INL/MIS-25-83213-Revision-1

RIM: Reliability and Integrity Management /ASME BPVC Section XI Division 2

February 2025

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Changing the World's Energy Future

Idaho National Laboratory

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Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

INL/MIS-25-83213

February 19, 2025

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Ad Hoc Task Group Responding to Issues

RIM: Reliability and Integrity Management ASME BPVC Section XI Division 2

Overview: Development of Responses to Issues Raised about RIM

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Acknowledgments

- At the May 2024 meeting of the ASME/JSME Joint Working Group on RIM Process and System Based Code (Chair: Shigeru Takaya, Vice Chair: Chris Wax), a discussion was held regarding questions received on Appendix II, and an informal *ad hoc* team was set up to work to address those questions.
- Commentary in these slides is based on discussions held by that group. That's not to say that every discussant agrees with everything said in these slides, and some would add key points (e.g., avoiding the word "component," discussion of "capability," …).

What is Reliability and Integrity Management (RIM)?

- Notional Application:
  - How to license a novel plant incorporating novel materials or materials deployed in novel environments?
  - A possible way: the Reliability and Integrity Management (RIM) approach as outlined in ASME BPVC Section XI Division 2.

RIM manages the risks associated with novel materials through a comprehensive program of Monitoring and Non-Destructive Evaluation (MANDE). This implementation ensures that the reliability targets for Structures, Systems, and Components (SSCs) are being met.

- In the RIM approach, applicants need to:
  - Given plant-level requirements, allocate target reliabilities to RIM SSCs that collectively support high-level safety and availability objectives.
  - Understand failure modes of SSCs reflected in the targets, and the degradation mechanisms that could lead to those failure modes.
  - Develop strategies to identify and/or monitor degradation prior to SSC failure.
  - Provide a means of reporting results, taking actions for anomalous or undesirable conditions, and assure the regulator of continued safe operations.

Preface to [BPVC] Section XI

PREFACE TO SECTION XI

…

Section XI, Division 2, Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Reactor Facilities, is a technology-neutral standard of the ASME Boiler and Pressure Vessel Code. It provides requirements for protecting pressure integrity of structures, systems, and components (SSCs) that affect reliability. Application of Division 2 begins when the requirements of the Construction Code have been satisfied. It is applicable regardless of the Construction Code classification used for an SSC if the SSC is designated as important to the safety and reliability of an operating facility.

