Harmonization of Codes and Standards under Unified Risk-Informed and Performance-Based Principles

- **Moderator:** Jim Xu, Senior Level Advisor, RES/DE

- **Panelists/Speakers:**
  - ANS: Robert Budnitz and Prasad Kadambi
  - ASCE: George Abatt and Andrew Whittaker
  - ACI: Shen Wang
  - ASME: Michael Cohen and Tim Adams
  - IEEE: Daryl Harmon
  - NEI: Thomas Basso and Stephen Geier
  - EPRI: Hasan Charkas

Harmonization of Codes and Standards (C&S) under Unified Risk-Informed and Performance-Based(RIPB) Principles

- **C&S harmonization and unified RIPB principles**
- **Panelist perspectives focus on:**
  - Benefits for achieving risk-balanced design objectives from the harmonization of C&S
  - Challenges for achieving C&S harmonization under unified RIPB principles
  - Effective and efficient approaches and metrics to coordination and collaboration to achieve the C&S harmonization
  - How do we move forward effectively and what roles can NRC play in facilitating C&S harmonization?
  - Disclaimer: Opinions presented hereinafter are of panelists’ personal views which do not necessarily reflect views or positions of their affiliated SDOs

Why Harmonization is Important

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NRC Standards Forum

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Major Steps to Achieve Harmonization of Codes and Standards Using RIPB Principles

- Need to identify what “risk” is involved OR what “performance” is being sought
- Need to identify how to “measure” the risk OR the performance
- Need to determine how much risk (OR how much degradation of performance) is tolerable
- Need to determine how much ”margin” is needed to achieve the “tolerable” level in the last bullet.
- If several Standards must be met simultaneously, HARMONIZATION is necessary.

One Example: A Typical NPP Heat Exchanger

<u>The</u> Issue: Many Standards That <u>Should</u> Work Together are Significantly "Out of Harmony"

One example: **a typical NPP heat exchanger**

One simple issue: **assuring adequacy of the seismic design**

seismic input --- from an ANS standard

tank --- ASME seismic code

resting on a steel support --- AISC seismic code

steel resting on a concrete floor --- ACI seismic code

on the third floor of an ASCE building

electrical inputs and controls --- IEEE seismic code

All of Those Codes Have Different "Margins"

A typical NPP heat exchanger:

Why different margins: Typically, each code committee (ASME, ASCE, ACI, AISC, IEEE) had a non-nuclear code for seismic safety that was converted into a "nuclear" version, often decades ago.

Each code committee put in whatever "margins" they thought were needed. Good for them!

But they never interacted. So the "margins" (above the "design basis") are all-over-the-place.

HARMONIZATION? It never came up!

Why? Things are "more than adequately safe," so "leave it alone!"

Harmonization

- One needs a "figure of merit" to use in "harmonizing."

- Two obvious ones are:
  - Meeting a specified "performance measure"
  - Meeting a specified "risk target"

- The "risk target" need not be "risk of a major nuclear acccident" – it could be "risk that the turbine will be damaged" or "risk of 24 hours of down time."

ANS, One of The SDOs

- I am firmly convinced that the American Nuclear Society will be (and can be) an important "player" in industry-wide efforts toward harmonization.

- I am also convinced that the initiative cannot even start with only one SDO. It must begin with multiple-SDO involvement.

Outcome-Directed Harmonization of Consensus Standards

American Nuclear Society

N. Prasad Kadambi, Chair

ANS Risk-informed, Performance-based Principles and Policy Committee

October 13, 2020

Outcomes and Harmonization

- A measure of harmonization is to assess whether a set of standards effectively support the desired outcome
- Representing the outcome within a systems engineering framework helps
- ANS (RP3C) has taken the lead in offering guidance to examine margins holistically within structured performance objectives

RP3C’s RIPB Guidance

- RP3C developed guidance for ANS Working Groups to focus on outcomes.
- Outcomes represented as structured performance objectives enable optimization of safety and economics.
- PB approach in a standard should:
  - o Clarify outcomes
  - o Specify criteria for performance success

o RI approach in a standard should:
  - o Define how to gain risk insights
  - o Define how to use risk insights

RP3C Supports ANS Initiatives

- Discussion of RIPB methods in monthly Community of Practice sessions.
- ANS conferences include RIPB sessions.
- Disseminate RIPB capabilities in ANS Position Statements.
- Support ANS outreach by developing RIPB training for external communication.
- SDO cooperation exemplified by ANS and ASME working together.

