Office for Nuclear Regulation

Lessons learned – a regulator's view

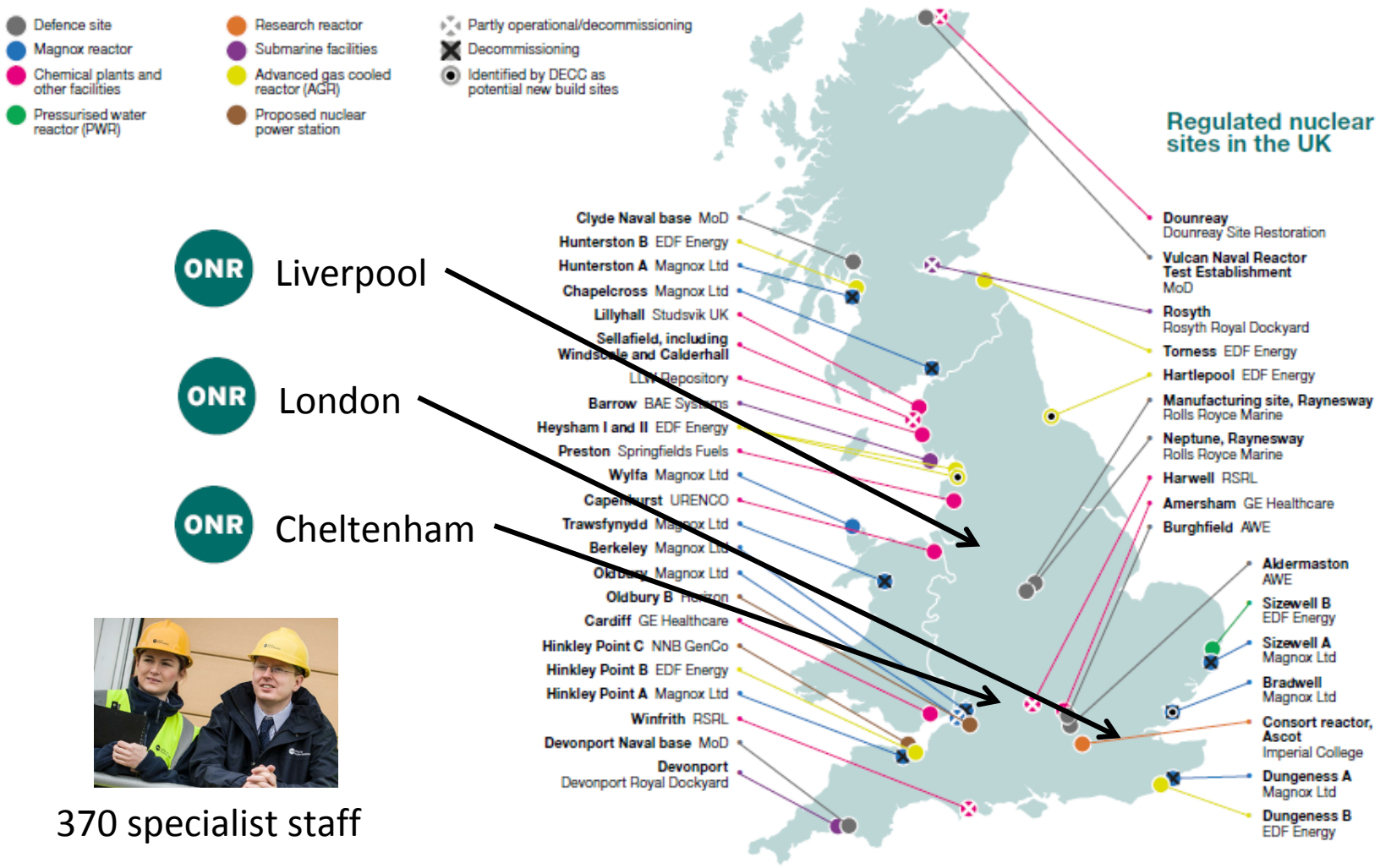
Luke Carter

Office for Nuclear Regulation

Contents

- NDT in the context of the nuclear safety case
- The basics of highest reliability NDT
- Why design for inspectability is so important
- Some examples of lessons learned

