



# **Qualification by Testing of Pressure Tubes - Summary -**

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# Outline

- **Qualification of production**
- **Qualification of properties**
- **Quality**



# Qualification of Production

- **Definition of requirements**
- **Assessment of changes to production route necessary to achieve requirements**
- **Discussion with manufacturers**
- **Production of developmental or prototype tubes**
- **Assessment of production**
- **Definition of production qualification**
- **Production of qualification tubes**
- **Assessments against requirements**
- **Documentation**
- **Full scale production**



# Qualification of Properties

- **Properties of as-manufactured tubes**
  - **Chemical composition**
  - **Strength and ductility testing**
    - **Axial and transverse tensile properties**
  - **Fracture toughness testing**
    - **Initiation toughness and  $dJ/da$  measurements**
  - **Delayed hydride cracking response**
    - **$K_{1H}$  and DHC velocity**
  - **Microstructure**
    - **Grain structure, crystallographic texture, dislocation density, beta phase Nb concentration**



# Qualification of Properties

- **Properties after irradiation**
  - Strength and ductility
  - Toughness
  - DHC
- **Builds upon past experience**
  - Irradiation to end-of-life neutron fluence levels not required



# Irradiation Response

- **Periodically monitor changes during irradiation program**
  - Corrosion and hydrogen ingress tests
  - Irradiation creep and growth tests
- **Compare results with expected behavior**



# Quality Program

- **Documentation at all stages of program**
  - **Design of program including all verification requirements with reference to quality standards for design qualification, e.g.**
    - **Component Verification Specifications**
    - **Inspection and Test Plans**
      - All procedures identified
    - **Test Reports**
    - **Analysis / Assessment reports**
    - **Design reviews at various stages**
    - **Other steps as appropriate**



# ACR Pressure Tube Qualification Program

- **Builds upon past experience in industry**
- **Designed to provide supporting data to meet implementation requirements**
  - **As-manufactured**
  - **After irradiation**
- **Good quality process**



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