American Nuclear Society

ans.org

Performance-Based Approach in ASCE Standards 4 and 43

F George Abatt
Vice Chair, ASCE DANS Committee and ASCE Nuclear Standards Committee

Performance-Based Concept

- Both standards are intended to be performance based
  - Ground motion developed using the seismic risk equation
- Both are based on the concepts of seismic design categories (SDCs) and limit states
  - The SDC is based on a safety analysis and the unmitigated consequences of failure
  - Limit state is the limiting acceptable condition of the SSC
    - Limit states defined at the system level
    - In contrast, risk targets defined at the component level – a disconnect
- The target performance goal (P_f) is a function of the SDC

Achievement of Target Performance Goals

- To meet the target performance goals, the seismic demands and capacities should be determined to meet the following criteria:

  1. Less than about a 1% probability of unacceptable performance for the DBE ground motion
  2. Less than about a 10% probability of unacceptable performance for 150% of the DBE ground motion

Achievement of Target Performance Goals – con't.

- The above criteria are achieved when
  - The seismic demand is determined at approximately the 80% non-exceedance level for the specified input response spectrum
    - The intent of ASCE 4 and 43
  - The seismic capacity is based on a 98% exceedance level
    - Assumed to be delivered by equations for design strength in ACI 349 and AISC 690

How the Standards are Typically Used

- The two standards are intended to provide a performance-based approach to seismic evaluation, but they still contain deterministic elements
- The inclusion of deterministic elements is by design to make the standards more useable to the engineering community
- Although the standards are performance based, risk metrics do not typically result from these analyses

Takeaways

- Inclusion of “more SPRA like” guidance in the standards will be helpful, but we should guard against mandating such an approach
- Encourage more cross-pollination between ASME, ASCE, ANS, ACI, AISC, and NRC in the development of codes, standards, and regulations
- ASME Section III Seismic Design Steering Group is a good example
- Especially important that the different groups understand the fundamental assumptions on which each of the codes, standards, and regulations are based and the target performance goals of each

American Concrete Institute
Always advancing

Concrete Design Codes for Nuclear Facility

NRC Standards Forum

October 13, 2020

Shen Wang, Ph.D. ,P.E. ACI 349 Committee

NuScale Power LLC

ACI 349-13

- Design code for nuclear safety related concrete structures
- ACI 349-13 referring to ACI 318-08 as parents code, with special requirements in
  - Design loads and load combinations
  - Minimum reinforcement
  - Cracking control
  - Seismic design provision
  - Testing and inspection
  - Record keeping and traceability
  - Quality control and assurance

ACI 349-13

- Current ACI 349 Code is NOT suitable for Risk-informed and Performance-based evaluation, because the Code is:
  - Based on Deterministic LRFD design principle
  - Using linear elastic structural analysis approach in general
  - Assuming that structural behavior remain essentially elastic
  - No provision on Beyond Design Basis or Design Extension Condition, except for Aircraft Impact
  - No provision on Probabilistic Safety Assessment or Safety Margin Assessment

ACI 359 / ASME III Div.2-2019

- Design Code for Concrete Containment established by joint ACI-ASME committee
- NOT suitable for Risk-informed and Performance-based evaluation, because the Code is:
  - Based on Deterministic ASD design principle
  - Using linear elastic structural analysis approach in general
  - Assuming that structural behavior remain essentially elastic
  - No provision on Beyond Design Basis or Design Extension Condition, except for Aircraft Impact
  - No provision on Probabilistic Safety Assessment or Safety Margin Assessment
  - Only Applicable to containment concept

Harmonization of Codes and Standards under Unified Risk Informed and Performance Based Principles – ASME

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October 13, 2020 • Virtual Meeting

Michael Cohen, Chair, SWG High Temperature Reactors Stockholders
Terrapower

Timothy M. Adams, Vice Chair, Standards Committee III
Jensen Hughes

- Code Summary
  - BPVC Section III (New Construction)
  - BPVC Section XI (Plant Operation)
  - O&M Code (Operation & Maintenance)
  - ASME/ANS-RA Series (PRA)
  - NOG/NUM Codes (Cranes)
  - AG-1 (Gas and Air Treatment)
  - NQA-1 (Quality Assurance)
  - QME-1 (Equipment Functional Qualification)

- Historically, They Are Component-Based Codes
  - Design, Inservice Inspection, Operation, and Maintenance
  - Primarily Deterministic Based
  - No Broad-based use of Risk Based Approaches
  - Risk Based Methods Selectively and Uniquely Applied

- Most ASME Codes are Developed for Component for Construction
- Manufacturers Need Explicit Rules/Guidance
- How to Integrate Risk Approaches into Component Design & Construction Codes?
- Current Thinking
  - Risk Levels to be Determined Outside ASME Construction Codes
  - ASME Codes Provide Graded Construction and Inspection Requirements Commensurate with Risk Level

- Better Integration Across ASME Standards is Needed
  - A consistent approach to Risk based considerations is needed across all ASME Nuclear Codes
  - Seamless Transition in Risk based approaches from Construction Codes to Operation and Maintenenace Codes
  - ASME approaches need to be Consistent with Non-ASME Standards.
- Input from Other Standards Needs Considered
  - ANS, ASCE, Other ASME Standards, etc.
  - Many Provide input to ASME Component Specific Design

Thank You!

