VITCEA Workshop

Oil and Gas Inspection:
NDT in Non-Metallic Materials

Richard Lee
Martin Wall

BAM
Federal Institute for Materials Research and Testing

Federal Institute for Materials Research and Testing

14:55 – 15:15 CET
13:55 – 14:15 GMT

17 February 2015

ESR Technology
A Hyder Consulting group company
Hyder

VITCEA Workshop

Non-metallic materials in oil & gas

Inspection & NDT/NDE

Information Sources

Codes & Standards

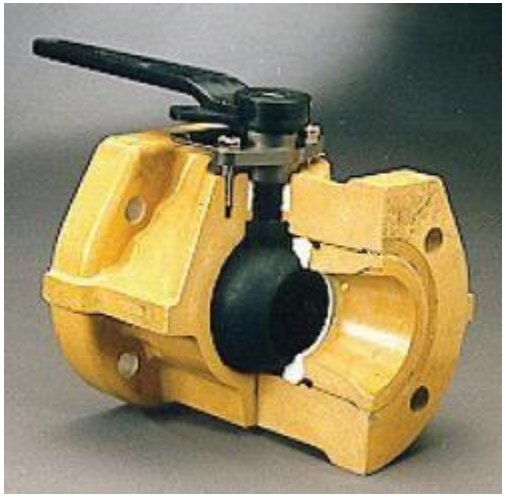
Summary

Q & A

(20 minutes)

Non-metallic Materials in Oil & Gas

- Composites are used in increasing range of applications
- NDT usually done at Manufacture
- NDT in Service is more difficult and less widely done
- Traditionally conservatively designed to allow for in-service damage or degradation
- Perception of difficulty to inspect in service and limitations of defect assessment methods have limited uptake of composites
- They are increasingly being used in large structural applications
- With recent developments there are a range of NDT methods that can be used in-service



Non-metallic Materials in Oil & Gas

Definition

Non-metallic materials include ceramics, polymers, elastomers as well as composite materials. We will restrict it to materials comprising polymeric resins reinforced with fibres. The resin may be one of a class of thermosets (epoxy, polyester, vinyl ester, phenolic, etc.) or thermoplastic (PA, PEEK, PPS, PVDF, etc.).

The fibre reinforcement may be glass, carbon or aramid and can be present in continuous or chopped lengths.

Sandwich structures comprising two layers of composite bonded to either side of a foam or honeycomb core may also be classified as a composite material.

They do not corrode in the conventional sense but degrade in-service due to chemical, physical and thermal ageing.

NDT Workshop in Non-Metallic Materials

Terms commonly used in the Oil and Gas industry for composite materials include:

GRP Glass reinforced polyester (where the fibre is glass and the resin is polyester)

GRE Glass reinforced epoxy (where the fibre is glass and the resin is an epoxy)

GRV Glass reinforced vinyl ester (where the fibre is glass and the resin is a vinyl ester)

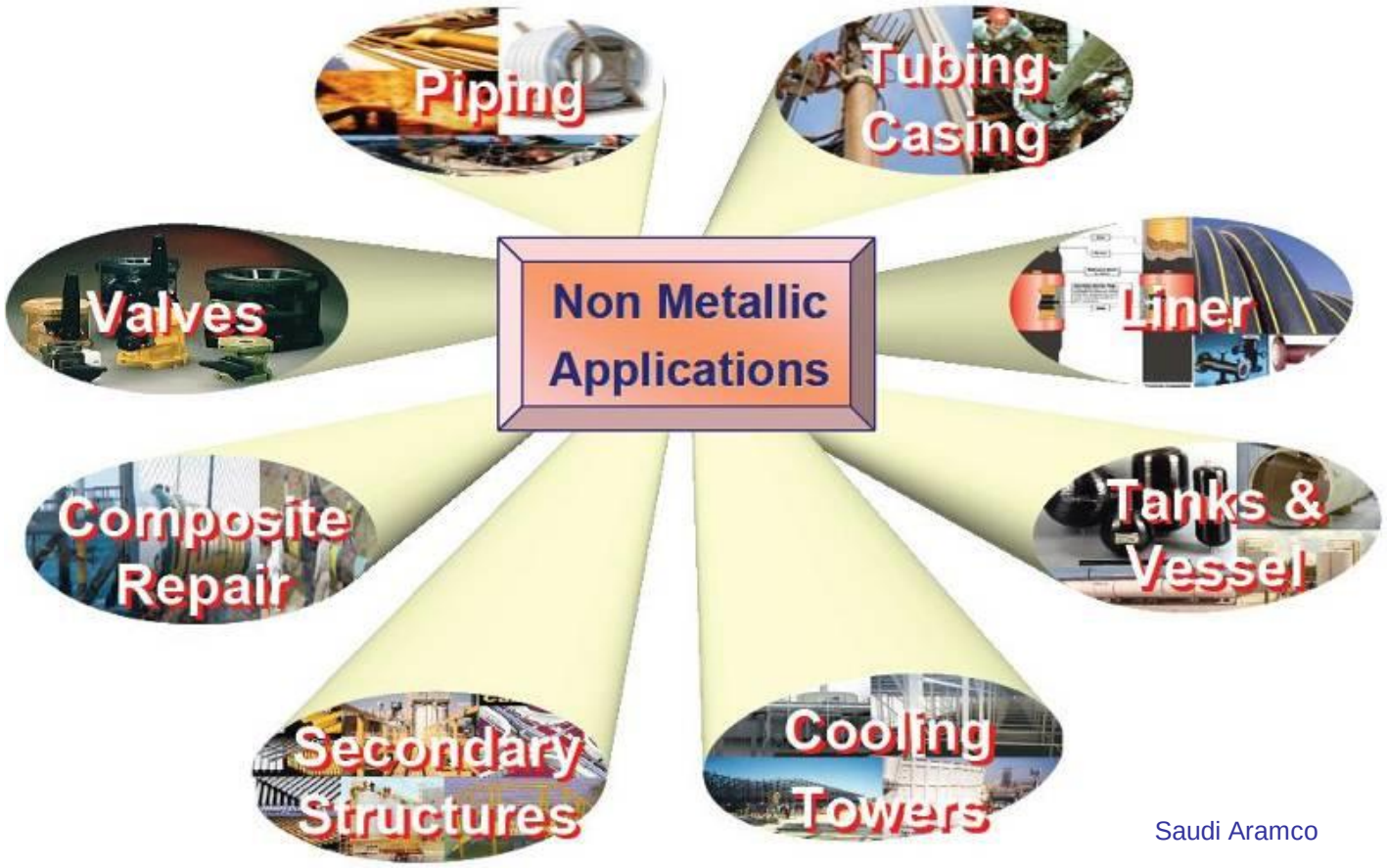
FRP Fibre reinforced plastic (where the fibre may be any of those listed above and the resin is any of the polymer resins)

