ASME Section XI, Division 2

Reliability and Integrity Management Programs

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January 22, 2026

What is Materials Management?

Materials Management

Identify applicable materials degradation for an AR environment

- Operating experience available?
- Research data available?
- Can the mechanism be modelled?

Assess impact of degradation

- Time-dependent or time-independent degradation?
- Critical/Detrimental to design integrity?

Can the degradation be designed out?

- Change geometries?
- Change materials?
- Change operating parameters/chemistry controls?
- SSC change, in general?

If not, then mitigate, monitor, or plan for replacement

- Cladding
- Peening
- Overlay
- New/Novel Mitigations
- Continuous monitoring
- Inspections
- Surveillance
- Plan for replacement

Design Phase

Materials Advisory Group
Materials Degradation Matrices
Degradation Mechanism Screening and Assessment

Reactor developer decision making process – reasonable assurance for material deployment

Operational Programs

ASME Section XI, Division 2 - RIM

"Issue Programs" – Forums for materials management operating experience sharing and research prioritization

Materials Management Programs

Current Fleet

For the operating, light-water reactor fleet, license holders use **a deterministic approach** to assure as-designed safety margins through a selection of mandated examinations and tests

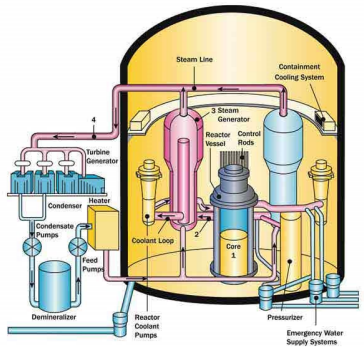
- **ASME Section XI, Division 1**
  - Developed and evolved with over 50 years of operating experience guiding the requirements. However, its requirements are often a poor fit for many new reactor designs.
- **NEI 03-08 Materials Initiative**
  - Industry requirement, endorsed by NRC, to proactively manage aging and degradation of materials

Future Fleet

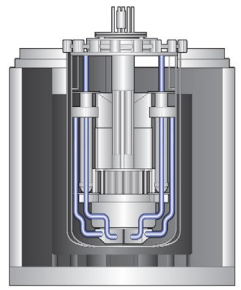
To support a broader range of reactor specifications/designs, a **performance-based alternative** approach to define examinations and tests is now available

- **ASME Section XI, Division 2 (RIM)**
  - A scalable framework designed to accommodate new technologies and evolving plant needs.

