Chockie Group International, Inc.

INSERVICE
ENGINEERING

Comparative Review of Risk-Informed Inservice Inspection Methodologies

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Presentation Topics

- Historical perspective
  - Development of ISI Rules
  - Development of RI-ISI Programs
- The Risk-Informed ISI Methodologies
  - WOG Methodology
  - EPRI Methodology
  - Code Case N-716
- Comparative Review of the Methodologies

Initial ISI Guidance

- Early 60's – ISI guidelines based on fossil plant experience
- Little consistency in original ISI programs
- Late 60's – AEC ISI study recommended
  - Inspection of important systems and components
  - 10 years to complete all inspections
  - Random-failure philosophy
  - Preservice exams
  - No guidance on what to do when indications were found

Operational Experience

- Operational experience showed service-induced failures were not due to
  - random causes
  - at random times
  - at random locations
- Failures were from high stresses, fatigue, incorrect materials, and operational errors
- Many could have been predicted with proper analysis or material selection criteria

Revised ASME Code

- 1973 Section XI Code was revised to
  - Target high stress areas
  - Address high cumulative usage factors (fatigue)
  - Incorporate requirements for
    - UT criteria
    - flaw acceptance standards
    - fracture mechanics analysis
    - repair and replacement
    - Class 2 & 3 systems

The Current ISI Requirements

- 1978 – Current ISI requirements established
  - 100% of B-F Class 1 welds
  - 25% of B-J Class 1 welds
  - 7 ½% of Class 2 welds
- Augmented Inspection Programs developed over time to address specific degradation issues
  - Intergranular Stress Corrosion Cracking (IGSCC)
  - Flow Accelerated Corrosion (FAC)
  - Microbiologically Induced Corrosion (MIC)

Lack of Effectiveness of ISI Programs

- ASME Code ISI exams found only 0.6% of welds contained flaws
- Almost all flaws were detected by IGSCC Augmented Inspection Program
- Inspections often focused on the wrong SSCs
- The appropriate locations were not being inspected
- The correct type of exams were not being performed

RI-ISI Development

- Mid-1980's – NRC program to develop RI-ISI methodology to take advantage of
  - PRA data
  - Industry and plant experiences
  - Information on specific damage mechanisms
- RI-ISI objective
  - focus inspections where failure mechanisms are likely to be present and enhanced inspections are warranted

Risk

$$\textit{Risk} = \textit{probability of event} \times \textit{its effects}$$

Probability of event – function of potential degradation modes as determined by physical characteristics & operational parameters

Effects – measured by CDF and LERF*

- Core Damage Frequency (CDF) – *damage to pressure vessel*
- Large Early Release Frequency (LERF)

