Introduction to ASME Section XI, Division 2
Reliability and Integrity Management (RIM)

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ANS
Risk-informed, Performance-based Principles and Policy Committee (RP3C)
Today’s Speaker

A. Thomas Roberts
POMO18 Consult LLC

Chairman of ASME Section XI Division 2
Reliability Integrity Management (RIM)
Mr. Roberts’ career summary spans over forty-five years’ experience, starting with the construction of several nuclear plant sites, then transitioning to management roles at three operating plants involving both pressurized water and boiling light water reactor technologies.

He has held direct responsibilities for:

Project and Construction Management, Nondestructive Examination, Welding Engineering, Engineering Program Management, and the responsibility for American Society of Mechanical Engineering (ASME) Code implementation during various plant construction sites and three operating units.

His involvement in nuclear industry related Codes and Standards development is diverse and includes:

- Current Co-Vice Chair of ASME Section XI Standards Committee
- Current Member of ASME Section XI Executive Committee
- Current Chair of the ASME XI Inquires Committee
- Current Chair of ASME Section XI Division 2 - Sub Group Reliability Integrity Management (RIM)
- Current Member of ASME/JSME Task Group on System Based Codes
- Current Member of the Nuclear Energy Institute Codes and Standards Task Force
Agenda

• Outline the process of Reliability Integrity Management (RIM)
  • What is RIM and why it is needed for advanced reactors?
• RIM process concepts
• Operational (monitoring) inspection challenges for advanced reactor designs
• RIM use & MANDE example
Outline of RIM

• Section XI, Division 2 Reliability Integrity Management (RIM) overview.

• What is RIM?

• Why is RIM essential to AR*, SMR* and MR* designers and not just to future Owners/Operators?

• What is important about RIM that AR, SMR & MR designers should consider throughout the design phase?

• How does Risk Informed Performance Based approaches integrate into RIM?

* AR = Advanced Reactors.
* SMR = Small Modular Reactors (i.e., <=300 MWe per unit) independent of technology
* MR = Micro Reactors (Info Link) https://www.energy.gov/ne/articles/what-nuclear-microreactor
Challenges for Advanced Design Reactors

- ASME Section XI Division 1, and similar international inservice inspection standards (e.g., KTA), are **not well suited** for most advanced design reactors currently in development.

- ASME Division 1 was developed primarily for light water reactor technology (e.g., BWRs & PWRs).

- ASME XI Division 1 tends to be “weld centric” in terms of what is inspected.
An ASME Section XI Sub-Group – developed the new ASME XI Division 2 Reliability Integrity Management (RIM)

- RIM is a detailed process to establish operational monitoring criteria for expected degradation mechanisms that are expected to occur, regardless of the reactor technology, (e.g., Molten Salt, HTGR, Liquid Metal, etc.)
  - RIM is "technology neutral" process – applicable to all reactor designs and technologies.
  - RIM criteria may be established by deterministic or probabilistic methods
  - RIM requires Monitoring and NDE (MANDE) to be assigned to SSC, based on expected credible degradation mechanisms in concert with an individual SSC’s contribution to risk for safe plant operation.

LINK TO WEBPAGE
https://aris iaea.org/
Reliability Integrity Management Basic Process Overview Concepts

1. RIM scope definition and SSC selection based on PRA

   INPUTS:
   - Licensing & Safety Requirements
   - Plant Level PRA
   - SSC Level PRA
   - Contribution to Risk

2. Degradation Mechanism Assessment

   INPUTS:
   - Assess Damage Mechanisms (DMs) relevant to the specific technology.
   - Examples - creep, corrosive coolants, deterioration of non-metallics, such as graphite.

3. Plant and SSC Reliability Target Allocation

   INPUTS:
   - Selected SSC Reliability Target value feeds into the required System and Plant Required Reliability needed to meet safety objectives.
   - Established by Frequency/Consequence Curve

4. Identification and establishment of RIM strategies and MANDE

   INPUTS:
   - MANDE is selected to monitor or inspect for DMs that are relevant to the specific reactor technology.

During design and operations
5. Evaluation of Uncertainties

INPUTS:
- Both PRA models as well as selected MANDE have associated uncertainties.
- These uncertainties must be accounted for to assure the fidelity of the required reliability of an SSC to meet its performance objectives.

6. RIM Program implementation

INPUTS:
- Program is initially implemented based on initial PRA, assigned RT values and selected MANDE.

7. Continuous monitoring and RIM Program and MANDE updates

INPUTS:
- As the plant is operated, the RIM program is continuously updated, modified, adjusted using the same processes as were employed during the initial development of the RIM Program but using newly gained insights from OE.
• Any SSC that could affect plant reliability must be scoped into the RIM program.

  o Non-Safety Related SSC* classified under historic SSC classification guidance as Non-Safety Related, but that are deemed risk significant, are required for inclusion in the RIM programs.

• This contrasts with the existing ASME XI Div. 1 Class 1, Class 2, Class 3, Class MC, Class CC, etc. ISI approach, with each class having different graduated criteria based on the Class of an SSC, rather than its risk significance.

* Using NEI 18-04 guidance such SSC would be classified as Non-Safety Related with Special Treatment (NSRST)
RIM Process Description: Part I

A ranking for risk contribution, known as a **Reliability Target Value**, is assigned to each SSC.