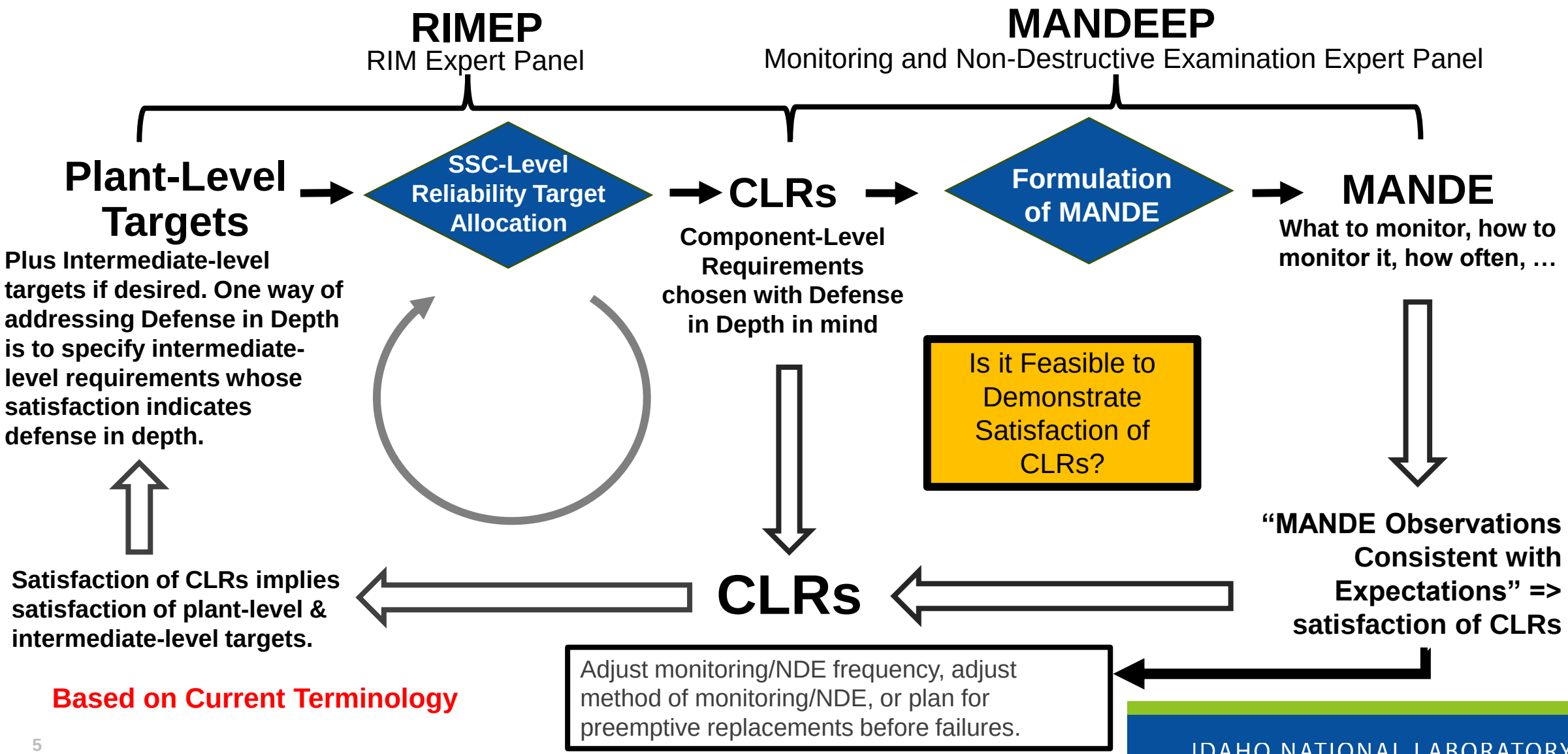
GENERAL

The rules of this Section constitute requirements to maintain the nuclear reactor facility and to return the facility to service, following facility outages, in a safe and expeditious manner.

…

Section XI, Division 1, rules require the development of a Reliability and Integrity Management (RIM) Program that considers the combination of design, fabrication, degradation mechanisms, inspection, examination, monitoring, operation, and maintenance of SSCs to ensure they will meet their required reliability target values. The rules also stipulate duties of the Authorized Nuclear Inservice Inspector to verify that the program has been completed, implemented, and updated in accordance with the requirements of Division 2.

Highly Simplified Diagram of RIM



Based on Current Terminology

Issues

- Questions were raised about Mandatory Appendix II: Derivation of Component Reliability Targets from Facility Safety Requirements.
- Possible improvements to provide interface with Licensing Modernization Project identified.
- Some questions concerned the specific steps in the Appendix, while others were about terminology. In its May 2024 meeting, the Joint Working Group created an informal *ad hoc* team** to address these questions. (team currently led by Youngblood)
  - This is not just a matter of answering the questions; although the questions were directed at the Appendix, resolving them will necessitate changes to RIM in some areas outside the Appendix.
- Information Gathering
  - Early on, the *ad hoc* group received briefings on the Licensing Modernization Project (LMP) by Karl Fleming and the System-Based Code by Shigeru Takaya, chair of the Joint Working Group (JWG), to provide the necessary background for discussions.
- Proposing Modifications
  - Currently, we are at the stage of formulating specific proposals for the JWG and the RIM Subgroup.

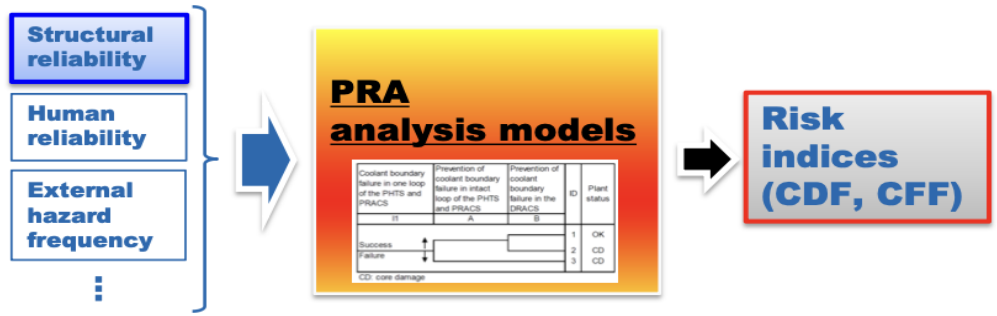
**The *ad hoc* team is not officially recognized within the Section XI organization. It is an action item assigned to group members.

