Community of Practice
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On a New Standard for RIPB in Reactor Designs ANS-30.1

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Goals of the discussion

- Provide some contextual history for ANS 30.1
- Establish and confirm the role of ANS 30.1 within the overall ANS standards efforts for advanced reactors
- Discuss the purpose of ANS 30.1 and summarize the few high-level requirements of ANS 30.1
- Elaborate on these requirements to dispel misconceptions of ANS 30.1 that continue to linger
- Provide a current status of ANS 30.1

History and background

- Origins of ANS 30.1 begin with ANS 51.1 and ANS 52.1
  - ANS 51.1, Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants
  - ANS 52.1, Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants
- Both were prepared in 1983 to replace existing standards and incorporate additional requirements for
  - Equipment classification
  - Plant conditions
  - Design criteria
- In 1993, ANS 58.14, Safety and Pressure Integrity Classification Criteria for Light Water Reactors was prepared to **revise, consolidate, and supersede** the safety and pressure integrity classification criteria in ANS 51.1 and ANS 52.1.

History and background

- This "consolidation" of safety and pressure requirements led to the creation of a working group in 1993 for ANS 50.1, Nuclear Safety Criteria for Light Water Reactors.
- ANS 50.1 was to revise and consolidate the remaining requirements of ANS 51.1 and ANS 52.1, i.e., the **deterministic design criteria**, into a single document and to address topics of design under development at that time, **including use of probabilistic risk assessment**.
- After 7 revisions, comments were unable to be fully resolved and the project ended in 1994 without publication of an approved standard.
- With the preparation of ANS 58.14 in 1993 superseding the classification parts of ANS 51.1 and ANS 52.1 and the stalled effort on ANS 50.1, LWR design criteria remained in the now "partial" ANS 51.1 and ANS 52.1.

History and background

- To address this gap, the ANS standards authority re-initiated ANS 50.1 working groups in both 2003 and 2011 to complete the document.
- Despite significant effort, the working groups was unable to obtain support from either existing reactors or advanced reactor designers for the continued preparation of the document.
- The second ANS 50.1 effort was ended in 2014.
- But the necessity for incorporation of RIPB guidance, methods, and information into ANS standards remained a top priority throughout the ANS organization.
- ***This necessity prompted a complete paradigm shift by the ANS Standards Board in how to approach future standards development.***

History and Background

- The ANS standards authority was also faced with a significant new challenge with preparation of standards for the advanced reactor designs
  - By the time ANS 51.1 and 52.1 (1978) had been issued, approximately 67 light water reactors that had received approval for operation
  - By issuance of ANS 51.1 and 52.1 (1983), an additional 14 were operational
- Consequently, the foundational design criteria standards for light-water power reactors had the experience benefit of approximately 80 operating units from which to draw “standard design practices”
- The ANS standards authority recognized this experience is not available for the development of standards for advanced reactors
- Waiting to accumulate that experience was not considered an option

History and Background

- With the second abandoned effort of ANS 50.1, it was clear that with their approved licenses and extensive operating history, existing reactors were hesitant to support revisions to ANS standards which could potentially challenge the status quo.
- This led the Standards Board to the following conclusions regarding the incorporation of RIPB guidance, methods, and information into ANS standards:
  - Revisions related to existing standards must be made with care and consideration of the potential impacts on the existing fleet of reactors
  - More attention should be made for the inclusion of both deterministic and RIPB design requirements during the development of standards for future reactor designs.