* Obtained from required Plant Plant Examinations using PRA methodology

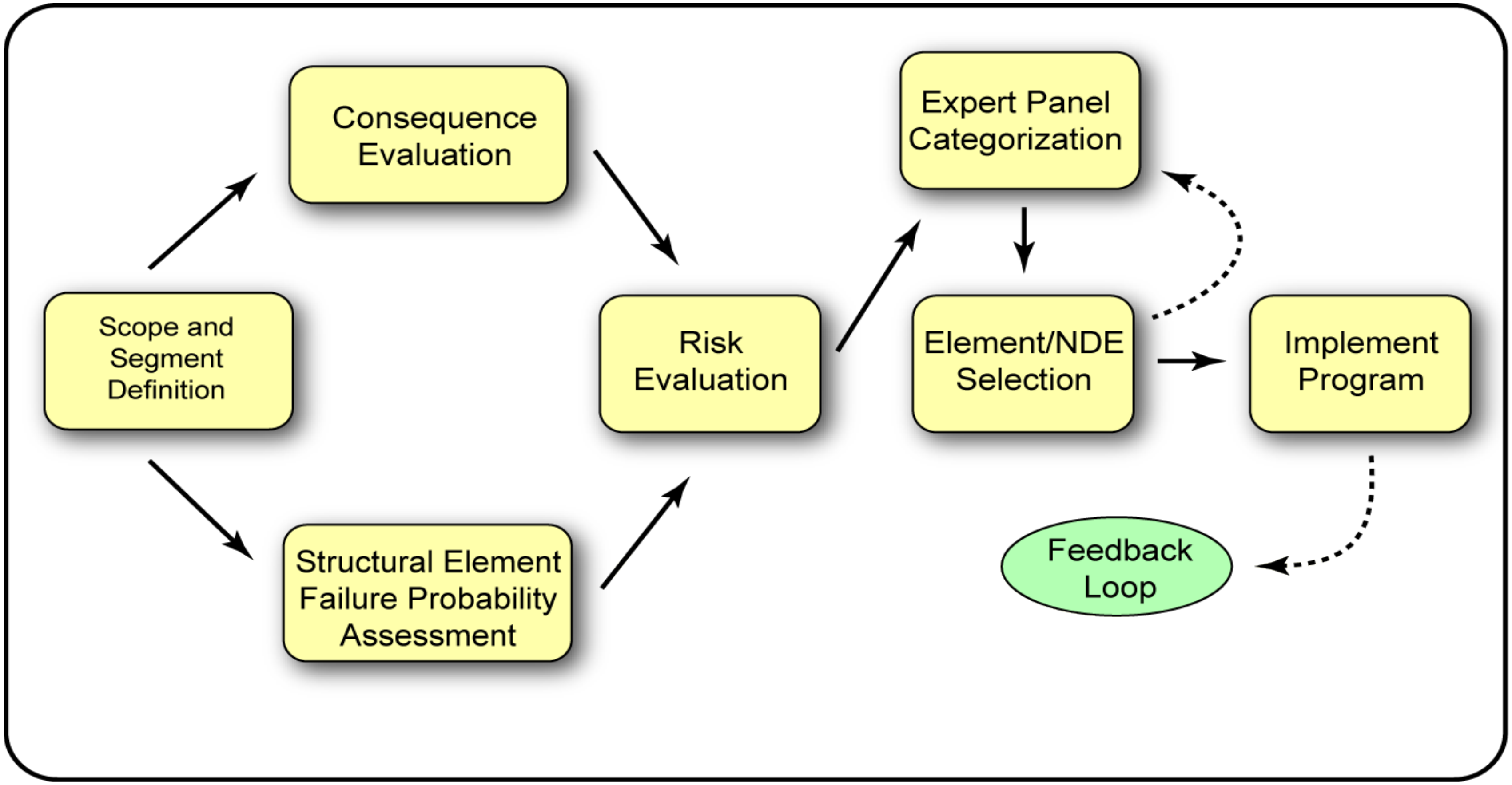
RI-ISI Methodologies

- Early 1990's – 3 Key ASME RI-ISI Code Cases
  - N-560 – Alternative exam requirements Class 1 B-J Piping Welds
  - N-577 – WOG RI-ISI Methodology
  - N-578 – EPRI RI-ISI Methodology