Office for Nuclear Regulation



ONR Liverpool

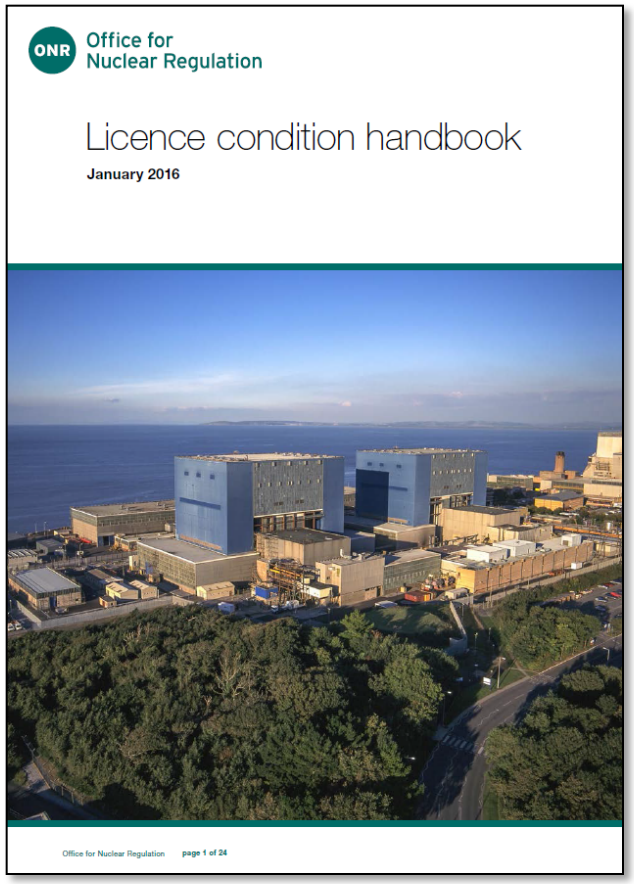
ONR London

ONR Cheltenham

370 specialist staff

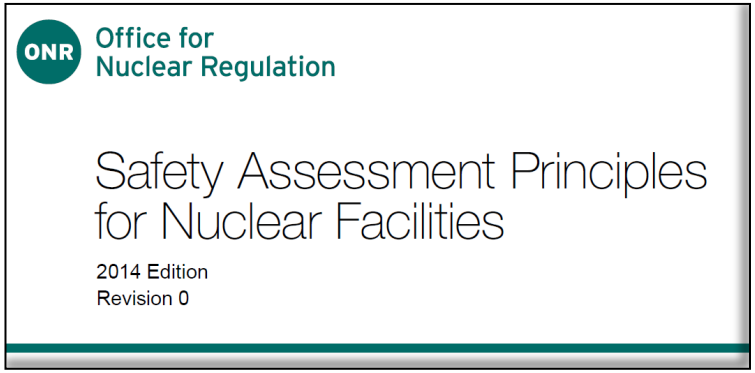
How ONR Regulates

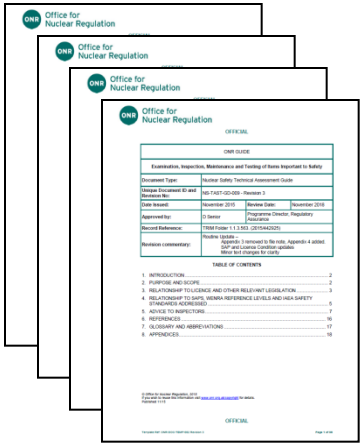
COMPLIANCE



36 Standard Licence Conditions

ASSESSMENT



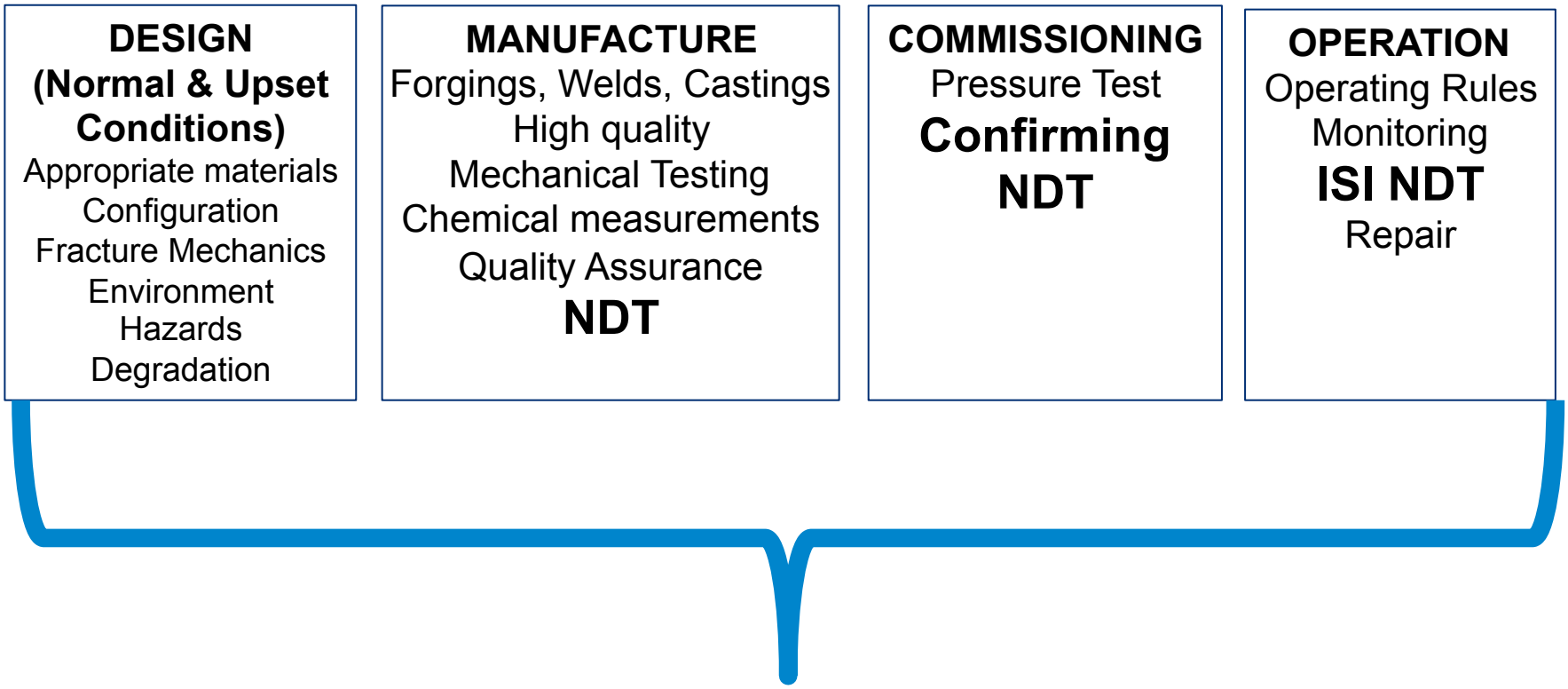


Technical Assessment Guides

RELEVANT GOOD PRACTICE

Office for Nuclear Regulation

Structural Integrity Safety Case



CONFIRM SAFETY FUNCTION OF THE COMPONENT CAN BE DELIVERED

Office for Nuclear Regulation

NDT reliability issues

Important nuclear safety decisions are made on the basis of NDT results:

- Repair/replacement of components (can be harmful to the plant)
- Plant shutdown, extended outages
- Early closure of reactors

Continuity of results
What is better NDT?
Fit for purpose

Good margins are important:

- Detection (signal to noise ratio, clear signals)
- Characterisation