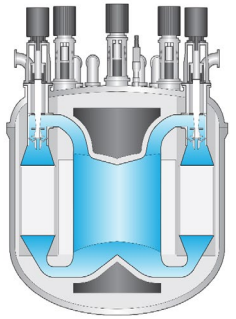
Typical Pressurized Water Reactor



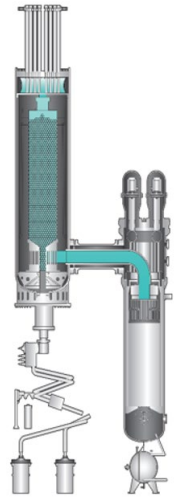
Fast Reactors



Molten Salt Reactors



High-temperature Gas-cooled Reactors

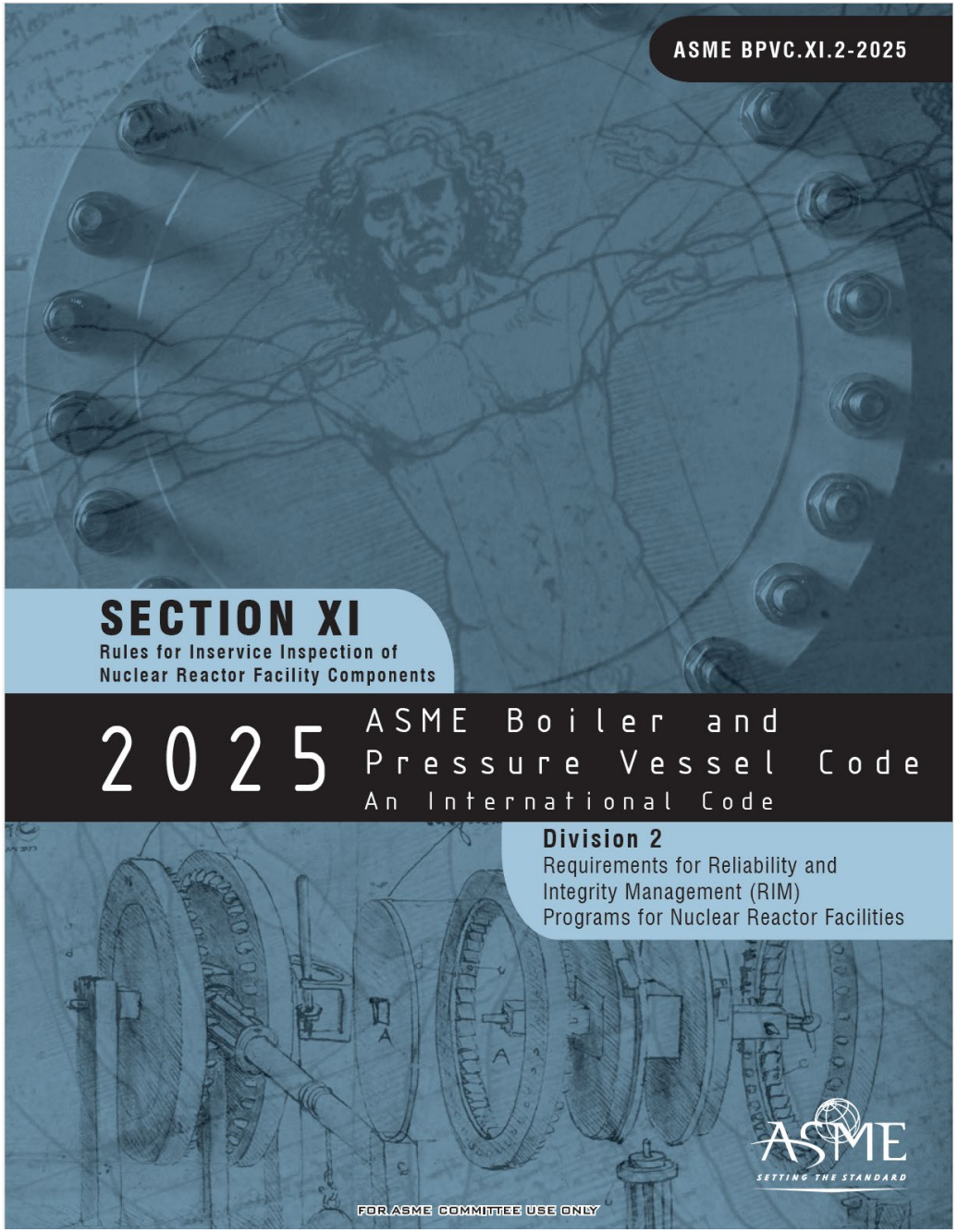


What is Materials Management for the Future Fleet?

