pipework, composite repair standards were introduced to quantify composite repairs and improve confidence

- ISO 24817 and ASME PCC-2 Article 4.1 were created as a result:
  - ISO/TS 24817 – Composite repairs for pipework – qualification and design, installation, testing and inspection
  - ASME PCC-2 Article 4.1 – Non-metallic composite repair systems for pipelines and pipework: high risk applications

- These standards have improved the popularity and overall acceptance of composite pipe repairs as suitable and valid repair solutions

Brief History of ASME PCC-2 Article 4

- Part of ASME Post Construction Committee formed in 1995 to develop codes and standards addressing technical issues after initial constructions
- Sub-group memberships made up of manufacturers, users, owners, consultants and research organisers
- In 2002 the committee identified a need for composite repairs for piping
- First edition was published in 2006
- Created in conjunction with ISO/TS 24817
- **Not as detailed or sophisticated as ISO 24817 standard. Initially they were basically the same but over time ISO is continuously updated technically whereas ASME has remained virtually the same**

What Do These Standards Cover?

Both standards cover:

- Design
- Qualification
- Testing
- Installation
- Inspection

Design methodologies based primarily on:

- Barlow's formula
- GRP pipeline design standards
- Thin wall cylinders

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ISO v ASME Comparison

- **Design Lifetime**
- **Thickness and Pressure validation**
- **Safety Factors**
- **Component Qualification**
- **Minimum Thickness of Repair**
- **Less Stringent Installer Competence**

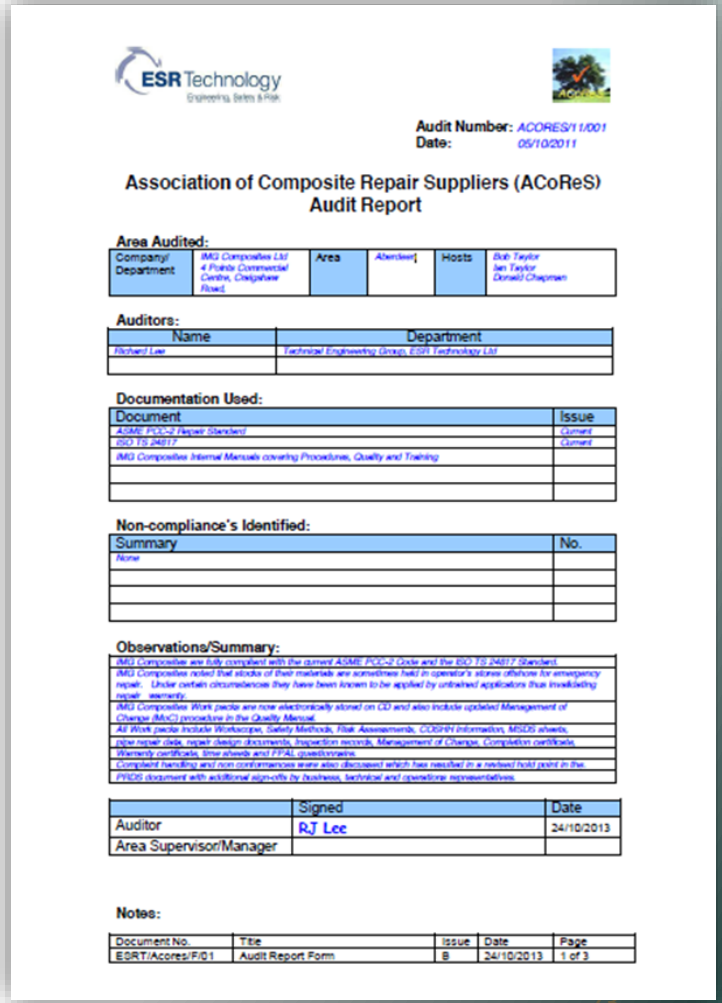
Further NOTE: ASME are trying to implement a 'generic material value' table within the standard based on vendor material properties. Inappropriate and misleading.