NPEC's Risk-Informed Standard and Harmonization with IEC Standards

Daryl Harmon
NPEC Chair

IEEE Nuclear Power Engineering Committee

- Within IEEE-PES NPEC is responsible for developing and maintaining standards for nuclear power plants and other facilities in the electrical and electronics area
- NPEC currently maintains 53 nuclear-related standards
- Subcommittees maintain standards in the following areas:
  - SC 2 Qualification
  - SC 3 Operations, Maintenance, Aging, Testing and Reliability
  - SC 4 Auxiliary Power
  - SC 5 Human Factors, Control Facilities and Human Reliability
  - SC 6 Safety Related Systems

IEEE Std 1819 – 2016:

Standard for Risk-Informed Categorization and Treatment of Electrical and Electronic Equipment at Nuclear Power Generating Stations and Other Nuclear Facilities

- NPEC has had a goal since 2005 to "Incorporate risk-informed methodologies into NPEC standards"
- Treatment of components is based on the safety significance of the component in risk-informed approach; no change to Class 1E classification
- Application of these methods has been shown to benefit both safety and cost effectiveness at existing plants
- The next step is to incorporate this methodology into other NPEC standards
- NPEC requested that NRC prioritize this standard for consideration for endorsement and NRC has responded that they are doing so

	Safety Related (Class 1E)	Non-Safety Related (Non-Class 1E)
Safety Significant	RISC-1 Safety Related Class 1E Safety Significant **(Current IEEE standards already apply)**	RISC-2 Non-Safety Related Safety Significant **(Increased requirements may utilize current IEEE standards)**
Low Safety Significant	RISC-3 Safety Related Class 1E Low Safety Significant **(Requirements of current IEEE standards can be adjusted)**	RISC-4 Non-Safety Related Low Safety Significant **(No special requirements)**

Risk Informed Safety Categorization

IEEE NPEC – IEC Joint Logo Standards Efforts

- For over 10 years NPEC and IEC have conducted a significant initiative to develop joint logo international standards thus harmonizing standards in many electronic and electrical areas
- Examples:
    - IEC/IEEE 60780-323 Qualification
    - IEC/IEEE 60980-344 Seismic Qualification
    - IEC/IEEE 62582-1-6 Condition Monitoring
    - IEEE-497 Accident Monitoring Instrumentation
    - IEC/IEEE 63113 Spent Fuel Pool Instrumentation (in final preparation)
- Challenges to harmonization
    - Agreement on terminology
    - Normative references (have used both IEEE and IEC sets in some standards)
    - Coordinating working group meetings, balloting and comment resolution

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NEI – Codes and Standards Role in Nexus between Safety and Performance

Thomas Basso, Senior Technical Advisor
October 13, 2020

NEI 20-04, *The Nexus Between Safety and Operational Performance in the US Nuclear Industry*

- Three main messages:

1. U.S. Industry Performance at All Time Highs
   - Compendium of performance data from multiple sources
2. Industry Performance Level Improves Safety
   - Demonstrates nexus between operational performance and improved safety
3. Risk-Informed Focus Improves Safety
   - Shows value of risk-informed approaches to improved safety and operational focus

NEI Codes and Standards Task Force (CSTF)

- NEI Codes and Standards Task Force (CSTF) interactions with NRC Embark Studio’s
    - Improvements to 10 CFR 50.59
- NEI Engagement with ASME Codes and Standards
    - Members of BNCS and ASME Committees
    - Routine interactions with ASME III and XI Executive Committees
    - Code Cases and Changes initiative by NEI CSTF Members
- Worked with ASME Section III, XI, and OM on identification of code committees seeking active participation by new reactor designers to ensure appropriate and applicable code revisions
    - Facilitating interactions between ASME code committees and new reactor community

NEI Support of Risk-informed Approaches

- 10 CFR 50.69 Implementation
- Supplemental Position Indication Susceptibility OM Code Case
- Risk-informed approach to MOV testing frequency
- ASME XI Optimization of Repair/Replacement Requirements
- Extension of Section XI and OM intervals and Program Updates

Sufficiency and efficiency

Andrew Whittaker, Ph.D., S.E.