- Accept/reject criteria
- **Recognises uncertainties**

Conservative approach:

- Selection of NDT methods
- Mature methods/techniques
- Physical principles understood
- Engineering solution rather than NDT

Office for Nuclear Regulation

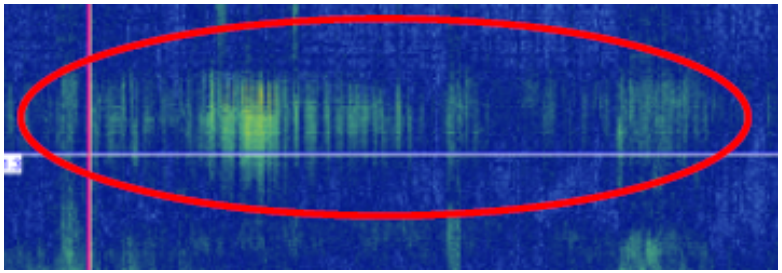
NDT reliability issues

Optimise conditions for NDT ✓

Develop clever techniques to overcome poor conditions ✗

Engineering principles: integrity of metal components and structures: design	Providing for examination	EMC.8
Geometry and access arrangements should have regard to the need for examination.		

Engineering principles: integrity of metal components and structures: manufacture and installation	Materials	EMC.13
Materials employed in manufacture and installation should be shown to be suitable for the purpose of enabling an adequate design to be manufactured, operated, examined and maintained throughout the life of the facility.		