RTR Reinforced Thermoset Resin (where the fibre is glass and the resin is any of the polymer resins)

CFRP Carbon fibre reinforced plastic (where the fibre is carbon (conductive) and the resin is any of the polymer resins)

Non-metallic Materials in Oil & Gas

Non Metallic applications is increasing…



Saudi Aramco

Non-metallic Materials in Oil & Gas

4 m GRP pipe installation in UAE

Future Pipe Industries

Non-metallic Materials in Oil & Gas

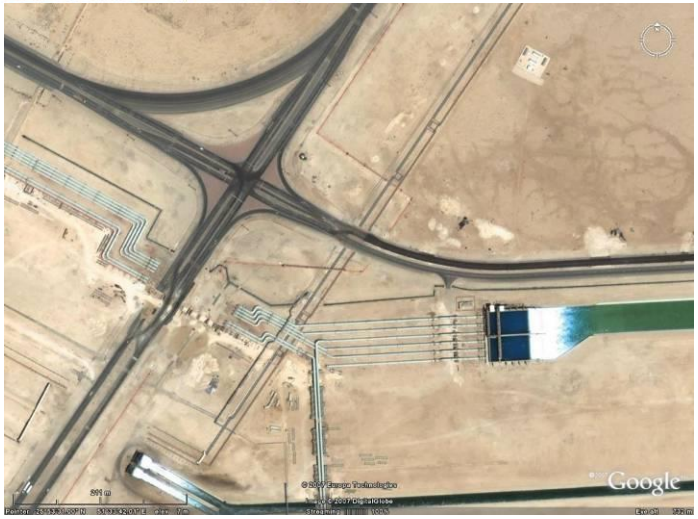
Large Industrial Complex in North East Qatar

Gas Processing Plants (LPG and GTL)

- Qatar Petroleum
- Qatar Gas
- Ras Gas
- Q-Power
- Shell
- Sasol

Up to 100,000 people on site

Over 6,000 Dodsal Contractors



Non-metallic Materials in Oil & Gas

Application examples – composite repairs

Materials : Glass/Epoxy

Diameter : 16 inch

Temperature : 25 C

Pressure : 30 bar

Ease of installation

No hot work permit needed

Corrosion resistant

Non-metallic Materials in Oil & Gas

On Site Spool Manufacture

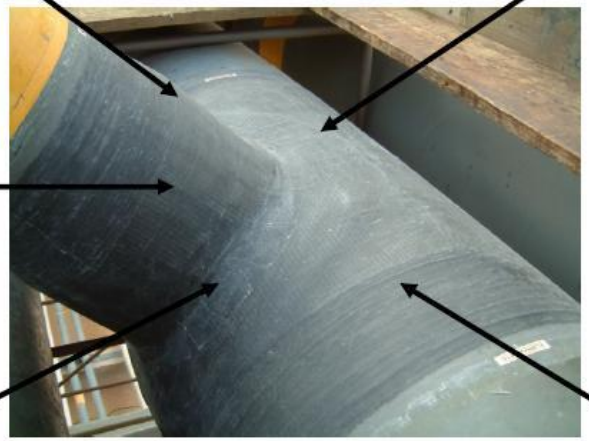
CFRP Pipe Repairs

Non-metallic Materials in Oil & Gas

Materials formed to shape on site with no pre-fabrication

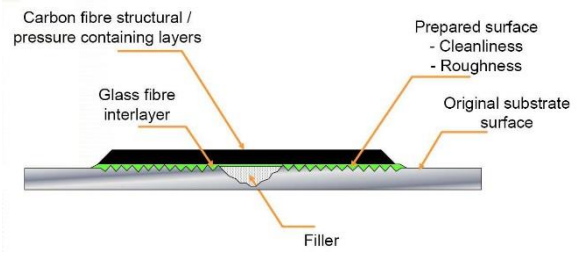
Flexible materials conform to difficult shapes

Epoxy bond to steel provides leak sealing capability, chemical & environmental resistance



Repairs are close fitting & can be applied in confined spaces

Lightweight repair kits are easy to transport & handle



Furmanite International

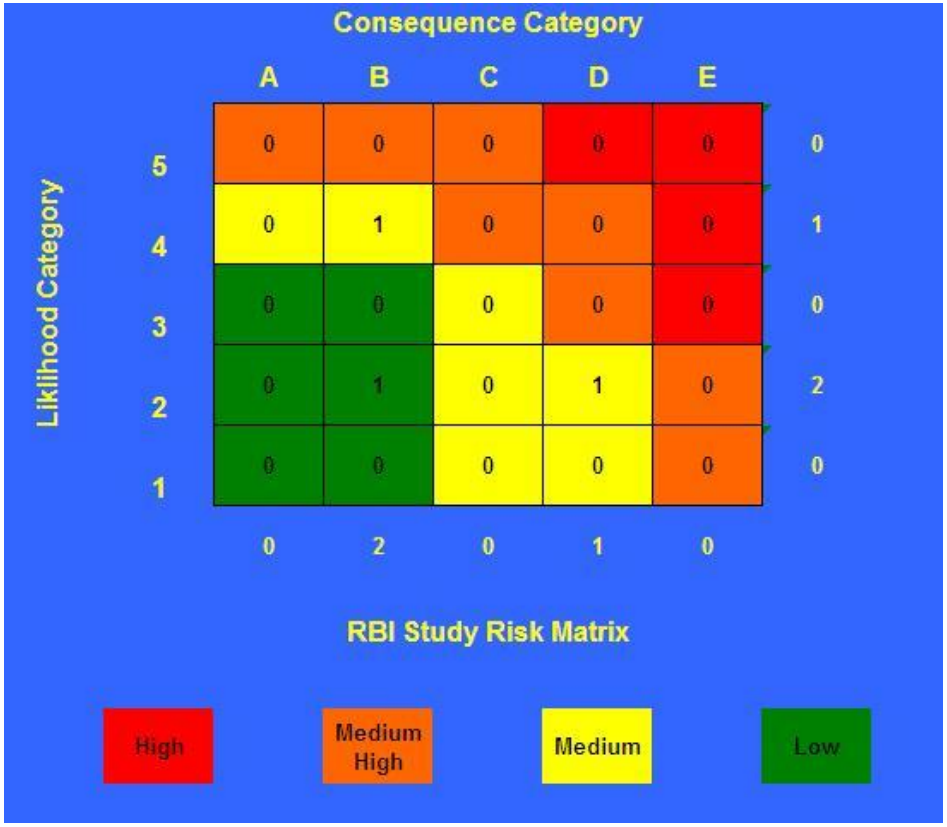
What to inspect

- Components
  - Tanks (above or below ground)
  - Pressure Vessels
  - Pipes & Joints
- Structures
  - Civil
  - Offshore
- Systems
  - Pressure
  - Actuators
  - Rotating equipment
  - Safety equipment, etc.

