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Asset Integrity

Provider of world class inspection services

…Inspection and Integrity Management…Non-Destructive Testing…Specialist Inspection Services. ..ACET…Pipeline inspection…Rope Access…Vendor Inspection…





The Microwave Inspection technique and Composite Reinforcements

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Microwave inspection - agenda

1. Introduction
2. Theory overview
3. Application
4. Pros and cons
5. Summary

Microwave inspection of non metallic materials

Materials

- Thermoplastics
- Fiberglass piping and patches
- Reinforced and non-reinforced rubber
- Concrete
- Ceramic
- Any other bulk dielectric/composite

Detectable defects

- Delaminations
- Disbonds
- Foreign Material Inclusions
- Voids
- Changes in thickness
- Moisture or liquid contamination
- Mechanical damage
- Physical changes due to chemical attack

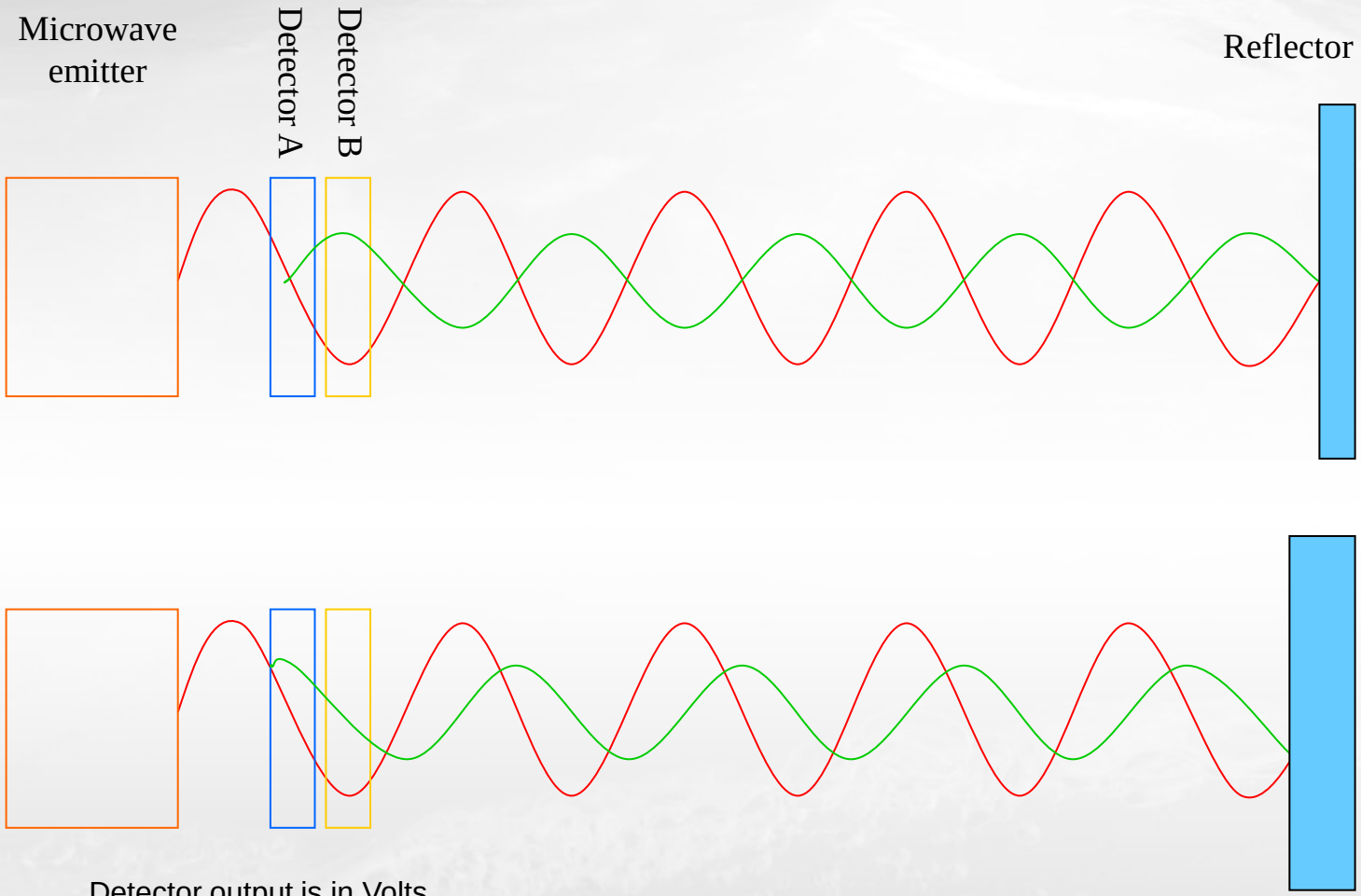
Principle of operation

Material test pieces are bathed in Microwave Energy of a constant frequency. (Low GHz)

Different dielectric constants reflect varying levels of μW energy to a detector.