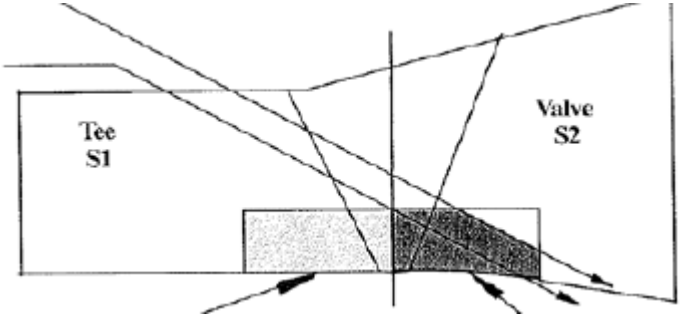


Apply ALARP

Office for Nuclear Regulation

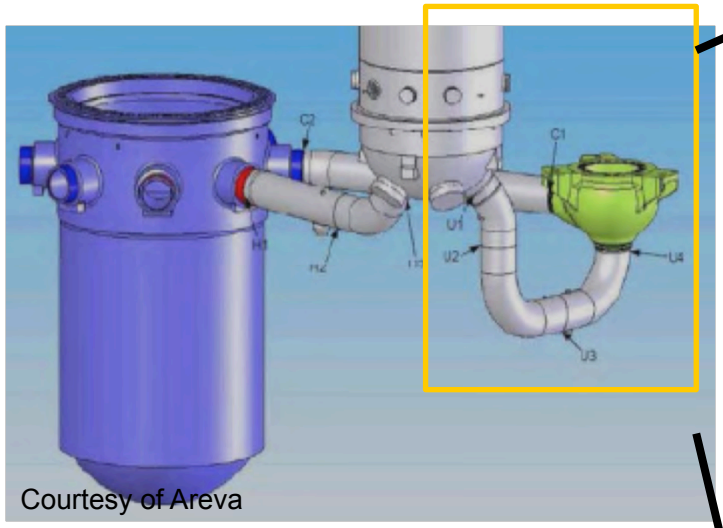
Design for inspectability

- UK gas-cooled reactors not, in general, designed with inspection in mind
  - Novel techniques often applied
  - Complex deployment techniques
- Components designed to ASME III often cannot meet the ASME XI NDE requirements
  - Component geometry
  - Physical access
  - Materials (cast stainless steel)
- ASME Code Case N-711-1
  - Revision of inspection volume to consider degradation effects.

