Outline

• Background

• Risk-Informed In-Service Inspection (RI-ISI) Programs

• Inspection Requirements for CANDU

• CNSC RI-ISI Guideline

• RI-ISI Pilot Study
Background

- Traditional in-service inspection programs are based on deterministic rules
- Inspection programs are based on defense-in-depth concept to prevent accidents by detecting degradation
- Deterministic inspection programs are mostly based on ASME BPVC XI
- Augmented inspection programs have been developed for specific degradation mechanisms such as erosion, corrosion, and inter-granular stress corrosion
Background (continued)

- Initiation of risk-based approach and incentives to reduce dose exposures and costs is moving the industry toward risk-informed inspections
- There have been widespread adaptations of RI-ISI concept by the operators and regulatory bodies globally
- The CNSC is interested in seeing development of risk-informed methodology to provide a consistent framework covering CSA N285.4 inspection programs as well as in-service inspection programs
RI-ISI Programs

- RI-ISI methodologies have been developed in several countries, however Electric Power Research Institute (EPRI), Westinghouse Owners Group (WOG), and ASME methodologies are widely applied methods.

- Based on risk insights, operating experience, and engineering judgment.

- Involves establishing scope, carrying out engineering analyses, identifying execution and monitoring program, and providing feedback mechanism.
RI-ISI Programs (continued)

- Despite different approaches to RI-ISI, they are based on common principles:
  - Assessment of potential of failure
  - Assessment of consequence of failure
  - Risk Ranking
  - Selection of inspection locations
Potential of Failure

• Assessment of potential of failure is either qualitative or quantitative:
  • Qualitative: degradation mechanism evaluation, operational characteristics, dynamic loads and flaw distribution
  • Quantitative: structural reliability models
Consequence of Failure

- Consequence of failure is based on Core Damage Frequency (CDF) and Large Early Release Frequency (LERF)

- Evaluates impacts of events originating from pressure boundary failure on overall plant risk

- Impact is either direct, indirect or combination

- Evaluation done using Probabilistic Safety Assessment (PSA)
Risk Ranking

- Performed using risk of pipe segment failure evaluated on the basis of expected failure potential and consequence

- Potential of Failure level can be High, Medium, or Low

- Consequence of Failure level can be High, Medium, Low or None
• Final ranking of piping segments may be conducted by expert panel
Inspection Location Selection

• Percentage of elements selected for inspection depends on the risk category

• Focus is on higher risk areas (e.g. 25% for categories 1,2,3, 10% for categories 4,5)

• Selection is based on but not limited to, plant history, past inspection results, active degradation mechanism, accessibility, radiation exposure, and inspection distribution among systems and components
Inspection Location Selection

- Elements not inspected under existing programs could be included in scope

- May result in scope with same risk but different level of radiation exposure

- In absence of degradation mechanisms, may focus on high stress and/or high fatigue locations
Change-in-Risk Evaluation

- Performed prior to implementation of program

- Identifies whether changes from existing ISI program to a RI-ISI program are in compliance with acceptance criteria by the regulator as determined by CDF and/or LERF

- Supplementary locations added if original selection produces non-compliant impacts on risk
Implementation

• Significant reduction in inspection scope achieved by implementing RI-ISI approach on ASME XI programs

• Risk levels did not change or increased within allowable limits

• Inspection focused on higher risk areas
Inspection Requirements for CANDU

• Canadian utilities follow CSA N285.4 and CSA N285.5

• In CSA N285.4, inspection requirements (categories) are determined based on failure size, fatigue usage factor, and stress intensity

• CSA N285.4 provides an implicit risk-related rationale for reducing the inspection scope based both on low likelihood of failure and low consequence
Inspection Requirements for CANDU (continued)

- Inspection scope minimized by reducing inspection on areas with low failure potential and consequence

- Identical pipe runs are grouped as “family”

- Reduction factors are applied on number of identical pipe runs in each family
Inspection Requirements for CANDU (continued)

• Single weld with highest fatigue usage factor and stress intensity is selected from each pipe run

• The above sampling is different from RI-ISI methodologies where a percentage of welds in each category is selected

• No requirement to use PSA analysis to justify assumptions
CNSC RI-ISI Guideline

• CNSC prepared “Guidelines for Risk-Informed In-Service Inspection for Piping”

• Provides instructions and acceptance criteria for licensees to develop a RI-ISI program

• Provides high level expectations for integrating risk insights and traditional analysis to establish alternate piping inspection programs

• Enhances regulatory stability in the review, approval, and implementation of licensees RI-ISI programs
CNSC RI-ISI Guideline (continued)

- Not intended to preclude use of other validated methodologies for the incorporation of risk insights, plant experience and knowledge of RI-ISI program

- Licensees can suggest use of other methods with exception that acceptable levels of quality and safety are maintained

- Does not establish specific licensing requirements and its use by licensees is voluntary
• Full scope and partial scope applications are both acceptable for RI-ISI programs for piping

• Partial scope applies when an alternative program is already in place (e.g. CSA N285.4 program)

• Piping exempt from CSA N285.4 may not be exempt from RI-ISI
In response to CNSC RI-ISI Guideline, utilities have established a piping RI-ISI Working Group (WG) in COG.

COG WG includes Bruce Power, NB Power, Hydro Quebec, OPG, and AECL.

Objectives of WG are to:

- Establish common Canadian utility position to apply RI-ISI to CANDU
- Develop common approach for CANDU to meet ongoing challenges that would facilitate introduction of risk-based solutions in a manner compatible with CSA N285.4
- Provide forum for discussion of common RI-ISI issues, sharing of knowledge, experience, and lessons learned among members
A pilot study is being performed to:

- Develop a CANDU best fitted methodology as expected by CNSC
- Evaluate risk levels between current inspection and RI-ISI programs

Darlington Unit 2 selected

Scope includes:

- Main and Auxiliary PHT, SDC, and ECI systems
- Two non-nuclear safety related systems (Boiler Feed, Main Steam - Boiler Feed currently inspected under FAC/MIC program)

EPRI/Structural Integrity Associates Inc. (SI) selected through bidding process
RI-ISI Pilot Study (continued)

• As part of this project, the following could also be explored:
  • Reduction in risk levels within the current scope by relocating inspection locations
  • Significant reduction in risk levels by adding small number of inspection points

• The RI-ISI application is in CSA N285B Technical Committee agenda (future) and COG project could be used as seed document to develop a new RI-ISI CSA standard