Audits for Compliance To ASME & ISO

- Auditing is important to ensure compliance to ISO 24817 and/or ASME PCC-2 Article 4
  - Material properties
  - Testing qualification
  - Design software
  - Engineering competency and understanding

- Important to use a reputable auditor with valid experience and knowledge (ESR Technology recommended)

- Increases reliability and confidence in repair supplier by ensuring they are competent to design ISO 24817 compliant repairs



ESR Technology

Audit Number: ACORES/11/001
Date: 05/10/2011

Association of Composite Repair Suppliers (ACoReS) Audit Report

Area Audited:

Company/ Department	IMG Composites Ltd 4 Points Commercial Centre, Craigshaw Road	Area	Aberdeen	Hosts	Bob Taylor Ian Taylor Donald Chapman

Auditors:

Name	Department
Richard Lee	Technical Engineering Group, ESR Technology Ltd

Documentation Used:

Document	Issue
ASME PCC-2 Repair Standard	Current
ISO TS 24817	Current
IMG Composites Internal Manuals covering Procedures, Quality and Training	

Non-compliance's Identified:

Summary	No.
None	

Observations/Summary:

IMG Composites are fully compliant with the current ASME PCC-2 Code and the ISO TS 24817 Standard.
IMG Composites noted that stocks of their materials are sometimes held in operator's stores offshore for emergency repair. Under certain circumstances they have been known to be applied by untrained applicators thus invalidating repair warranty.
IMG Composites Work packs are now electronically stored on CD and also include updated Management of Change (MoC) procedure in the Quality Manual.
All Work packs include Workscope, Safety Methods, Risk Assessments, COSHH information, MSDS sheets, pipe repair data, repair design documents, Inspection records, Management of Change, Completion certificate, Warranty certificate, time sheets and FPAL questionnaire.
Complaint handling and non conformances were also discussed which has resulted in a revised hold point in the PRDS document with additional sign-offs by business, technical and operations representatives.

	Signed	Date
Auditor	RJ Lee	24/10/2013
Area Supervisor/Manager		

Notes:

Document No.	Title	Issue	Date	Page
ESRT/Acores/F/01	Audit Report Form	B	24/10/2013	1 of 3

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HOIS & HSL PROJECTS

ESR Technology and HSL are currently running joint industry projects to improve acceptance and use of composite pipework repairs for long-term use:

- HSL – long-term integrity of composite repairs
- ESR (HOIS) - NDT Best Practice In The Oil And Gas

However, this is a two-way process and helping vendors acknowledge and accept the standards is a key issue that must be overcome

CompoSol® Structure

- Structural repairs have come a long way:
  - Not initially designed or required to take structural loads i.e. incidental strengthening only
- Designed to restore or upgrade capacity
- Applied to a variety of structures
  - Decks
  - Caissons
  - I-beams
  - Hollow sections

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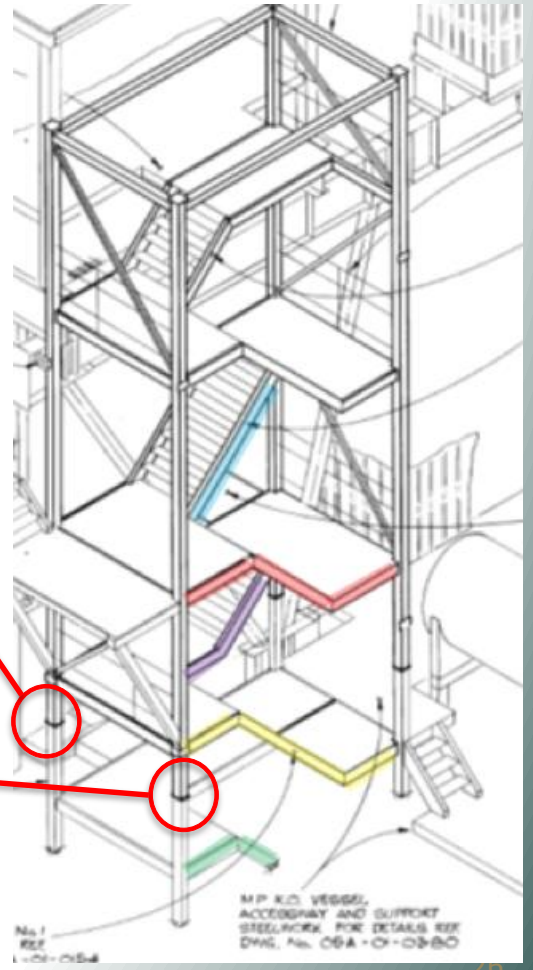
Case Study – Stair Tower Column and Beams