Challenges - In-Service NDT

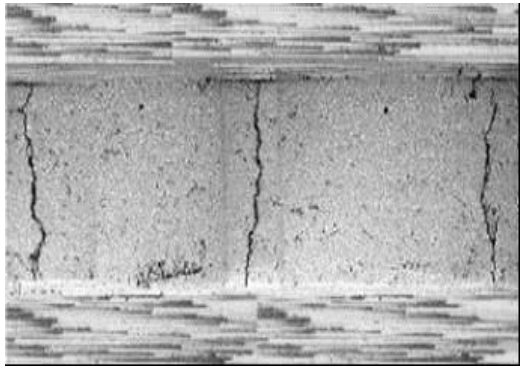
- Thickness
- Accessibility
- Coupling & surface condition
- Positive Materials Identification
- Signal attenuation and scattering
- Inhomogeneous and anisotropic structure
- Lack of adequate standards
- Interpretation of inspection results (Probability of Detection)
- Unfamiliarity with nonmetallic structures
- Increased reliance on operator experience

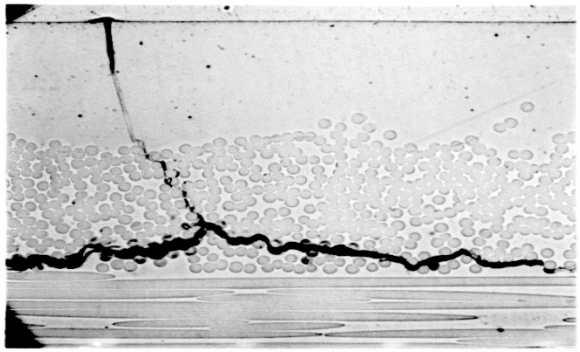
Inspection Strategy – Large Structures

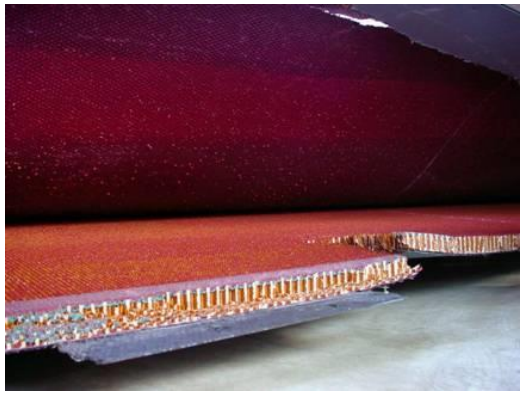


- Global inspection methods
- Monitoring (e.g. Acoustic Emission)
- Fast screening *with detailed inspection of indications found*
- Risk-Based Inspection – *Locations and types of likely damage mechanisms known*

Defect Types – In Service and Installation







CompositeNDT

NPL

Composites are damage tolerant.

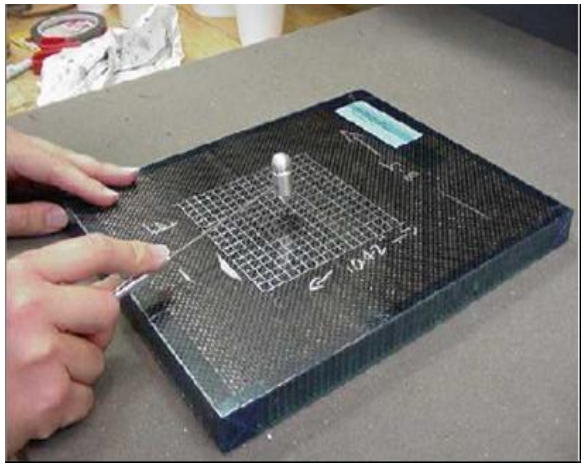
Variety of *in-service* defects are possible

Most significant are

- Delaminations (debonding)
- Impact damage (localised)
- Matrix cracking (overstress)
- Weepage (leak)
- Environmental ingress (swelling)
- Thermal damage and lightning strike
- Disbonding – joints and repair applications
- Loss of thickness – due to erosion or severe chemical attack

Other failure mechanisms may also be present, e.g. UV degradation and possibly fibre failure but less of a concern.

Standards and Information



- ISO14692
- NORSOK
- Company and In-House specifications
- Generic NDT procedures
  - NPL/ QinetiQ ultrasonic C-Scan procedures
  - HOIS Guidance In-Service Inspection

www.MaterialsSolutions.info

www.HOIS.co.uk

Example ISO 14692 (under revision)

INTERNATIONAL STANDARD

ISO 14692-4

First edition
2002-12-15

Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping —

Part 4:
Fabrication, installation and operation

Industries du pétrole et du gaz naturel — Canalisations en plastique renforcé de verre (PRV) —

Partie 4: Construction, installation et mise en œuvre

Reference number
ISO 14692-4:2002(E)

Rapid C-Scanning

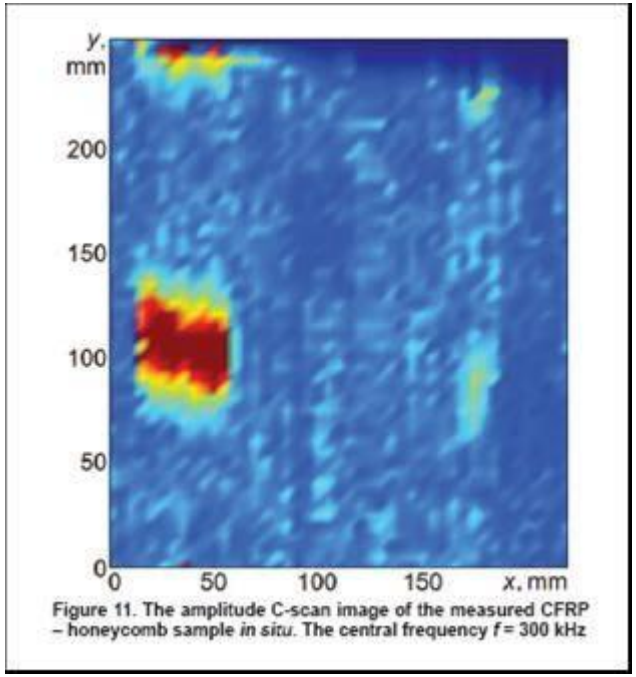
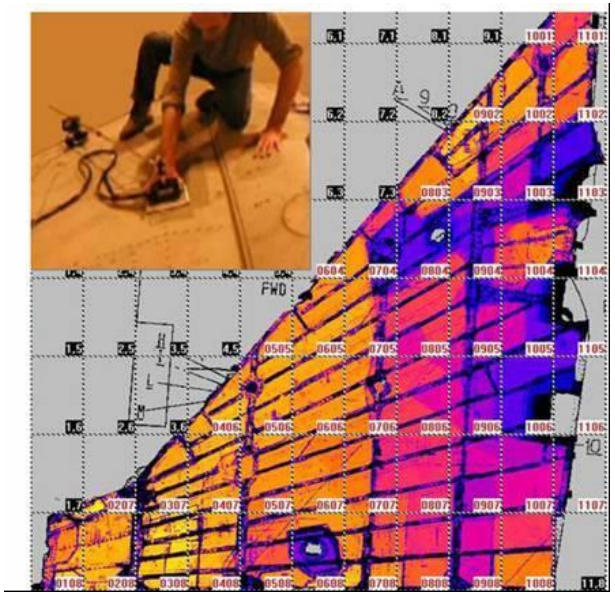