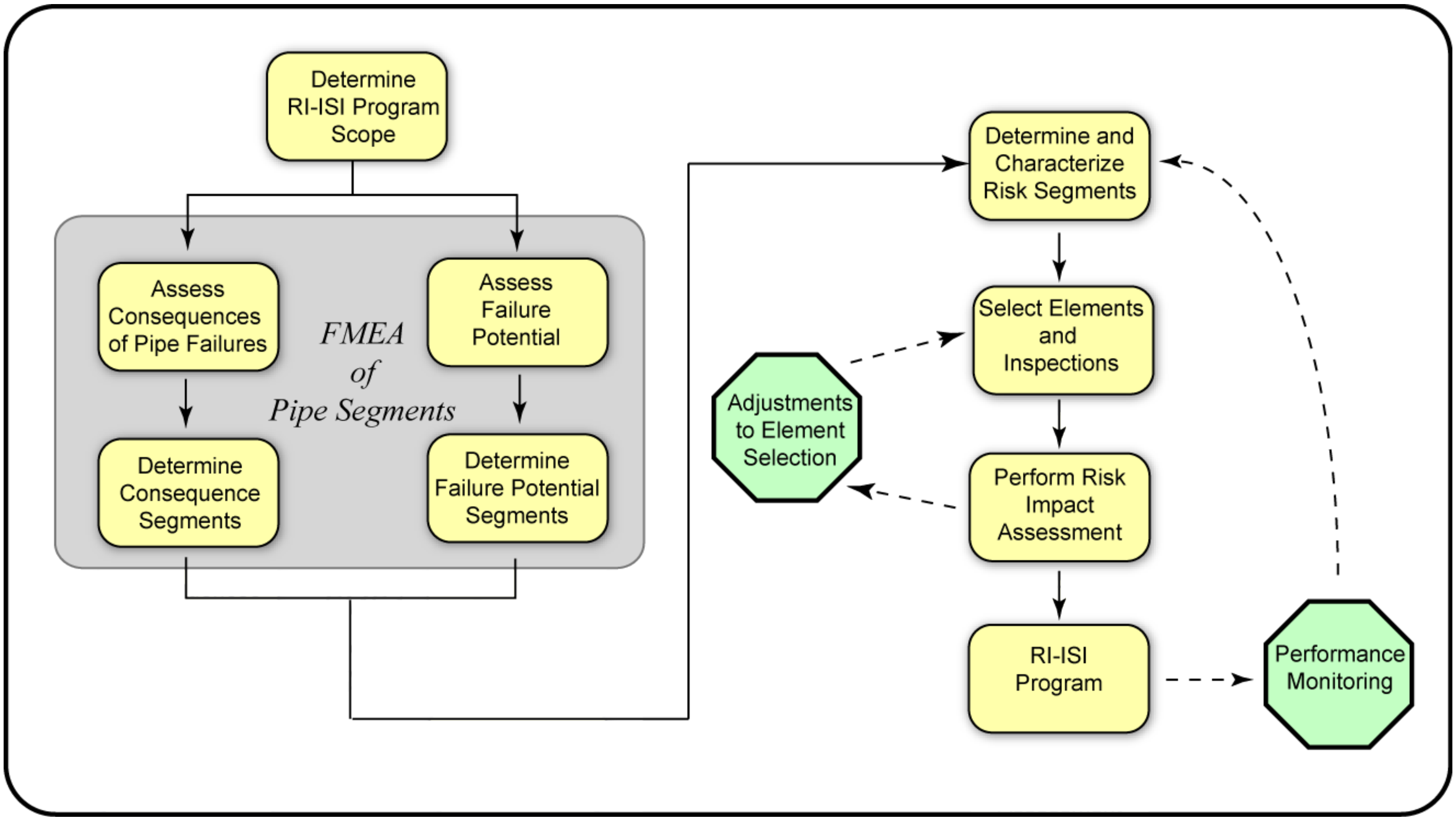
Basic Risk-Informed ISI Principles

1. Scope Determination
2. Segment Definition
3. Consequence Determination
4. Failure Probability Assessment
5. Risk Ranking
6. Element Selection
7. Change in Risk Evaluation