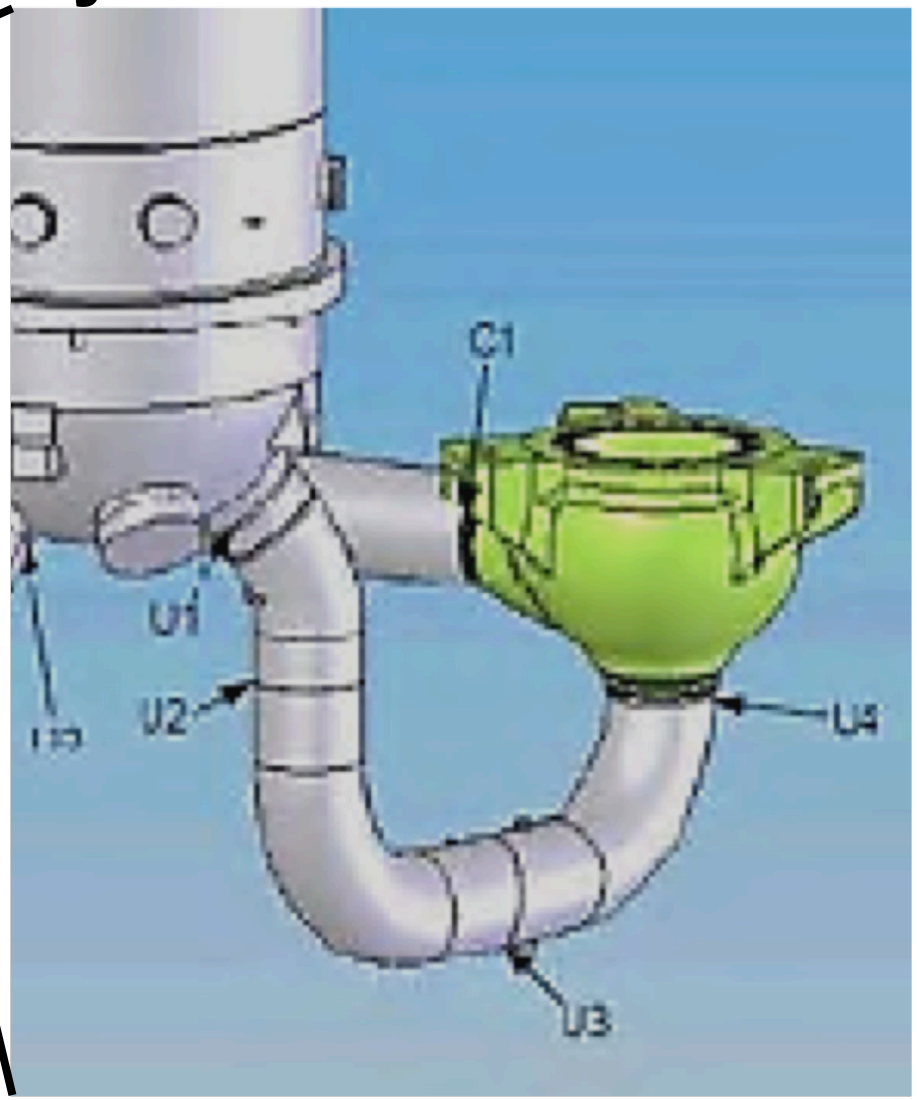


Office for Nuclear Regulation

Design for inspectability



Courtesy of Areva



Initial design not optimised for ultrasonic Inspection.
Design modified to provide a 250mm straight section on the ends of the bends.

UK EPR Main Coolant Lines

Office for Nuclear Regulation

Highest reliability components

- Safety case claims for components and structures the likelihood of gross failure is so low it may be discounted, but if failure did occur the consequences would be extreme
- Additional measures (beyond codes and standards) required to assure the integrity (including NDT)

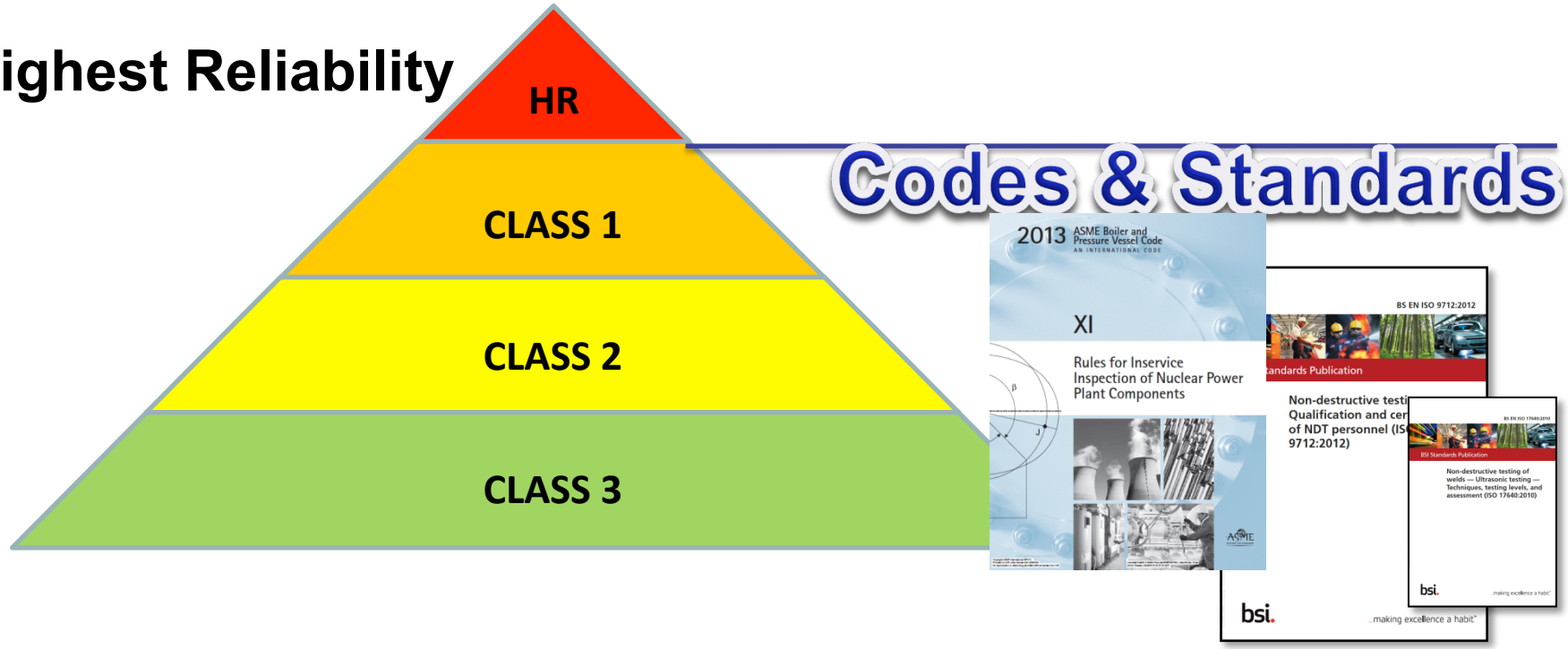
Engineering principles: integrity of metal components and structures: highest reliability components and structures	Safety case and assessment	EMC.1
The safety case should be especially robust and the corresponding assessment suitably demanding, in order that a properly informed engineering judgement can be made that: (a) the metal component or structure is as defect-free as possible; and (b) the metal component or structure is tolerant of defects.		