Forward and Inverse Application of PRA Logic Models

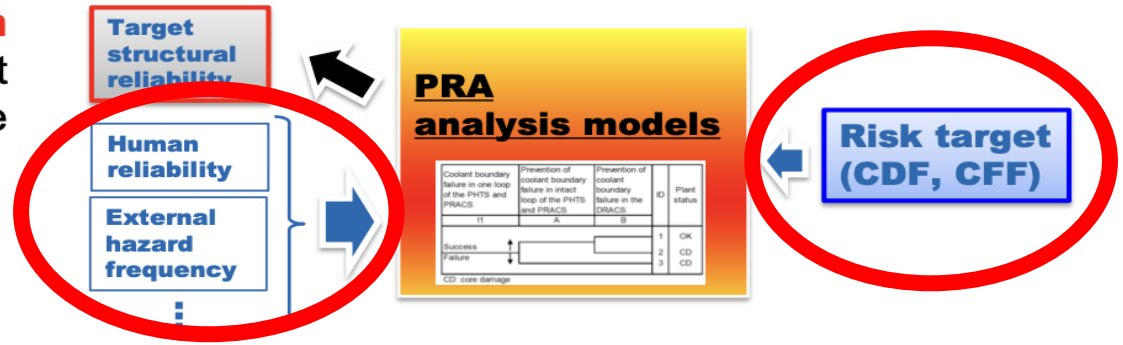
GEN IV International Forum

Key Technical Elements:
Derivation of Component Level Target Reliability (App. I)

- Probabilistic Risk Assessment (PRA) is usually used to integrate the individual reliabilities into the risk index.



- The developed method uses PRA **in a reverse way** to derive component level structural reliability from the plant level risk target.



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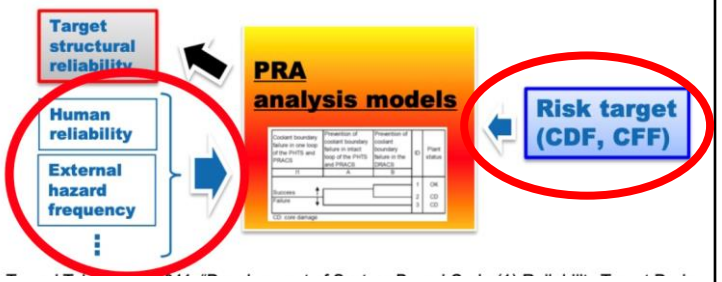
Expertise | Collaboration | Excellence

Kurisaka, K., Nakai, R., Asayama, T., and Takaya, S., 2011, "Development of System Based Code (1) Reliability Target Derivation of Structures and Components", J. Power Energy Syst., Vol. 5, pp.19-32. DOI: 10.1299/jpes.5.19

20

Examples:
Questions for the Subgroup RIM to Consider

Terminology Questions

Question / Comment		
Quote From ASME BPVC.XI.2-2019	Discussion	Suggestion
(c) The Reliability Target allocation includes the following considerations: *(3)* The event trees relevant to passive component failures shall be identified for the accident category. The event tree top events (e.g., see ASME/ANS RA-S-1.4-2013) related to dynamic component failures and human errors may be removed by assuming that their probability is 1. The sequences depending only on dynamic functions shall be excluded from the event trees. Reliability Targets allocated for the accident category shall be divided and distributed for the accident category due to passive component failures and other contributors.	The term "dynamic component failure" is not a defined term in the code, nor is it an industry standard term. Setting the probability of a failure or human error to "1" does not remove the top event as stated. Sequences depending only on "dynamic functions" would be present as the initiating events and a sequence of top events set to 1. The final sentence to further divide and distribute the reliability target within an accident category is not understood. "Other contributors" is not understood since the reliability targets are intended for the passive component failures only.	Part of the subject of the question seems to be the content of the figure below. 

Slide from May 2024 JWG Meeting

Clarifications on Terminology and Definitions

Clip from RIM

II-1.1 SCOPE

This Appendix shall be used for deriving component (or SSC) level requirements (CLRs) from plant-level safety requirements using probabilistic risk assessment (PRA). This Appendix provides a method for deriving CLRs in the form of SSC Reliability Targets.

Related Comment

"Plant-level safety requirements" is not a defined term in the code, nor is it an industry standard term.

The term CLR used here and again only in II-2.1 is not understood in relation to "reliability target", which is the focus of this appendix.

Opinion: Wherever this phrase (plant-level safety requirements) appears in RIM, it should be changed to refer to "targets," not requirements. This usage comports with the LMP, the RG endorsing the LMP, and with NEI 21-07. Similar comments apply to phrases including the word "goals."