The energy level is sampled across the test piece and plotted to create an image.

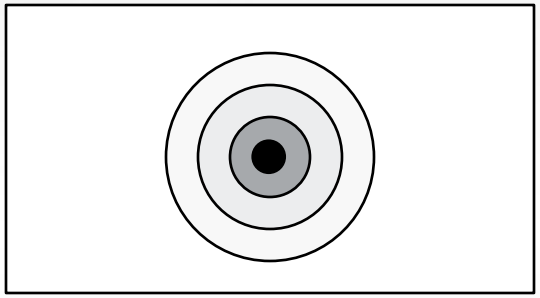
Principle of operation

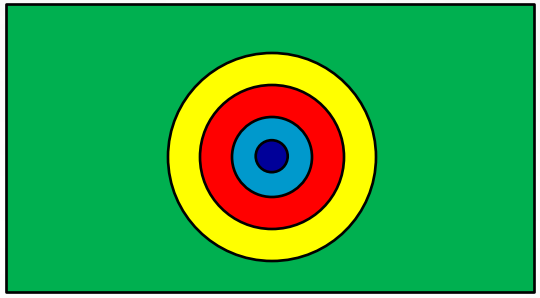


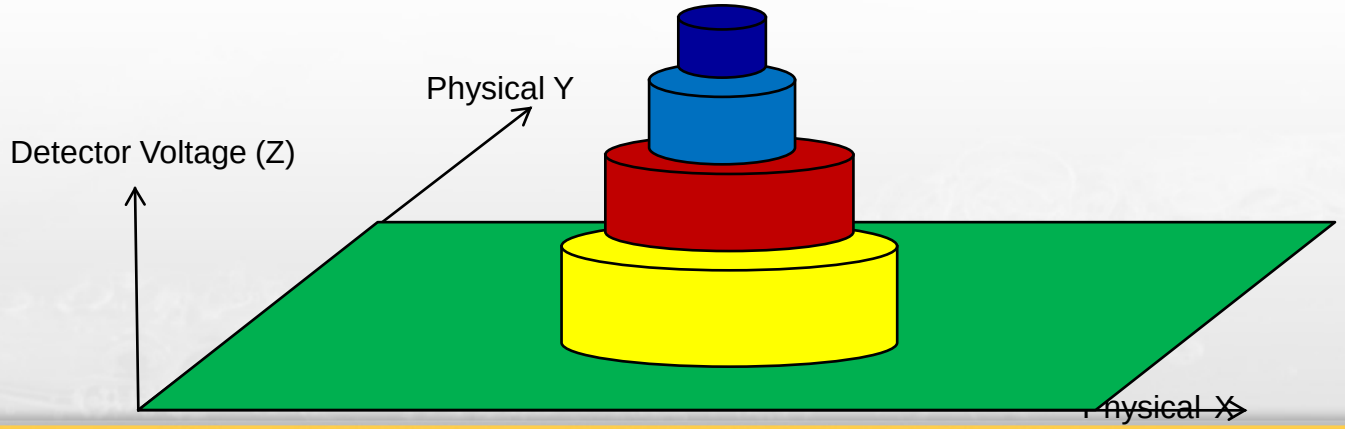
Detector output is in Volts

Data presentation

- Detector voltage A, B and C (A-B) at an X,Y position
- Amplitude in Gray scale or Color
- Data plot can be manipulated in quasi 3D







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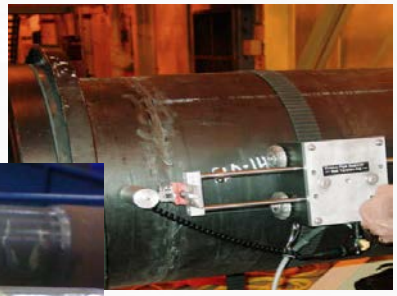
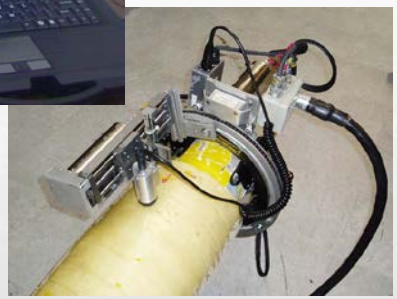
Equipment