WOG Methodology Overview



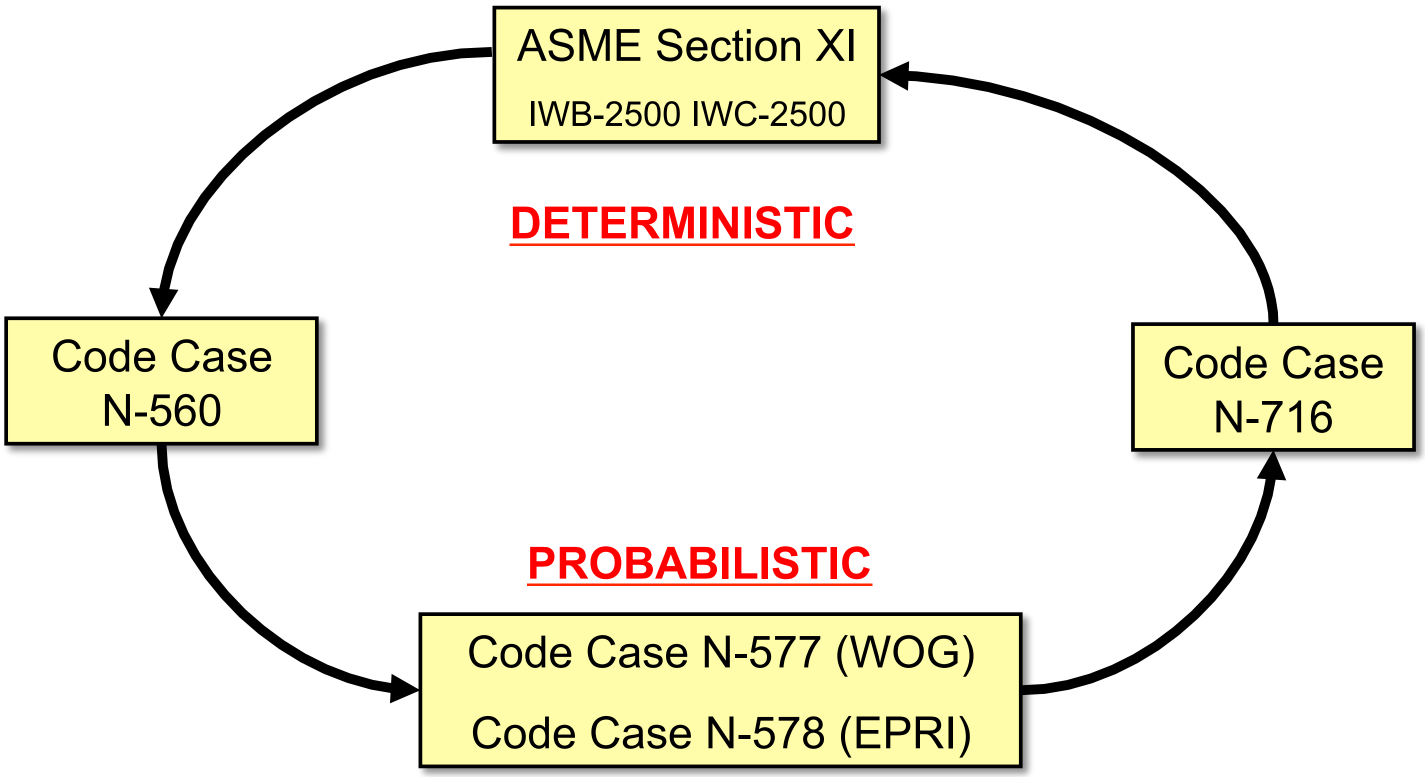
EPRI Methodology Overview



N-716 – Latest RI-ISI Methodology

- ASME Code Case N-716 – developed to
  - Take advantage of lessons learned
  - Reduce RI-ISI program development effort
  - Potentially eliminate many low value added exams

Comparison of ISI Methodologies



Advantages and Disadvantages

<u>EPRI Methodology</u>

- Advantages
  - Required expertise normally available in plant staff
  - Reduction in NDE examinations
  - Simplified yet fully risk-informed process
  - Less expensive than WOG approach
  - No increase in pressure testing
- Disadvantages
  - Results are categorized rather than individually quantified
  - May require more resources than N-716 approach

Advantages and Disadvantages

WOG Methodology

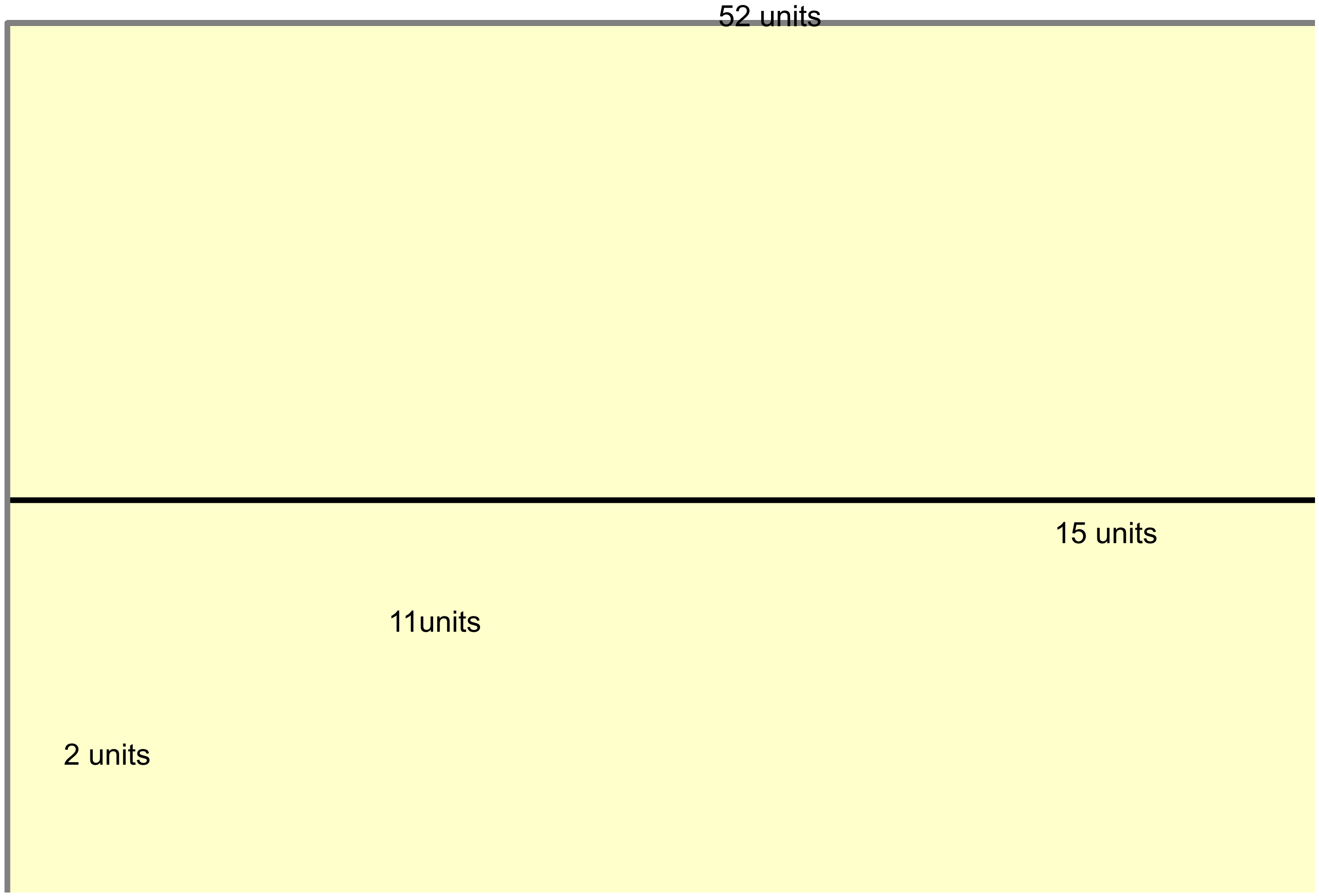
- Advantages
  - Provides quantified result
  - May require fewer NDE examinations
- Disadvantages
  - Does not allow exemptions
  - Requires determination of stresses for each segment
  - Requires PFM & statistical expertise expertise not normally available in plant staff
  - May require pressure testing of Class 2 every outage
  - Typically most expensive initial cost