Section XI, Division 2 - Reliability and Integrity Management (RIM) Programs

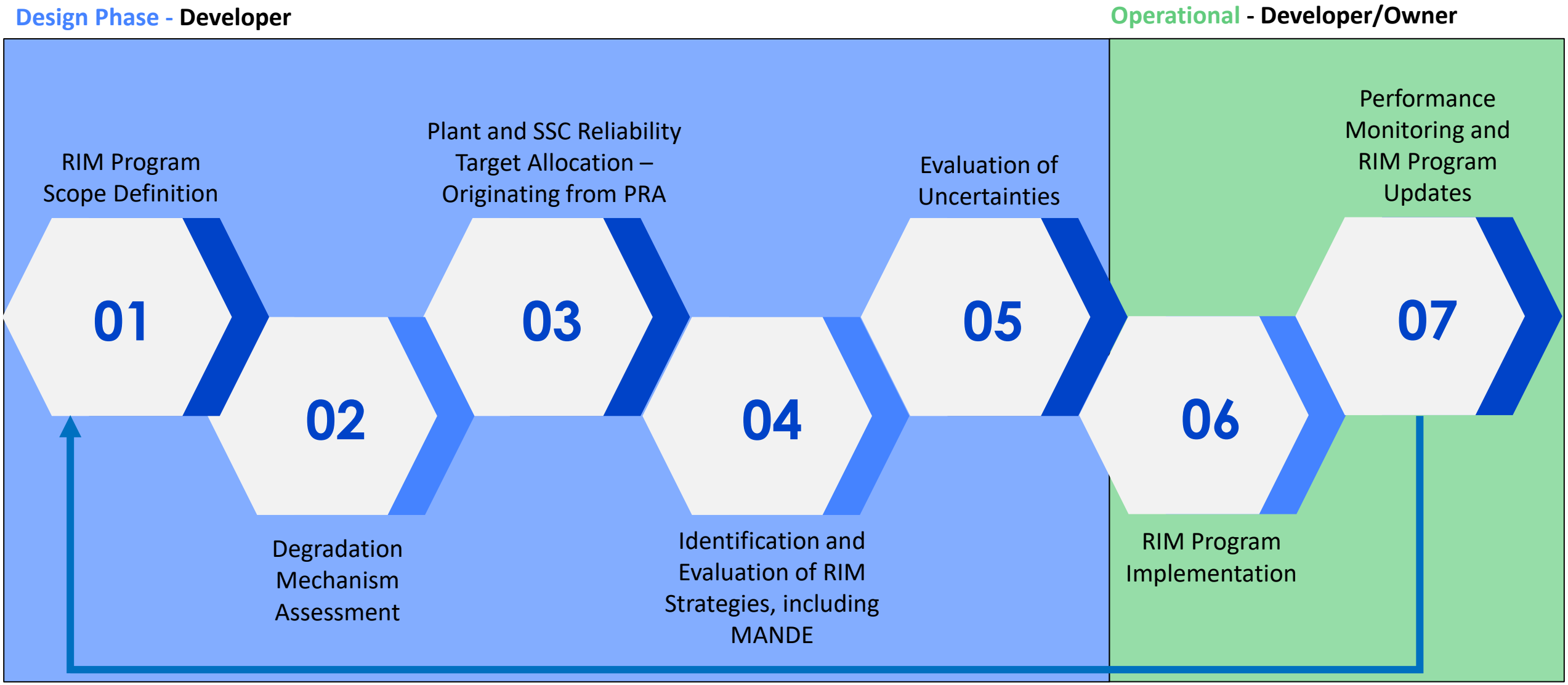
Establishes a flexible, risk-informed, performance-based framework for managing material degradation across all types of nuclear facilities—supporting modern design needs and long-term operational safety. **Not a design Code, but impacts decisions made during the design phase**

- Provides requirements for developing **Risk-Informed Materials Programs** applicable to any nuclear facility
- Offers **flexibility** by allowing implementation without prescriptive inspection tables (unlike Division 1's -2500 tables)
- Supports modern reactor designs by aligning material inspection strategies with safety significance and performance goals



Advanced Reactor Materials Management - The RIM Process

ASME Section XI, Division 2



RIM Technical Areas – Challenges/Opportunities

Materials Degradation

- Code Qualification for High Temperature Alloys
- Environmental Compatibility
- Degradation Applicability and Assessment
- Non-Metallic Materials

Probabilistic Risk Assessment

- Program Scope Definition
- Plant and SSC Reliability Target Allocation
- Accounting for Uncertainty
- Correlating Qualitative Condition Monitoring to Quantitative PRA Feeback

RIM Strategies

- Identification and Evaluation of RIM Strategies
- MANDE Technique / Technology Readiness and Maturation Plans
- Innovative, Novel, Advanced Monitoring and NDE Techniques
- Performance Demonstration Requirements and Program

Relevant Considerations

Reactor environments and designs may preclude traditional NDE approaches	Higher temperatures Limited access Time-dependent degradation mechanisms
Practical NDE innovations are likely to rely on guidance from RIM Programs	RIM Programs are likely to rely on available technology Technology development relies on ROI
Specific tailoring of the ultimate NDE deployment will require application inputs	Key stakeholders (reactor developers, EPRI, MANDE technology developers, service providers, etc.) need to work together to ensure deployment feasibility
MANDE methods and techniques will to be subjected to a qualification process and performance demonstration program before authorized for use	Performance Demonstration of MANDE, other than UT, is required – up to the MANDE Expert Panel discretion on level of rigor for the use cases
New NDE modalities may be required to support operations	Reliance on monitoring methods and non-traditional NDE are being proposed

Expert Panels

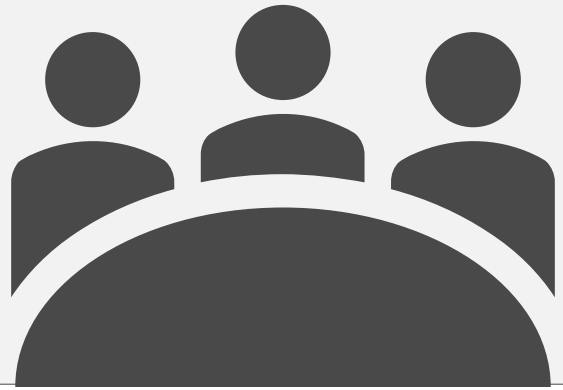
Expert Panels (EP)