Figure 11. The amplitude C-scan image of the measured CFRP – honeycomb sample *in situ*. The central frequency $f = 300$ kHz



- Wheel probes
- Rapidscan™ or Phased Array
- Air coupled UT probes

Example - NDT of Composites

- Mainly GRP
- Variable wall thickness (2-50mm) and section
- Connections, nozzles and flanges an issue
- Variable material properties and quality
- NDT may be affected by high porosity or poor surface finish
- NDT methods difficult to apply in thicker sections
- Access for NDT an issue. Piping often close packed e.g. water treatment plant
- Special issues in some applications – escape craft, firewater mains, lined vessels, etc.

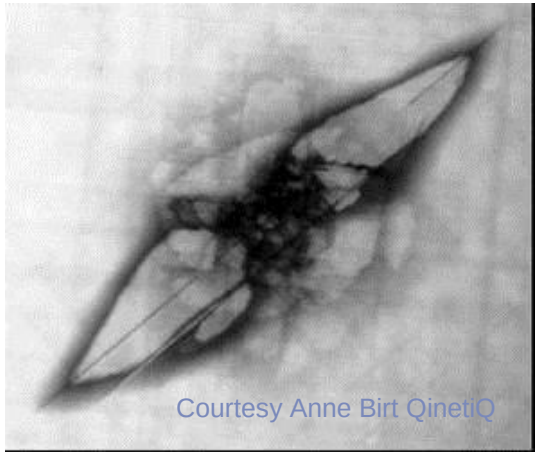
NDT Information, current news, forums, etc.

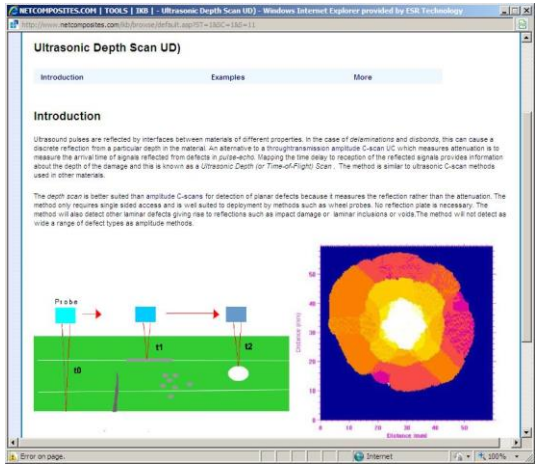
NDT.net	General NDT database & journal
NDT Cabin	Internet magazine for NDT professionals
NDT Resource Center	Source of information and materials for NDT/ NDE technical education
NDT.org	Dedicated to Inspection and Nondestructive Testing.
ASNT	*American Society for Non-destructive Testing*
API	*American Petroleum Institute*
ASTM	*American Society For Testing and Materials*
ASME	Boiler & Pressure Vessel Code Section V Non Destructive Examination
BINDT	*British Institute of Non-Destructive Testing website*
NetComposites	Tools - NDT
RCNDE	Research Centre in NDE (UK)
MMS15	IKB Inspection of Composites

Defect Assessment - Oil & Gas

Defect type	Defect assessment procedure	Comment
Matrix cracking	Damage mechanics approach to estimate density	Procedure in development and under test
Lack of adhesive	Simply area of de-bond (< 30% of bond area OK)	Used in ISO 14692
Loss of thickness	Simple 1-D assessment using estimated minimum wall	Very conservative for localised defects
Delamination	Linked to damage mechanics plus also fracture mechanics approached	Damage approach under development. For fracture approach difficult to quantify critical values

NDT Methods





- Visual VT
- Ultrasonics UT
- Radiography RT
- Thermography TT
- Laser Shearography LS
- Microwave MW
- Acoustic Emission AE
- Other, e.g. coin and tap testing AI

UT Thickness Meter

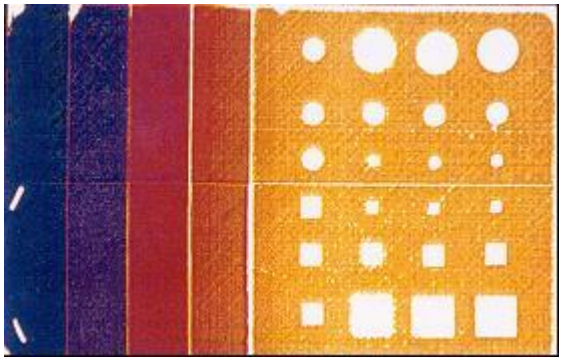
UT Thickness Meter

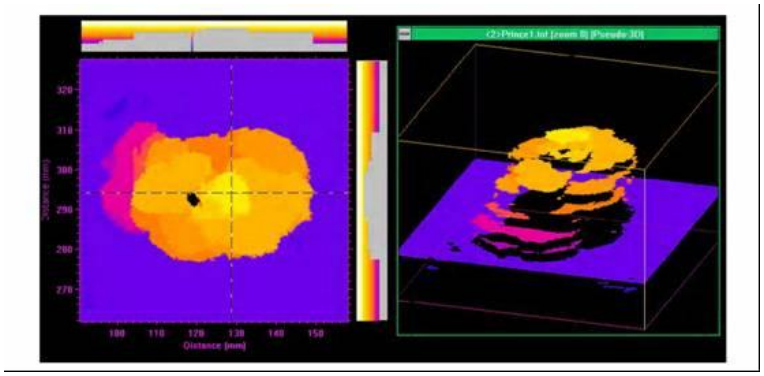
The 35HP gages are excellent tools to measure fiberglass or composite parts, from aerospace structures to boat hulls and storage tanks that require thickness control.

