British Nuclear Group

Intelligent nuclear clean-up

Non-Destructive Examination of Reactor Plant.

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Topics Covered

- Introduction
- Key Drivers for Research
- Overview of Research Collaboration Activities
- Current Challenges
- Highlights of Recent Achievements
- Examples of current research areas
- Programme for 05/06
- Summary and Conclusions

Introduction

- Scope: Research and Development in NDT/NDE including remote visual inspection
  - Includes work funded by Magnox directly and collaborations with other parts of BNFL and British Energy.
- Aims of Research:
  - To keep abreast of current developments, nationally and internationally and participate in sponsored research where necessary to ensure that inspections of reactors take account of the latest knowledge and techniques.

Key Drivers for Research

- Adequate NDE capability has to be maintained for the In-Service Inspection (ISI) of operating plants and repair of components where necessary.
- Key reasons for research into inspection techniques are:
  - to match inspection capability to increasing challenges of safety cases
  - to develop reliable, efficient inspection techniques that minimise disruption to outages
  - to develop accurate NDE techniques, qualified where necessary to give confidence in results
  - to provide suitably qualified staff to operate the techniques and interpret results
  - to provide reliable remote operations capability to minimise disruptions to outages

Overview of Research Collaboration Activities

- Research directly funded by Magnox – often directly funded by projects
- Research funded jointly with British Energy – much NDT is equally applicable to all reactor types
- Research funded jointly with other parts of BNFL via the Research Centre for NDE
- Other UK interactions
- International interactions

UK Research Centre in NDE (RCNDE)

Vision

World-leading centre of excellence in NDE research through active partnership with industrial community

Aims

- Excellence in NDE research
- Industrial benefit at minimum cost
- Raised quality of industrial NDE

UK Research Centre for NDE (RCNDE)

- Established in April 2003 by EPSRC at:
  - **Imperial College, Strathclyde, Bristol, Bath, Warwick, Nottingham,**
  - **Other universities can also participate on targeted projects eg London South Bank.**
- Industrial members include; BNFL, RWEnPower, Rolls-Royce, Airbus, Dstl, Shell, Serco Assurance, HSE

Current Challenges – linked to Nuclear Research Index (NRI) issues

- Quicker and more efficient inspection qualification
  eg NRI 1.3.4(6) and 1.3.4(9)
- Continued improvement in characterisation and sizing of defects
  eg NRI 1.3.5(12)
- More remote inspection of components – including those buried in concrete - using guided waves eg (NRI 1.3.3(7) and 1.3.3(8))
- NB: Many 'research' activities are funded by Magnox without being identified as an issue in the NRI.

Highlights of Recent Achievements

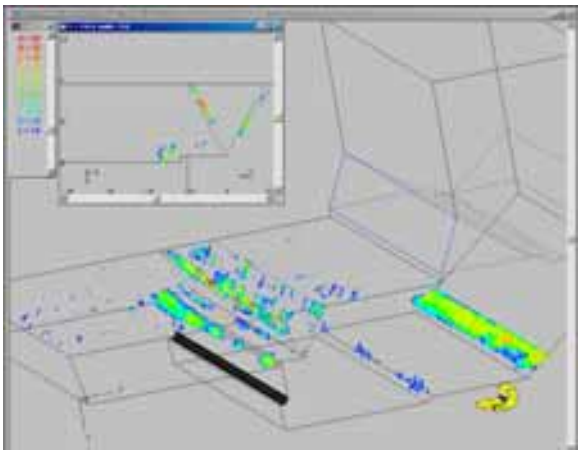
- Use of new 3D package (NDT Workbench) for mathematical modelling, design of inspections and analysis of data.
- Use of ultrasonic phased arrays for critical inspections
- Validation of mathematical models
- Improved understanding of the capabilities and limitations of inspection techniques
- Development of smaller, higher resolution thermography camera

Examples of current research – 1: NDT Workbench

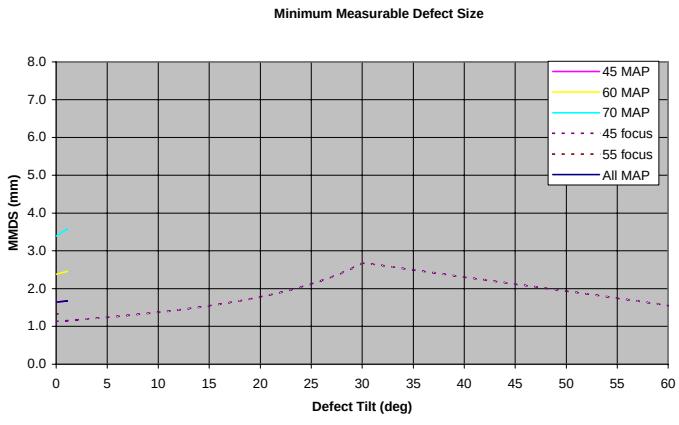
- Features:
  - » Mathematical modelling
  - » 3D data analysis
  - » Inspection qualification tools eg prediction of worst case defects
- Current system:
  - » Applied to a critical standpipe inspection in 2005 with sizing qualification.
  - » Being licensed commercially
- Latest research project supported by Magnox (Oct 04-Oct 07):
  - » Agent- based software
  - » Improvements in mathematical modelling

