Office for Nuclear Regulation

Materials testing, welding & manufacturing control

Martin LAMB

Beyond code safety requirements for nuclear pressure systems

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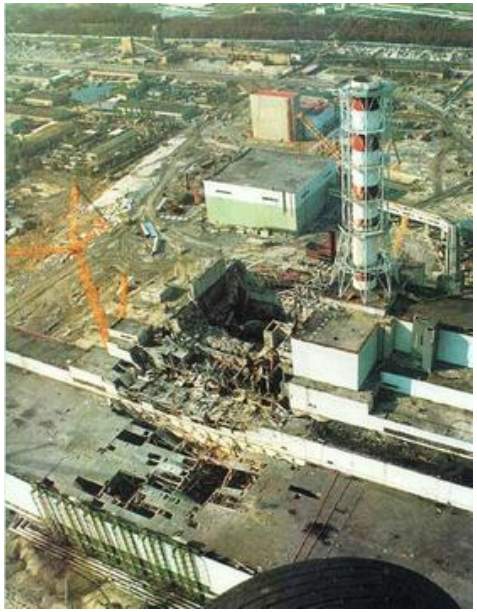
Scope

- Materials testing, welding & manufacturing control
  - When beyond code expectations apply
  - SAPs
  - TAG 16
  - Safety case

When beyond code expectations apply

Beyond code expectations apply

- When the consequences of failure are intolerable and a licensee claims that the likelihood of gross failure is so low that it may be discounted



Chernobyl after the disaster — source

SAPs

SAPs

- For highest reliability SSCs
  - EMC.1 Safety case and assessment
  - EMC.2 Use of scientific and technical issues
  - EMC.3 Evidence

EMC.1 & EMC.2

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 judgment 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.		

292. In the first instance the safety case development process should identify situations that fall under Principle EMC.1. For non-redundant items (e.g. a pressure boundary), the emphasis will be on avoiding defects; for redundant items (e.g. some support structures) the emphasis might lie more in the redundancy argument than in the avoidance of defects.

Engineering principles: Integrity of metal components and structures: Highest reliability components and structures	Use of scientific and technical issues	EMC.2
The safety case and its assessment should include a comprehensive examination of relevant scientific and technical issues, taking account of precedent when available.		

293. Wherever possible, safety cases should not rely on claims of extremely high structural integrity.

294. A minor failure in a component or structure that performs a principal role in ensuring nuclear safety should not lead to significant radiological consequences.

EMC.3 as related to materials

Engineering principles: Integrity of metal components and structures: Highest reliability components and structures	Evidence	EMC.3
Evidence should be provided to demonstrate that the necessary level of integrity has been achieved for the most demanding situations [identified in the safety case].		

295. To meet Principles EMC.1 and EMC.2, the safety case should include appropriate evidence of the following:

(a) & (b) *Not materials-related*
(c) **Consideration of potential in-service degradation mechanisms**
(d) *Not materials-related*
(e) **Use of proven materials**
(f) **Confirmatory testing to demonstrate that the parent materials and welds have the appropriate material properties, especially strength and the necessary resistance to fracture**
(g) **Application of high standards of manufacture**, including manufacturing inspection and examination
(h) **High standards of quality management throughout all stages of design, procurement, manufacture**, installation and operation (see also paragraph 207 on excluding foreign material)
(i) to (k) *Not materials-related*
(l) **In-service materials monitoring schemes**
(m) **A process for review of facility operation to ensure the facility is operated and materials performance is within the assumptions of the safety case**
(n) *Not materials-related*
(o) A process for review of experience from other facilities, developments in design and analysis methodologies and the **understanding of degradation mechanisms** for applicability to the component or structure in question
(p) *Not materials-related*

296. The strength and extent of the evidence provided here should be commensurate with its importance to the overall safety case.