The success of the RIM Program is a product of the expert elicitation process

RIM EP

Responsible for overseeing the RIM Program development, documentation, and implementation

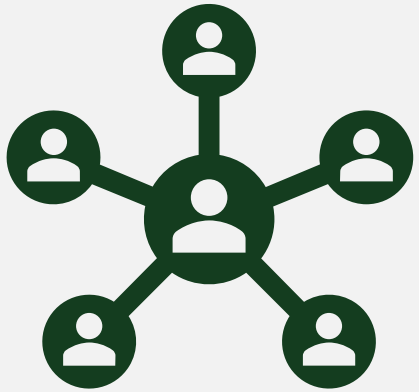
- Identify RIM Program scope, associated Reliability Targets, and RIM Strategies



MANDE EP

Responsible for establishing MANDE specification and overseeing the qualification of MANDE methods and techniques

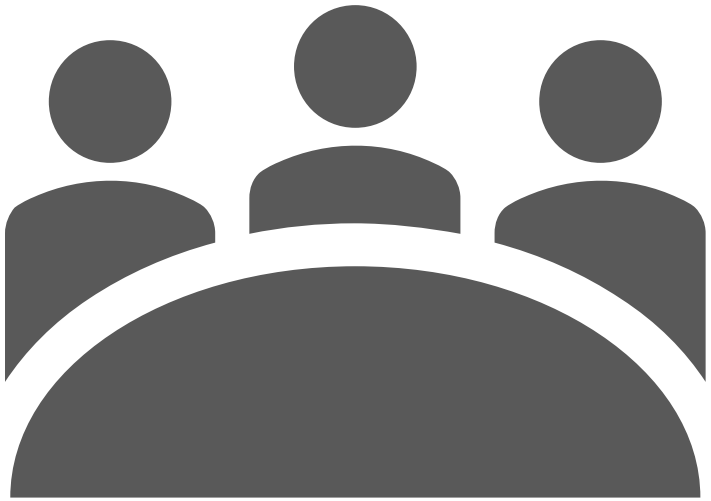
- Specify coverage, frequency, location, and volume for inspection



Expert Panels – RIM EP

This is an overarching panel with the purview of **ensuring each of the process steps is completed**. There is also a need for this panel to have a **broader perspective and understanding of the facility safety case** to assist in RIM program scoping, as well as setting the reliability targets for systems, structures, and components. This panel **interfaces with the system design expertise to understand the system requirements**.

Design Expert (Construction Code Analyses)
Design Expert (General Facility Design Requirements)
Materials Degradation Expert(s)
Facility Operations Expert
Probabilistic Risk Assessment Expert(s)
MANDE EP Chair (for coordination)
Licensing Expert (Licensing Modernization Project Expert)