LIVE A-SCAN (WAVEFORM) AND ADJUST MODE

Operator can view thickness and waveform with the optional A-scan mode

Data Presentation

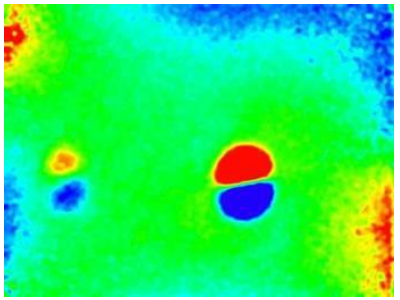




Courtesy NPL, QinetiQ

- Digital Image
- A-Scan *Signal v arrival time*
- B-Scan T*hrough thickness slice*
- C-Scan *Map from above surface*
- D-Scan Orthogonal view
- Depth scan or Time-of-Flight TOFD
- Digital data set
- Similar presentations used irrespective of NDT method used

Laser Shearography



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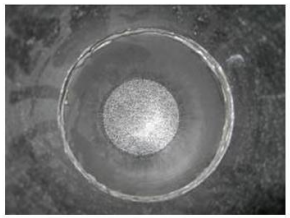
UNIVERSIDADE FEDERAL DE SANTA CATARINA

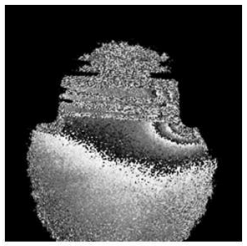
COMPOSITE INSPECTION
Advanced Non Destructive Testing

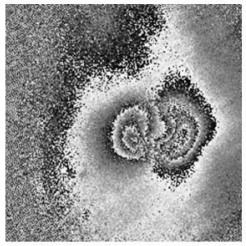
Laser Shearography

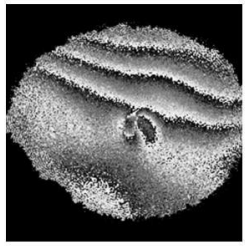
Collar Joint Pipe

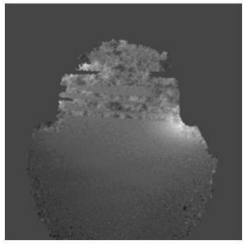


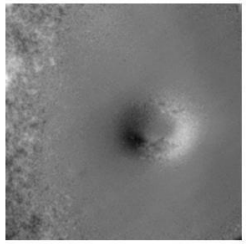
Vacuum Loading of Collar Joints

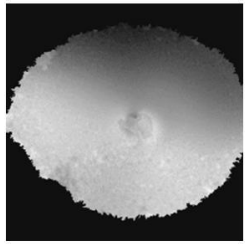












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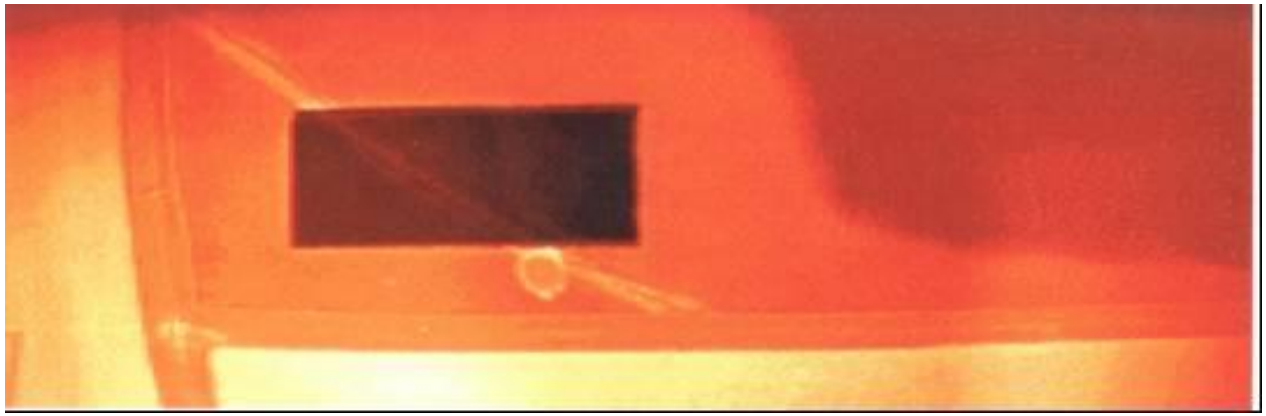
Thermography