Microwave essentials – integrated data acquisition and scanner controller, 24 GHz. microwave probe and ruggedised laptop

Deployment



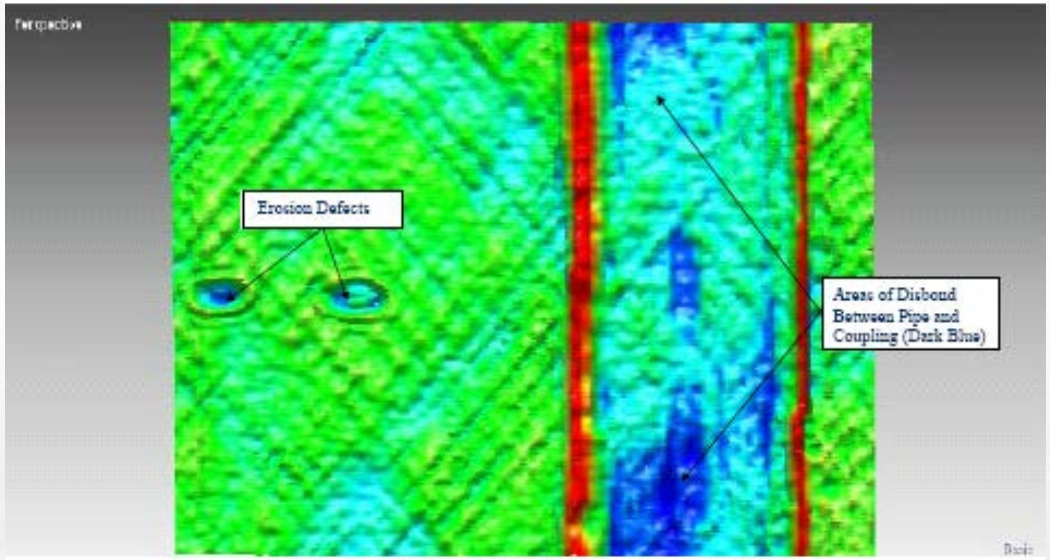


Example – Fiberglass pipe coupon

Fiberglass Pipe Coupon

Two Four Inch Pieces of FRP Pipe Connected Via Glued Coupling

Fiberglass Pipe Coupon



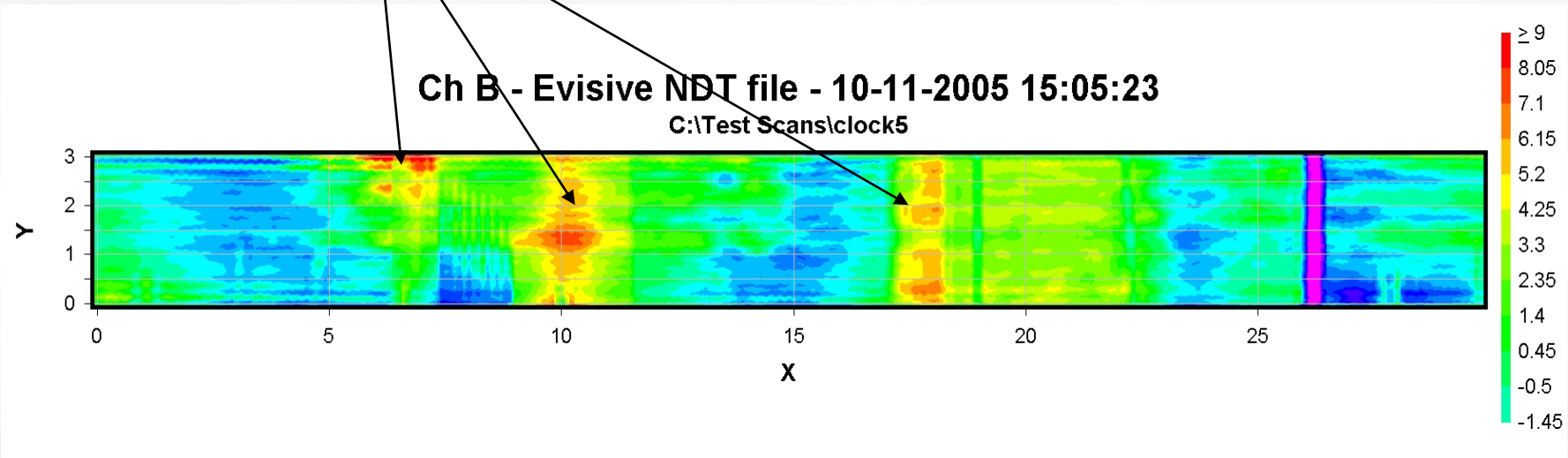
Scan Results
(Shown rolled out into flat plane for ease of viewing)

