In-Service Inspection and Surveillance

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Outline

- Focus on reactor coolant pressure boundary
- Range of application of ASME Section XI requirements
- Components requiring alternative approach
- Fuel Channel Inspections
- Compliance with applicable GDCs

Application of ASME Section XI

- All Class 1 boundary components outside reactor core and feeder pipes covered by Section XI
  - Scope per Section XI IWB-1000
  - Intervals per IWB-2000

Application of ASME Section XI

- Two areas where risk informed approach to Section XI is used
  - Reactor Coolant System Feeder Pipes
  - Fuel Channels

- Both cases take into account the CANDU specific materials and design

Feeder Pipes

- Design
  - 568 feeder tubes, 2.5”-3.5” diameters, a number of welded joints on each
  - Physical clearance for inspection meets 10CFR50.55a(g)(3)
- Preservice inspections will be in accordance with conventional ASME Section XI
- Section XI ISI would be per IWB-2411

Proposed ISI of Feeder Tubes

- AECL proposes an alternative approach using a risk-informed inspection program similar to code case N-577-1
- The examination program and supporting data will be included in the application for ACR-700 design certification

Fuel Channel ISI

- Fuel channels are designed to rules of NB-3000
  - Coolant pressure boundary includes only Zr-2.5%Nb pressure tube, 403 SS end fitting and closure plug
- No provision in ASME Section XI for fuel channel ISI
- Established program in use on CANDU
- The inspection program for ACR fuel channels will be included in the application for design certification

Proposed ISI Program for Fuel Channels

- Alternate approach to IWB 2400 that is intended to satisfy 10CFR50.55a(g)(4)
  - Risk informed program based on prior operating experience in CANDU reactors
  - Reflected in CAN/CSA N285.4 Standard
    - 4th Edition in final editing

Proposed ISI Program for Fuel Channels

- Program both addresses individual reactor fitness for service and overall surveillance of reactor fleet
- Sample of pressure tubes inspected on a periodic basis
- Inspection regimen will include tests and measurements that are beyond what would be the minimum requirements under ASME Section III piping

Pressure Tube Inspection Requirements

- Volumetric inspection of entire pressure tube
  - Includes rolled joint region
- Pressure tube diameter
- Pressure tube wall thickness
- Garter spring location

Pressure Tube Inspection Requirements

- Channel vertical deflection (sag)
- Pressure tube / calandria tube gap
- Channel position on bearings
- Hydrogen isotope concentration
  - By sampling or NDE measurement
- Fracture toughness and DHC velocity
  - Requires pressure tube removal for surveillance destructive examination

Basis for Inspection

- Channel components manufactured to high standards
  - Pressure tubes all subject to stringent manufacturing inspection
    - Tubular geometry ensures good inspection
    - Each a single piece of material with no welds
  - End fittings are all single forgings of 403 SS
    - No known degradation mechanisms in coolant environment
      - Not subject to erosion / corrosion or SCC
  - Channel closures
    - No welds in pressure boundary
    - No identified degradation mechanisms

Basis for Inspection

- Inspection is directed at detecting generic degradation
  - Degradation that would occur in a large fraction of tubes
- Provides assurance that pressure tubes are operating as-designed
- Any unexpected degradation would require increasing inspection scope

Basis for Inspection

- Rolled joints are mechanical seals
  - Dimensionally checked and leak tested following assembly
  - Degradation would lead to leakage that would be detectable by the annulus gas leak detection system
  - Performance of rolled joints in CANDU plants to date has been outstanding

Surveillance Requirements

- Measure fracture toughness and DHC velocity in removed pressure tube
  - Applied to lead unit
- Lead unit concept is primarily based upon irradiation effects on the pressure tube material
  - Irradiation conditions would be very similar in every unit
  - Expect that ACR pressure tube material manufactured to the same specification by the same manufacturers would respond to irradiation in a similar way
  - Hydrogen ingress into pressure tubes (that depends somewhat on coolant chemistry conditions) is subject to inspection program for every unit

Inspection Qualification

- AFCIS example
  - Performance requirements defined with input from standards, internal and customer requirements
  - 35 requirements defined
  - Test program witnessed by customers and regulators

Inspection Qualification

- Gap Measurement
  - Requirement to measure pressure tube to calandria tube gap within +/- 1 mm of a known value
  - Demonstrated in full-scale fuel channel mock-up in which gap could be varied over the total possible range
  - AFCIS measurements compared with independently measured gap
    - Shown to be within +/- 0.4 mm

Acceptance Criteria

- Gap measurement
  - CAN/CSA N285.4 Clause 12.7.2.3 requires no contact within next operating interval
  - Demonstrated uncertainty of gap measurement would be factored into calculation of gap at the end of the next operating interval
  - In any case in which gap closure was predicted, additional measures would be required to demonstrate acceptability, e.g.
    - Shorter interval
    - Further inspection
    - Remedial measures

Summary

- RCS components will follow inspection rules of ASME Section III and Section XI in accordance with 10CFR50.55a
- For components with CANDU specific design or materials (fuel channels and feeder pipes), inspection requirements will be established which address 10CFR50.55a(g) and risk informed practice will be proposed
- GDC 14 inspection objective - "*so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture*" - will be met by the ACR inspection programs


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