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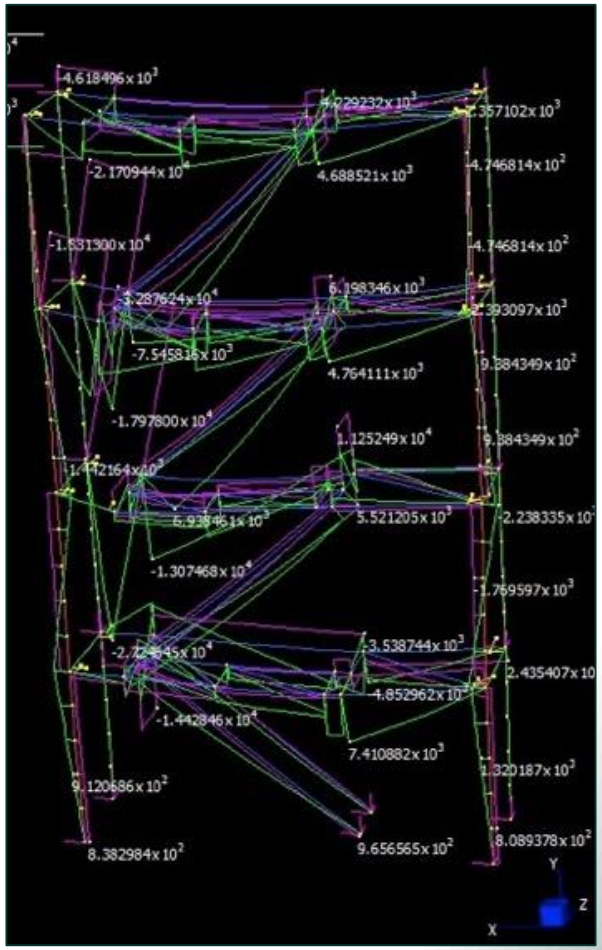
Case Study – Stair Tower Column and Beams

Solution: CompoSol® Structure

Designed to account for two main factors:

1. Upgraded Loading Capacity to account for:
   - axial compressive loads (live and dead loading)
   - wind loading
   - Lateral loads (moment and shear)

2. Bond Analysis
   - Lap shear
   - Energy Release Rate



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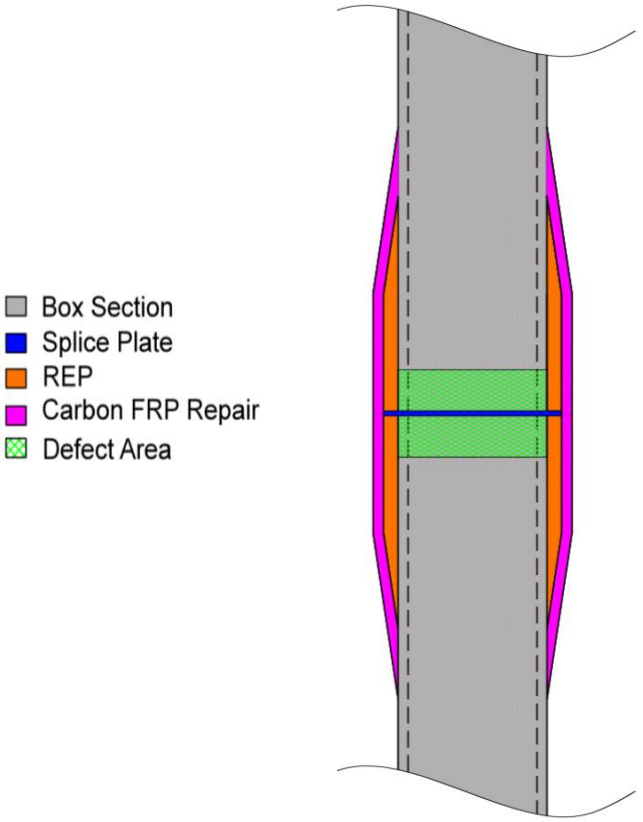
Case Study – Stair Tower Column and Beams