Example – Fiberglass reinforcement

Fiberglass Reinforced O.D. Pipe Patch

Example – Fiberglass reinforcement

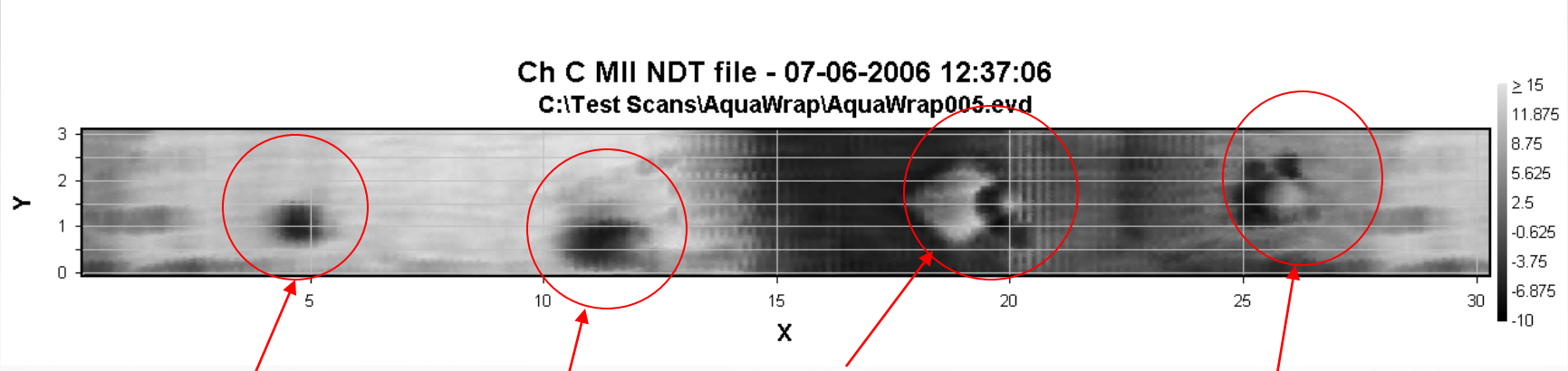
Flaw Areas
Poor Substrate Adhesion



Example – “AquaWrap” reinforcement

Reinforcement applied over 4 rectangular air bags (approx 0.005 air gap) First (0.5” x 0.5’) applied to surface at 0 degree, second (1” x 1”) at 90 degrees, third (1” x 1”) obliquely at 180 degrees between layers 2 and 3 and fourth (1” x 1”) obliquely at 270 degrees between layers 6 and 7 of 8.