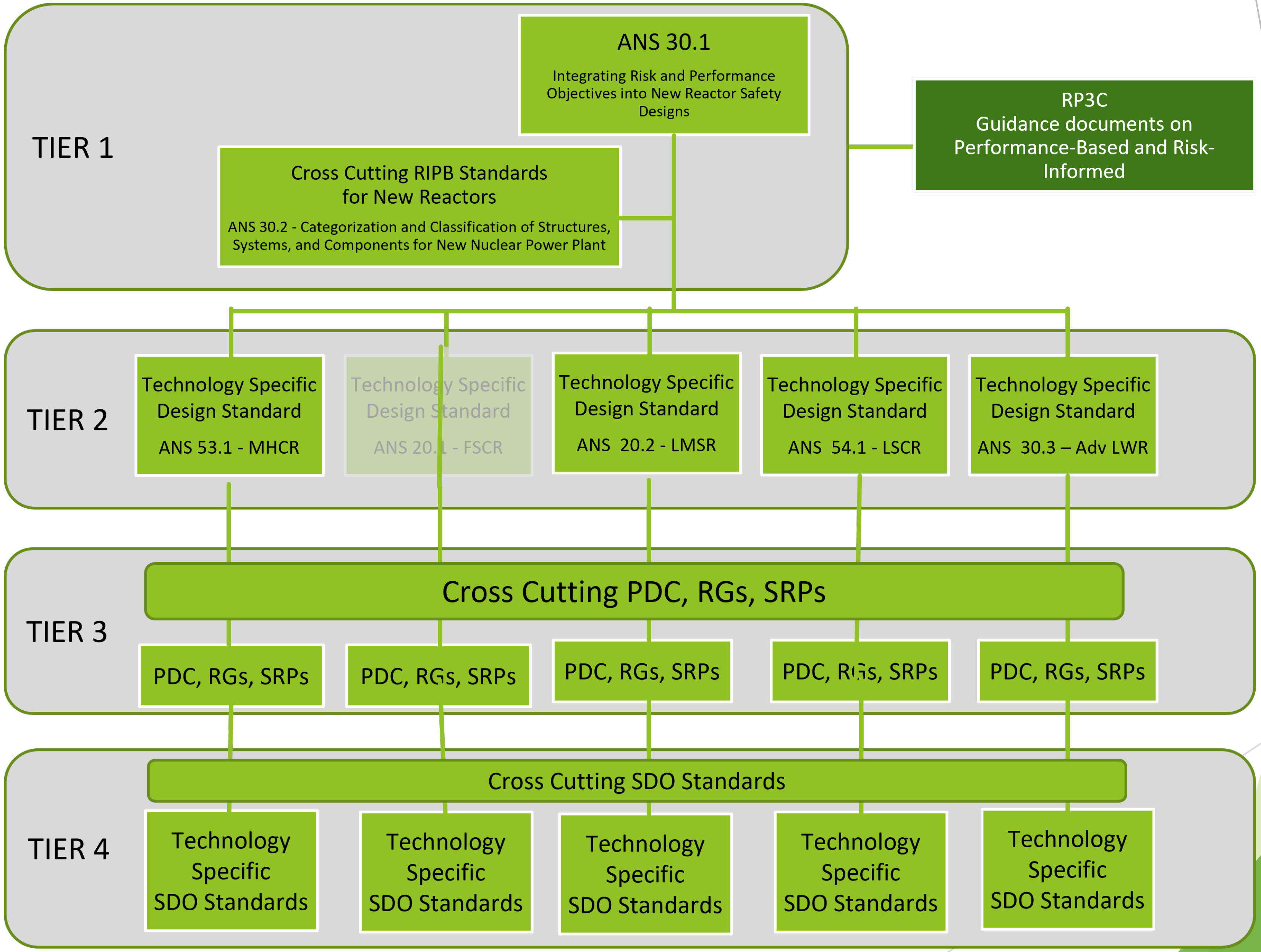
History and Background

- First, the paradigm shift affected the ANS organization
  - Inward-looking change was made to create the Risk-informed, Performance-based Principles and Policy Committee (RP3C)
    - Advisory committee to the Standards Board
    - Oversight of ANS plan for implementing risk-informed and performance-based principles into ANS standards.
  - Outward-looking change was made to create a joint committee in conjunction with ASME – ANS/ASME Joint Committee on Nuclear Risk Management (JCNRM)
    - For preparation and maintenance of consensus standards for completion of risk assessments including PRA.
- These organizational changes were to permit RIPB principles and methods to be addressed for all nuclear facilities in a rational and planned manner.

History and Background

- Second, the paradigm shift involved ANS structural changes
  - The Advanced Initiatives subcommittee of the Research and Advanced Reactors Consensus Committee (RARCC) was tasked with the development of consensus standards for the design, operation, maintenance, operator selection and training, and quality assurance for new reactors (light-water and non-light-water cooled).
  - A tiered hierarchy of advanced reactor standards preparation was approved
- These structural changes were to permit RIPB principles and methods to be incorporated for advanced nuclear facilities in a broad and appropriately flexible manner.
- ANS 30.1 becomes of importance in this second set of changes

Advanced Reactor Standards Hierarchy



ANS 30.1 Requirements for RIPB Design

- What is ANS 30.1?
  - It provides requirements and guidance for the preparation of lower tier, technology-specific new reactor design standards
  - It is technology-neutral
  - It is written to guide working group members that are preparing new, technology-specific reactor design standards
  - It addresses objectives for incorporating risk- and performance-based design information into new reactor safety designs through all stages of the facility lifecycle
  - It supplements traditional design process
    - Balances the "structuralist" and "rationalist" philosophies of design
  - It is applicable to single or multiple reactors as well as the broader needs and missions of advanced reactors