Advantages and Disadvantages

Code Case N-716

- Advantages
  - Does not require consequence analysis for Class 1
  - Does not require update to failure rate analysis
  - Least labor intensive to implement
- Disadvantages
  - Incorporates less plant-specific information
  - Relies upon input from RI-ISI performed at other plants
  - Requires consideration of Class 3 and Non-class piping
  - Typically results in more NDE exams than EPRI or WOG

Units implementing each methodology



RI-ISI Cost & Radiation Reduction

- Average cost savings
  - ~ $870K per unit per interval for a Class 1 & 2 application
- Estimated reduction in radiation exposure
  - ~ 75% to 90% for a Class 1 & 2 application
  - ~ 60% to 75% decrease in welds selected for exam
  - Surface exams essentially eliminated
- Cost and radiation exposure reduction figures similar for both BWRs and PWRs

Conclusions

- Widely accepted by both NRC and industry – safety improvement and cost reductions
- RI-ISI success has led to use of risk-informed processes for other components and systems
- Growing support to continue development and refinement of RI processes to improve plant performance and safety

Advantages and Disadvantages of each methodology

RI-ISI Methodology/ Code Case Utilized	Plant, Unit	RI-ISI Scope	Previous Insp Elements	Revised Insp Elements	Chan Insp Elements
EPRI (N-716)[1]	ANO, U1	Class 1, 2, 3 & Non-Classed	40	42	2
EPRI (N-716)[2]	ANO, U2	Class 1, 2, 3 & Non-Classed	167	81	-86
EPRI (N-716)	Calvert Cliffs, U1	Class 1, 2, 3 & Non-Classed	105	79	-26
EPRI (N-716)	Calvert Cliffs, U2	Class 1, 2, 3 & Non-Classed	105	72	-33
EPRI (N-716)[3]	Nine Mile Pt, U1	Class 1, 2, 3 & Non-Classed	53	69	16
EPRI (N-716)[4]	North Anna, U1	Class 1, 2, 3 & Non-Classed	56	178	122
EPRI (N-716)[4]	North Anna, U2	Class 1, 2, 3 & Non-Classed	56	183	127
EPRI (N-716)[5]	Vogtle, U1	Class 1, 2, 3 & Non-Classed	108	136	28
EPRI (N-716)[5]	Vogtle, U2	Class 1, 2, 3 & Non-Classed	106	141	35

[1] Converted from N-560, submitted, awaiting approval (1 unit). Comparison on Examination Category B-J welds onl

[2] Converted from N-578, submitted, awaiting approval (1 unit). Original application was through full scope pilot applic

[3] Converted from N-578, submitted, awaiting approval (1 unit).