Case Study – Stair Tower Column and Beams

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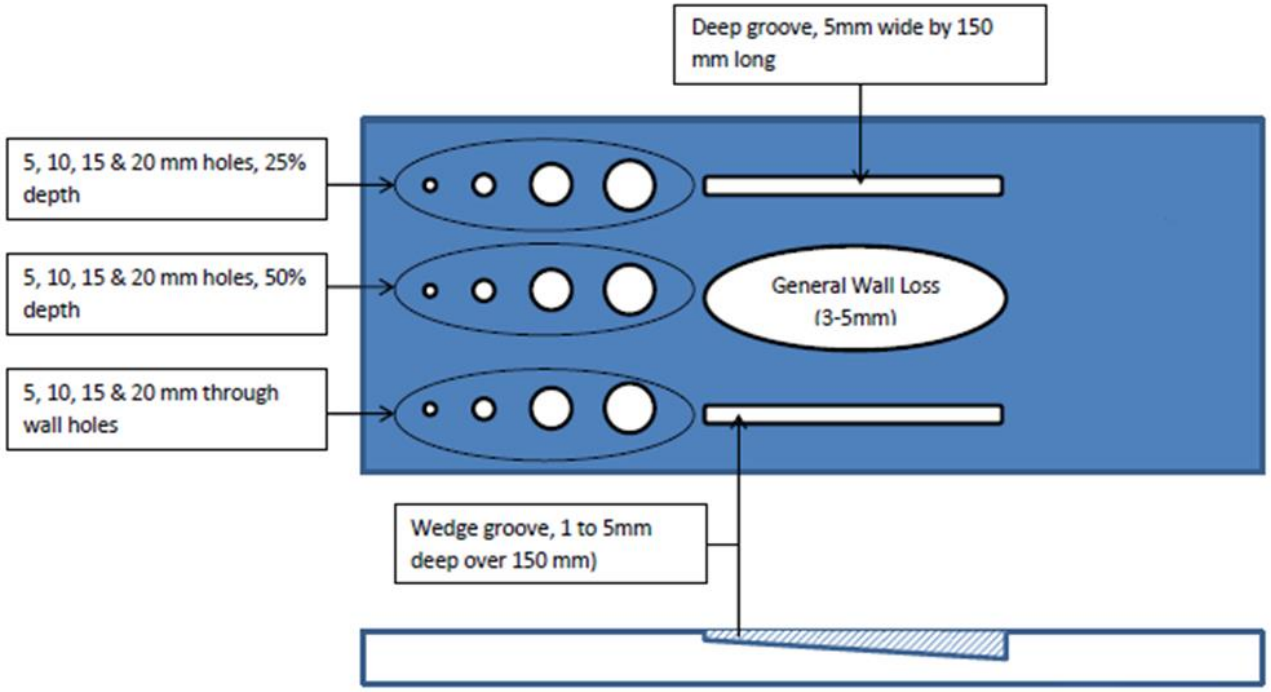
INSPECTION: ANOTHER LIMITATION?

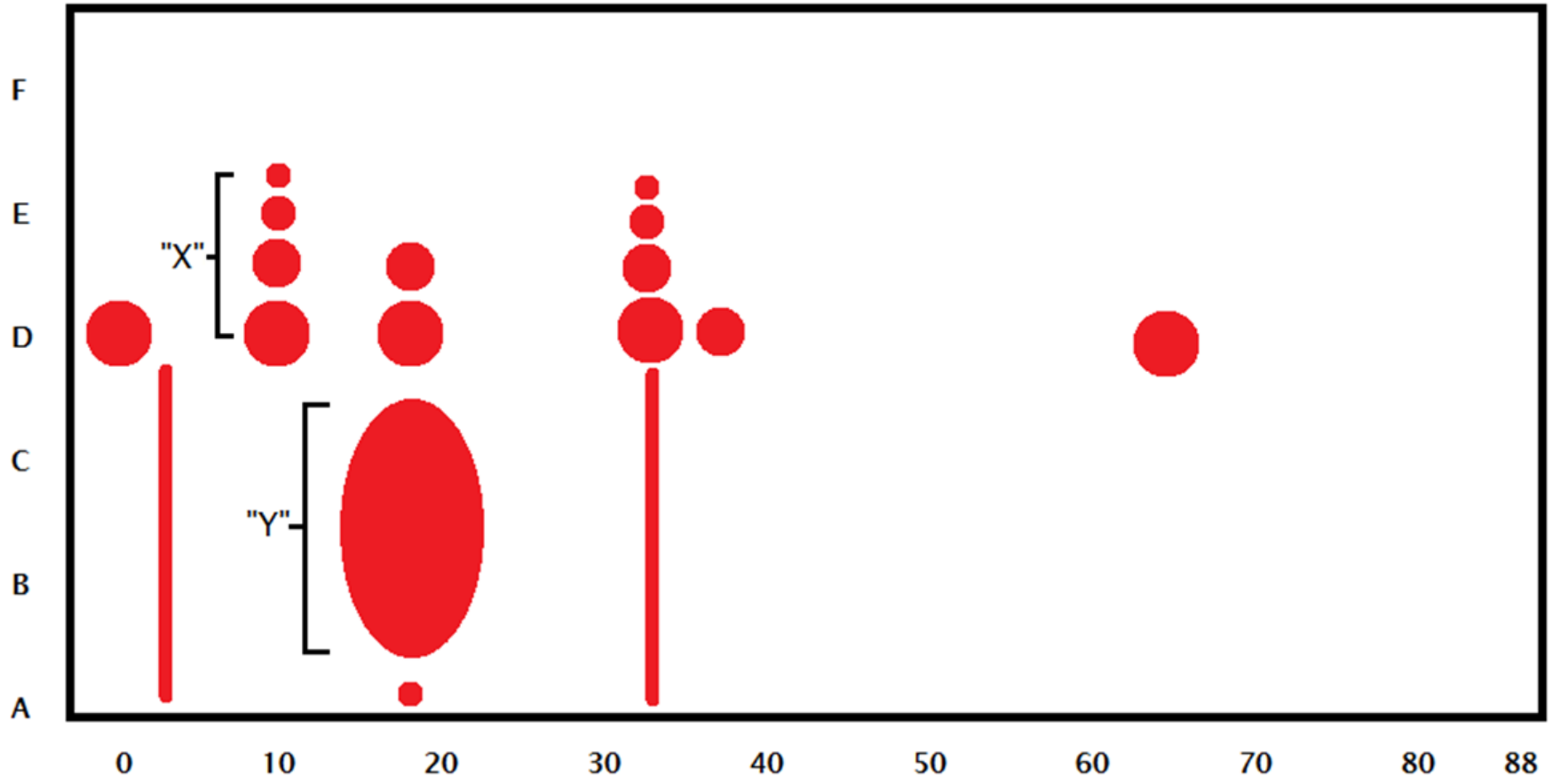
- Simple inspection through composites is not possible with traditional techniques and has perhaps limited take-up and long term reliance by operators.
- Many techniques have been tested by IMG Composites, as well as other companies, and now a range of techniques suitable for various scenarios are recommended.
- PEC/SLOFEC, Radiography & Dynamic Response Spectroscopy are useful tools.

