# 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

13 October 2020

NRC Standards Forum

Robert J. Budnitz

Energy Geosciences Division (retired)

Lawrence Berkeley National Laboratory

University of California

Berkeley CA 94720 USA

<RJBudnitz@LBL.gov>

# 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

# The Issue: Many Standards That Should 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. <u>It must begin with multiple-SDO involvement</u>.

# 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.

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# 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

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# 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

SETTING THE STANDARD

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

**NRC Standards Forum**
October 13, 2020 • Virtual Meeting


Michael Cohen, Chair, SWG High Temperature Reactors Stockholders
Terrapower

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


JENSEN HUGHES
Advancing the Science of Safety

- 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<br>Safety Related Class 1E<br>Safety Significant<br>**(Current IEEE standards already apply)** | RISC-2<br>Non-Safety Related<br>Safety Significant<br>**(Increased requirements may utilize current IEEE standards )** |
| Low Safety Significant | RISC-3<br>Safety Related Class 1E<br>Low Safety Significant<br>**(Requirements of current IEEE standards can be adjusted)** | RISC-4<br>Non-Safety Related<br>Low Safety Significant<br>**(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

# NRC 2020 Standards Forum

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

Thomas Basso, Senior Technical Advisor
October 13, 2020

NUCLEAR ENERGY INSTITUTE

# 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.

University at Buffalo

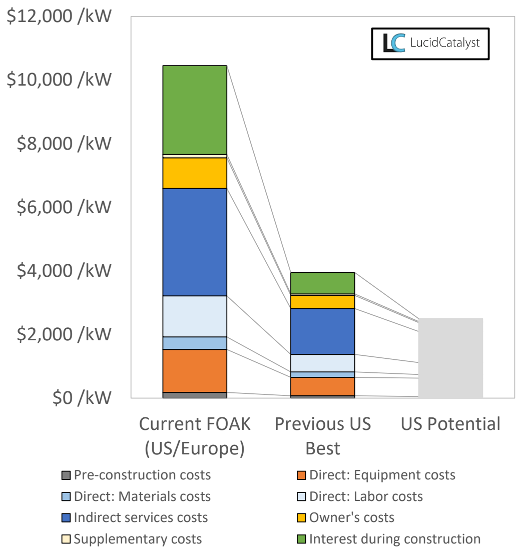
Chair, ASCE Nuclear Standards Committee

awhittak@buffalo.edu

# Codes and standards

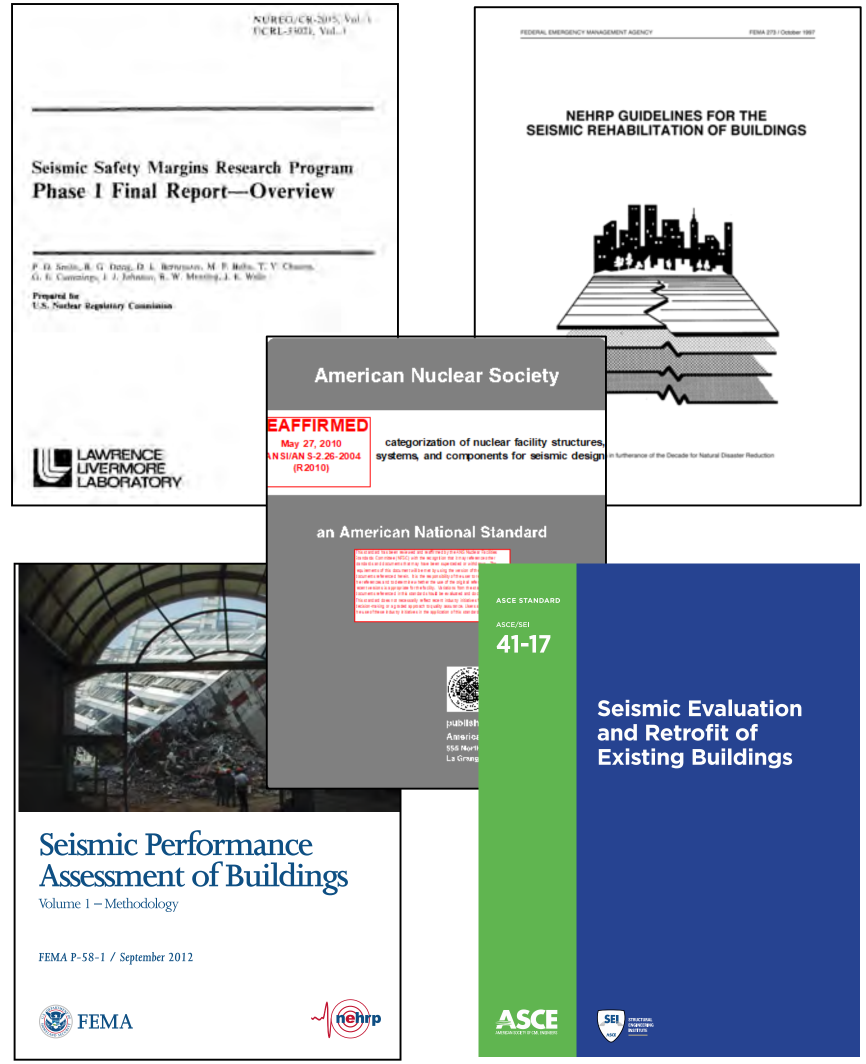
- Developed in silos
- Sufficiency
  - Adequate for service
- Efficiency
  - Minimum cost
  - Time to design, review, build
- Harmonization
  - Traditional design
  - RI+PB design (the future?)

(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).