Re CLR "Component-Level Requirements":

The above clip describes SSC Reliability Targets as CLRs. Component-level requirement (CLR) is defined in RIM-7.1, Terms and Definitions. That definition does not explicitly rule out using the expression "CLR" for reliability targets, but the glossary wording seems to expect the term to be used mainly in reference to not exceeding a specific level of a specific sort of physical component degradation. Thinking a bit more broadly: we may need to specify a needed physical capability, a target reliability, AND a set of physical measurements that are deemed to be consistent with that target reliability.

Clarifications on Terminology and Definitions (2)

Clip from RIM	Related Comment
II-2.1 PLANT-LEVEL SAFETY REQUIREMENTS **(a) For light water reactor (LWR) types use the plant-level safely goals that are established in terms of Core Damage Frequency (CDF) and Large Early Release Frequency (LERF).**	**This implies an LWR plant will have CDF and LERF safety goals ("use" instead of "establish"); there is no regulatory requirement for such goals and it is not defined term in the code, nor is it an industry standard term. If the intent is to require establishing such goals, additional guidance is required as it is not clear if the goals could be different than the baseline CDF/LERF values. Since the baseline CDF/LERF would change over time due to accumulation of plant-specific data, changes to the plant and its operating practices, it is expected that such a goal would be higher than the baseline CDF (so that the goal is being achieved).**
II-2.1 PLANT-LEVEL SAFETY REQUIREMENTS **b) For advanced non-LWR types, such as the High-Temperature Gas Reactor (HTGR), use appropriate plant-level safety goals, based on metrics such as regulatory limits on the risks, frequencies, and radiological consequences of licensing basis events.**	**This implies existing plant-level safety goals; for non-LWR advanced reactors, NEI 18-04 as endorsed by RG 1.233 establishes the F-C target line – it is not clear if that is what is intended as the safety goal, or if something more is required to establish a plant-level safety goal. The goal should be above the calculated F-C target (so that the goal is being achieved).**

As indicated on an earlier slide, references to "plant-level requirements," "goals," etc. should arguably be modified to say "targets." RIM is trying to be more technology-neutral and expects RIMEP to specify plant-level targets.

There's a lot to discuss about the material in the lower right cell. Arguably RIMEP has enormous discretion there. The F-C line is an example of something RIMEP could choose to use.

If Appendix II becomes Non-Mandatory, the main body will need to spell out more clearly what the properties of the targets should be, at both the facility level and the SSC (component?) level.

Summary: What Is Being Done About Issues Raised

- The *ad hoc* group is currently working three issue areas:
  1. There are many places where terminology is used inconsistently.
     - We are working to fix the terminology and clarify the related concepts.
  2. The Appendix presents ONE way of doing allocation, *prescribing certain choices* along the way. The Appendix is not the ONLY way to do allocation.
     - We are pursuing an approach within which the Appendix is (a) clarified, and (b) becomes NON-Mandatory.
  3. Modifying the terminology and changing the Appendix will imply significant changes to the main body.
     - For example: Right now, the main body expects the targets to come from application of the Mandatory Appendix. If the Appendix is not mandatory anymore, and if we are not going to prescribe a specific method of allocation, we have to say something about the properties of the set of targets.
  4. Improvements to improve interface with LMP are being addressed.

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Backup

Can we specify properties that an acceptable high-level allocation needs to have, and require RIMEP to formulate such an allocation?

Possible properties:

- The high-level targets should make sense.
  - Absent a comprehensive allocation assigning probabilities to all basic events, we cannot in general assign a unique value for a top-level risk metric. If a PRA is available, the implications of the chosen set of high-level targets could be discussed in terms of that; if a compliant "PRA" is not available, one could decide to limit the frequencies of designated families of undesirable events (e.g., breaches of particular pressure boundaries, …).** The spirit of the present suggestion is that this would be formulated by RIMEP.
- Three things have to be true of the SSC-level targets:
  1. Satisfaction of them should imply satisfaction of the high-level targets.
  2. They should be consistent with defense in depth.
     - This means not over-relying on some components to achieve overall safety.
  3. It has to be practical for MANDE to show whether the SSC-level targets are being satisfied.
     - Extremely low values of unreliability are not supportable by realistic MANDE.

**Fleming *et al.*, Reliability and Integrity Management (RIM) Program for Modular High Temperature Gas-Cooled Reactors (MHRs) (2008)