HUGINN PROJECT

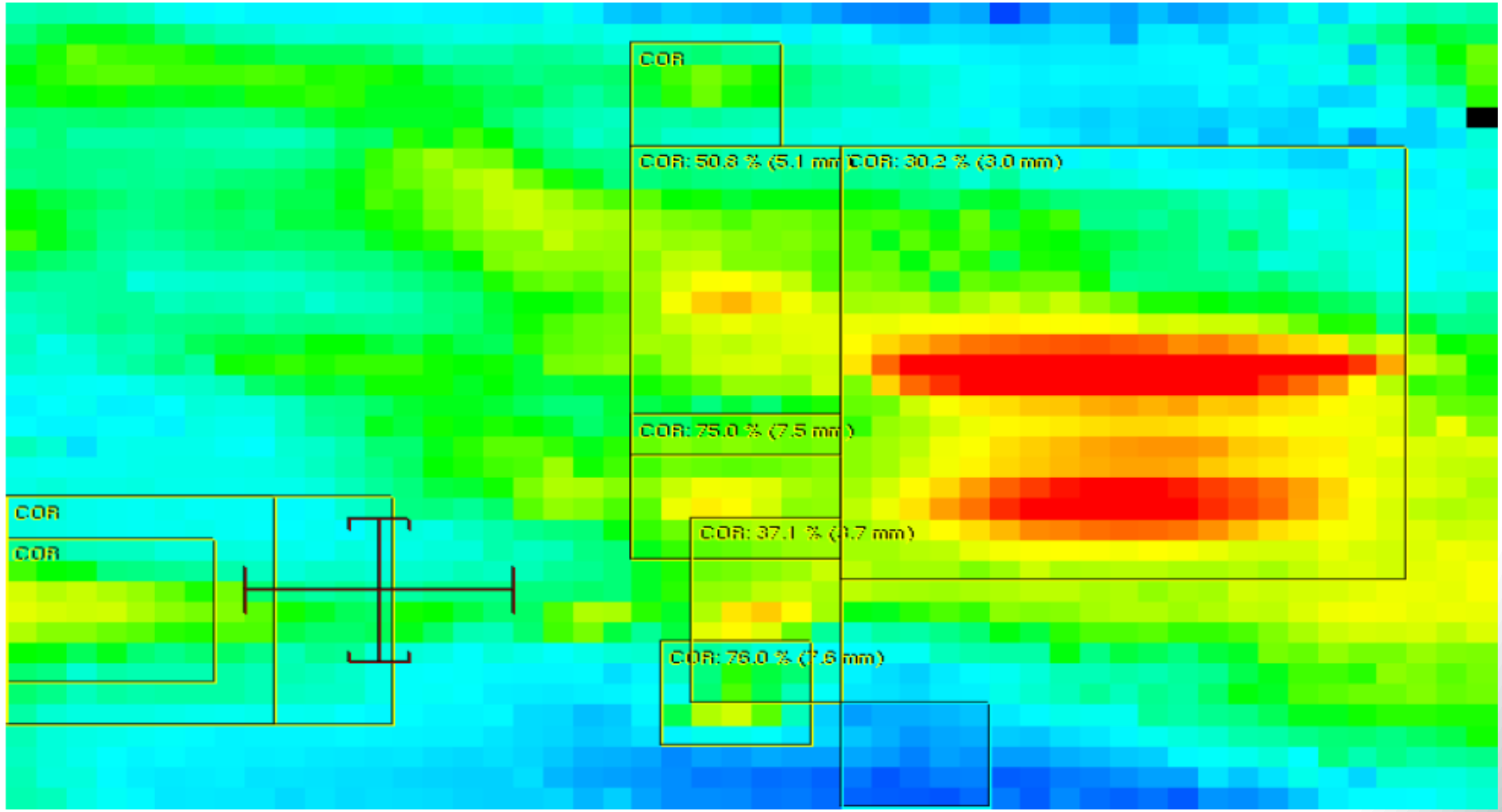
- Project utilized wrapped CompoSol® Spools with different defects, such as the below with machined defects