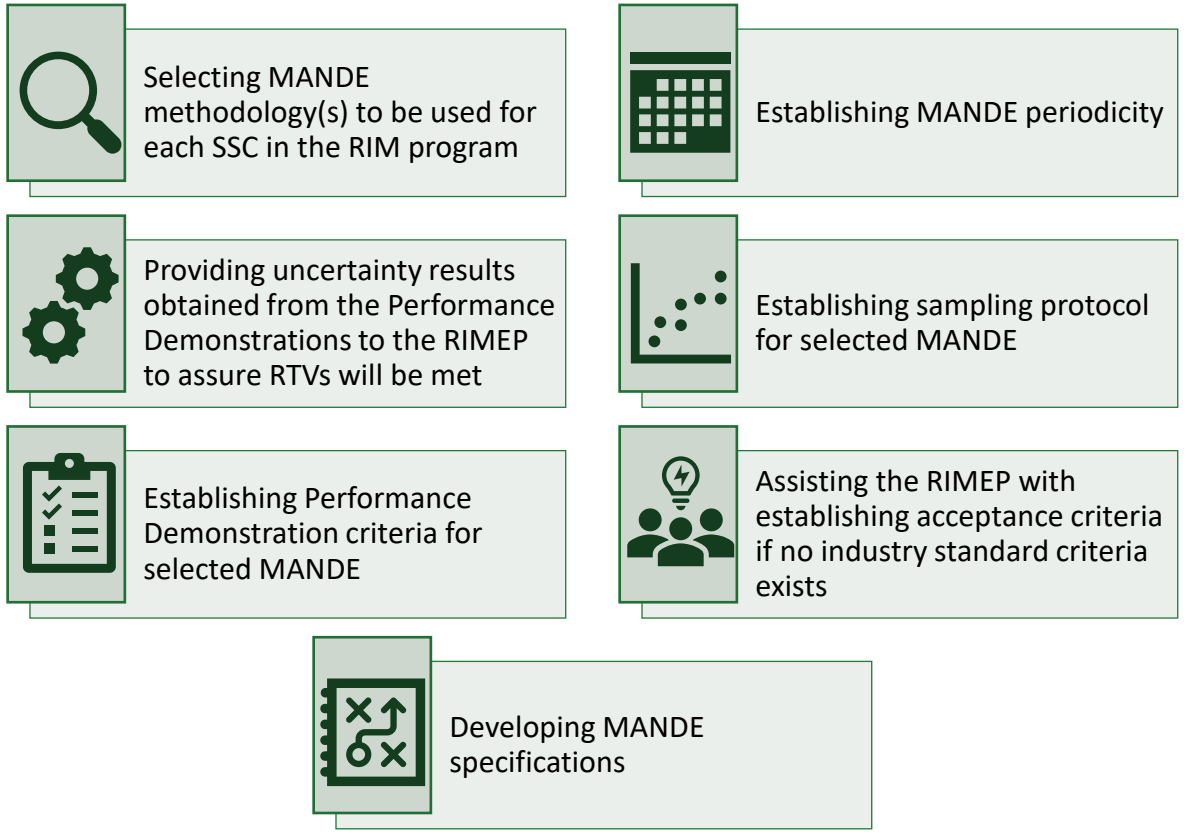


- Determining the SSCs to be included in the RIM Program
- Setting the Reliability Target Values for each SSC
- Coordinating with the MANDE EP to establish what MANDE method(s) should be assigned
- Coordinating with the plant Owner/Designer to assure specific SSC scoped in the program can accommodate selected MANDE
- Validating that uncertainties from initial PRA use or from MANDE selection and performance demonstration actions do not adversely impact required RTVs (reliability target values)

Expert Panels – MANDE EP

This panel **oversees more of the technical background** to assist in the decision-making process. The inspection type and periodicity requirements will be the product of understanding the materials degradation, flaw growth characteristics, critical flaw sizes, available MANDE techniques/mitigation techniques, and the uncertainties in each of those inputs.

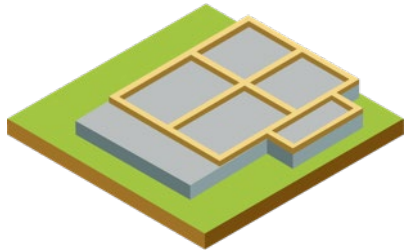
- MANDE Chair with extensive background in NDE
- Fracture Mechanics expert(s)
- Various NDE Technique Experts
  - Acoustic Emissions
  - Eddy Current Testing
  - Leakage Testing (incorporates potential tests for multiple different designs)
  - Liquid Penetrant Testing
  - Magnetic Particle Testing
  - Online Monitoring
  - Ultrasonic Examinations
  - Radiographic Examinations
  - Visual Examinations
  - Surveillance Sampling
- Monitoring and Sensors / Instrumentation and Controls Expert
- Materials Degradation Expert(s)
- Materials Fabrication Experts
- Welding Expert
- Modelling and Evaluation Expert
- Chemistry Expert
- Code Expert



RIM-Related Industry Guidance

RIM Tasks - Ongoing

At EPRI, the Advanced Nuclear Technology Program is actively engaged in RIM:



1. Defining the needs of the industry and building the tools to enable its application

2. Providing guidance to build RIM programs in a robust but optimized fashion

3. Working with developers to implement the RIM Process during the design phase

4. Updating the ASME Code for future versions of RIM

Some tasks at EPRI include:

- Published a report that summarizes the RIM Process, identifies gaps to implementation, and proposes strategies for gap closure (3002029267)
- Published guidance for the implementation of the RIM EP and MANDE EP to build an effective RIM Program (3002029268)
- Published guidance for completing degradation mechanism assessments (3002032226)
- Developing guidance on the requirements of a PRA and establishing the reliability target values (3002032238)
- Molten Salt Reactor Materials Degradation Matrix (3002030754)
- Sodium Fast Reactor Materials Degradation Matrix (3002032265)
- Building off EPRI's successes in materials management programs for the current nuclear fleet (MRP, BWRVIP, SGMP, NDE), provide a foundation to address the differences in design and operation of the future fleet (future Materials Programs)

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