as defect-free as possible

Office for Nuclear Regulation

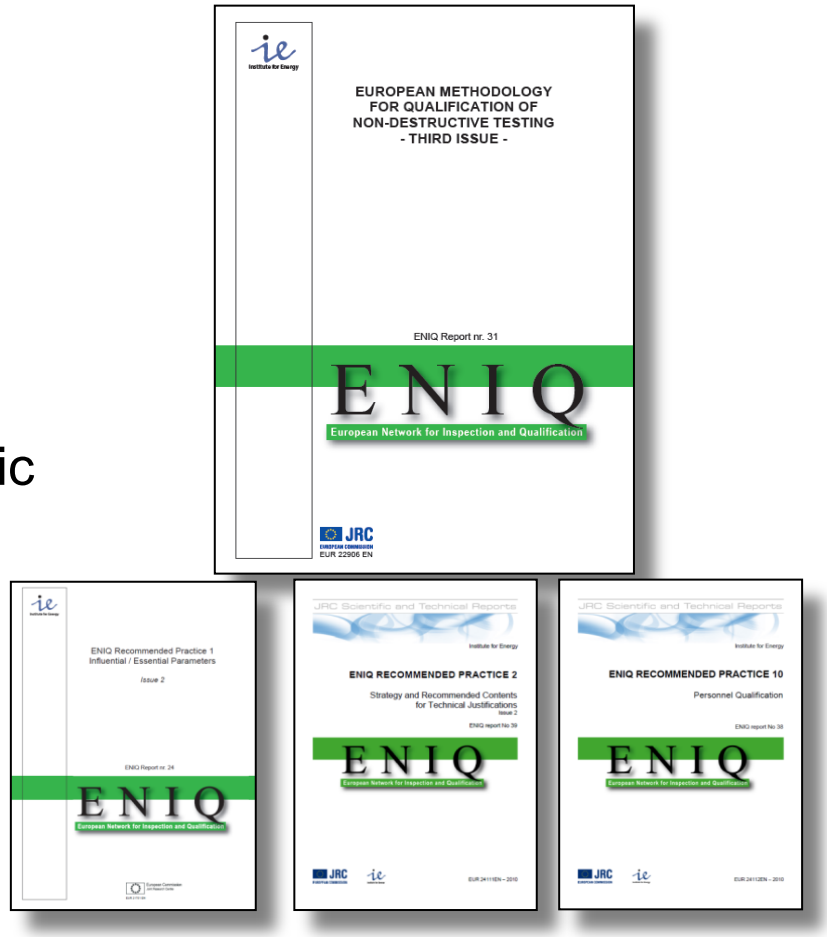
- Objective based manufacturing NDT to meet specific safety case needs
- Design considerations for NDT: ‘Design for inspectability’
- Qualified NDT performed in manufacture.
- Repeat NDT
- Enhanced quality assurance/control