Example – "AquaWrap" reinforcement



0.5" Disbond at surface

1" Disbond between layers 2 and 3

1" Disbond at surface

1" Disbond between layers 6 and 7

Example – GRP to GRP

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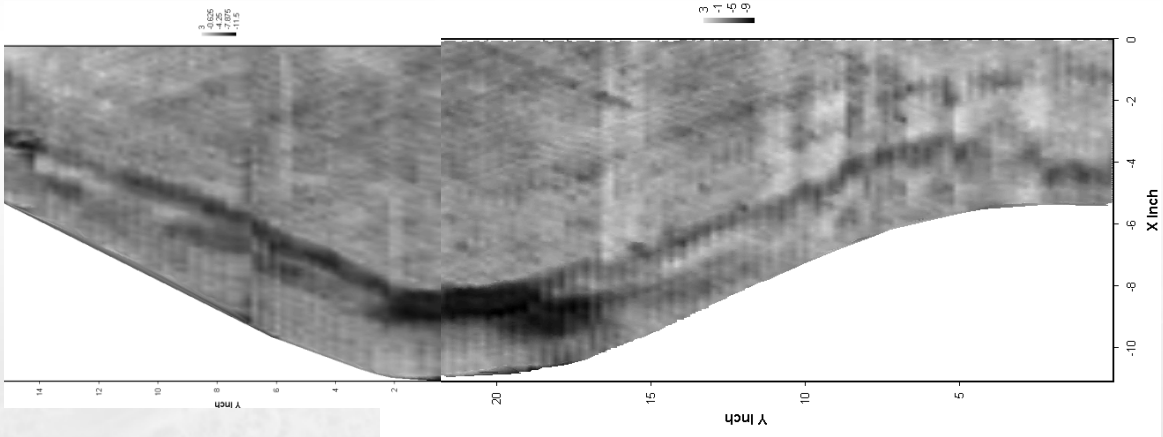
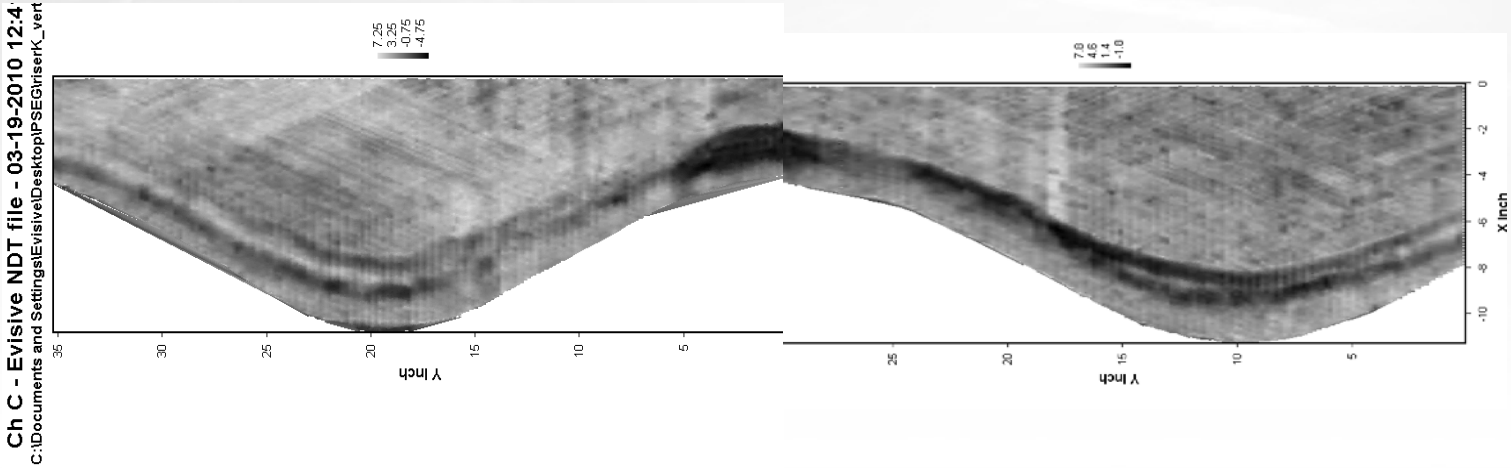


Example – GRP to GRP



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Composite repair test samples

- It was decided that this sample was not ideal for microwave scanning

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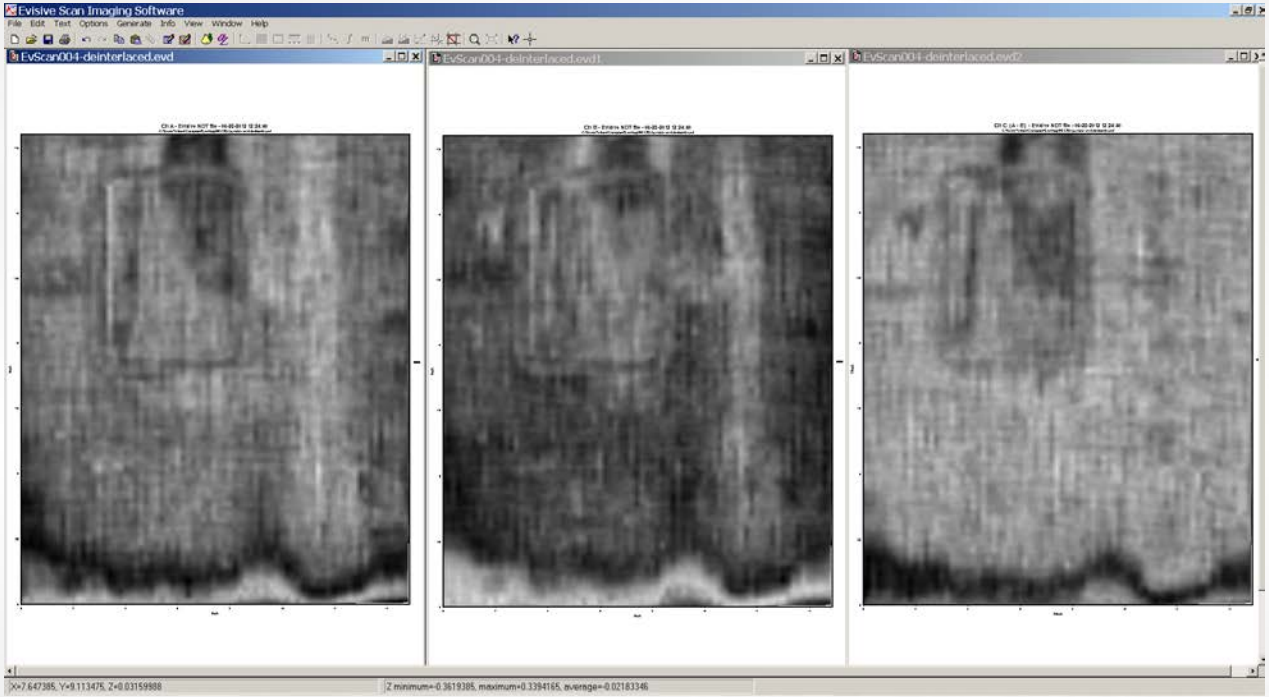
Composite repair test samples