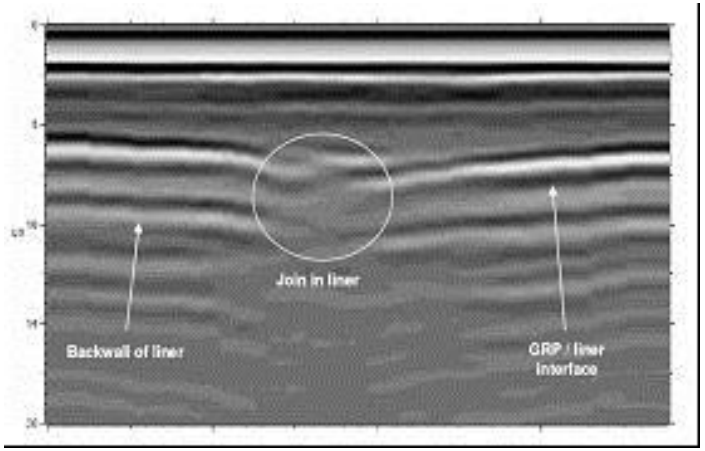


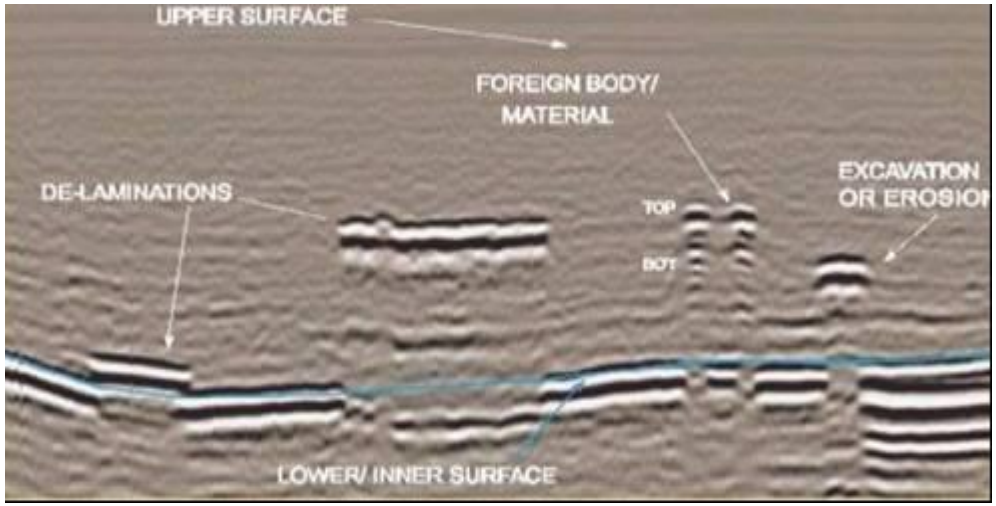
LOT
LOT Oriel Group Europe

FLIR

Thermal Wave Imaging
THE ART OF INSPECTION

Ultrasonic B-Scan and TOFD

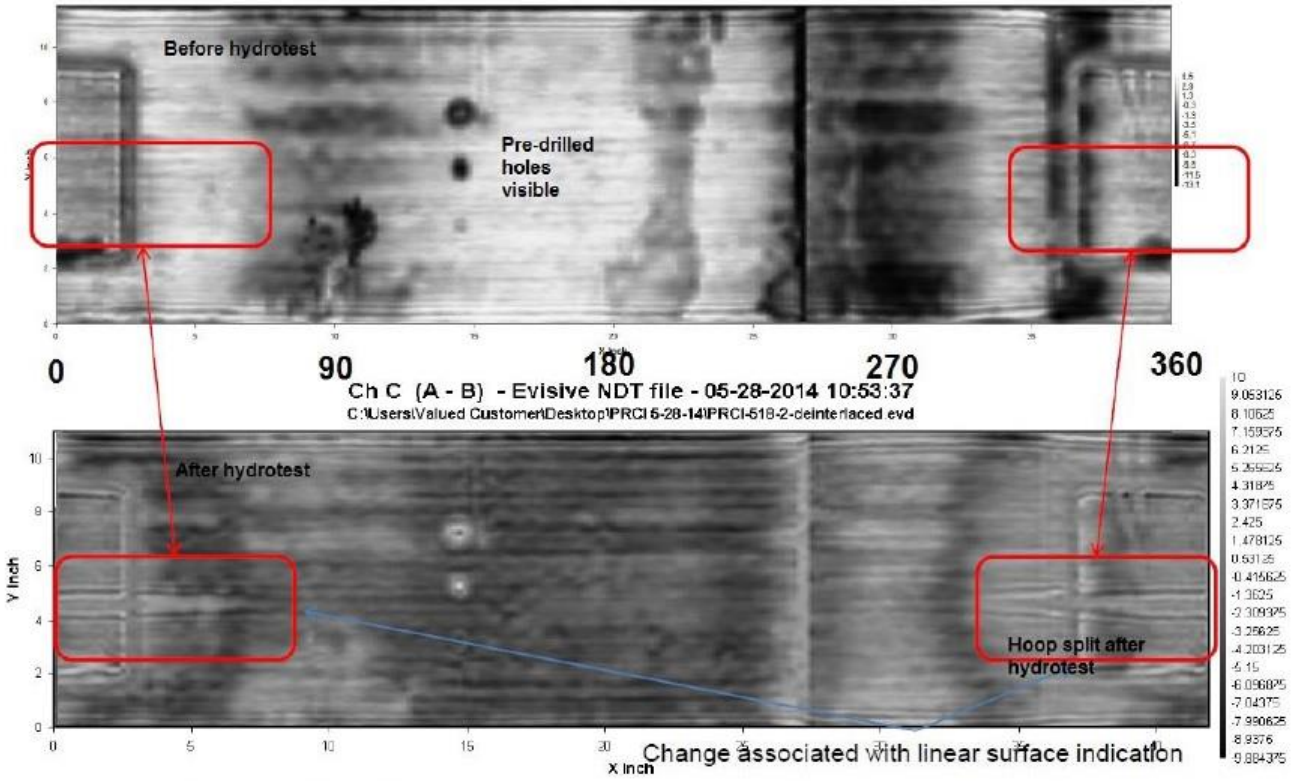




Pipe wall loss through severe chemical attack

Erosion and wall loss, liner damage