Wylfa standpipe inspection: Scanner

3D data display with inset 2D display



Wylfa standpipe inspection: Sizing of small defects

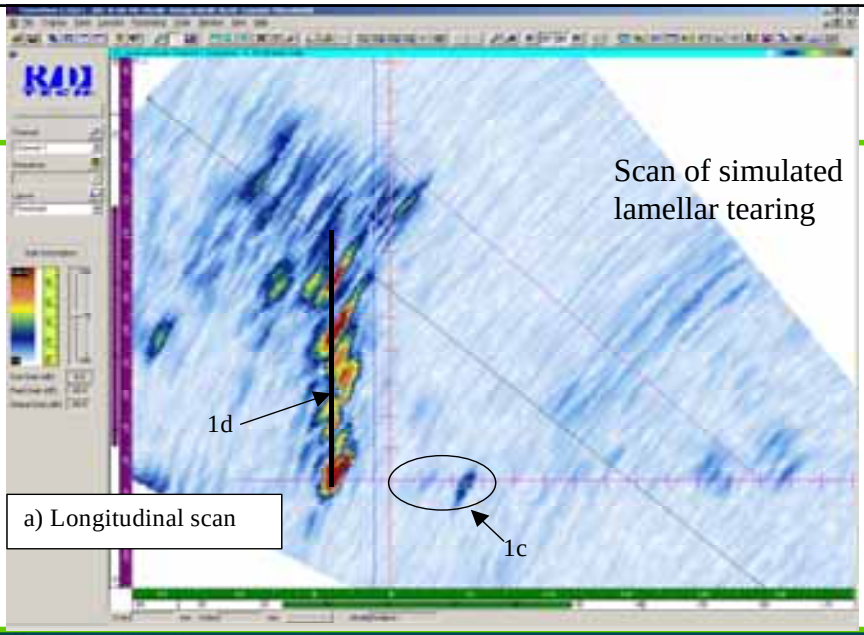


Examples of current research- 2: Phased Arrays

- Commercial equipment but in-house training and certification
- Full inspection qualification for use with Sizewell A and Oldbury boilers
- Valuable confirmatory role for turbine inspection
- National training and certification scheme based on Magnox approach
- Active work at Bristol University (RCNDE) to improve signal processing methods (supported by BNFL)

Restricted working conditions for fillet weld inspection

Phased array scanner inspecting box section weld

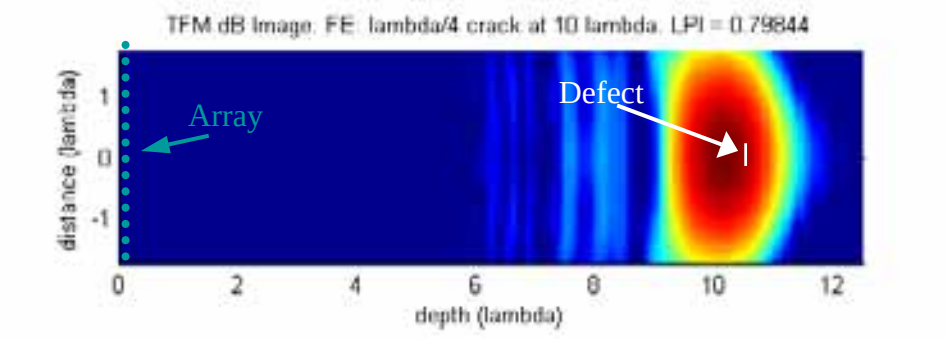


Examples of current research – 3: Guided Waves

- Trials performed for Wylfa reactors on pipes embedded in concrete indicated need for improved resolution.
- 3 year project at Imperial College to improve defect characterisation and sizing (supported by BNFL).

Trials of Guided Wave Array on Wylfa economiser

Image small defect using Total Focussing Method (TFM)



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Prototype Guided Wave array connected to plate tester system

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Magnox NDT Programmes for 05/06: Part 1- with NRI where relevant

Research Activity	NRI Issue	Joint with BE
•Theoretical Modelling of NDT		
•Reduce weakness in rough defect model	1.3.4(9)	Yes
•Evaluate caustic correction for edge diffraction	-	Yes
•Extra signal paths in corner response	-	Yes
•Programmers manuals and documented codes	-	Yes
Participation in RCNDE		
•NDT Workbench agent based software	-	No
•Ultrasonic guided wave inspection	1.3.3 (7),(8)	Yes (part)
•Monitor thermography at RCNDE	-	No

Magnox NDT Programmes for 05/06: Part 2- non NRI

Research Activity	Joint with BE
Phased array Improvements •Train and certificate operators	No
NDT Workbench support •Training course and exam	Yes
SAGE Working Group •Review of latest cameras and radiation testing of components	Yes

Other Research Collaboration Activities

- UK activities
  - British Institute of NDT – various committees including the new UK NDT Research Advisory Group

    Aim: Maintain technical awareness and encourage improvements where possible

  - HSE programme for Assessment of NDT in Industry - PANI 3

    Aim: Improve understanding of human factors and reasons for operator variability
- International interactions
  - European Network for Inspection Qualification (ENIQ)

    Aim: Improve effectiveness of qualification by sharing knowledge and specimens and by improved methodologies (eg Capability Statements)
  - Gap Analysis for Inspection of Nuclear plant (GAIN) - Euratom Framework 6 Project

    Aim: Encourage EU funding to target areas of greatest need

Conclusions

- NDE research needs for Magnox reactors are reducing fast, but need to retain intelligent customer capability.
- Unplanned problems require experienced well-informed staff
- Close links with British Energy on reactor plant research.
- Close cooperation with other BNFL research needs for reprocessing/waste management via RCNDE.
- NDA commitment required to continue RCNDE support and to move research products into commercial use (licensing NDT Workbench)
- Active involvement with national initiatives eg BINDT, PANI
- Active involvement with international initiatives eg ENIQ and GAIN project