The perfect specimen scanning results

Channel A Channel B Channel C



ISO - Non Destructive Testing

Table 2 NDE selection and acceptance criteria for defects that could potentially occur during operation (Update of Table 5 from ISO 14692 Pt. 4, additions shaded in light blue)

Operational defects	Cause(s)	Consequence(s)	Recommended NDE method(s) ISO 14692	Other potential NDE methods	Criteria	Corrective action	Comments
Flange cracks, leaks	Bolts over- or under-torqued. GRP against raised-face flanges. Wrong GRP flange design selected.	Joint not sealed, leakage. Reduced life	Visual inspection	Ultrasonics. Radiography	No leakage permitted	Replace flange (major defect). Grind and fill minor cracks with resin.	Radiography unlikely to be successful unless well aligned.
System failure, e.g. burst pipe	Design conditions, loads, temperatures exceeded. Operational procedures inadequate (e.g. water hammer due to valve opening).	System failure	Visual inspection	Monitoring by acoustic emission or leak detection methods	No failure permitted	Replace pipe or system	NDE not likely to be applicable
Ageing	Long-term materials degradation	Weepage	Ultrasonics	Ultrasonics, microwave, shearography, acousto-ultrasonics or transient thermography to detect delamination damage associated with ageing or impact.	More than 20 % reduction in original axial modulus	Accept, but monitoring required	Delamination may occur in the latter stages of ageing leading to weepage. Main initial damage mechanism is matrix cracking. Linear scanning UT methods (B-scan, C-scan) more likely to pick up delaminations. Phased array or rapid scanning wheel probes may be considered, given greater speed and quality of visual indication, if GRP quality and surface finish sufficient to allow higher frequencies (1-2.5 MHz)

ISO - Non Destructive Testing

Operational defects	Cause(s)	Consequence(s)	Recommended NDE method(s) ISO 14692	Other potential NDE methods	Criteria	Corrective action	Comments
Ageing (Continued)				Destructive testing and characterisation of condition or NDE using Ultrasonic velocity to measure matrix cracking non - destructively.			Normal practice for life extension is destructive testing using representative samples to compare actual condition with regression curve assumed in design (ISO 14692). NDE methods now developed to measure matrix crack spacing from ultrasonic velocity measurements.
Impact damage	Impact e.g. from dropped scaffolding, tools	Weepage	Ultrasonics. Visual inspection	Transient thermography, ultrasonics, microwave, shearography or acousto ultrasonics to detect delamination damage associated with impact.	In accordance with Table A.1 Visual inspection	Replace (major defect). Temporary repair (minor defect)	Visual inspection would be normal practice. Thermography can have a good sensitivity to the characteristic features of impact damage (conical damage area, multilayer delamination). Ultrasonic A-scan or phased array can detect damage dependent on surface finish and thickness. Shearography potentially good but expensive.
Earthing cable damage	Some cables susceptible to corrosion in marine atmosphere	Earthing reduced or eliminated	Visual inspection Mega-ohm meter	None	None permitted	Replace cables	NDE unlikely to be applicable

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Microwave - summary

- Microwave can detect and characterise irregularities that cannot be detected by other NDE techniques.
- Inspection speed and cost is comparable with Ultrasonic methods
- No hazardous emissions
- No environmental impact
- Major regulatory body approval in process