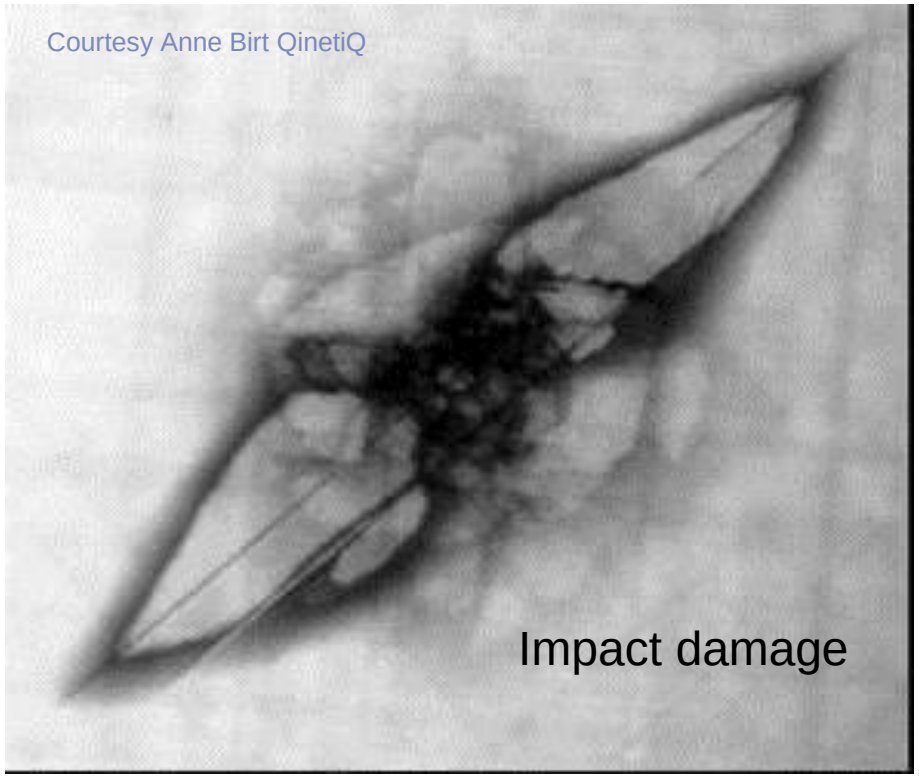
Microwave Inspection

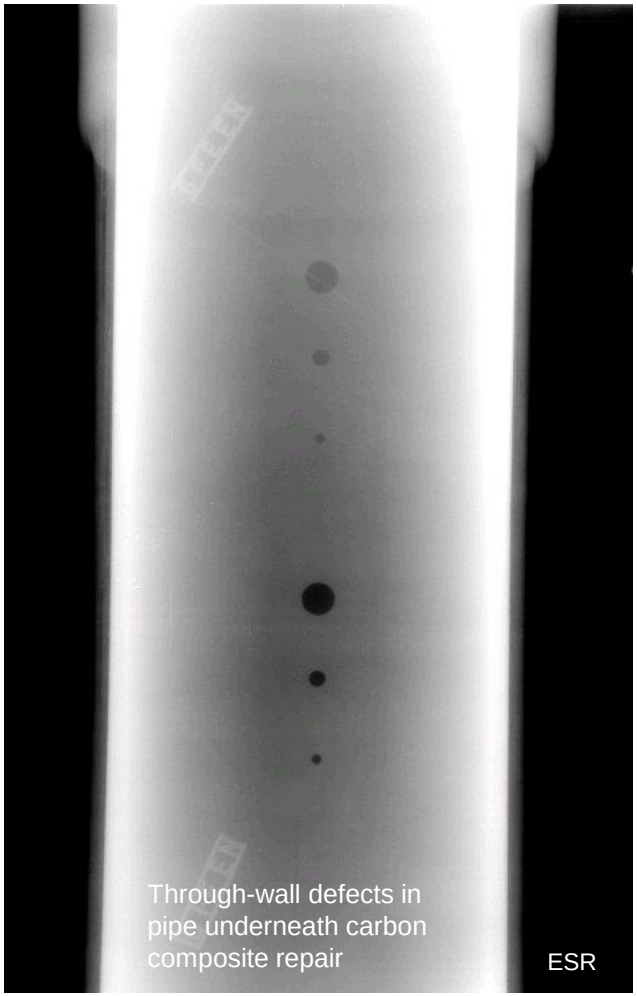


Clock Spring microwave scans (before and after hydrotest showing changes).

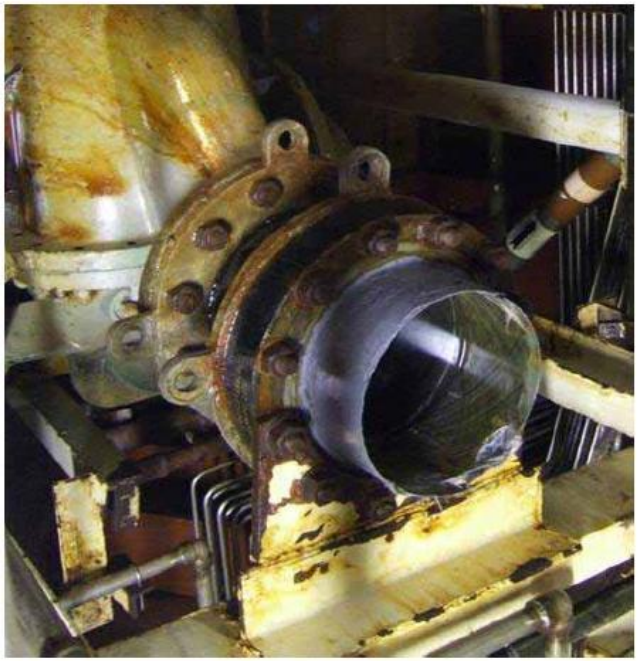
EVISIVE MICROWAVE NDE TECHNOLOGY

Radiography



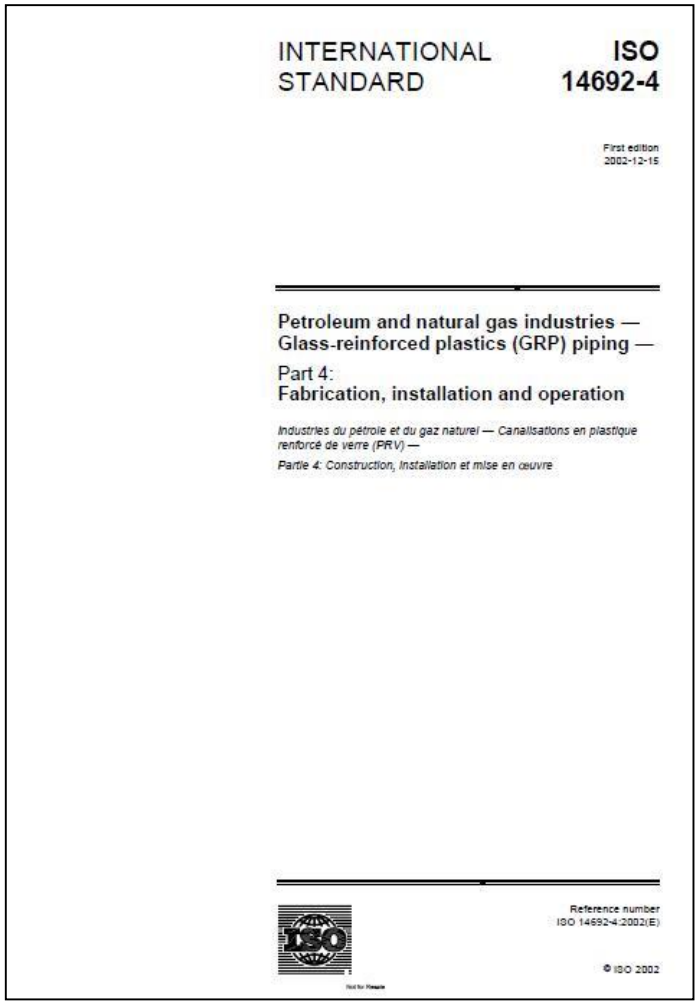


We want to avoid this...