Highest Reliability



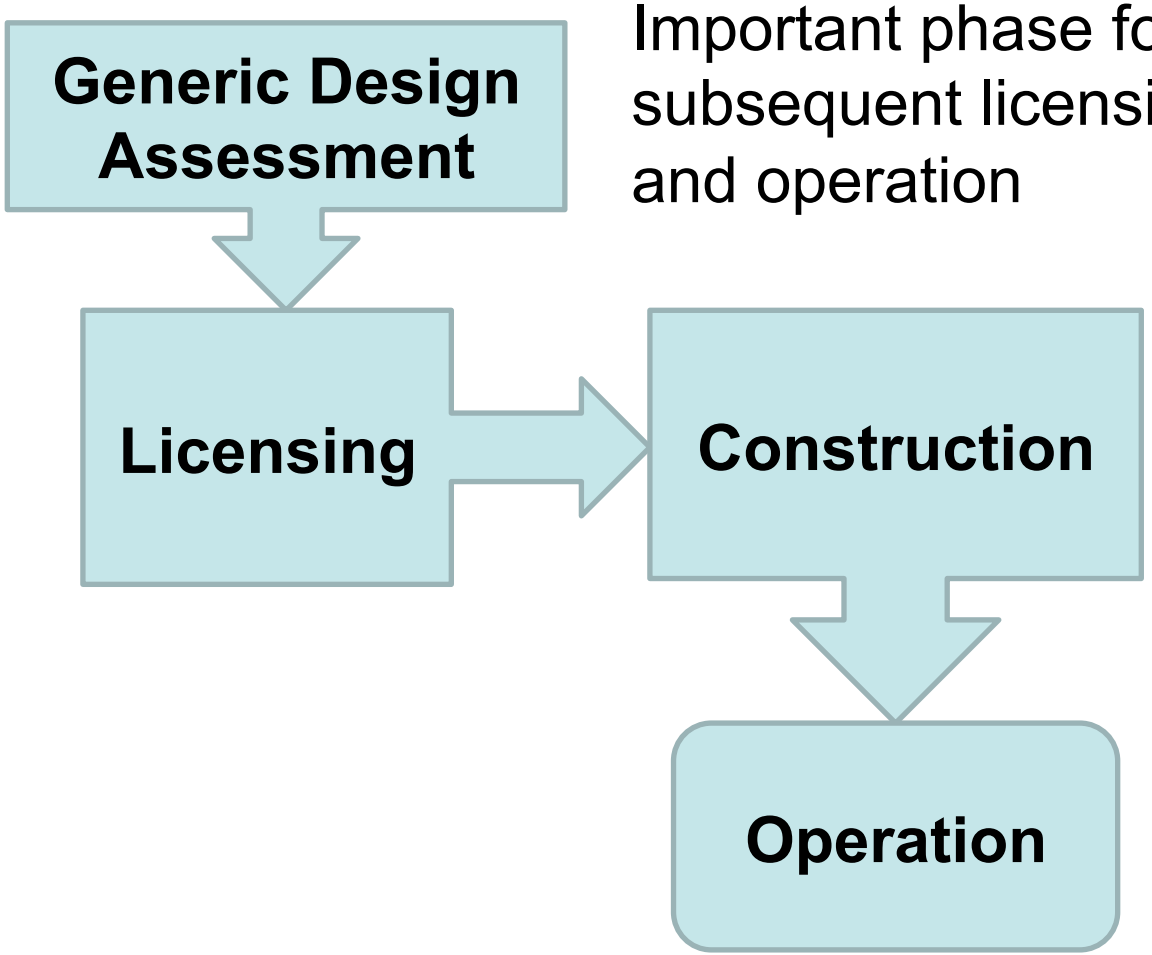
High Reliability NDT: Inspection Qualification

- The elements of the inspection qualification process that ONR is seeking are:
  - Objective Based
  - Procedure qualified using technical justification and practical trials
  - Personnel qualified against a specific NDT procedure using blind trials
- These elements are found in the ENIQ Methodology
- Founded on the Sizewell B 'Validation' approach