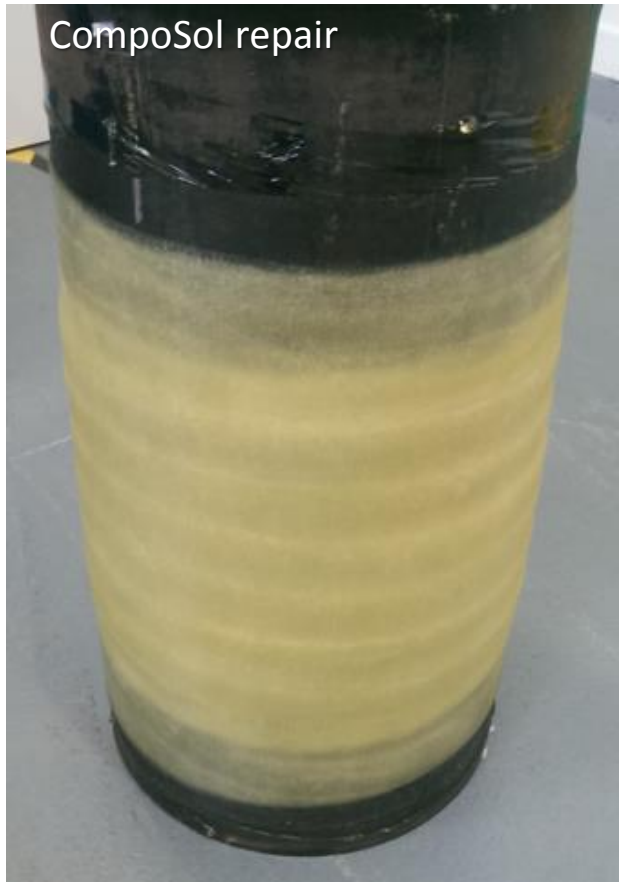
RADIOGRAPHY: SPOOL A



PEC: Spool A

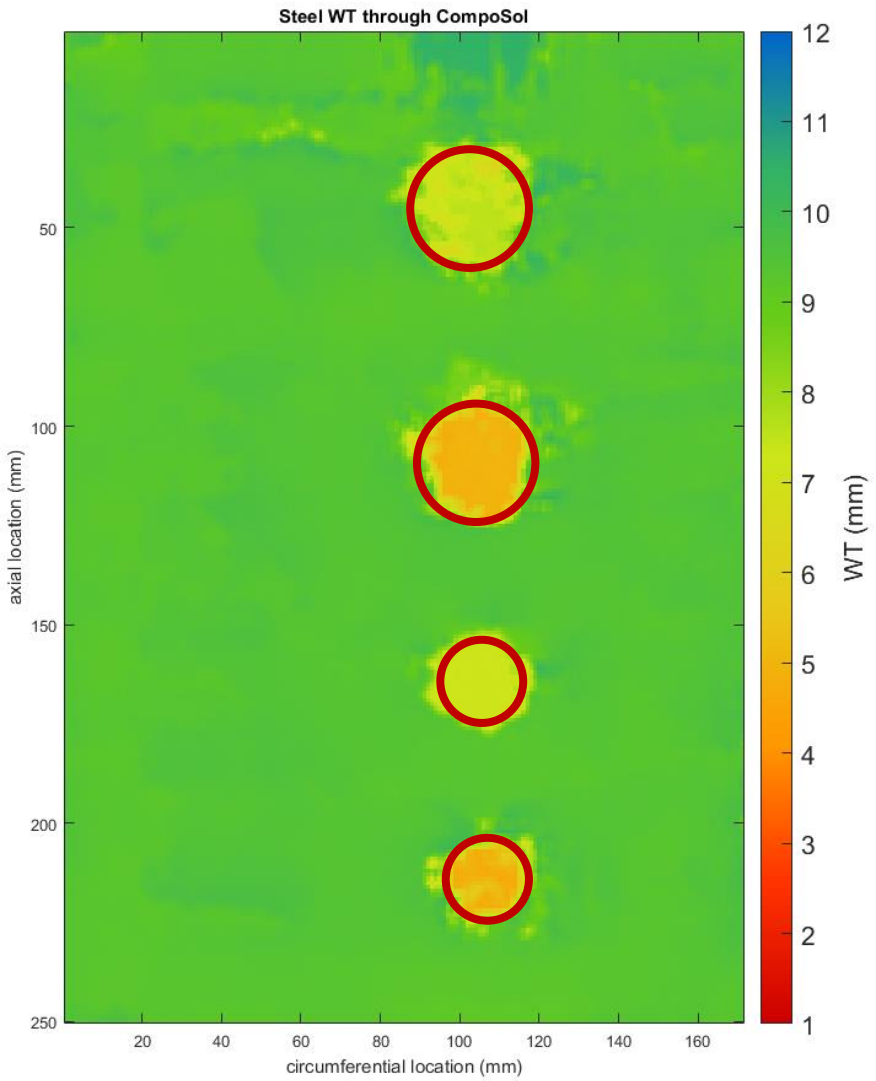

COR
COR: 50.8 % (5.1 mm)
COR: 30.2 % (3.0 mm)
COR: 75.0 % (7.5 mm)
COR
COR
COR: 37.1 % (3.7 mm)
COR: 76.0 % (7.6 mm)

Dynamic Response Spectroscopy



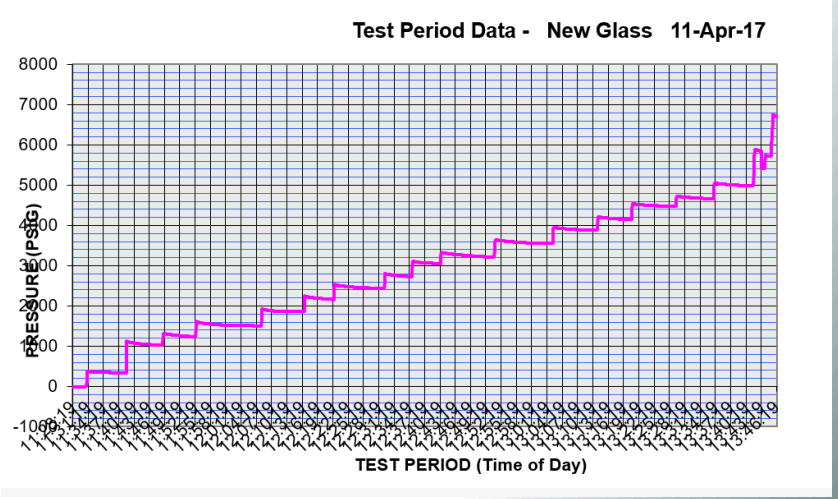
Dynamic Response Spectroscopy

DRS	Machined (centre point)
7.3 mm	7.0 mm
4.9 mm	4.5 mm
7.2 mm	7.0 mm
4.8 mm	4.5 mm