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Chair, ASCE Nuclear Standards Committee

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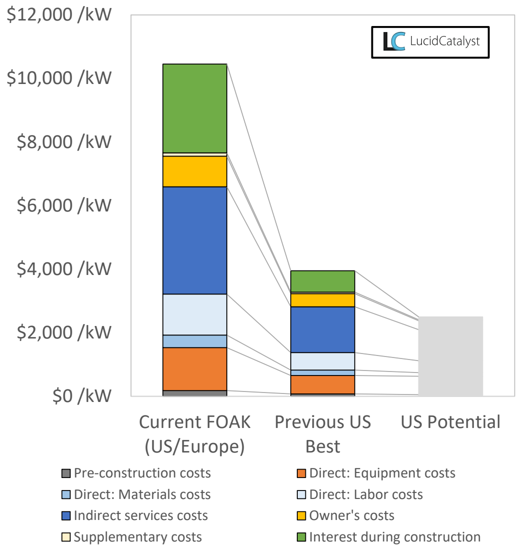
Codes and standards

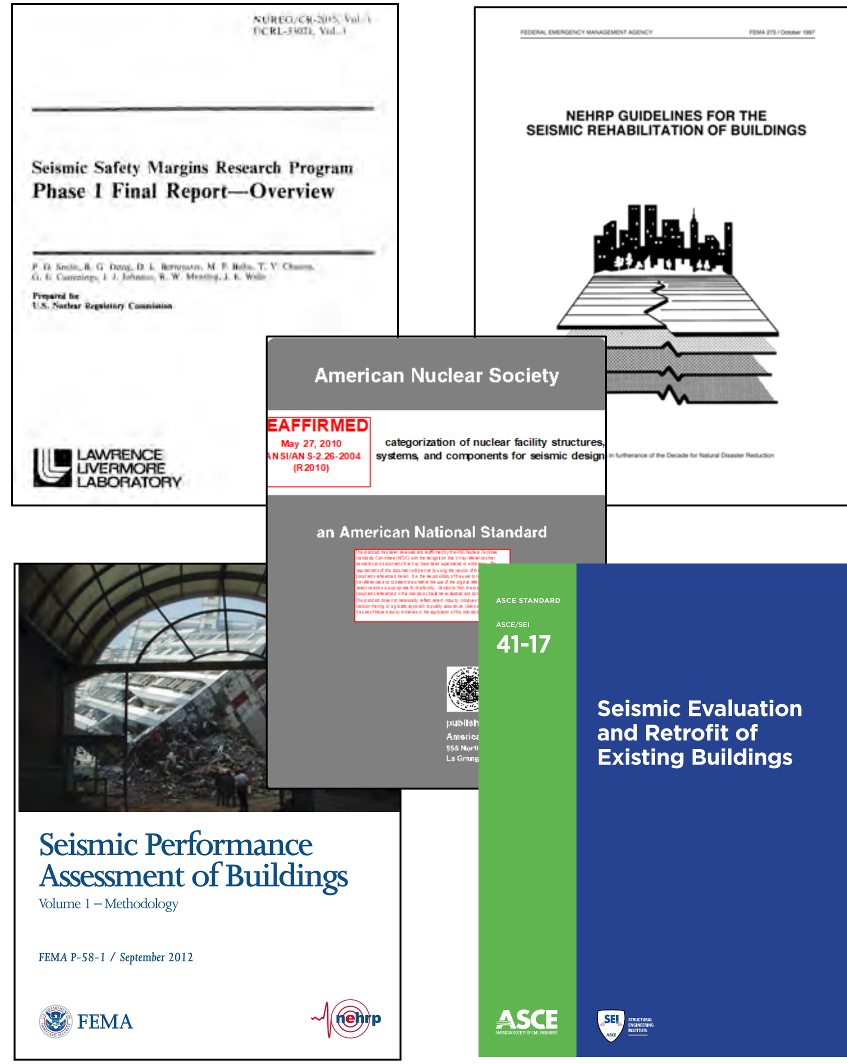
- Developed in silos
- Sufficiency
  – Adequate for service
- Efficiency
  – Minimum cost
  – Time to design, review, build
- Harmonization
  – Traditional design
  – RI+PB design (the future?)

(Giles, 2005)



Harmonization

- Risk markers
  - *Sufficiency* and *efficiency*
  - Harmonization not an option but a *must*
- PB design is not RI design
  - Limit states, continuum, risk
- C+S must be extended and silos demolished



Audience engagement

- Series of presentations from SDO members
- Traditional practice *sufficient* but not *efficient*
- Needed for RI+PB design?
  - Common language and framework
  - *Quantitative* performance statements
  - Risk tools by discipline
  - Systems engineering
- What do you think?
- Next steps for the SDOs?
  - And yes, we are talking

ASCE 43-19

Table 1-2. Deformation and Damage by Limit State.

Limit State	Expected Deformation	Expected Damage
A	Large permanent distortion, short of collapse	Significant damage
B	Moderate permanent distortion	Generally reparable
C	Limited permanent distortion	Minimal damage
D	Essentially elastic behavior	Negligible damage

Source: Adapted from ANS 2.26 (ANS 2017).