SAPs — Key expectations — 1

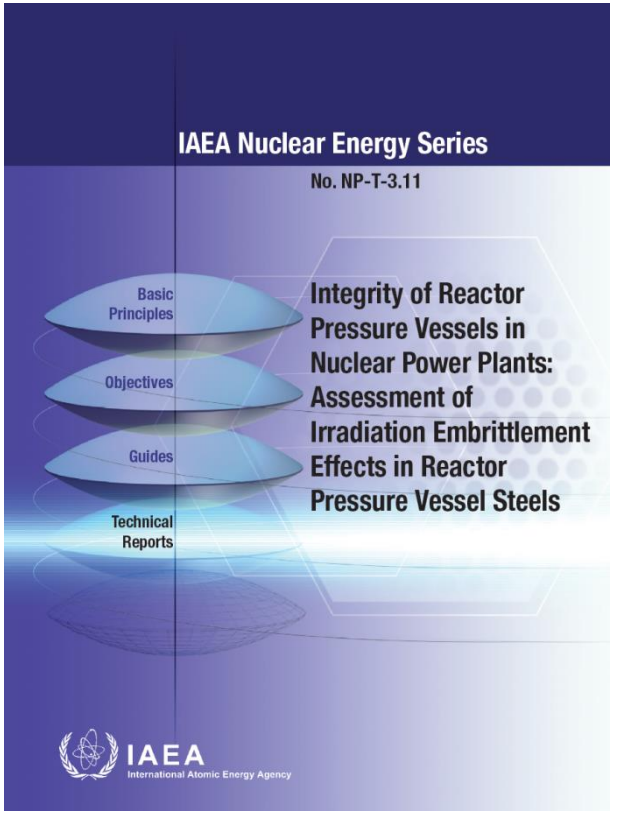
- Design
  - Use of proven materials
  - Consideration of in-service degradation mechanisms
- Manufacture
  - High standards of manufacture and quality management through design, procurement and manufacture and installation

SAPs — Key expectations — 2

- Testing
  - To underpin the properties, especially strength and fracture toughness, of parent steels and welds
- Review
  - Of materials performance for alignment with the safety case
  - To understand degradation mechanisms

SAPs — Key expectations — 3

- Surveillance
  - In-service materials monitoring schemes
    - Fracture toughness test specimens