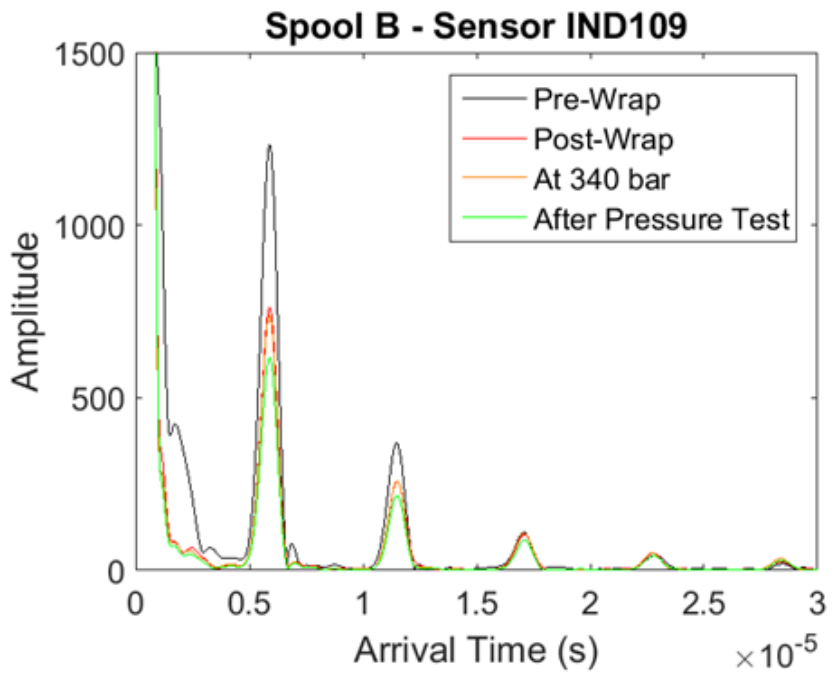
Spool B: Results

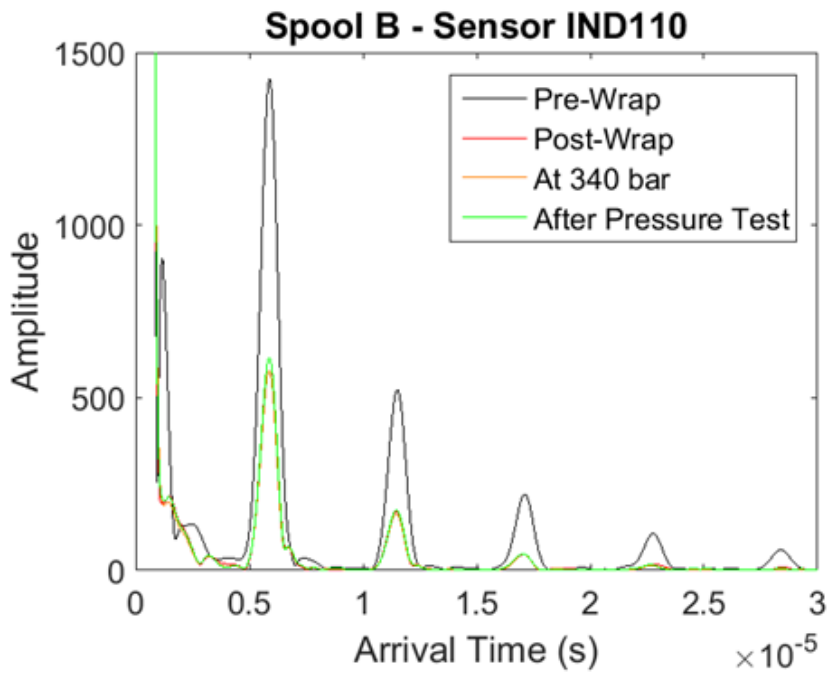
- Surface Prep: St.2
- Thickness: 8 Layers
- Test Increments: 20 bar every 5 minutes
- Burst Pressure: No Failure up to 400 bar



SENSOR FUNCTION: SPOOL B

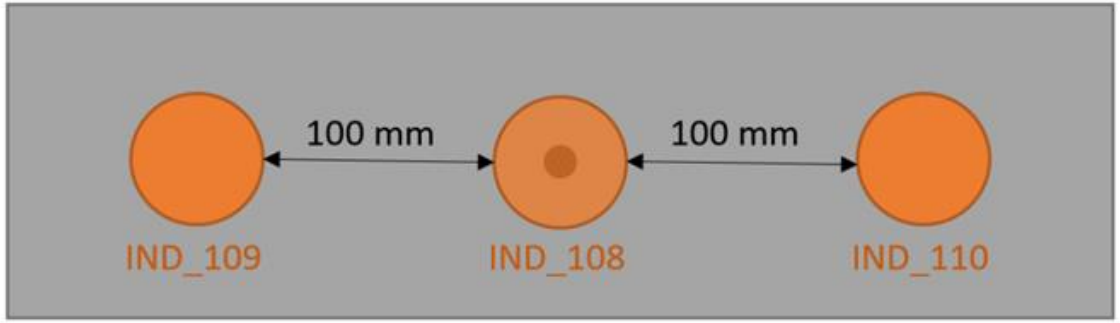
- The loss in signal amplitude may be attributed to the increased distance between the sensor and measurement coils caused by the presence of the repair wrap.





SENSOR FUNCTION: SPOOL B

- Two sensors either side of defect functioned well after wrap and during the test



Measurement Point	Measured Thickness (mm)	
	IND109	IND110
Before wrap	17.141	17.025
After wrap	17.133	17.013
At 340 bar pressure	17.133	17.037
After pressure released	17.117	17.056

CONCLUSION

- Composite materials have the potential to greatly improve cost effectiveness for asset integrity, especially for mature assets.

- Approval to and use of the ISO24817 Standard is not a box to be ticked but a process that should be constantly engaged with.

- 3rd party Auditing is an excellent way of promoting this transparency. Initiatives like the HSE Joint Research Project are helpful but ultimately only Operators can make the difference in changing the way composites are utilised to benefit aging assets.