ANS 30.1 Requirements for RIPB Design

- What is ANS 30.1?
  - It recognizes detailed state of practice for advanced reactor design is not generally available in the manner of previous large LWRs
    - ANS 30.1 does not provide a design process
    - ANS 30.1 does not discuss implementation of RIPB information for any specific advanced reactor technology
  - It specifies process elements that, when integrated into the design process, increase assurance that a minimum necessary design structure is available to achieve the full benefits of RIPB design, regardless of the reactor technology or its application
  - It requires use of RIPB information in assessing nuclear safety but acknowledges other risks may exist that warrant specific design consideration

ANS 30.1 Requirements for RIPB Design

- What is ANS 30.1?
  - While state of practice for advance reactors is not generally available, 50 years of PRA application to the current nuclear power industry has certainly established the state of practice for the realization of systematic and robust RIPB results as derived from industry accepted PRA methods
  - This RIPB state of practice is defined within this standard by four high level and relational elements to be applied during the preparation of new reactor design standards. These four elements are:
    - An interdisciplinary design process based on the methods and processes of the systems engineering (SE) discipline (addresses the need for sound SE practices),
    - The development of principal design criteria (addresses regulatory processes of new reactor design),
    - A defense-in-depth process that is structured and systematic with decisions based on a coherent system of measurement of need and adequacy, and
    - The evaluation of the design is conducted using complete plant response or event sequence information in order to establish competent safety cases from industry acceptable hazard analyses processes.

ANS 30.1 – SE Requirement

- Requirement - An interdisciplinary design process based on the methods and processes of the systems engineering discipline shall be implemented
    - For a complete lifecycle design
    - For design coherency and consistency
    - For management and balance of multiple purposes and needs
    - Focus is on the whole system rather on individual parts
- Minimum process requirements are
    - Establish requirements
    - Evaluate design options
    - Identify acceptable designs
    - Track integration of requirements and design
- No specific SE process is recommended or endorsed

ANS 30.1 – Principal Design Criteria Requirement

- Requirement - The preparation of and compliance with principal design criteria (PDC) for a proposed new reactor design shall be completed
  - PDC establish design, fabrication, construction, testing, performance requirements for structures, systems, and components important to safety
  - PDC are required for all LWR and non-LWR reactors licensed under 10 CFR Part 50
  - Requires proposed PDC to demonstrate its applicability to the public safety as well as fundamental safety concepts such as necessary safety functions and defense-in-depth
  - Recommends preparation early in design process but acknowledges criteria may be revised or changed as design progresses
  - Examples are provided but no PDCs are recommended or endorsed for any specific technology or reactor design

ANS 30.1 – Structured and Systematic DID

- Requirement - A DID process that is structural (relationship of parts to a complex whole), systematic (repeatable), and with decisions based on a coherent system of measurement of need and adequacy shall be implemented for the evaluation, prevention, and mitigation of hazards
  - Five attributes that integrate to achieve a robust philosophy of DID are described
  - Eight objectives for the use of RIPB methods and information in the assessment of DID are provided
  - The IAEA five levels of DID is provided as an illustration of a structured and systematic DID process
  - No specific process for DID evaluation is recommended or endorsed

ANS 30.1 – Event Sequence-Bases Assessments

- Requirement - Accidents used for the purposes of licensing shall be derived from a spectrum of plant responses which includes initiator, plant response successes and failures, and defined end state
  - The standard discusses generation of this "spectrum" in general terms; a detailed PRA is not required or recommended for all design circumstances
  - The uses of event sequences-based assessments recognize the reactor design will evolve and allows
    - Optimum selection from multiple design options
    - Recognition that identified successes are just as important as identified failures
    - Allows natural transition from design goals to design requirements
    - Provides realistic risk profiles to be determined.
  - Sequence-based information is the purposed output of industry accepted RIPB methods and analysis

ANS 30.1 – Status

- Ballot draft is currently undergoing review by the Advanced Initiatives sub-group of RARCC, RP3C, and SCoRA. Closing date is September 4, 2021
- Informal review previously conducted generated approximately 150 comments
  - A substantial number of these comments attempted to address topics and concerns that were not within the purpose, scope, or applicability of the standard
- The core premise of the standard has not yet been addressed in any comment cycle, that being

The full benefits of risk and performance evaluation methods as applied to the design for a new reactor are achieved through a disciplined and quantitative evaluation of options considered during the design process. The effectiveness of these evaluation methods relies on the presence of four process elements that ensure a minimum necessary design process structure is available for these evaluations. These four process elements are:

Systems engineering process
Principal design criteria
Structured and systematic defense-in-depth
Event sequence-based assessments

- It is hoped this forthcoming review will provide technical input on this premise