  - Risk insights and judgments to enhance plant capabilities
  - Inherent reactor, facility, and site characteristics
  - Radionuclide physical and functional barriers
  - Passive and active SSCs in performance of safety functions
  - SSC reliability in prevention of events
  - SSC capability in mitigation of events
  - SSC redundancy and diversity
  - Defenses against common cause failures
  - Conservative design margins in SSC performance

- **Deterministic Evaluation**
  - Risk insights and judgments to enhance programmatic assurance

- **Programmatic Defense-in-Depth**
  - Performance targets for SSC reliability and capability
  - Design, testing, manufacturing, construction, operations, and maintenance programs to meet performance targets
  - Tests, inspections, and monitoring of SSC performance and corrective actions
  - Operational procedures and training to compensate for human errors, equipment failures, and uncertainties
  - Technical specifications to bound uncertainties
  - Capabilities for emergency plan protective actions

**Figures from NEI 18-04**
As part of initial design as well as during operations, SSCs that are deemed risk significant are scoped into the RIM Program.

- This determination is established by the RIM Expert Panel (RIMEP)
- RIMEP must use accepted PRA criteria to make this determination at the plant, system and SSC level.
- This applies to passive components that would not normally be considered in traditional PRA evaluations.

- A ranking of relative risk, known as a Reliability Target Value, is assigned to each SSC.

Figure from INL Report INL/PT-22-68899 Link: https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_64127.pdf
RIM Process Description: Part I

• An SSC’s **Reliability Target** value is the assigned numerical index that must be maintained for an SSC within the program to assure it will:
  
  o Perform its required function over its expected life cycle
  
  o Not challenge safe plant operation or reduce overall Plant or System Reliability criteria
As part of the RIM process, the RIMEP and a second RIM prescribed expert panel called the MANDE Expert Panel (MANDEEP) are required to perform an SSC Degradation Mechanism Assessment (DMA)

- The DMA establishes what credible degradation mechanisms might apply to an SSC for a specific reactor technology over the life of the SSC (e.g., Creep, Stress Corrosion Cracking, Flow Induced Vibration, coolant chemistry excursions, etc.).
The RIMEP and MANDEEP are responsible for determining and assigning MANDE.

Any MANDE selected must be "performance demonstrated" before being employed.

This assures that any MANDE selected is effective in detecting the degradation mechanism.

RIM is not focused exclusively on weld examinations. Any credible degradation mechanism must be accounted for in MANDE selection (e.g., general corrosion).

NOTE: Some AR intend on using CO2 as a coolant.
The MANDE that is selected is chosen for the purpose of being able to detect credible degradation mechanisms that are expected to apply to a particular reactor technology.

Because DMs may not be limited to just weld locations, MANDE needs to be accounted for in the design of an AR to be able to employ RIM.

Based on the previous example of corrosion phenomena in a CO2 environment, a system may need to be outfitted with installed transducers to be able to detect changes in wall loss due to general corrosion effects.

Regardless of the method of MANDE selected, a provision of RIM is that MANDE must be performance demonstrated.

- That is to say, what is the “confidence level” of the MANDE chosen to be able to reliably detect changes in wall thickness of any SCC exposed to CO2 as might be necessary for the noted example.
RIM Process Description: Part II

• RIM is an on-going “Living Program”.
• It applies over the entire plant life cycle for risk significant SSC:
  
  o The periodicity for any prescribed MANDE is based on SSC’s:
    ▪ Active degradation mechanisms
    ▪ Required Reliability Target value of an SSC and
    ▪ Operating conditions (e.g., longer fuel cycles than PWR or BWR)
  
  o As operating experience is gained, the RIM Program must be updated
    ▪ RIM can therefore be thought of as an ongoing age management program.
Advanced Reactor Designer Considerations:

• Integrating RIM considerations during conceptual and detailed design efforts is essential and should include:
  
  o Establishing what the population of risk significant SSCs are for inclusion of the RIM Program, design specific considerations, and the plant level PRA
  
  o Determining credible degradation mechanisms for RIM scoped SSCs
  
  o Defining Reliability Target values for SSC
  
  o Demonstrating MANDE selected for SSC within the RIM Program
  
  o Working with ASME XI Division 2 committees to update and revise RIM, in order to best address specific or unique reactor design considerations and accommodate various reactor designs as they evolve.
Summary

• Advanced nuclear reactors have varied designs and purposes
  
  o Alternative approaches to current ISI activities are needed to accommodate new technologies.

  o Technology is moving to designs other than traditional LWRs

  o Some proposed reactors are for applications other than power production (e.g., medical isotope production, desalination, experimental test reactors, etc.)

  o RIM was developed to address and accommodate these new designs.
Summary

• RIM is a process that can be used:
  - For any reactor design or application.
  - It provides targeted MANDE criteria for all unique designs.
  - It serves as a living program to monitor aging effects on risk significant SSC.

• Nuclear reactor applications are moving toward new designs, miniaturization, etc. but reactor safety and long-term reliability remains paramount.

• RIM can accommodate these changes while maintaining long term safety and reliability.
Questions & Answers

• RIM itself is a living document and the work has just started!

• Interested in learning more about the BPVC-XI-2 Standards or how to get involved with the Committee?

• Contact presenter:

  Tom Roberts
  POMO18 Consult LLC
  tom@pomo18.com
  609-560-1778