Example of an adhesive bond failure of GRE pipework in service

Applicable Standards



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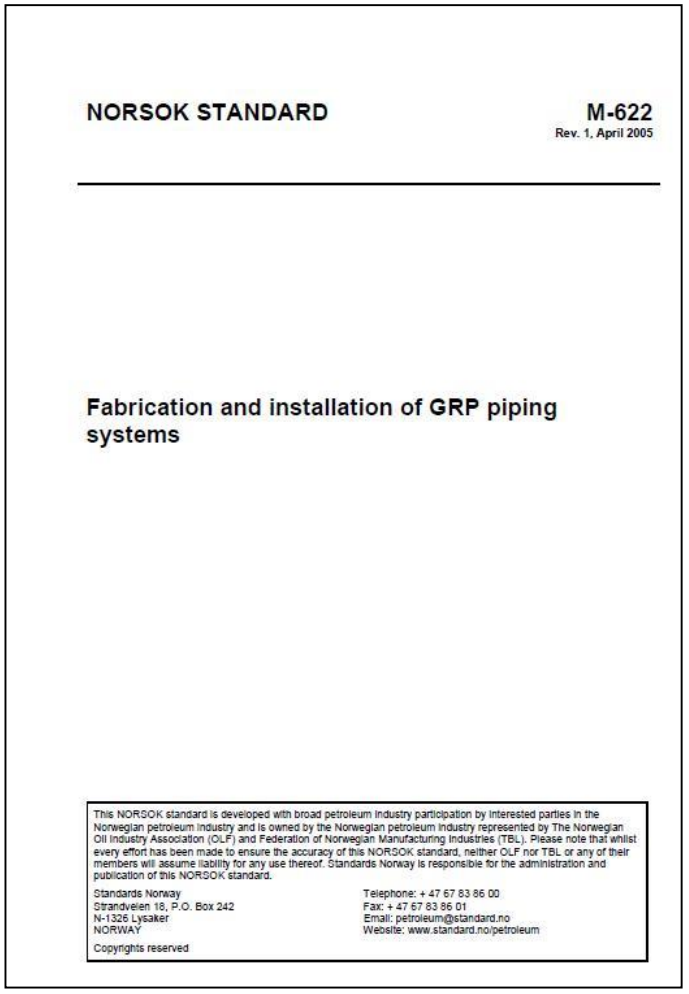


NORSOK STANDARD

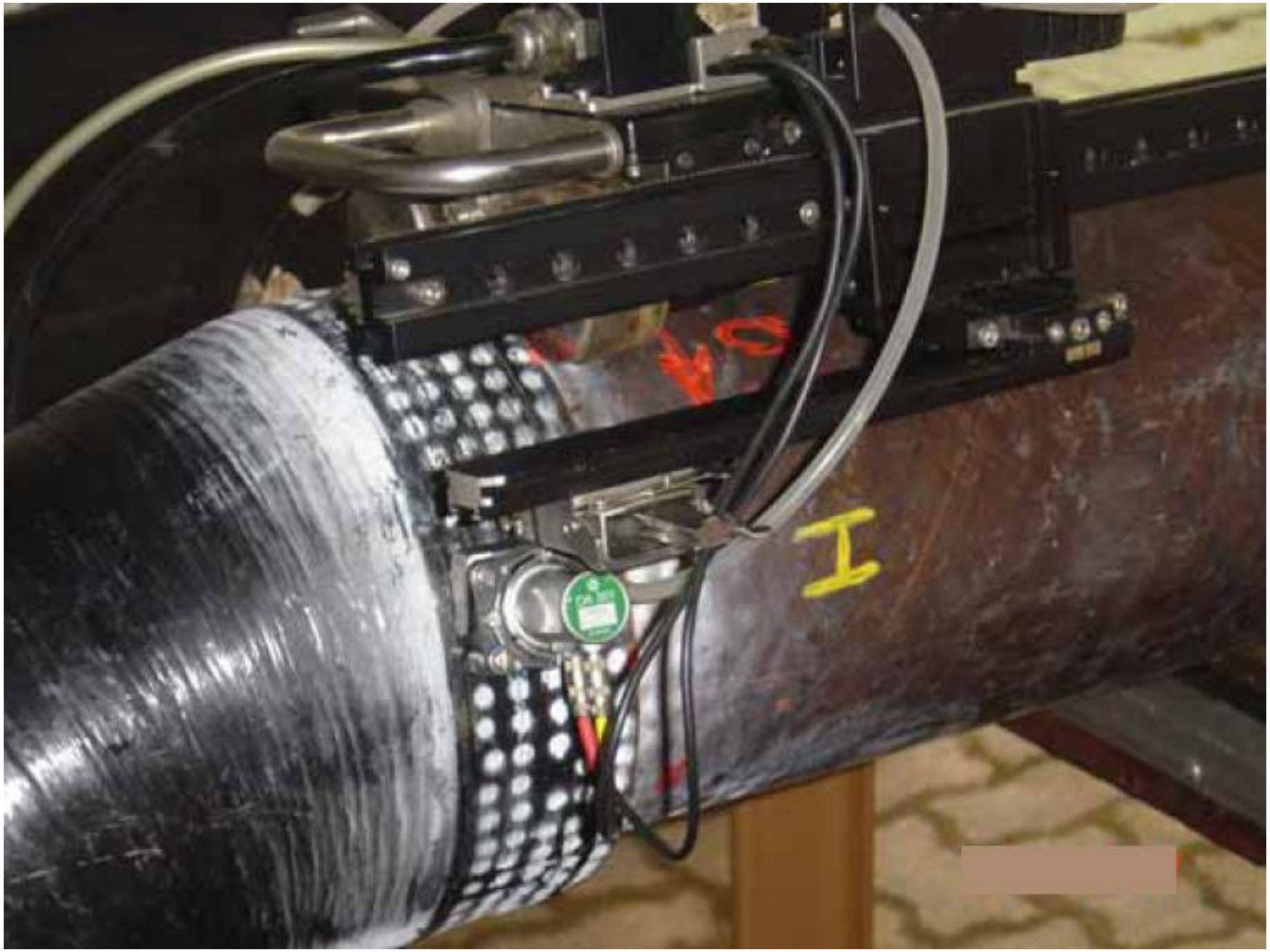
M-622
Rev. 1, April 2005

Fabrication and installation of GRP piping systems

Standards Norway
Strandveien 18, P.O. Box 242
N-1326 Lysaker
NORWAY

Telephone: + 47 67 83 86 00
Fax: + 47 67 83 86 01
Email: petroleum@standard.no
Website: www.standard.no/petroleum

UT inspection of GRP pipe joint



Future Developments

- Improvements in rapid screening methods and monitoring techniques
- Improved defect assessment methods
- Application of risk-based methods. Identify critical areas
- Reliability and performance of composite NDT Methods POD
- Use of simulation and NDT reliability models
- Improved standards for in-service composite NDT

VITCEA Workshop

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Richard Lee
Martin Wall

Mr Richard Lee
Principal Technical Consultant
ESR Technology, 22 East Central
127 Olympic Avenue, Milton Park,
Abingdon, Oxfordshire OX14 4SA, UK

Mobile: +44 (0)7968 096044
Direct: +44 (0)1235 213416

Richard.Lee@esrtechnology.com
www.esrtechnology.com
a Hyder Consulting group company

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