Office for Nuclear Regulation

New UK nuclear build



Important phase for de-risking subsequent licensing, construction and operation

Office for Nuclear Regulation

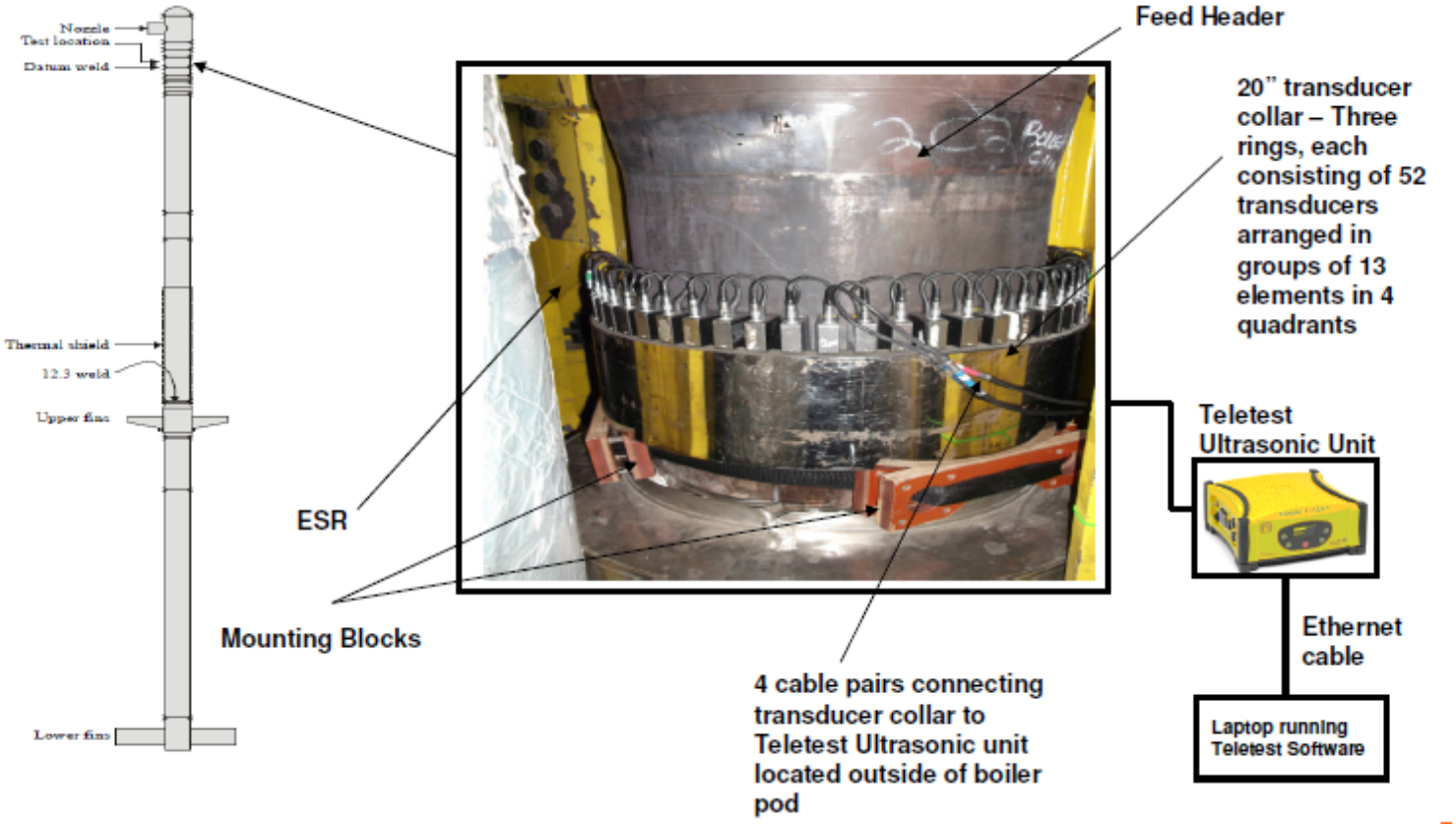
Doel 3/Tihange 2 Hydrogen Flakes

- Around 10,000 defects identified in the RPV forgings in 2012, understood to be present at manufacture.
- Significant NDT failure applying ASME based procedures – difficult to establish the root cause.
- The Sizewell B RPV forgings were subject to several qualified mechanised inspections.
- EDF were able to provide good evidence that hydrogen flakes were not present in Sizewell B RPV

Courtesy of EDF

Office for Nuclear Regulation

Boiler spines



Office for Nuclear Regulation

Corrosion under insulation

- The issue isn't specifically related to NDT (but NDT plays an important part!) but it is a very relevant lesson
- Management and risk assessment of all supporting equipment is key to operations
- Careful design and operation of plant is key and is bolstered by good design of inspections at a suitable frequency.
- Requirement to continuously review the situation (corrosion doesn’t go away)

Office for Nuclear Regulation

Conclusions

- There is a golden opportunity for every nuclear operator at the design stage to ensure the design will cater for appropriate fit for purpose NDT and high reliability where required.
- It is possible in most instances to use a combination of engineering and NDT methods to back-fit inspection techniques to otherwise un-inspected components **but** this is often extremely costly and time consuming and often sparks significant interest by ONR.
- Expect the unexpected – a common re-occurring lesson for everyone. As a nuclear regulator, we still see cases of unexpected degradation – hence why a conservative approach based on sensible classification of components is what we always expect as an approach.

Office for Nuclear Regulation

Thank you