Overview of Improvements in Work Practices and Instrumentation for CANDU Primary Heat Transport Feeders In-Service Inspections

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Agenda

• Introduction
• Thinning – Feeder Bends
• Thinning – Grayloc Weld Area
• Cracking – Feeder Bends
• Cracking – Feeder Welds
• Conclusions
Introduction

• In-service degradation mechanisms in CANDU feeder piping system
  – Wall thinning
    • Flow accelerated corrosion
  – Cracking
    • Intergranular stress corrosion cracking
    • Low temperature creep cracking
CANDU Reactor face
Feeder Configuration
Feeder Configuration
Inspection Tooling Requirements

- Thinning at tight radius bends
- Thinning at Grayloc weld area
- Cracking at tight radius bends
- Cracking at Grayloc weld area

OBJECTIVES

- Meet the inspection specifications
- Inspection tool reliability
- Minimize radiation exposure
- Efficiency
THINNING – FEEDER BENDS
Thinning – Feeder Bends

• Initial Developments
  – Thickness gauge with templates
    • Slow process
    • Limited scope
  – Ontario Hydro’s four probe assembly
    • Efficient for easy access feeders
    • Encoded axially – hand operated
    • Limited coverage
Thinning – Feeder Bends

• METAR Bracelet
  – Developed by IREQ, contracted by Hydro-Quebec
    • Encoded axially – hand operated
    • Assembly of fourteen (14) 10MHz probes
    • Covers approx. 120° circumferentially
    • 0.03mm thickness measurement resolution
    • Accuracy to 1 micron with signal processing
METAR Bracelet System Components
Thinning – Feeder Bends

- METAR Bracelet
  - Limitations
    - Manually driven
    - Operator dependant
    - Inconsistent signals in relation to tooling adjustments
    - Equipment failures
Thinning – Feeder Bends

• Future Developments
  – Main Objectives
    • Automated tool
    • 360° coverage
    • Improved Repeatability
    • Improved data quality
    • Meet inspection specifications
New Bend Thinning Tool Prototype
THINNING – GRAYLOC WELD AREA
Thinning – Grayloc Weld

• SixPack Bracelet
  – Developed by OPG
    • Assembly of six (6) small transducers in a water wedge housing
    • Circumferentially encoded – hand operated
  – Limitations
    • Data collection difficult and poor repeatability
    • Highly operator dependent
SixPack Bracelet
Thinning – Grayloc Weld

• GAIT
  – Development by Kinectrics, funded by COG
    • Assembly of eight (8) small transducers in a water wedge housing
    • Circumferentially encoded – hand operated
    • Better coverage in intrados region
    • Improved repeatability
Thinning – Grayloc Weld

- GAIT
  - Limitations
    - Scanner assembly can be wobbly
    - Limited adjustment with respect to distance from the weld
    - Poor signal to noise ratio
Thinning – Grayloc Weld

• GRAVIS
  – Development funded by COG for weld cracking
    • Similar probe assembly as GAIT
    • Modular design
    • Circumferentially encoded, axial adjustments – automated
    • Highly effective (approx. 30 seconds per scan)
    • Much better worker safety, data quality and repeatability
GRAVIS Configured for Thickness Measurements
Thinning – Grayloc Weld

• GRAVIS
  – Limitations
    • Poor signal to noise ratio
    • Applicable only on Grayloc welds
Thinning – Grayloc Weld

- Future Developments
  - Main Objectives
    - Inspection over the weld cap
  - Two approaches:
    - Adaptive focal laws
    - Full matrix capture
Adaptive Focal Laws – Inspection over weld cap
CRACKING – FEEDER BENDS
Cracking – Feeder Bends

• Manual Inspection
  – Full circumference covered with 6 scans/passes
    • Qualified by CIQB in March 2010
  – Limitations
    • Manual operation – High dose intake
    • No recorded data
    • Limited reliability for second bends
Cracking – Feeder Bends

• Bend Cracking Crawler
  – Developed by Hydro Québec
    • Axially and circumferentially encoder – automated
    • Highly repeatable
    • Highly efficient (approx. 60 sites per day at G-2)
    • Qualified by CIQB in 2010
Cracking – Feeder Bends

- Bend Cracking Crawler – Eddy Currents
  - Developed by Hydro Québec
  - Used to confirm OD flaws
  - Same principles as UT Bend Cracking Crawler
Eddy Current BCC
CRACKING – FEEDER WELDS
Cracking – Feeder Welds

• Manual Inspection
  – Phased Array
    • PA required to inspect full volume
    • Circumferentially encoded – hand operated
    • Aligned jig for axial positioning
  – Limitations
    • Manual operation – High dose intake
    • Poor data quality, operator dependant
Manual Phased Array Weld Inspection
Cracking – Feeder Welds

• GRAVIS
  – Project funded by COG
    • Circumferentially encoded, axial index – automated
    • Highly efficient (approx. 1 or 2 minutes per scan)
    • Highly repeatable
GRAVIS Configured for Weld Cracking Inspection
Conclusions

- The use of automated tool as proven to be very efficient in-situ
- Extensive training critical for successful campaigns
- Cracking inspection now mature
- Future developments in bend and weld thinning can benefit from cracking development OPEX