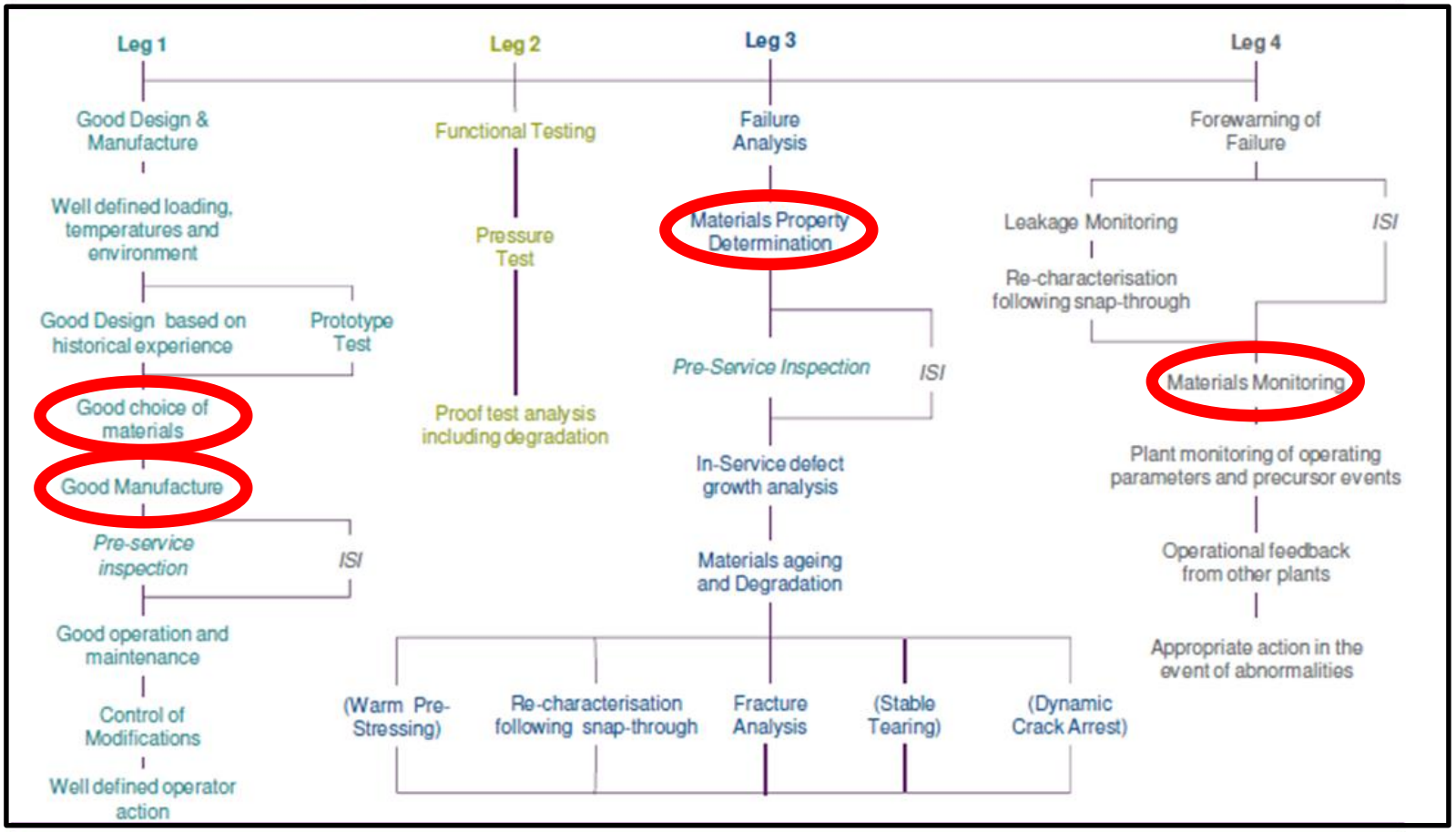
TAG 16

Integrity of metal SSCs — 'TAG 16'

- Integrity of metal SSCs NS-TAST-GD-016
  - Whether ONR expectations for the highest reliability SSCs apply
    - Advice for highest reliability SSCs
  - Relevant case studies
    - Sizewell A boiler shells
    - Flamanville 3 RPV domes

Safety case

TAGSI safety case approach - P140, 1997



Leg 1 — Good design & manufacture

- Good choice of materials
  - EMC.3 Evidence (f) Materials & EMC.13 Confirmatory testing
    - Materials should be shown to be suitable for the purpose of enabling an adequate design to be manufactured, operated and maintained through life

Leg 1 — Good design & manufacture

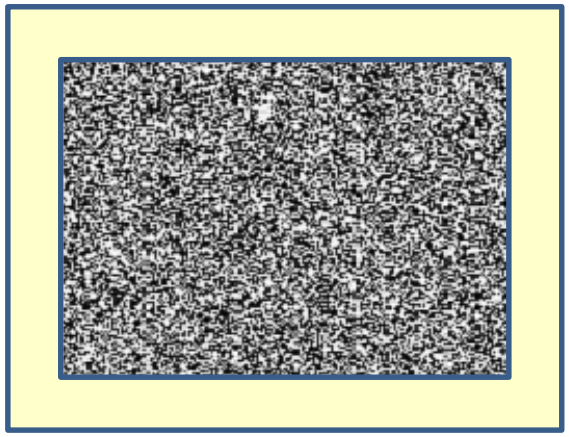
- Good manufacture
  - EMC.3 Evidence (g) Application of high standards of manufacture & EMC.14 Techniques & procedures
    - Techniques & procedures should be proven and approved to minimize the occurrence of defects

Leg 3 — Failure analysis

- Materials properties determination
  - EMC.3 Evidence (f) Confirmatory testing
    - To demonstrate that the parent materials and welds have the appropriate material properties, especially strength and the necessary resistance to fracture
      - Allowance for variations in material properties

Leg 4 — Forewarning of failure

- Material monitoring
  - EMC.3 (o) Review of degradation mechanisms *inter alia* & EAD.3 Ageing -Periodic measurement of material properties
    - Where material properties could change with time and affect safety, provision should be made for their periodic measurement
      - Surveillance schemes
        - Fast & thermal neutrons
      - Thermal ageing
        - Several mechanisms



Thank you